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- GPSC Lecturers - Civil
- Engineering Services
- Civil Services
- GATE, M.E. Entrance Tests
- Municipal Corporation Tests
- Interviews and Recruitment Tests

OBJECTIVE CIVIL ENGINEERING

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PREFACE

I take an opportunity to present this treatise entitled as **"Objective Civil Engineering"** to the students preparing for GPSC, Engineering services, Civil services, Municipal corporation tests and other competitive examinations, interviews.

A large number of objective type questions with answers and explanations are provided for each topic. Almost all the subjects related to Civil Engineering have been covered in this book. Multiple choice questions from various competitive examinations have been incorporated in the various topics. I hope the book will embrace the requirements of the students of civil engineering.

Any errors, omissions and suggestions for the improvement of this book brought to my notice, will be thankfully acknowledged.

I thank **Shri Hemendrabhai Shah** and **Shri Bipinbhai Shah** for their keen interest in publishing this book.

August 2016 **Dr. R. P. Rethaliya**

INDEX

♦♦♦

1.

Applied Mechanics

1 : Introduction

1.1 ENGINEERING MECHANICS :

Engineering mechanics is the branch of applied science, which deals with the laws and principles of mechanics along with their applications to engineering problems.

Engineering Mechanics

Statics

– It deals with the forces and their effects, while acting upon the bodies at rest.

Dynamics

– It deals with the forces and their effects, while acting upon the bodies in motion.

Kinetics

– It deals with the bodies in motion due to the application of forces.

Kinematics

– It deals with the bodies in motion without any reference to the forces which are responsible for the motion.

1.2 SCALAR AND VECTOR QUANTITIES :

Scalar quantity : A scalar quantity is one which can be completely specified by it's magnitude only. For example

length,	Area
mass,	volume
time,	density
distance,	speed
temprature,	work
	energy
	moment of Inertia, etc.

Vector quantity : A vector quantity is one which requires magnitude and direction both to completely specify it. For example,

displacement, Force

velocity,	Weight
acceleration,	Angular velocity
momentum,	Angular acceleration
moment,	Impulse, etc.

1.3 FUNDAMENTAL UNITS :

All the physical quantities used in engineering mechanics are expressed in terms of three fundamental quantities, i.e.

1. Length 2. Mass 3. Time

The units of these fundamental quantities are called **fundamental units** or **base units.**

Derived units : The units of some physical quantities are derived from fundamental units. Such units are called **derived units**. e.g.

Units of area, velocity, acceleration etc.

1.4 CONVERSION OF UNITS :

1m = 100 cm

1m = 1000 mm

1 cm = 10 mm

1 km = 1000 m

1 cm^2 = 100 mm^2

1 m^2 = 10^6 mm^2

1 MPa = 1 N/mm^2

1 GPa = 10^3 N/mm^2

1 N.m = 1 Joule

1 Watt = 1 N.m/s = 1 J/S

1 kg f = 9.81 N $\simeq$ 10 N

1 kN = 10^3 N

1 MN = 10^6 N = 10^3 kN

1 GN= 10^9 N

1 kW = 10^3 watt

1 hp = 746 watt

1 degree = $\frac{\pi}{180}$ radian

IMPORTANT SHORT QUESTIONS

1. Speed is a .... quantity.
2. Which are the fundamental quantities ?
3. What is S.I. unit of power ?
4. What is unit of density ?
5. 1 kg = ... N
6. 1 MN = ... N
7. The system of units used internationally is ....
8. The unit of force in S.I. units is ....
9. 1 Pascal = ...
10. The branch of engineering mechanics dealing with study of motion of a body, causes of motion are not studied is called ....

ANSWERS

1. Scalar	2. Length, mass, time	3. Watt	4. kg/m^3	5. 9.81
6. 10^6	7. S.I. system	8. Newton	9. 1 N/m^2	10. Kinematics.

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2 : Coplanar Concurrent Forces

2.1 FORCE :

An agent which produces or tends to produce, destroys or tends to destroy motion of a body is called **force.**

Unit of force is Newton (N).

Force is a vector quantity.

1 N force : A force which can produce an acceleration of 1 m/s^2 in a mass of 1 kg is called **1 N Force.**

1 kgf force : A force which can produce an acceleration of g m/s^2 (gravitational acceleration) in a mass of 1 kg is called **1 kgf force.**

- **Characteristics of a force :**

Followings are the characteristics of a force :

(1) **Magnitude :** Magnitude of a force may be 10 kN, 50 kN, 200 N etc.

(2) **Direction :** i.e. – along OX,
– towards east
– at 30° West of North

(3) **Nature :** The nature of force may be tensile or compressive.

(4) **Point of application :**

The point at which the force acts on the body is called the **point of application.**

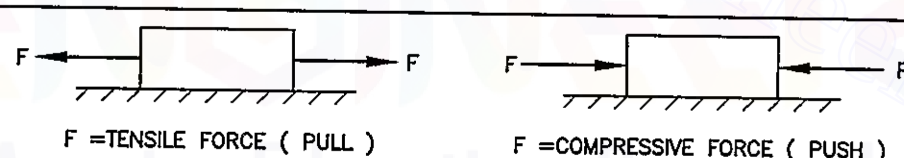


FIG. 2.1

2.2 WEIGHT AND MASS :

Weight (W) : The force by which the body is attracted towards the centre of the earth is called **Weight** (W) of the body.

Weight is a vector quantity.

Unit of weight is N, kN, kgf.

Mass (m) : The matter contained in the body is called mass.

Mass is a scalar quantity.

Unit of mass is kg, tonne.

$$\boxed{W = m \cdot g}$$

Where, W = weight (N)
m = mass (kg)
g = Acceleration due to gravity
= 9.81 m/sec^2

2.3 SYSTEM OF FORCES :

When two or more forces act on a body, they are called to form a **System of forces.**

Following systems of forces are important.

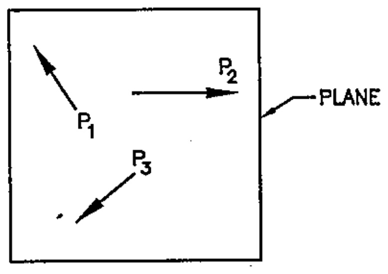


FIG. 2.2

(1) Coplanar forces :

The forces whose line of action lie on the same plane, are known as **coplanar forces.**

Here, forces P_1, P_2, P_3 are coplanar forces.

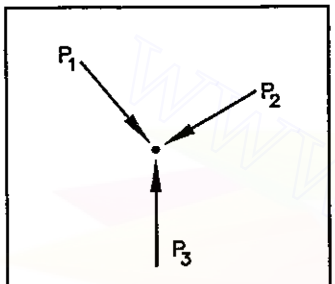


FIG. 2.3

(2) Concurrent forces :

The forces which meet at one point, are known as **concurrent forces.**

Forces P_1, P_2, P_3 are concurrent forces.

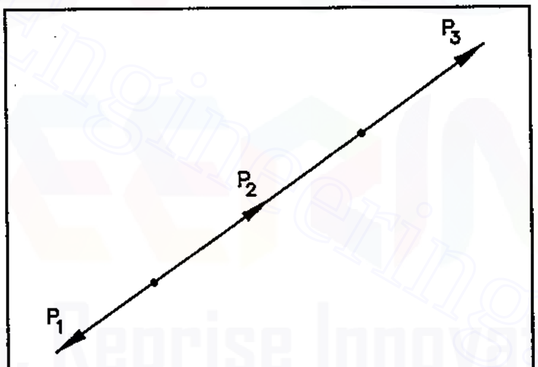


FIG. 2.4

(3) Collinear forces :

The forces whose lines of action lie on the same line, are known as **collinear forces.**

Forces P_1, P_2, P_3 are collinear forces.

(4) Coplanar concurrent forces :

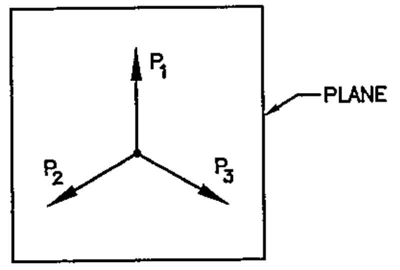


FIG. 2.5

The forces which meet at one point and their lines of action also lie on the same plane are known as **coplanar concurrent forces.**

Forces P_1, P_2, P_3 are coplanar concurrent forces.

(5) **Coplanar non–concurrent forces :**

The forces whose lines of action lie on the same plane but they do not meet at one point are known as **coplanar non-concurrent forces.**

Forces P_1, P_2, P_3 are coplanar non–concurrent forces.

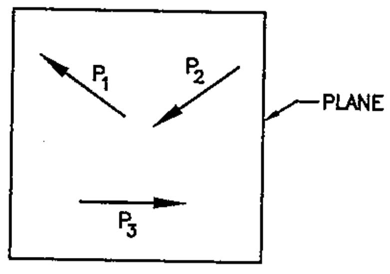


FIG. 2.6

(6) **Non–coplanar concurrent forces :**

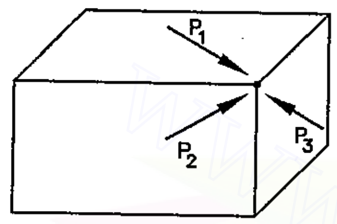


FIG. 2.7

The forces whose lines of action do not lie on the same plane, but they meet at one point are known as **Non–coplanar concurrent forces.**

Forces P_1, P_2, P_3 are non–coplanar concurrent forces.

(7) **Non–coplanar non–concurrent forces :**

The forces whose lines of action do not lie on the same plane and they do not meet at one point are known as **non-coplanar non-concurrent forces.**

Forces P_1, P_2, P_3 are non–coplanar non-concurrent forces.

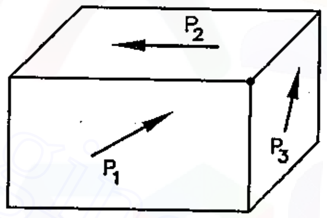


FIG. 2.8

FIG. 2.9

(8) **Like parallel forces :**

The forces, whose lines of action are parallel to each other and all of them act in the same direction are known as **like parallel forces.**

(9) **Unlike parallel forces :**

The forces, whose lines of action are parallel to each other but all of them do not act in the same direction are known as unlike **parallel forces.**

FIG. 2.10

2.4 RESULTANT FORCE :

If a number of forces P_1, P_2, P_3, P_4 ... etc. are acting simultaneously on a particle, it is possible to find out a single force which could repiace them i.e. which would produce the same effect as produced by all the given forces. This single force is called **resultant force,** and the given forces P_1, P_2, P_3, P_4 ... etc. are called component foces.

Equilibrant force :

To balance the resultant force (to bring the body in equilibrium), a force of same magnitude but of opposite direction is required. This opposite balancing force is called **equilibrant–force.**

rigid body : A rigid body may be defined as a body which can retain its shape and size, even if subjected to some external forces. In actual practice, no body is perfectly rigid. But for the sake of simplicity, we consider the body as a rigid body.

2.5 PARALLELOGRAM LAW OF FORCES :

It states,

"If two forces, acting simultaneously on a particle, be represented in magnitude and direction by the two adjacent sides of a parallelogram; their resultant may be represented in magnitude and direction by the diagonal of the parallelogram which passes through their point of intersection."

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$

where, R = Resultant force

θ = angle between P and Q

α = angle between P and R.

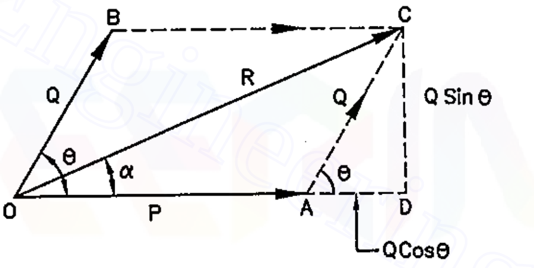


FIG. 2.11

2.6 LAMI'S THEOREM :

"If three coplanar forces acting at a point be in equilibrium, then each force is proportional to the sine of the angle between other two forces."

Mathematically,

$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

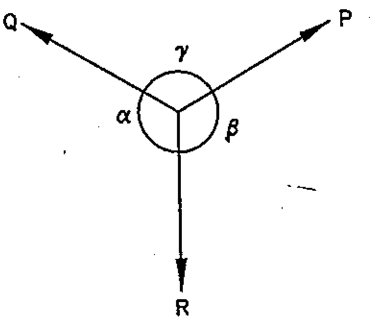


FIG. 2.12

2.7 TRIANGLE LAW OF FORCES :

"If two forces acting at a point be represented in magnitude and direction by two sides of a triangle taken in order, their resultant may be represented in magnitude and direction by the third side of the triangle, taken in opposite order."

For example,

Consider two forces P = 40 N, Q = 30 N acting at right angle to eachother.

R = Resultant force = ac

= 5 cm × 10

= 50 N

Q = Angle of R with P

2.8 POLYGON LAW OF FORCES :

"If a number of forces acting at a point be represented in magnitude and direction, by the sides of a polygon taken in order, then the resultant of all these forces may be represented, in magnitude and direction by the closing side of the polygon taken in opposite order."

Consider a system having four forces acting at a point.

2.9 RESULTANT OF MORE THAN TWO CONCURRENT FORCES :

Consider P_1, P_2, P_3, P_4 ... etc. are acting at a point as shown in figure.

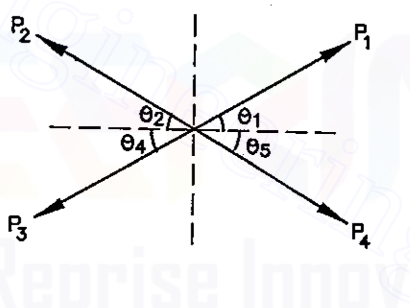


FIG. 2.13

ΣH = Algebric sum of horizontal forces.

ΣV = Algebric sum of vertical forces.

R = Resultant of all forces

$$\therefore\ R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$$

$$\tan\theta = \frac{\Sigma V}{\Sigma H},$$

θ = angle of resultant with horizontal

IMPORTANT SHORT QUESTIONS

1. List the characteristics of a force.
2. What is relation between weight and mass ?
3. The resultant of two concurrent tensile forces is maximum, when angle between them is ....
4. The resultant of two concurrent tensile forces is minimum, when angle between them is ....

5. The conditions of equilibrium for coplanar concurrent forces are ....
6. A 20 kN force is acting vertically upward. Its horizontal component is equal to ....
7. What is equilibrant force ?
8. For a coplanar concurrent force system if ΣH = +ve and ΣV = –ve, the resultant force lies in the ....
9. The statement, "the effect of a force upon a body is the same at every point on its line of action" refers to ....
10. A body isolated from all other members which are attached to it is called the ......

ANSWERS

1. Magnitude, direction, nature, point of application.
2. $W = m \cdot g$
3. 0°
4. 180°
5. $\Sigma H = 0$, $\Sigma V = 0$, $\Sigma R = 0$.
6. Zero
7. A force of same magnitude but of opposite to the resultant force is called equilibrant force.
8. Fourth quadrant.
9. Principle of transmissibility.
10. Free body.

3. Coplanar non-concurrent forces

3.1 MOMENT :

Moment of a force at any point is defined as the product of a force and perpendicular distance of line of action of force from that point.

∴ Moment = Force × perpendicular distance

Unit of moment is N.m or kN.m

FIG. 3.1

∴ $\boxed{M_0 = P \cdot x}$

Types of Moment

- Clockwise Moment
- Anticlockwise Moment

FIG. 3.2

Clockwise Moment	Anticlockwise Moment
$M = P \cdot x$ ↻	$M = P \cdot x$ ↺
– It rotates the body in a clockwise direction.	– It rotates the body in anticlockwise direction.
– Normally, clockwise moment is considered positive (+ve).	– Normally, anticlockwise moment is considered negative (–ve).

- **Applications of moment :**
  1. To open or close a door.
  2. To tight nut using spanner.
  3. To rotate steering wheel of car.

3.2 VARIGNON'S PRINCIPLE OF MOMENTS :

It states,

"If a number of coplanar forces are acting simultaneously on a particle, the algebric sum of the moments of all the forces about any point is equal to the moment of their resultant force about the same point."

For example,

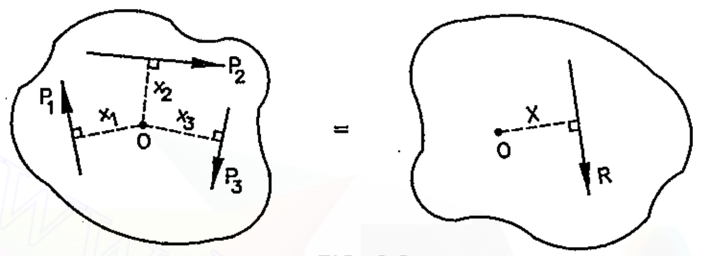


FIG. 3.3

body subjected to three coplanar forces	body subjected to resultant of three forces.
Moment of all the forces about O,	Moment of resultant force about O,
$= P_1x_1 + P_2x_2 + P_3x_3$	$= R \cdot x$

∴ According to Varignon's principle,

$$\boxed{P_1x_1 + P_2x_2 + P_3x_3 = R \cdot x}$$

3.3 COUPLE :

A couple is defined as a system of two equal and opposite forces separated by a definite distance.

Types of couple

Clockwise couple	Anticlockwise couple
$M = P \cdot a$ ↻	$M = P \cdot a$ ↺

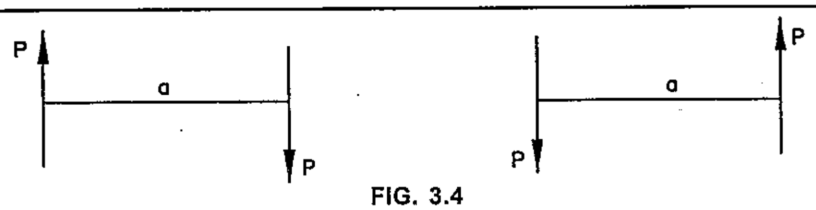


FIG. 3.4

It rotates the body in a clockwise directin.	It rotates the body in anticlockwise direction.
It is considered as positive (+ve).	It is considered as negative (–ve).

Arm of couple : The perpendicular distance between two forces of a couple is called arm of couple.

Moment of couple :

Moment of couple = force × arm of couple

$$\boxed{M = P \times a}$$

Unit of moment of couple is N.m. or kN.m.

3.4 TYPES OF BEAMS :

Different types of beams are shown below.

(1) Simply supported beam :

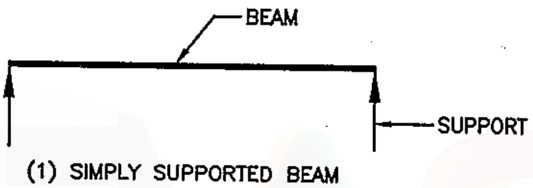


FIG. 3.5

(2) Overhanging beam :

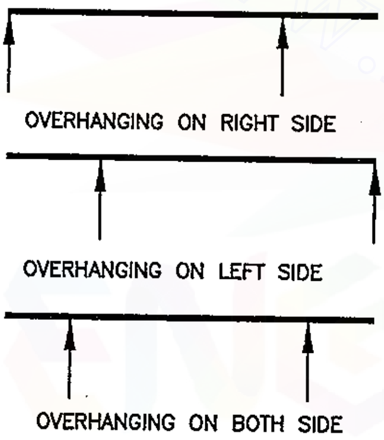


FIG. 3.6

(3) Cantilever beam :

It has one end fixed and other end free.

FIG. 3.7

(4) Fixed beam :

It has both ends fixed.

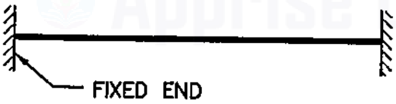


FIG. 3.8

(5) Continuous beam :

It has more than two supports.

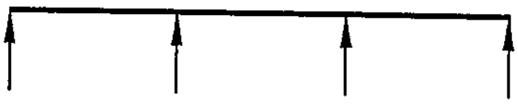


FIG. 3.9

(6) Propped cantilever beam :

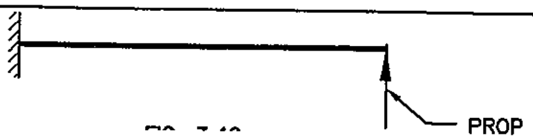


FIG. 3.10

3.5 TYPES OF LOADS :

There are three types of loads.

(1) Point load or concentrated load :

W_1 and W_2 are point loads.

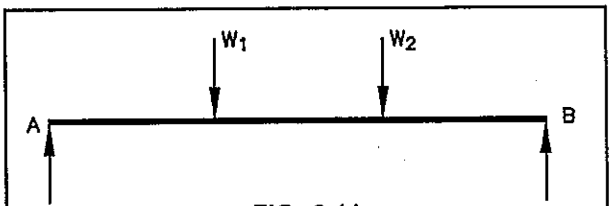


FIG. 3.11

- The load concentrated at one point is called point load.
- Unit of point load is N or kN.
  e.g. 20 kN, 100 N, 60 kN etc.

(2) Uniformly distributed load.

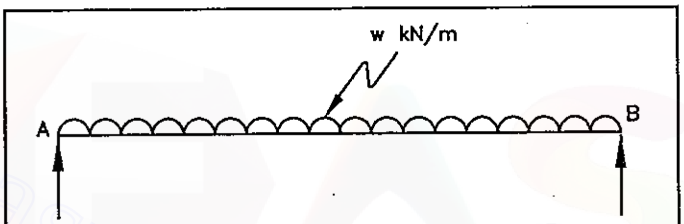


FIG. 3.12

- Load uniformly distributed on certain length of a beam is called uniformly distributed load.
- It is written as u.d.*l.*
- It is shown by w.
- Unit of u.d.*l.* is kN/m or N/m

For example,
20 kN/m, means 20 kN load on 1m length.

If span of beam is 4 m,
total load = 20 × 4 = 80 kN

(3) Uniformly varying load :

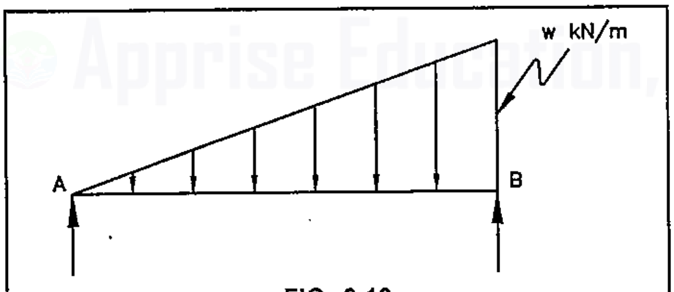


FIG. 3.13

This type of load gradually increase or decrease on the length of the beam.

It is also called triangular load.

3.6 TYPES OF SUPPORTS :

Different types of supports are :

1. Simple support
2. Hinged support
3. Roller support
4. Fixed support

(1) Simple support :

- In this type of support, beam is simply supported on the support.
- There is no connection between beam and support.
- At this type of support, only vertical reaction will be produced.

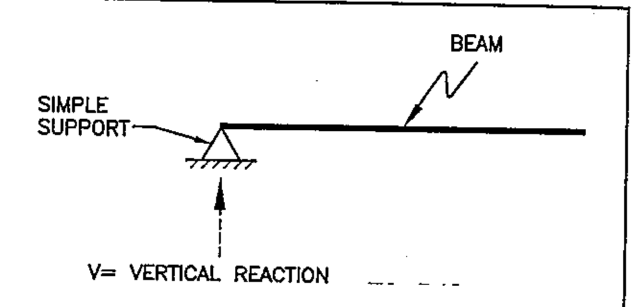


FIG. 3.14

(2) Hinged support :

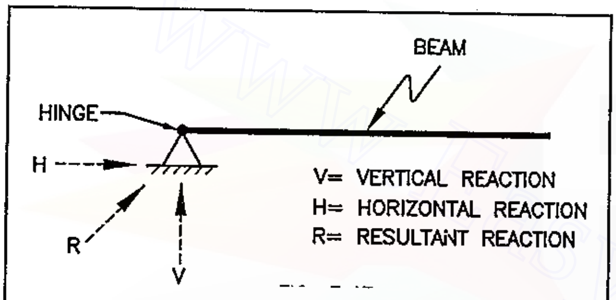


FIG. 3.15

- Beam and support are connected by a hinge.
- Beam can rotate about the hinge.
- Reactions may be vertical, horizontal or inclined.

(3) Roller support :

- In this type of support, rollers are placed below beam and beam can slide over the rollers.
- Reaction will be perpendicular to the surface on which rollers are supported.
- This type of support is normally provided at the end of a bridge.

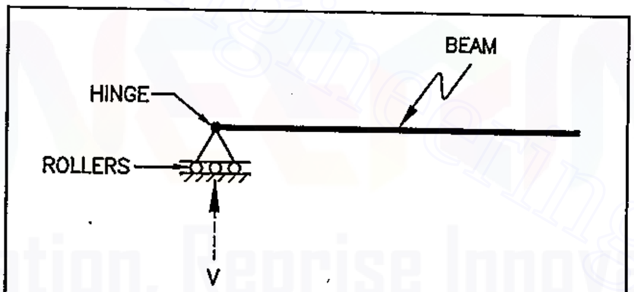


FIG. 3.16

Due to breaking forces of vehicles and temperature forces, bridge slab can slide over the roller support and damage to bridge pier can be avoided.

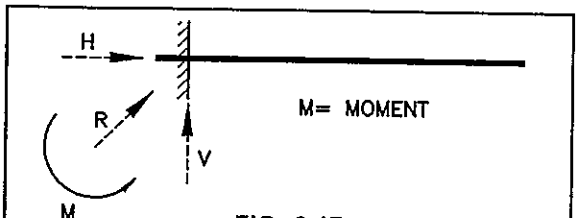


FIG. 3.17

(4) Fixed support :

- Beam is completely fixed at end in the wall or support.
- Beam can not rotate at end.
- Reactions may be vertical, horizontal, inclined and moment.

IMPORTANT SHORT QUESTIONS

1. Moment is equal to ....
2. The unit of couple is ....
3. Give two examples of moment.
4. Give two examples of couple.
5. Resultant force of couple is ....
6. Principle of moment is based on .... theorem.
7. A couple is formed by ....
8. If three equal forces 150 kN each are acting along three sides of triangle in clockwise direction, their resultant is ....
9. The support normally provided at the end of a bridge is ....
10. At fixed support, the possible reactions are,
11. The reaction at the roller support of a beam is always,

ANSWERS

1. Force × Perpendicular distance of line of action of force.
2. N.m or kN.m
3. (i) To open or close the door.
   (ii) To tight the nut by spanner.
4. (i) To rotate the steering wheel of car by two hands.
   (ii) To rotate key in the lock.
5. Zero
6. Varignon's
7. Two equal, opposite and non-collinear forces
8. Zero
9. Roller support
1 Vertical (V), Horizontal (H),
  Moment (M)
11. Vertical

❖❖❖

4. Centroid and Centre of Gravity

4.1 CENTROID :

In plane figures like square, rectangle, triangle, circle etc., the point at which whole area of the figure is concentrated, is called **centroid.**

Plane figures do not have mass.

They are two–dimensional.

4.2 CENTRE OF GRAVITY (C.G.) :

In solid bodies like cube, cuboid, cone, sphere etc., the point at which whole mass of the body is concentrated, is called **centre of gravity (c.g.).**

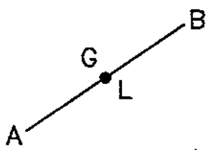
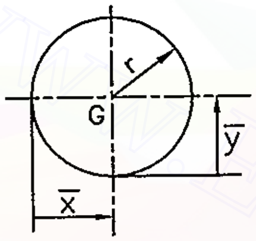
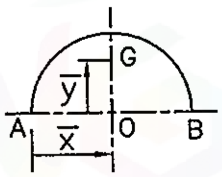
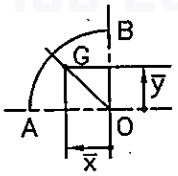
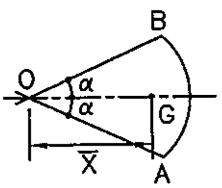
In solid bodies gravitational force act on c.g.

- **Difference between centroid and C.G. :**

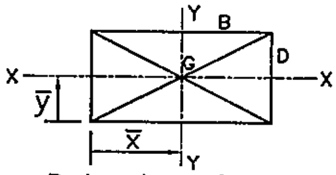
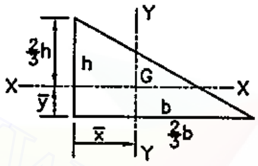
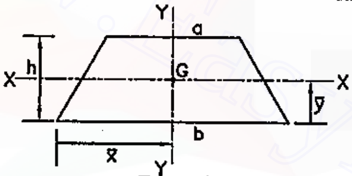
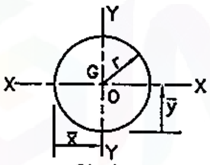
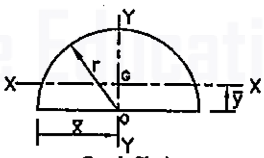
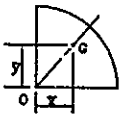
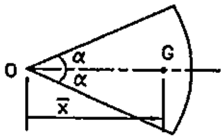
Centroid	Centre of gravity
(i) In case of plane figures the point at which whole **area** of the figure is concentrated is called centroid.	(i) In case of solid bodies the point at which whole **mass** is concentrated is called c.g.
(ii) Centroid word is used for 2–D figures. For example, Square, Rectangle, Triangle, Circle etc.	(ii) Centre of gravity word is used for 3–D figures. For example, cube, cuboid, cone, sphere etc.

4.3 CENTROIDS OF STANDARD SHAPE :

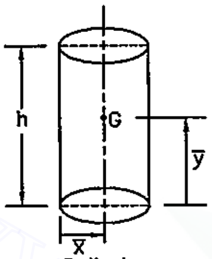
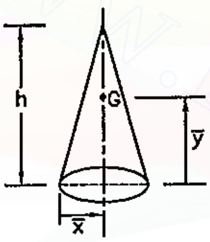
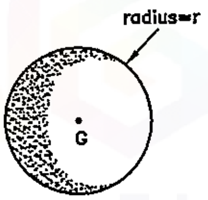
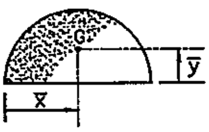
A . ONE DIMENSIONAL (WIRES)

Sr.No	Geometrical Shape	Length	$\bar{x}$	$\bar{y}$
1	 Straight Wire AB	L	Centre of Length (L/2)	
2	 Wire ring	$2\pi r$	Centre of Circle (r) $\bar{x}=r$	$\bar{y}=r$
3	 Semicircular Wire AB	πr	r	$\frac{2r}{\pi}$
4	 Quarter–circular Wire AB	$\frac{\pi r}{2}$	$\frac{2r}{\pi}$	$\frac{2r}{\pi}$
5	 Arc of circle AB	$2\alpha r$ α:rad	$\frac{r \sin\alpha}{\alpha}$ α=angle in radians	On axis of Symmetry

B. TWO DIMENSIONAL FIGURES

Sr.No	Geometrical Shape	Area	$\bar{x}$	$\bar{y}$
1	 Rectangular or Square	$A=B.D$	$\frac{B}{2}$	$\frac{D}{2}$
2	 Rigth Angle Triangle	$A=\frac{1}{2}b.h$	$\frac{1}{3}b$	$\frac{1}{3}h$
3	 Trapezium	$A=(a+b)\frac{h}{2}$	$\frac{b}{2}$	$\frac{h}{3}\left(\frac{b+2a}{b+a}\right)$
4	 Circle	$A=\pi r^2$ OR $A=\frac{\pi}{4}d^2$	r	r
5	 Semi Circle	$A=\frac{\pi r^2}{2}$	r	$\frac{4r}{3\pi}$
6	 Quarter Circle	$A=\frac{\pi}{4}r^2$	$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$
7	 Circular Sector	$A=\alpha r^2$ α :rad	$\frac{2}{3}\frac{r\sin\alpha}{\alpha}$	On axis of Symmetry

C. THREE DIMENSIONAL FIGURES (SOLIDS)

Sr.No	Solid	Volume	$\bar{x}$	$\bar{y}$
1	 Cylinder	$V=\pi r^2 h$	r	$\frac{h}{2}$
2	 Cone	$V=\frac{\pi}{3} r^2 h$	r	$\frac{h}{4}$
3	 Sphere	$V=\frac{4}{3}\pi r^3$	r	r
4	 Hemisphere	$V=\frac{2}{3}\pi r^3$	r	$\frac{3r}{8}$

IMPORTANT SHORT QUESTIONS

1. Centroid is defined as a point about which ....
2. Centre of gravity is defined as a point about which ....
3. The centroid of semi-circular area lies at distance of .... from base along the vertical axis.
4. The centroid of semi-circular wire lies at distance of .... from base along the vertical axis.
5. The C.G. of hemisphere lies at a distance of .... from its base along the vertical axis.
6. For T-section having flange 60 × 10 mm and web 10 × 60 mm, $\bar{x}$ = ...
7. What is symmetry of L-section ?
8. The C.G. of a right circular cone of diameter (d) and height (h) lies at a distance of .... from the base measured along vertical axis.
9. The C.G. of equilateral triangle with each side (a) is .... from any of the three sides.
10. If the area is symmetrical about y-axis, the centroid lies on .... axis.

ANSWERS

1. The entire line, area or volume is assumed to be concentrated.
2. The entire weight (or mass) of the body is assumed to be concentrated.
3. $\frac{4r}{3\pi}$
4. $\frac{2r}{\pi}$
5. $\frac{3r}{8}$
6. 30 mm
7. L-section is not symmetrical about any axis.
8. $\frac{h}{4}$
9. $\frac{a}{2\sqrt{3}}$
10. y-axis.

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5. Friction

5.1 FRICTION OR FRICTION FORCE :

When a body slide or tends to slide on a surface on which it is resting, a resisting force opposing the motion is produced at the contact surface. This resisting force is called **friction** or **friction force.**

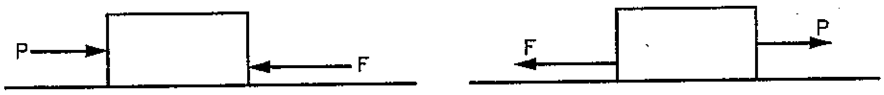


FIG. 5.1

P = external force

F = Friction force

⇒ Friction force (F), always act in the direction opposite to the movement of the body.

⇒ If contact surfce is smooth, friction force (F) will be less.
If contact surface is rough, friction force (F) will be more.

⇒ In machine parts like piston, bearings, liner etc. attempts are made to reduce friction to increase life of parts and efficiency of machine.

⇒ Outer surface of vehicle tyres is made rough to increase friction between tyre and road surface for safe driving.

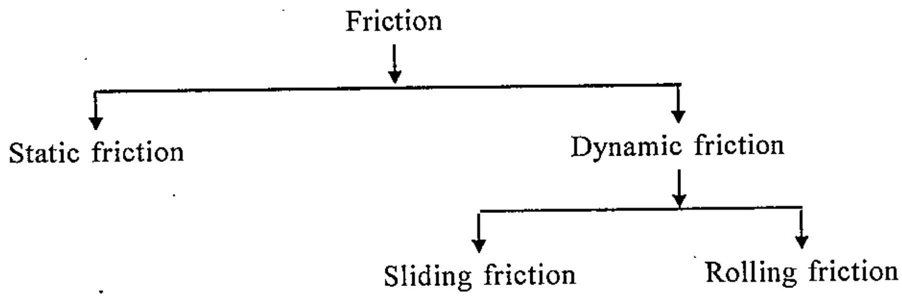
5.2 LIMITING FRICTION :

Consider a body resting on the surface. If a little force is applied on the body, it will not move, because friction force (F) will resist the motion.

With further increase in external force, body will not move. But, there is a limit of developing friction force. If external force becomes greater than friction force, body will move.

The maximum friction force that can be developed at the contact surface, when body is just on the point of moving is called limiting friction.

5.3 TYPES OF FRICTION :



- **Static friction :** Friction experienced by a body when it is at rest is called **static friction.**

  In case of static friction,

$P < F$	P = external force
∴ there is no motion	F = friction force

- **Dynamic friction :**

  Friction experienced by a body, when it is in motion is called **dynamic friction.**

  Dynamic friction is always less than static friction.

- **Sliding friction :** Friction experienced by a body when it slides over another body, is called **sliding friction.**

  e.g. to push the table on floor.

- **Rolling friction :** Friction experienced by a body, when it rolls over another body, is called **rolling friction.**

  e.g. – to move the drum by rolling.

  – Ball bearing used in machines.

5.4 ANGLE OF FRICTION : ϕ

W = Weight of block

N = Normal reaction

P = external force

F = Friction force

R = Resultant of N and F.

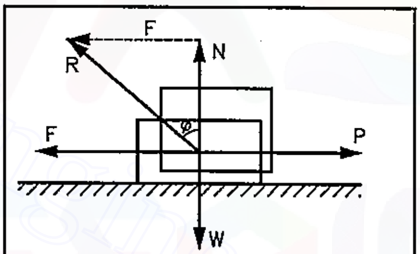


FIG. 5.2

The angle between normal reaction (N) and resultant force (R) is called **angle of friction.**

It is also called **limiting angle of friction.** The value of ϕ is more for rough surface as compared to smooth surface.

5.5 COEFFICIENT OF FRICTION : μ

Limiting friction (F) is proportional to the normal reaction (N).

$\therefore \quad F \propto N$

$\therefore \quad F = \mu \cdot N$

$\therefore \quad \boxed{\mu = \frac{F}{N}}$ ... (i)

The ratio of Limiting fricion (F) and Normal reaction (N) is called coefficient of friction.

from figure 5.2,

$\tan\phi = \frac{F}{N}$ ... (ii)

From equation (i) & (ii),

$\therefore \quad \boxed{\mu = \tan\phi}$

5.6 ANGLE OF REPOSE :

With increase in angle of the inclined surface, the maximum angle at which, body starts sliding down is called **angle of repose.**

Consider a body of weight W, is resting on the plane inclined at angle α with horizontal.

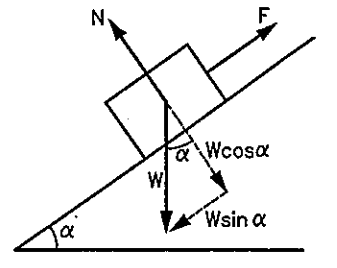


FIG. 5.3

Weight (W) has two components,

Component parallel to the plane = W sin α

Component perpendicular to the plane = W cos α

Resolve ⊥ to plane,	**Resolve ∥ to plane**
∴ N = W cos α	∴ F = W sin α

$$\therefore \quad \mu = \frac{F}{N} = \frac{W \sin\alpha}{W \cos\alpha} = \tan\alpha \quad \text{... (i)}$$

We know that,

$\mu = \tan\phi$ ... (ii)

From equation (i) and (ii),

$\tan\alpha = \tan\phi$

$\therefore \quad \alpha = \phi$

Where, α = angle of inclined plane

Hence, when the angle of inclined plane (α), becomes equal to the limiting angle of friction (ϕ), body will slide down the plane.

∴ Angle of repose = angle of friction = ϕ

5.7 LAWS OF STATIC FRICTION :

Following are the laws of static friction.

1. The friction force always act in a direction, opposite to that in which the body tends to move.
2. The magnitude of friction force is equal to the external force.

   ∴ F = P
3. The ratio of limiting friction (F) and normal reaction (N) is constant.

   $$\therefore \frac{F}{N} = \mu = \text{constant.}$$
4. The friction force does not depends upon the area of contact between the two surfaces.
5. The friction force depends upon the roughness of the surfaces.

IMPORTANT SHORT QUESTIONS

1. Maximum value of static friction is known as ....
2. Friction force acts in .... direction to the motion of the body.
3. Dynamic friction is also known as ....
4. Angle of repose is always equal to ....
5. The ratio of limiting friction (F) and normal reaction (N) is known as ....
6. The value of μ_k is found to be .... than μ_s for the same pair of contact surfaces.
7. Dry friction is also called ....
8. The coefficient of friction μ and angle of repose ϕ are related by the expression ....
9. The friction force depends upon the .... of the surfaces.
10. When a body is subjected to force P, and it is at rest, the relation between P and F is ....

ANSWERS

1. Limiting friction
2. Opposite
3. Kinetic friction
4. Angle of friction
5. Coefficient of friction (μ)
6. less
7. Coulomb friction
8. $\mu = \tan \phi$
9. roughness
10. $P < F$

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6. Simple Lifting Machines

6.1 TECHNICAL TERMS RELATED TO SIMPLE MACHINES :

1. Mechanical advantage (MA) :

The ratio of load lifted (W) and effort required (P) is called **Mechanical advantage.**

$$MA = \frac{\text{load lifted}}{\text{effort required}}$$

$$\therefore \boxed{MA = \frac{W}{P}}$$

where, W = load

P = effort

2. Velocity ratio (VR) :

The ratio of distance moved by effort and the distance moved by load is called **velocity ratio.**

$$VR = \frac{\text{distance moved by effort}}{\text{distance moved by load}}$$

$$\therefore \boxed{VR = \frac{y}{x}}$$

3. Input :

Input = effort × distance moved by effort

$$\therefore \boxed{\text{Input} = P \cdot y}$$

4. Output :

Output = load × distance moved by load

$$\therefore \boxed{\text{Output} = W \cdot x}$$

5. Efficiency (η) :

The ratio of work done by the machine and work done on the machine is called efficiency of the machine.

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100\%$$

We know that

output = $W \cdot x$

input = $P \cdot y$

$$\therefore \quad \eta = \frac{\text{output}}{\text{input}} \times 100$$

$$= \frac{W.x}{P.y} \times 100$$

$$= \frac{\frac{W}{P}}{\frac{y}{x}} \times 100$$

$$\eta = \frac{MA}{VR} \times 100\%$$

$$\therefore \eta = \frac{\text{output}}{\text{input}} \times 100\% = \frac{MA}{VR} \times 100\%$$

6. Ideal machine :

A machine having 100% efficiency is called an **ideal machine.**

In an Ideal machine friction is zero. For Ideal machine,

Output = Input

or

MA = VR

7. Effort lost in friction (P_f) :

In a simple machine, effort required to overcome the friction between various parts of a machine is called **effort lost in friction.**

let, P = effort

P_o = effort for Ideal machine

P_f = effort lost in friction

∴ effort lost in friction,

$$P_f = P - P_o$$

For Ideal machine

$$VR = \frac{W}{P_o} \qquad \therefore P_o = \frac{W}{VR}$$

$$\therefore \quad P_f = P - P_o$$

$$\therefore \quad P_f = P - \frac{W}{VR}$$

∵ For Ideal machine

MA = VR

$$P_o = \frac{W}{VR} = \text{ideal effort}$$

due to friction, $P > P_o$

8. Friction load (W_f) :

Total friction force produced when machine is in motion is called **friction load.**

W = load

W_o = load for Ideal machine

P = effort

For Ideal machine,

$$VR = \frac{W_o}{P}$$

$\therefore W_0 = P \times VR$

Now,

Friction load,

$W_f = W_0 - W$

$\therefore W_f = (P \times VR) - W$

$\because$ for ideal machine

MA = VR

$W_0 = P \times VR$ = ideal load

9. Reversible machine :

If a machine is capable of doing some work in the reverse direction, after the effort is removed, is called **reversible machine.**

For reversible machine, $\eta \geq 50\%$

10. Non-reversible machine or self-locking machine :

If a machine is not capable of doing some work in the reverse direction, after the effort is removed, is called **non-reversible machine** or **self-locking machine.**

For non-reversible machine, $\eta < 50\%$

11. Condition for reversibility of machine :

W = load lifted

P = effort required

x = distance moved by load

y = distance moved by effort

$P \cdot y$ = input

$W \cdot x$ = output

Machine friction = $P \cdot y - W \cdot x$

for a machine to reverse,

output > machine friction

$\therefore W \cdot x > P \cdot y - W \cdot x$

$\therefore 2 W \cdot x > P \cdot y$

$$\therefore \frac{W \cdot x}{P \cdot y} \geq \frac{1}{2}$$

$\therefore \dfrac{\text{Output}}{\text{Input}}$ ¤ 0.5

$\therefore \eta \geq 50\%$

$\therefore$ For a machine to reverse, $\eta \geq 50\%$

12. Law of machine :

For a particular machine, if we record various values of effort required to lift the corresponding loads and plot a graph between effort and load, we shall get a straight line AB as shown in figure.

Mathematically, the law of machine is given by relation :

$$\boxed{P = mW + C}$$

where,

P = effort applied

W = load lifted

m = constant

(coefficient of friction)

= slope of line AB

C = constant

= machine friction

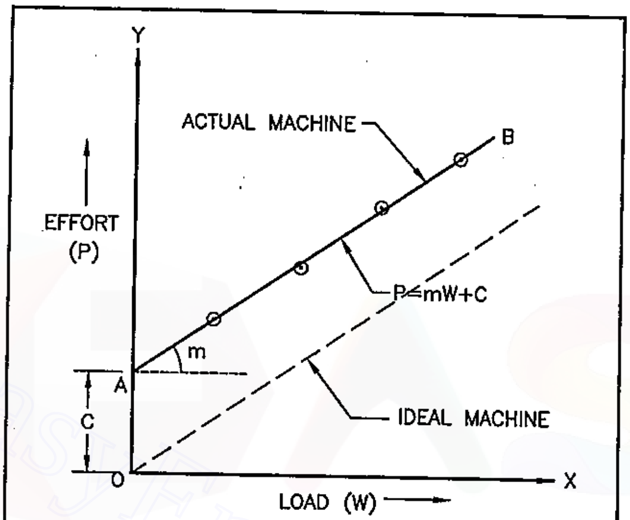

FIG. 6.1 LAW OF MACHINE

Following observations are made from the graph :

1. On a machine, if W = 0, effort C is required to run the machine. Hence, effort C is required to overcome machine friction.
2. If line AB crosses *x-x* axis, without effort (p), some load can be lifted, which is impossible. Hence, line AB never crosses *x-x* axis.
3. If line AB passes through origin, no effort is required to balance friction. Such a graph is for Ideal machine.

13. Maximum mechanical advantage :

We know that,

$$MA = \frac{W}{P}$$

from law of machine P = mW + C

$$\therefore \quad MA = \frac{W}{mW + C}$$

$$= \frac{1}{m + \frac{C}{W}} \qquad \text{neglecting } \frac{C}{W}$$

$$\boxed{\text{Maxi, } MA = \frac{1}{m}}$$

14. Maximum efficiency (η_{max}) :

We know that,

$$\eta = \frac{MA}{VR}$$

$\because$ Substitute

$$\therefore \quad \eta = \frac{\frac{1}{m}}{VR}$$

$$MA = MA\ max = \frac{1}{m}$$

$$\therefore \quad \boxed{\eta_{max} = \frac{1}{m \times VR}}$$

6.2 SYSTEMS OF PULLEY :

There are main three systems of Pulley

1. First system of pulley : $VR = 2^n$

   where, n = no. of moving Pulley

2. Second system of pulley : VR = n

   where, n = total no. of Pullies.

3. Third system of pulley : $VR = 2^n - 1$

   where, n = total no. of Pullies.

6.3 DIFFERENT SIMPLE MACHINES AND THEIR VELOCITY RATIO :

(1) Simple wheel and axle :

$$VR = \frac{D}{d}$$

D = diameter of wheel

d = diameter of axle

(2) Simple wheel and differential axle :

$$VR = \frac{2D}{d_1 - d_2}$$

D = dia. of wheel

d_1 = dia. of bigger axle

d_2 = dia. of smaller axle

(3) Weston's differential pully block :

$$VR = \frac{2D}{D - d}$$

D = dia. of bigger pulley

d = dia. of smaller pulley

(4) Worm and worm wheel :

$$VR = \frac{RT}{r}$$

OR

$$VR = \frac{RT}{nr}$$

R = Radius of effort wheel

= Length of handle

r = Radius of load drum

T = no. of teeth on worm wheel

n = no. of worm thread

(5) Single purchase crab :

$$VR = \frac{l}{r} \times \frac{T_1}{T_2}$$

l = length of handle

r = radius of load drum

T_1 = No. of teeth on main gear (spur wheel)

T_2 = No. of teeth on pinion

(6) Double purchase crab :

$$VR = \frac{l}{r} \times \frac{T_1}{T_2} \times \frac{T_3}{T_4}$$

l = length of handle

r = radius of load drum

T_1, T_3 = No. of teeth on main gears (spur wheel)

T_2, T_4 = No. of teeth on pinions.

(7) Simple screw jack :

$$VR = \frac{2\pi l}{p}$$

l = length of handle

p = pitch of screw

IMPORTANT SHORT QUESTIONS

1. A lifting machine having an efficiency less than 50% is known as, ...
2. For an ideal machine, ...
3. The maximum mechanical advantage of a lifting machine is, ...
4. Write the equation for law of machine.
5. For the first system of pulleys with 4 pulleys, velocity ratio is, ...
6. In a law of machine, P = mW + C term C represents, ...
7. In an ideal machine, the mechanical advantage is .... to velocity ratio.
8. Write equation of VR for simple screw jack.
9. The maximum efficiency of a lifting machine is .....
10. What is condition for reversibility of a machine ?

ANSWERS

1. Non-reversible machine
2. MA = VR, Output = Input, η = 100%
3. $\frac{1}{m}$
4. P = mW + C
5. $2^n = 2^4 = 16$
6. Machine friction
7. equal
8. $VR = \frac{2\pi l}{\text{pitch}}$
9. $\frac{1}{m \cdot VR}$
10. $\eta \geq 50$

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7. Work, Power, Energy

7.1 WORK :

Whenever a force acts on a body, and the body undergoes a displacement, some work is said to be done.

Work done = Force × displacement

$$W = F \times S$$

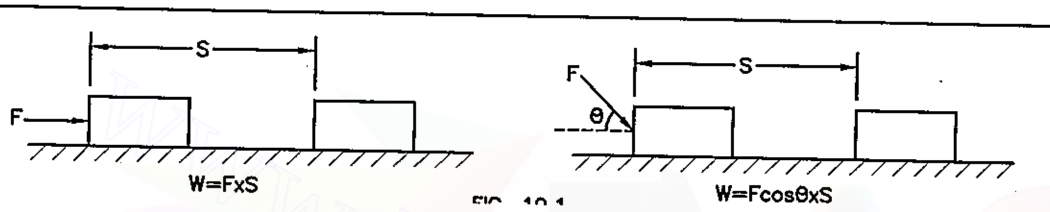

FIG. 7.1

Unit of work :

In S.I. system, unit of work is **Joule.**

1 Joule = 1 N.m

1 Kilojoule = 1 kN.m

When a force of 1 N, displaces a body through 1 m, work done is 1 joule (1 N.m)

7.2 WORK NECESSARY FOR LIFTING THE BODY :

To lift mass (m) from position-1 to position-2, upward force F is required.

upward force (F) = weight (W) of body.

W = weight of body

$F = W = m \cdot g$

∴ Work done

= Force × displacement

= F × h

$$= mgh$$

where,

m = mass (kg)

g = gravitational acceleration

= 9.80 m/s^2

h = height (m)

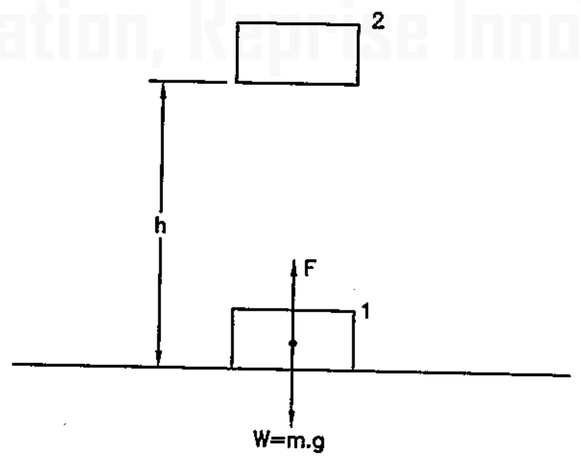

FIG. 7.2

7.3 POWER :

The power may be defined as the rate of doing work.

It indicates the speed of doing work by a force.

$$\text{Power} = \frac{\text{work done}}{\text{time taken for work done}}$$

$$= \frac{F \times S}{t} \qquad \because \text{ Velocity} = V = \frac{S}{t}$$

$$= F \times \frac{S}{t}$$

$$\boxed{P = F \times V}$$

Unit of power :

Unit of power is N.m/s or Joule/s.

In S.I. system unit of power is Watt.

1 N.m/s = 1 J/s = 1 Watt

1 kW = 1000 Watt

In gravitational unit,

unit of power is H.P. (Horse power)

1 H.P. = 746 Watt

1 H.P. = 0.746 kW

7.4 ENERGY :

Energy may be defined as the capacity to do work.

Unit of energy is N.m or joule.

7.5 POTENTIAL ENERGY :

Energy stored in a body due to its position is called potential energy.

Potential energy = mgh

7.6 KINETIC ENERGY :

Energy possessed by a body, by virtue of its mass and velocity is called kinetic energy.

Kinetic energy = $\frac{1}{2}$ $m \cdot v^2$

7.7 LAW OF CONSERVATION OF ENERGY :

"The energy can neither be created nor destroyed though it can be transformed from one form into any of the forms, in which the energy can exist."

It means total energy remains constant without change.

IMPORTANT SHORT QUESTIONS

1. What is the S.I. unit of work ?
2. Define 1 Joule work.
3. If a mass m, is lifted through height h, what is work done ?
4. Define power.
5. What is S.I. unit of power ?
6. 1 H.P. = ... Watt
7. Energy stored in a body due to its position is known as .....
8. Energy possessed by a body, by virtue of its mass and velocity is known as ....
9. Give formula for kinetic energy.
10. Give formula for potential energy.
11. Give formula for work done by torque.

ANSWERS

1. Joule
2. When a force of 1 N, displaces a body through 1 m, work done is 1 Joule.
3. Work done = mgh
4. Power is defined as the rate of doing work.
5. Watt
6. 746
7. Potential energy
8. Kinetic energy
9. K.E. = $\frac{1}{2}$ mv^2
10. P.E. = mgh
11. Work done by torque = $T \times \theta$

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8. Moment of Inertia

8.1 MOMENT OF INERTIA (I) :

The second moment of area about any axis is called **moment of inertia.**

The First moment of area = a·x

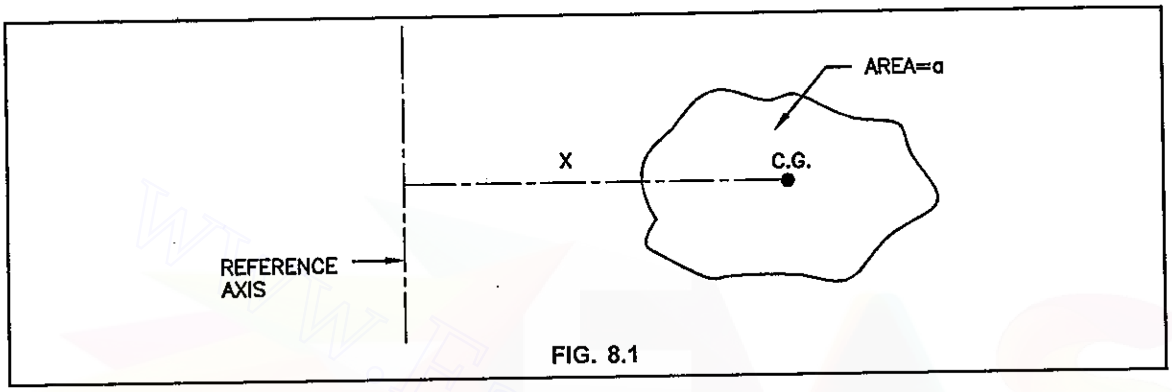

FIG. 8.1

The second moment of area $= (ax)x$

$= ax^2 = \text{M.I}$

$\therefore$ Moment of inertia = I = ax^2

The unit of M.I. is mm^4, cm^4 or m^4.

8.2 SECTION MODULUS (Z) :

$$\text{Section modulus} = \frac{\text{M.I.}}{\text{distance of extreme fibre from neutral axis}}$$

$$\therefore \boxed{Z = \frac{I}{y_{max}}}$$

unit of Z is mm^3 or cm^3.

For rectangular section,

$$Z_{xx} = \frac{I_{xx}}{d/2}$$

$$Z_{yy} = \frac{I_{yy}}{b/2}$$

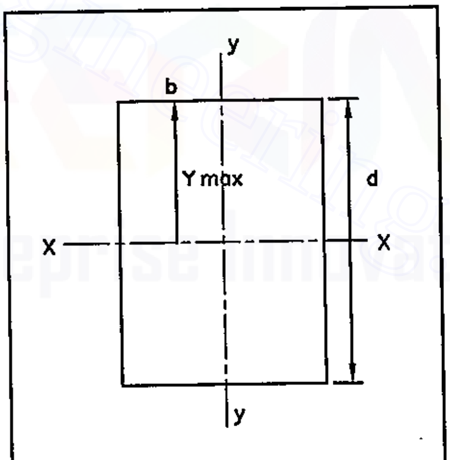

FIG. 8.2

8.3 RADIUS OF GYRATION (k) :

The distance from the given axis, at which, if all the small elements of the given lamina are placed, the M.I. of the lamina about the given axis does not changes. This distance is called **radius of gyration.**

Mathematically,

$I = Ak^2$

$\therefore \quad k = \sqrt{\frac{I}{A}}$

where,

I = momet of inertia

A = Area

k = radius of gyration.

8.4 MOMENT OF INERTIA OF SOME STANDARD SECTIONS :

(1) Rectangular Section :

$$I_{xx} = \frac{b.d^3}{12}$$

$$I_{yy} = \frac{d.b^3}{12}$$

$$\therefore Z_{xx} = \frac{I_{xx}}{y_{max}} = \frac{\frac{bd^3}{12}}{\frac{d}{2}} = \frac{bd^2}{6}$$

$$Z_{yy} = \frac{I_{yy}}{y_{max}} = \frac{\frac{db^3}{12}}{\frac{b}{2}} = \frac{db^2}{6}$$

$$I_{base} = \frac{bd^3}{3}$$

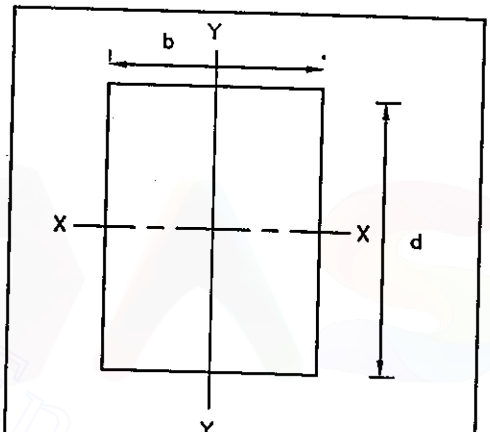

FIG. 8.3

(2) Hollow rectangular section :

$$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12}$$

$$I_{yy} = \frac{DB^3}{12} - \frac{db^3}{12}$$

$$Z_{xx} = \frac{I_{xx}}{y_{max}} = \frac{\frac{BD^3}{12} - \frac{bd^3}{12}}{\frac{D}{2}} = \frac{(BD^3 - bd^3)}{6D}$$

$$Z_{yy} = \frac{I_{yy}}{y_{max}} = \frac{\frac{DB^3}{12} - \frac{db^3}{12}}{\frac{B}{2}} = \frac{(DB^3 - db^3)}{6B}$$

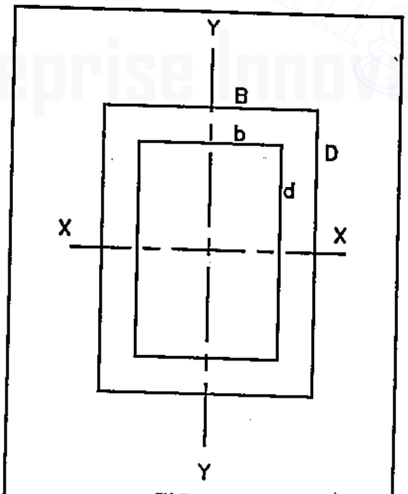

FIG. 8.4

(3) Circular section :

$$I_{xx} = \frac{\pi}{64}.D^4$$

$$I_{yy} = \frac{\pi}{64}.D^4$$

$$Z_{xx} = \frac{I_{xx}}{y_{max}} = \frac{\frac{\pi}{64}.D^4}{\frac{D}{2}} = \frac{\pi}{32}.D^3$$

$$Z_{yy} = \frac{I_{yy}}{y_{max}} = \frac{\frac{\pi}{64}.D^4}{\frac{D}{2}} = \frac{\pi}{32}.D^3$$

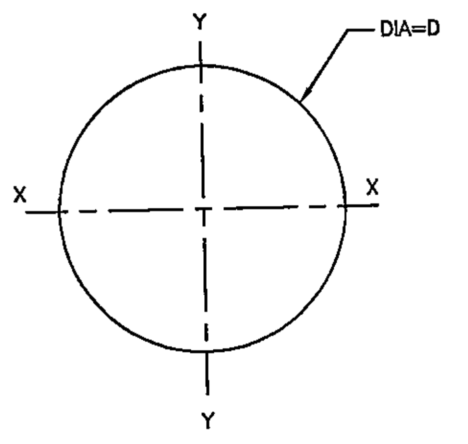

FIG. 8.5

(4) Hollow circular section :

$$I_{xx} = \frac{\pi}{64}(D^4 - d^4)$$

$$I_{yy} = \frac{\pi}{64}(D^4 - d^4)$$

$$Z_{xx} = \frac{I_{xx}}{y_{max}} = \frac{\frac{\pi}{64}(D^4 - d^4)}{\frac{D}{2}} = \frac{\pi(D^4 - d^4)}{32D}$$

$$Z_{yy} = \frac{I_{yy}}{y_{max}} = \frac{\frac{\pi}{64}(D^4 - d^4)}{\frac{D}{2}} = \frac{\pi(D^4 - d^4)}{32D}$$

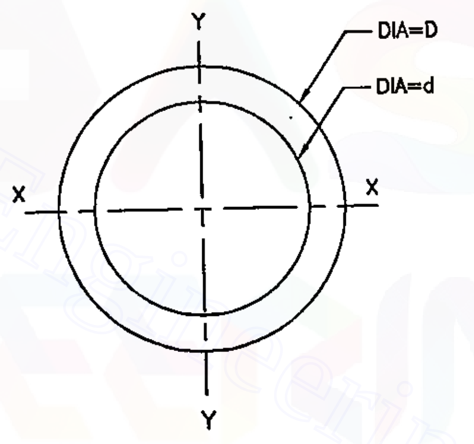

FIG. 8.6

(5) Triangular section :

$$I_{base} = \frac{bh^3}{12}$$

$$I.c.g. = \frac{bh^3}{36} \qquad I_{DD} = \frac{bh^3}{4}$$

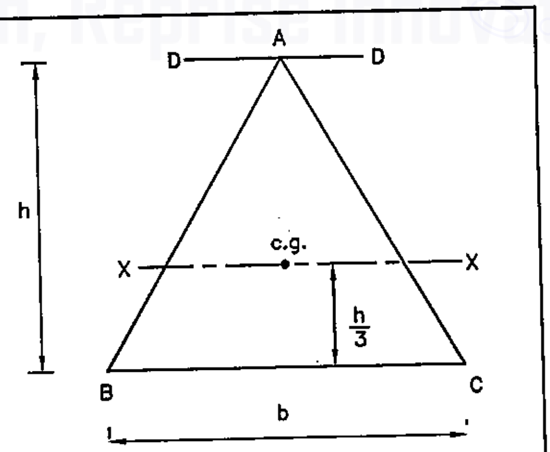

FIG. 8.7

(6) **Semicircular section :**

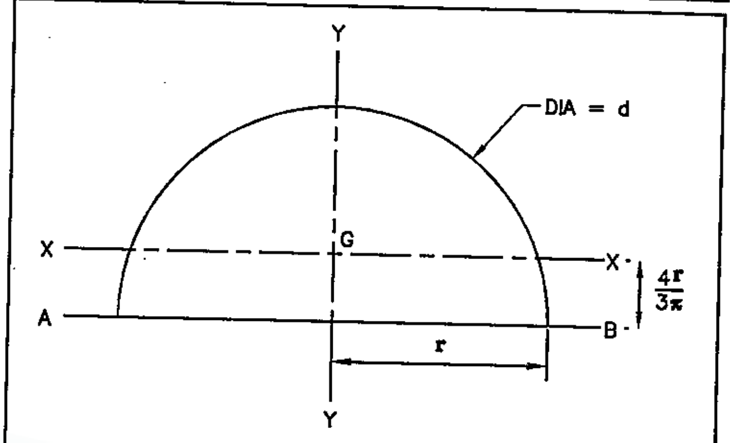

FIG. 8.8

$I_{xx} = 0.11\ r^4$

$$I_{AB} = \frac{\frac{\pi}{64} d^4}{2} = \frac{\pi}{128} d^4$$

$$I_{yy} = \frac{\pi}{8} r^4$$

$$= 0.393\ r^4$$

$$= \frac{\pi}{128} d^4$$

(7) **Quarter circle :**

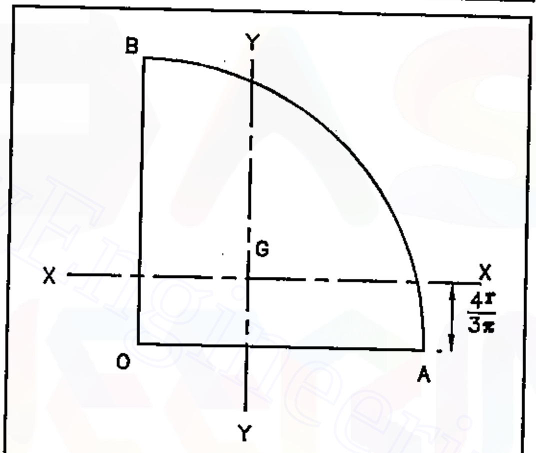

FIG. 8.9

$I_{xx} = I_{yy} = 0.055\ r^4$

$$I_{OA} = I_{OB} = \frac{\pi}{16} r^4$$

8.5 PARALLEL AXIS THEOREM :

"If Ig is the moment of inertia of a plane area about an axis passing through its centre of gravity, then, moment of inertia of the area about axis AB, parallel to the first axis, and at a distance h from centre of gravity is given by :

$$\mathbf{I_{AB} = I_g + ah^2}$$

where, I_{AB} = M.I. of area about AB

I_g = M.I. of area about c.g.

a = area of the section

h = distance between c.g. of section and axis AB.

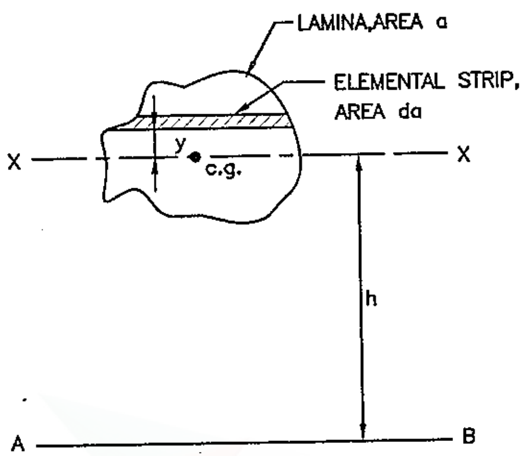

FIG. 8.10

8.6 PERPENDICULAR AXIS THEOREM :

"If, I_{xx} and I_{yy} be the moments of inertia of a plane section about two perpendicular axes meeting at 0, the moment of inertia I_{zz} about the z – z axis, perpendicular to the plane and passing through the intersection of x – x and y – y axes is given by :

$$I_{zz} = I_{xx} + I_{yy}$$

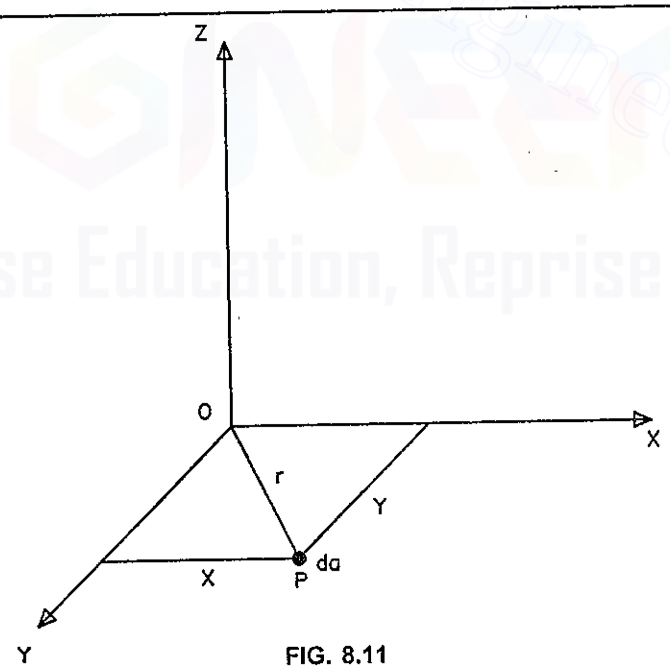

FIG. 8.11

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MCQ'S

1. **The unit of force in S.I. system is**
(a) Kilogram (b) Newton (c) Dyne (d) Watt
2. **A force which can produce an acceleration of 1 m/s^2 in a mass of 1 kg is called**
(a) 1 N (b) 1 kgf (c) 1 dyne (d) 1 watt
3. **1 kgf = ________ N**
(a) 8.91 (b) 10 (c) 9.81 (d) 12
4. **1 Joule is equal to**
(a) 1 N – m (b) 9.81 N–m (c) 1 kgf – m (d) None
5. **1 MN = ________ N**
(a) 10^{12} (b) 10^9 (c) 10^6 (d) 10^3
6. **Which is not a vector quantity ?**
(a) Weight (b) Velocity (c) Momentum (d) Distance
7. **The resultant of two forces P and Q acting at an angle θ is**
(a) $\sqrt{P^2 + Q^2 - 2PQ\sin\theta}$ (b) $\sqrt{P^2 + Q^2 + 2PQ\sin\theta}$
(c) $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ (d) $\sqrt{P^2 + Q^2 - 2PQ\cos\theta}$
8. **The resultant of two forces acting at a point is maximum when angle between them, θ is**
(a) 0° (b) 45° (c) 90° (d) 180°
9. **The resultant of two forces acting at a point is minimum when angle between them, θ is**
(a) 0° (b) 45° (c) 90° (d) 180°
10. **Force is a**
(a) Scalar quantity (b) Vector quantity (c) linear quantity (d)Non–measurable quantity.
11. **The component of a force (P) at right angles to its direction will be**
(a) Zero (b) P (c) $\frac{P}{2}$ (d) 2P
12. **The resultant of two equal forces P acting in opposite directions will be**
(a) 2P (b) $\sqrt{P}$ (c) 0.707 P (d) zero
13. **The concurrent forces P and Q (P > Q) acting along the same straight line, but in opposite direction, their resultant will be equal to**
(a) P + Q (b) P – Q (c) P/Q (d) Q/P
14. **If P and Q are the two forces acting at an angle θ and their resultant makes an angle ∝ with P, then**
(a) $\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$ (b) $\tan\alpha = \frac{Q\sin\theta}{P + Q\sin\theta}$
(c) $\tan\alpha = \frac{Q\sin\theta}{Q + P\cos\theta}$ (d) $\tan\alpha = \frac{P\sin\theta}{Q + P\cos\theta}$

15. **When two forces each equal to P act at 90° to each other, then their resultant will be**
(a) $\sqrt{2}$ P (b) 2P (c) 0.707 P (d) zero

16. **If resultant of two equal forces is equal to either of them, then angle between them is** **(IES)**
(a) 30° (b) 60° (c) 90° (d) 120°

17. **Two forces of equal magnitude P act at an angle θ to each other. Their resultant is equal to** **(IES)**
(a) $2\text{ P}\sin\frac{\theta}{2}$ (b) $2\text{P}\cos\frac{\theta}{2}$ (c) $2\text{P}\cos\theta$ (d) $2\text{P}\cos 2\theta$

18. **Two forces of 6 kN and 8 kN act at right angles to each other, the resultant force will be**
(a) 10 (b) 14 (c) 28 (d) 100

19. **If a number of forces are acting at a point, their resultant is given by**
(a) $(\Sigma H)^2 + (\Sigma V)^2$ (b) $\sqrt{(\Sigma H)^2 + (\Sigma V)^2}$
(c) $(\Sigma H)^2 + (\Sigma V)^2 + 2(\Sigma V)(\Sigma H)$ (d) $\sqrt{(\Sigma H)^2 + (\Sigma V)^2 + 2(\Sigma V)(\Sigma H)}$

20. **If a number of forces are acting at a point, the angle of resultant with horizontal will be**
(a) $\tan\theta = \Sigma V/\Sigma H$ (b) $\tan\theta = \Sigma H/\Sigma V$ (c) $\tan\theta = \Sigma V \times \Sigma H$ (d) $\tan\theta = \sqrt{(\Sigma V) \times (\Sigma H)}$

21. **The set of forces, whose resultant is zero, are known as**
(a) Coplanar forces. (b) Concurrent forces.(c) Equilibrium forces. (d) Collinear forces.

22. **The forces whose line of actions meet at one point are called**
(a) Coplanar forces. (b) Concurrent forces (c) Equilibrium forces. (d) Collinear forces.

23. **The forces whose line of action lie on the same line are known as**
(a) Concurrent forces. (b) Coplanar forces.(c) Equlibrium forces. (d) collinear forces.

24. **The necessary condition of equilibrium of a body is**
(a) $\Sigma H = 0$ (b) $\Sigma V = 0$ (c) $\Sigma M = 0$ (d) $\Sigma H = 0, \Sigma V = 0, \Sigma M = 0$

25. **"If three coplanar forces, acting at a point be in equilibrium, then each force is proportional to the sine of the angle between the other two." It is called**
(a) Laws of moments. (b) Lami's theorem .
(c) Condition of equilibrium. (d) Varignon's theorem.

26. **In S.I. units, the unit of moment is**
(a) kg.m (b) N–m (c) N–m/sec (d) kgf

27. **When two equal unlike parallel forces cause rotary motion of a body then this force system is called as**
(a) Moment of force. (b) Couple. (c) Principle of moments. (d) Parallel force system.

28. **A smooth cylinder lying on convex surface remains in ________ equilibrium.**
(a) unstable (b) stable (c) neutral (d) any of the above

29. **Four forces P, 2P, 3P and 4P act along the sides taken in order of a square. The resultant force is**
    (a) zero (b) $2\sqrt{2}$ P (c) 2P (d) $\sqrt{5}$ P
30. **A smooth sphere lying on a ________ is in neutral equilibrium.**
    (a) Convex surface (b) Concave surface (c) horizontal surface (d) inclined surface
31. **For a sphere suspended as shown in fig. the tension T in the string is**
    (a) 10 N
    (b) 11.55 N
    (c) 5.77 N
    (d) 5 N

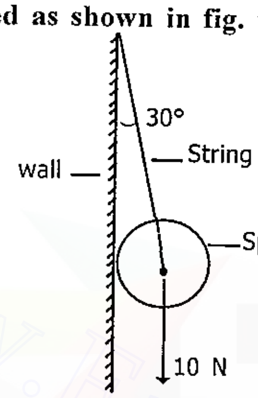

Fig. Q.31

32. **A 20 kN force is acting vertically upward. Its horizontal component is**
    (a) 0 (b) 20 kN (c) 14.14 kN (d) 10 kN
33. **The statement, "effect of a force upon a body is the same at every point on its line of action" refers to**
    (a) Principle of superposition. (b) Principle of transmissibility.
    (c) Principle of moments. (d) Lami's theorem.
34. **The resultant of the force system shown below is**
    (a) 150 kN (b) 450 kN (c) 75 kN (d) 0

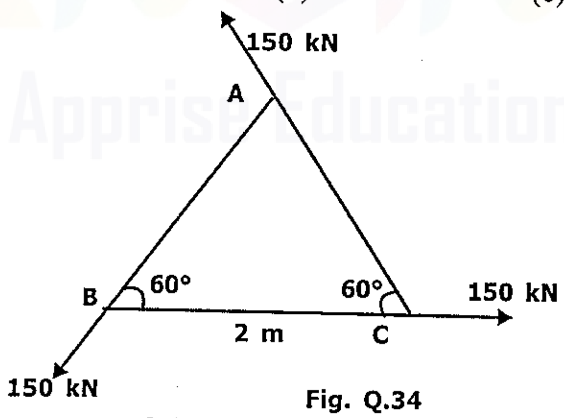

Fig. Q.34

35. **The moment of the couple at the centre of rectangle shown in fig. is**
    (a) 8.4 kN.m
    (b) 4.2 kN.m
    (c) 4.8 kN.m
    (d) 0

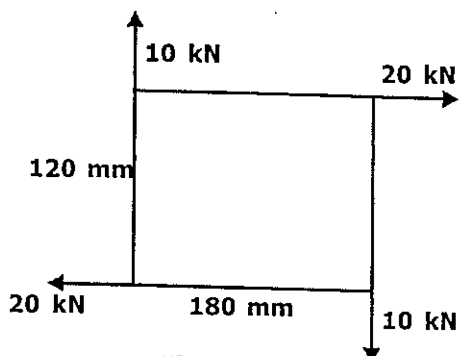

Fig. Q.35

36. The resultant of the force system shown in Q.35 above is
(a) 0 (b) 10 kN (c) 20 kN (d) 60 kN

37. Reactions acting at horizontal roller support is
(a) only H (b) only V (c) V, H both (d) Only moment

38. The type of support provided at the abutment of a bridge is
(a) Fixed (b) Hinged (c) Roller (d) Simple

39. For a beam loaded as shown below, unknown weight W will be
(a) 60 kN (b) 40 kN (c) 30 kN (d) 100 kN

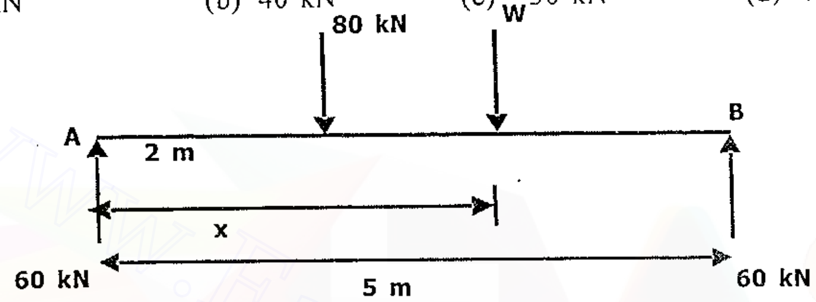

Fig. Q.39

40. For a beam shown in Q.39 above, x = ________
(a) 4 m (b) 3 m (c) 3.5 m (d) 2.5 m

41. The centroid of semi–circular area lies at a distance of ________ from base along the vertical axis.
(a) $\frac{4r}{3\pi}$ (b) $\frac{2r}{3\pi}$ (c) $\frac{r}{2}$ (d) $\frac{3r}{8}$

42. The C.G. of hemisphere lies at a distance of ________ from its base along the vertical axis.
(a) $\frac{4r}{3\pi}$ (b) $\frac{2r}{3\pi}$ (c) $\frac{r}{2}$ (d) $\frac{3r}{8}$

43. The centroid of semicircular wire arc lies at a distance of ________ from its base along the vertical axis.
(a) $\frac{4r}{3\pi}$ (b) $\frac{2r}{\pi}$ (c) $\frac{3r}{8}$ (d) $\frac{r}{2}$

44. For a T–section having flange 60 × 10 mm and web 10 × 60 mm, $\bar{x}$ = ________
(a) 30 mm (b) 60 mm (c) 5 mm (d) 20 mm

45. The C.G. of a solid cone lying on its axis will be
(a) $\frac{h}{2}$ above the base. (b) $\frac{h}{3}$ above the base (c) $\frac{h}{4}$ above the base (d) $\frac{2}{3}$ h above the base.

46. Two identical balls, one made of gold and other one of steel will have
(a) their C.G. at variable positions. (b) Their C.G. at the same position.
(c) The C.G. of steel ball will be nearer to the base as compared to gold.
(d) The C.G. of gold ball will be nearer to the base as compared to steel.

47. The C.G. of a quadrant of a circle lies along its central radius at a distance of
(a) 0.3 R (b) 0.44 R (c) 5 R (d) 0.6 R

48. The centroid of plane lamina is not at its geometrical centre if it is a
(a) square. (b) rectangle.
(c) circle. (d) right angled triangle.

49. M.I. of a rectangle of width (b) and depth (d) about its base is
(a) $\frac{bd^3}{12}$ (b) $\frac{db^3}{12}$ (c) $\frac{bd^3}{3}$ (d) $\frac{bd^3}{36}$

50. Which statement is correct for M.I.
(a) It is the second moment of area (b) Its unit is mm^4
(c) $I = Z.\ y_{max}$ (d) all of the above

51. M.I. of a triangle of base (b) and height (h) about x–x axis is
(a) $\frac{bh^3}{12}$ (b) $\frac{bh^3}{36}$ (c) $\frac{bh^3}{4}$ (d) $\frac{hb^3}{12}$

52. M.I. of a triangle of base (b) and height (h) about horizontal base is
(a) $\frac{bh^3}{12}$ (b) $\frac{bh^3}{36}$ (c) $\frac{bh^3}{4}$ (d) $\frac{hb^3}{12}$

53. Moment of inertia of a circular section about its diameter (d) is
(a) $\frac{\pi}{16}d^3$ (b) $\frac{\pi}{32}d^3$ (c) $\frac{\pi}{32}d^4$ (d) $\frac{\pi}{64}d^4$

54. M.I. of a circular section about an axis perpendicular to the plane of section is
(a) $\frac{\pi}{16}d^3$ (b) $\frac{\pi}{32}d^3$ (c) $\frac{\pi}{32}d^4$ (d) $\frac{\pi}{64}d^4$

55. M.I. of a square of side (a) about axis passing through centre of gravity is
(a) $\frac{a^4}{36}$ (b) $\frac{a^4}{12}$ (c) $\frac{a^4}{8}$ (d) $\frac{a^4}{4}$

56. Moment of inertia is the
(a) second moment of force. (b) second moment of area.
(c) second moment of mass. (d) all of these.

57. The unit of M.I. of an area is
(a) $kg.m^2$ (b) kg/m^2 (c) m^4 (d) $kg–m–s^2$

58. A circular hole of 50 mm diameter is cut out from a circular disc of 100 mm diameter as shown in figure. The centre of gravity of the section will lie
(a) at O .
(b) in the hole.
(c) in the shaded area.
(d) outside the disc.

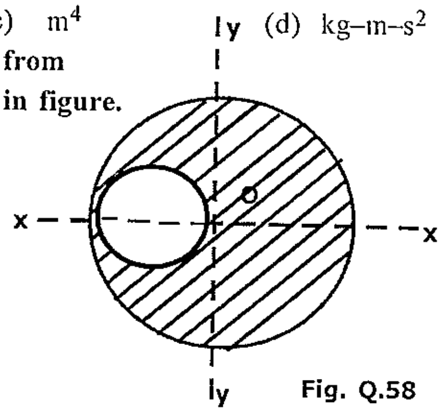

Fig. Q.58

59. The unit of modulus of section is

(a) kg–m^2 (b) m^3 or cm^3 (c) m^4 or cm^4 (d) m^2 or cm^2

60. If I is the M.I. and 'A' is the total area, then 'k' radius of gyration will be

(a) $k = \frac{I}{A}$ (b) $k = \sqrt{\frac{I}{A}}$ (c) $k = \sqrt{I.A}$ (d) $k = I.A^2$

61. In case of beams, greater the M.I. of the section

(a) greater would be its load carrying capacity.
(b) Smaller would be its load carrying capacity.
(c) The load carrying capacity does not change.

62. The strength of a section

(a) increase with increase in radius of gyration.
(b) decrease with increase in radius of gyration.
(c) does not change with change in radius of gyration.

63. The friction force always acts in the direction

(a) of the force
(b) opposite to the force
(c) opposite to that in which the body tends to move
(d) perpendicular to the force.

64. The force of friction between two bodies in contact

(a) depends upon the area of their contact.
(b) depends upon the roughness of the surfaces.
(c) depends upon the relative velocity between them.
(d) all of the above.

65. The magnitude of the force of friction between two bodies, one lying above the other depends upon the roughness of the

(a) upper body. (b) lower body.
(c) both the bodies. (d) body having more roughness.

66. Identify the correct statement.

(a) When body is in equilibrium, the friction force is known as static friction force.
(b) When body just start moving, the friction. force is known as limiting friction force.
(c) When body is in motion, the friction force is known as kinetic friction force.
(d) all of the above

67. Identify the correct statement.

(a) The force of friction does not depend upon the area of contact.
(b) The magnitude of limiting friction bears a constant ratio to the normal reaction between two surfaces.
(c) The static friction is slightly less than the limiting friction.
(d) all of the above.

68. The efficiency of a screw jack may be increased by
(a) increasing its pitch. (b) decreasing its pitch.
(c) increasing the load to be lifted. (d) decreasing the load to be lifted..

69. The efficiency of a screw jack is maximum when the helix angle is equal to
(a) $45° + \frac{\phi}{2}$ (b) $45° - \frac{\phi}{2}$ (c) $\frac{\phi}{2} + 30°$ (d) $\frac{\phi}{2} - 30°$

70. Identify the correct statement.
(a) When resultant lies within the cone of friction the body will be in motion.
(b) When resultant lies outside the cone of friction the body will be at rest.
(c) When resultant lies on the surface of cone the body will be in limiting equilibrium.

71. Static friction is always
(a) less than dynamic friction. (b) greater than dynamic friction.
(c) equal to the dynamic friction. (d) none of the above.

72. If F is the limiting friction, N is the normal reaction, then coefficient of friction μ will be equal to
(a) $\mu = F + N$ (b) $\mu = F - N$ (c) $\mu = F/N$ (d) $\mu = N/F$

73. A ladder is resting on a smooth floor and leaning against a rough vertical wall, the force of friction acts
(a) towards the wall at its upper end. (b) away from the wall at its upper end.
(c) upward at the upper end. (d) downward at the upper end.

74. The angle of inclination of the plane at which the body tends to move down the plane is called
(a) angle of friction. (b) angle of repose. (c) angle of projection. (d) none of these.

75. The maximum frictional force which comes into play when a body just begins to slide over the surface of another body is known as
(a) Sliding friction (b) Dynamic friction (c) Limiting friction (d) Rolling friction

76. Coulomb friction is
(a) Friction between bodies having relative motion.
(b) Friction between dry surfaces.
(c) Friction between solids and liquids.
(d) Friction between electrically charged bodies.

77. If the angle of friction is zero, a body will experience
(a) Infinite friction. (b) zero friction.
(c) The force of friction will act normal to the plane.
(d) The force of friction will act in the direction of motion.

78. If the angle of friction is φ, the efficiency of screw jack is
(a) $\frac{1 - \sin\phi}{1 + \sin\phi}$ (b) $\frac{1 + \sin\phi}{1 - \sin\phi}$ (c) $\frac{1 + \sin\phi}{\cos\phi}$ (d) $\frac{1 - \sin\phi}{\cos\phi}$

79. The mechanical advantage of a lifting machine is the ratio of
(a) output to input.
(b) distance moved by effort to the distance moved by load.
(c) load lifted to the effort applied.
(d) all of the above.

80. A screw jack used for lifting loads is
(a) a reversible machine. (b) non–reversible machine.
(c) ideal machine. (d) none of these.

81. A lifting machine having an efficiency less than 50% is known as
(a) Reversible machine (b) Non-reversible machine
(c) Ideal machine (d) None of the above

82. The maximum mechanical advantage of a lifting machine is
(a) m (b) 1 + m (c) 1/m (d) 1 - m

83. For an ideal machine, which is incorrect ?
(a) MA = VR (b) Output = input
(c) $\eta = 100\%$ (d) machine friction is maximum

84. The maximum efficiency of a lifting machine is
(a) $\frac{1}{m(VR)}$ (b) $\frac{m}{VR}$ (c) $\frac{1}{m}$ (d) $\frac{VR}{m}$

85. The velocity ratio of a simple wheel and axle with D and d as the diameters of effort wheel and load axle is
(a) D + d (b) D - d (c) $\frac{D}{d}$ (d) $\frac{2D}{(D-d)}$

86. The VR of a single purchase crab can be increased by
(a) increasing the length of the handle.
(b) increasing the radius of the load drum.
(c) increasing the number of teeth on pinon.
(d) all of the above.

87. For the first system of pulleys with 4 pulleys, velocity ratio is,
(a) 8 (b) 16 (c) 4 (d) 32

88. For the second system of pulleys, velocity ratio is,
(a) 2n (b) 2n - 1 (c) n (d) 2n - 1

89. If efficiency of a lifting machine is kept constant, its velocity ratio is directly proportional to its
(a) Mechanical advantage. (b) Machine friction.
(c) Effort applied. (d) all of the above.

90. In an ideal machine, the mechanical advantage is .... velocity ratio.
(a) Less than (b) Greater than (c) Equal to

91. In a law of machine, P = mW + C term C represents,

(a) Coefficient of friction (b) Machine friction
(c) Input (d) Output

92. The efficiency of a lifting machine is the ratio of
(a) Output to input (b) MA to VR
(c) Work done by machine to work done on machine
(d) all of the above

93. In a simple screw jack with l as the length of handle and p as the pitch of the screw, its velocity ratio is
(a) $\frac{2\pi p}{l}$ (b) $\frac{2\pi l}{p}$ (c) $\frac{\pi l}{2p}$ (d) $\frac{\pi p}{2l}$

94. For a simple lifting machine, ideal effort is.
(a) $\frac{W}{MA}$ (b) $\frac{W}{VR}$ (c) $\frac{MA}{VR}$ (d) $\frac{output}{input}$

95. For self locking machines, the efficiency of machine should be ....
(a) 50% (b) more than 50% (c) less than 50%

96. On oiling the lifting machine .... is not affected.
(a) velocity ratio (b) mechanical advantage (c) efficiency (d) law of machine

97. The rate of doing work is called
(a) Work done (b) power (c) energy (d) none of these

98. 1 H.P. = ________ watt
(a) 346 (b) 546 (c) 746 (d) 1046

99. S.I. unit of power is
(a) kg–m (b) watt (c) joule (d) dyne

100. In S.I. unit, the unit of work is
(a) Kg–m (b) Newton (c) arg (d) Joule

101. 1 Joule = ________ N.m
(a) 1 (b) 9.81 (c) 10 (d) 0.1

102. One joule work means that
(a) Work done by a force of 1 N when it displaces a body through 1 m.
(b) Work done by a force of 1 kg when it displaces a body through 1 m.
(c) Work done by a force of 1 dyne when it displaces a body through 1 cm.
(d) None of these.

103. 1 watt = ________
(a) 0.1 Joule/s (b) 1 Joule/s (c) 10 Joule/s (d) 100 Joule/s

104. If 'W' is the weight of a body and 'h' is the height at which body is kept, then the potential energy stored by the body will be
(a) $\frac{Wh^2}{2}$ (b) $\frac{Wh}{2}$ (c) Wh (d) Wh^2

105. A body of mass 'm' is moving with a uniform velocity 'v', the kinetic energy stored by the body will be

(a) $\frac{mv^2}{g}$ (b) $\frac{mv^2}{2g}$ (c) $\frac{mv^2}{2}$ (d) mv^2

106. In terms of work, energy is defined as

(a) quantity of work. (b) capacity of doing work.
(c) rate of doing work. (d) rate of change of doing work.

107. When the spring of a watch is wound, it will possess

(a) strain energy. (b) heat energy. (c) kinetic energy. (d) electrical energy.

108. The sum of potential and kinetic energy possessed by a moving body

(a) varies from point to point.
(b) is maximum in the start and minimum at the end.
(c) is minimum in the start and maximum at the end.
(d) is constant at all points.

109. A truck of mass 10,000 kg is moving with a velocity of 36 kmph. Kinetic energy will be

(a) 50,000 N.m (b) 500,000 N.m (c) 1,00,000 N.m (d) 5,000 N.m

110. A block weighing 500 N is resting on a horizontal floor. A force of 200 N applied at 30° with horizontal moves the block to a distance of 60 m. Work done is

(a) 10392.3 N.m (b) 12000 N.m (c) 6000 N.m (d) 5196 N.m

111. Two forces under equilibrium must be

(a) collinear. (b) like parallel. (c) unlike parallel. (d) non parallel.

112. Law of transmissibility is applicable for ________ only

(a) deformed bodies (b) solid bodies (c) rigid bodies (d) any of these

113. Varignon's principle is used to find

(a) Resultant of coplanar concurrent forces
(b) Resultant of coplanar non-concurrent forces
(c) Location of resultant of coplanar concurrent forces
(d) Location of resultant of coplanar non–concurrent forces

114. On a ladder resting on the ground and leaning against a smooth vertical wall, the force of friction acts

(a) downward at upper and. (b) upward at upper end.
(c) towards the wall at lower end. (d) away from the wall at lower end.

: ANSWERS :

1. (b)	2. (a)	3. (c)	4. (a)	5. (c)
6. (d)	7. (c)	8. (a)	9. (d)	10. (b)
11. (a)	12. (d)	13. (b)	14. (a)	15. (a)
16. (d)	17. (b)	18. (a)	19. (b)	20. (a)

21. (c)	22. (b)	23. (d)	24. (d)	25. (b)
26. (b)	27. (b)	28. (a)	29. (b)	30. (c)
31. (b)	32. (a)	33. (b)	34. (d)	35. (b)
36. (a)	37. (b)	38. (c)	39. (b)	40. (c)
41. (a)	42. (d)	43. (b)	44. (a)	45. (c)
46. (b)	47. (d)	48. (d)	49. (c)	50. (d)
51. (b)	52. (a)	53. (d)	54. (c)	55. (b)
56. (d)	57. (c)	58. (c)	59. (b)	60. (b)
61. (a)	62. (a)	63. (c)	64. (b)	65. (c)
66. (d)	67. (d)	68. (a)	69. (b)	70. (c)
71. (b)	72. (c)	73. (c)	74. (b)	75. (c)
76. (b)	77. (b)	78. (a)	79. (c)	80. (b)
81. (b)	82. (c)	83. (d)	84. (a)	85. (c)
86. (a)	87. (b)	88. (c)	89. (a)	90. (c)
91. (b)	92. (d)	93. (b)	94. (b)	95. (c)
96. (a)	97. (b)	98. (c)	99. (b)	100. (d)
101. (a)	102. (a)	103. (b)	104. (c)	105. (c)
106. (b)	107. (a)	108. (d)	109. (b)	110. (a)
111. (a)	112. (c)	113. (d)	114. (c)	

EXPLANATIONS

12. (d) $P = P,\ Q = P,\ \theta = 180°$

$$\therefore\ R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$
$$= \sqrt{P^2 + P^2 + 2PP(-1)}$$
$$= \sqrt{P^2 + P^2 - 2P^2} = 0$$

13. (b) $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ $\theta = 180°$

$$= \sqrt{P^2 + Q^2 + 2PQ(-1)}$$
$$= \sqrt{P^2 - 2PQ + Q^2}$$
$$= \sqrt{(P-Q)^2} = P - Q$$

15. (a) $P = P,\ Q = P,\ \theta = 90°$

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$\cos 90° = 0$

$= \sqrt{P^2 + P^2 + 2P.P\cos 90°}$

$= \sqrt{P^2 + P^2}$

$= \sqrt{2P^2} \qquad = \sqrt{2}\,P$

16. (d) P = P, Q = P, R = P

$\therefore \quad R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$P = \sqrt{P^2 + P^2 + 2P^2\cos\theta}$

$P = \sqrt{2P^2(1+\cos\theta)}$

$\therefore \quad P^2 = 2P^2(1 + \cos\theta)$

$\therefore \quad 1 + \cos\theta = \frac{1}{2}$

$\cos\theta = -0.5$

$\therefore \quad \theta = 120°$

17. (b) P = P, Q = P

$R = \sqrt{P^2 + P^2 + 2P.P\cos\theta}$

$R = \sqrt{2P^2 + 2P^2\cos\theta}$

$R = \sqrt{2P^2(1+\cos\theta)}$

$R^2 = 2P^2(1 + \cos\theta)$

$R^2 = 2P^2 \,.\, 2\cos^2\frac{\theta}{2} \qquad \because \quad 1 + \cos\theta = 2\cos^2\frac{\theta}{2}$

$R^2 = 4P^2\cos^2\frac{\theta}{2}$

$\therefore \quad R = 2P\cos\frac{\theta}{2}$

18. (a) $R = \sqrt{6^2 + 8^2 + 2 \times 6 \times 8 \times \cos 90°} \qquad \cos 90° = 0$

$= \sqrt{6^2 + 8^2}$

$= \sqrt{100}$

$= 10$ kN

29. (b)

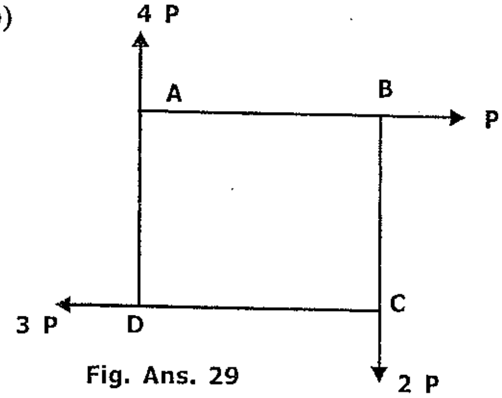

Fig. Ans. 29

$\Sigma H = P - 3P = -2P$

$\Sigma V = 4P - 2P = 2P$

$\therefore \quad R = \sqrt{(-2P)^2 + (2P)^2}$

$= \sqrt{8P^2}$

$= 2\sqrt{2}\,P$

31. (b)

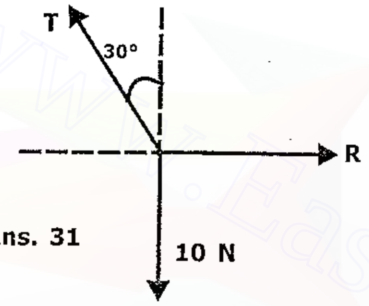

Fig. Ans. 31

$\Sigma V = 0,$

$\therefore \quad T \cos 30° = 10$

$\therefore \quad T = 11.55$ N

34. (d) $\Sigma H = 150 - 150 \cos 60° - 150 \cos 60°$

$= 150 - 75 - 75$

$= 0$

$\Sigma V = 150 \sin 60° - 150 \sin 60°$

$= 0$

$\therefore \quad R = 0$

35. (b) $M = (20 \times 0.12) + (10 \times 0.18)$

$= 4.2$ kN.m clockwise

36. (a) $\Sigma H = 20 - 20 = 0$ $\quad \therefore \quad R = 0$

$\Sigma V = 10 - 10 = 0$

39. (b) $R_A + R_B = 80 + W$

$60 + 60 = 80 + W \quad \therefore \quad W = 40$ kN

40. (c) $\Sigma M_A = 0$

$\therefore \quad 60 \times 5 = (80 \times 2) + 40\,x$

$300 = 160 + 40\,x$

$\therefore \quad x = 3.5$ m

47. (d)

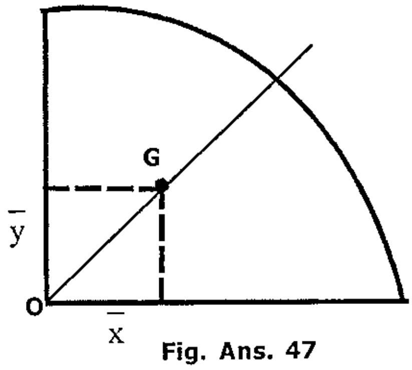

Fig. Ans. 47

$$\bar{x} = \frac{4r}{3\pi}, \quad \bar{y} = \frac{4r}{3\pi}$$

$$\therefore \quad OG = \sqrt{\left(\frac{4r}{3\pi}\right)^2 + \left(\frac{4r}{3\pi}\right)^2}$$

$$= \sqrt{\frac{32r^2}{9\pi^2}}$$

$$= 0.6\ r$$

54. (c) $Izz = Ixx + Iyy$

$$= \frac{\pi}{64} d^4 + \frac{\pi}{64} d^4$$

$$= \frac{\pi}{32} d^4$$

55. (b) $I = \frac{bd^3}{12} = \frac{a \cdot a^3}{12} = \frac{a^4}{12}$

87. (b) For the first system of pulleys

$VR = 2^n$

$= (2)^4 = 16$

109. (b) $m = 10{,}000$ kg

$$V = 36 \text{ kmph} = \frac{36 \times 1000}{3600} = 10 \text{ m/s}$$

$$\text{Kinetic energy} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \times 10{,}000 \times (10)^2$$

$$= 500{,}000 \text{ N.m}$$

110. (a)

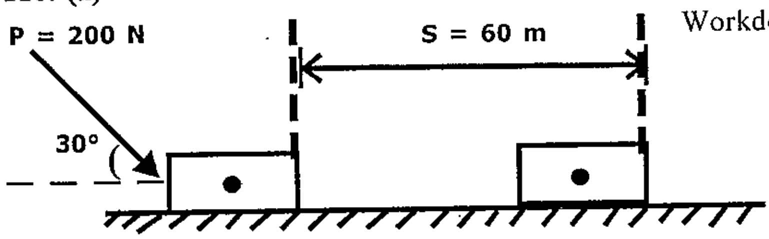

Fig. Ans. 110

Workdone = 200 cos 30° × 60

= 10392.3 N.m

2. Strength of Materials

1 : Mechanical Properties of Materials

1.1 IMPORTANT MECHANICAL PROPERTIES :

From an engineering point of view, the followings are the important mechanical properties of the materials.

1. Strength
2. Elasticity
3. Plasticity
4. Ductility
5. Brittleness
6. Malleability
7. Toughness
8. Hardness
9. Stiffness
10. Creep
11. Fatigue strength

1. Strength :

The capacity of material to withstand load is called strength.

The strength of material is its ability to sustain loads without undue distortion, rupture or collapse.

A material should have adequate strength in tension, compression, shear, bending or torsion.

The maximum stress that any material can withstand is called ultimate strength or tenacity.

2. Elasticity :

On a material, when external load is applied it undergoes deformation and on removal of the load, it returns to it's original shape. This property of a material is known as elasticity. Such a material is called elastic material.

Some materials possess elasticity up to considerable range of load (stress), while some materials possess elasticity for a very low range of stress.

The elastic properties of a material are of great importance to a design engineer since materials loaded beyond their elastic limit develop a permanent deformation or strain.

3. Plasticity :

If a material does not regain its original shape, on the removal of the external load, it is called a plastic materials.

Plasticity is the property of a material by virtue of which material can be moulded in to desired shape. It is the lack of elasticity.

4. Ductility :

If a material can undergo a considerable deformation, without rupture (e.g. if a material can be drawn into wires) it is called a ductile material.

Ductile materials undergoes large deformations during tension test. Ductile material is the most suitable material for tension member.

Steel, Copper, Wrought-iron, Aluminimum alloys are ductile materials, stainless steel is the most ductile material and Grey cast iron is the least ductile material.

Higher the percentage of elongation, more ductile is material.

As temperature increases, ductility increases.

Metals having elongation, more than 15% are ductile.

5. Brittleness :

If a material cannot undergo any deformation, when some external forces act on it and it fails by rupture, it is called a brittle material.

Brittle materials are stronger in compression and weak in tension.

C.I., Glass, Concrete, Brick, China-ware are the examples of brittle materials.

It is a compressive quality of a material.

Materials having less than 5% elongation are considered as brittle.

6. Malleability :

It is a property of a material by virtue of which material can be converted in to thin sheets by hammering.

Malleable material can be easily rolled and forged without cracking or breaking.

Gold, Silver, Copper, Aluminimum, Tin, Lead steel are the examples of malleable materials.

Gold is the most malleable materials while C.I. is the least malleable material.

This is also a compressive quality of a material.

7. Toughness :

Resistance to impact or shock loading is called toughness.

OR

Capacity of a material to absorb energy before rupture is called toughness.

OR

Work required to cause rupture, under static load is called toughness.

Toughness of a material is the ability to withstand large stresses and strains without fracture.

Mild steel, Wrought iron, Manganese steel etc. have good toughness property.

Toughness is the highly desirable quality in materials for structural and machine parts subjected to shocks and vibrations.

8. Hardness :

Resistance of a material to abrasion, indentation, wear and scratches is called hardness.

High resistance to indentation is desired in a components like crank shafts, rails, gears, axles etc.

An alloyed C.I. is the hardest material while magnesium alloy is the softest material.

9. Stiffness :

Resistance to deformation or strain is called stiffness.

OR

Force required to produce unit deformation in a material is called stiffness.

The stiffness of a material is measured by its 'Modulus of Elasticity (E)'. The higher the value of E, the more is stiffness.

Steel is considered as a stiffer material.

10. Creep :

Increase in strain under sustained load is known as creep.

OR

Inelastic deformation due to sustained load is known as creep.

Metals, having low melting temperatures like Lead, Tin, Zinc may exhibit considerable creep at normal temperature.

Creep phenomena is important for soft metals used at room temperature, steel cables, Nuclear reactor field etc.

11. Fatigue strength :

When a material is subjected to repeated loading, it is said to be in a 'state of fatigue'.

The maximum stress, which a material can withstand, under repeated stress cycles without fracture is called "Fatigue strength'.

The capacity of a material to withstand repeated stress cycles is known as endurance of a material.

For most of the materials there is limiting stress below which a stress or a load may be repeated infinite number of times without causing failure. This limiting stress is known as endurance limit or Fatigue limit.

Homogeneous material :

Homogeneous material means that the material of the member is of the same kind through its length.

For example, if a beam is made of steel, the material of beam does not change throughout the length of the beam.

Isotropic material :

Isotropic means it possesses the same elastic properties in all the directions.

❖❖❖

2 : Direct Stress and Strain

2.1 SRESS, STRAIN, δl CALCULATIONS :

1. **Stress (σ) :** On a body when external force (load) is applied, it undergoes some deformation and internal resisting forces are set up.

   This resistance to force per unit cross sectional area is called stress.

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$\therefore \quad \boxed{\sigma = \frac{P}{A} = \frac{R}{A}}$$

P = external force

R = Resisting force

S.I. unit of stress is N/mm^2 (MPa)

1 Pa = 1 N/m^2

1 KPa = 10^3 Pa = 10^3 N/m^2

1 MPa = 10^6 Pa = 1 N/mm^2

1 GPa = 10^9 Pa = 10^3 N/mm^2

K = Kilo = 10^3, M = Mega = 10^6,

G = Gega = 10^9

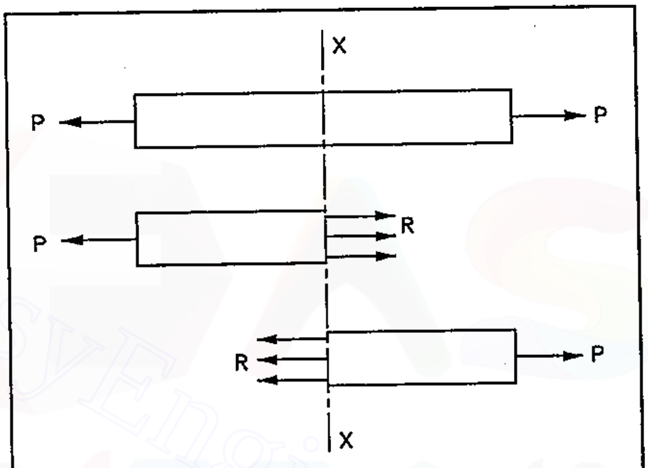

FIG. 2.1

2. **Strain (ε) :** It is defined as the ratio of change in length to the original length of the member

$$\therefore \quad \text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$$

$$\varepsilon = \frac{\delta l}{l}$$

Strain has no unit.

It is a measure of deformation produced in a member due to the loads acting on it.

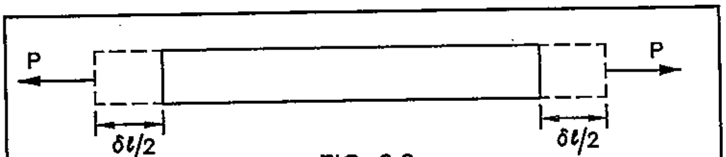

FIG. 2.2

3. **Direct stress (Normal stress) :** The stresses which act normal to the plane on which the forces act are called as normal stress or direct stress.

   These are two types :

   (i) **Tensile stress :** When a body is subjected to two equal and opposite pulls, the stress produced is known as **tensile stress.**

(ii) **Compressive stress :** When a body is subject to two equal and opposite pushes, the stress produced is known as **compressive stress.**

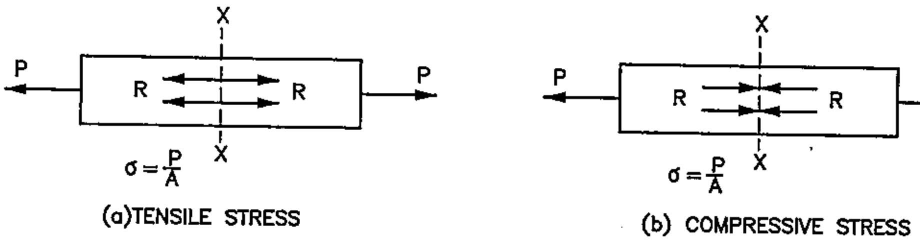

FIG. 2.3

- If the stress is tensile, the corresponding strain is known as **tensile strain.**
- If the stress is compressive, the corresponding strain is known as **compressive strain.**

4. **Elasticity :** It is the property of a body to regain its original position after the removal of external force.

   If a body is elastic, it will deform on application of external force, but as soon as the force is removed, it comes back to its original shape and size.

5. **Elastic limit :** Maximum value of force, up to and within which the deformation entirely disappears on removal of the force, is called elastic limit.

6. **Hooke's Law :** It states, "Within elastic limit, stress is proportional to strain".

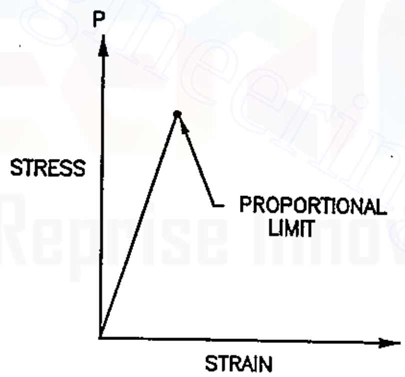

FIG. 2.4

Stress σ strain

$\therefore \quad \sigma \propto \varepsilon$

$\therefore \quad \sigma = \text{constant} \times \varepsilon$

$\therefore \quad \frac{\sigma}{\varepsilon} = \text{constant}$

7. **Modulus of elasticity (Young's modulus) : E** It is the ratio of direct stress to the direct strain.

$$\therefore \quad \text{Modulus of elasticity} = \frac{\text{direct stress}}{\text{direct strain}}$$

$$\therefore \quad \boxed{E = \frac{\sigma}{\varepsilon}}$$

S.I. unit of E is N/mm^2.

For mild steel $E = 2 \times 10^5\ N/mm^2$

8. Equation of δl :

We know that,

$$\sigma = \frac{P}{A}$$

$$\varepsilon = \frac{\delta l}{l}$$

$$E = \frac{\sigma}{\varepsilon}$$

$$\therefore \quad E = \frac{\sigma}{\varepsilon} = \frac{P/A}{\delta l / l} = \frac{P.l}{A.\delta l}$$

$$\therefore \quad \boxed{\delta l = \frac{P.l}{AE}}$$

Remember :

1. Stress, $\sigma = \frac{P}{A}$
2. Strain, $\varepsilon = \frac{\delta l}{l}$
3. Modulus of elasticity, $E = \frac{\sigma}{\varepsilon}$
4. $\delta l = \frac{P.l}{AE}$

- **Deformation of a body due to self weight (For uniform section) :**

$$\delta l = \frac{wl^2}{2AE}$$ ...where w = weight per unit length

- **Stresses in bars of uniformly tapering circular section :**

$$\delta l = \frac{4Pl}{\pi E d_1 d_2}$$

where,

d_1 = dia. at larger end

d_2 = dia. at smaller end

2.2 COMPOSITE SECTION :

If a bar is made up of two or more different materials, it is called **composite section.**

For example,

- steel and copper
- steel and brass
- copper and aluminium
- concrete and steel, etc.

Consider the composite section shown in figure.

Let,

P = total load on the bar

P_1 = load shared by bar 1,

P_2 = load shared by bar 2,

A_1 = Cross sectional area of bar 1,

A_2 = Cross sectional area of bar 2,

E_1 = modulus of elasticity of bar 1,

E_2 = modulus of elasticity of bar 2,

For composite bar,

elongation or contraction of each bar is same

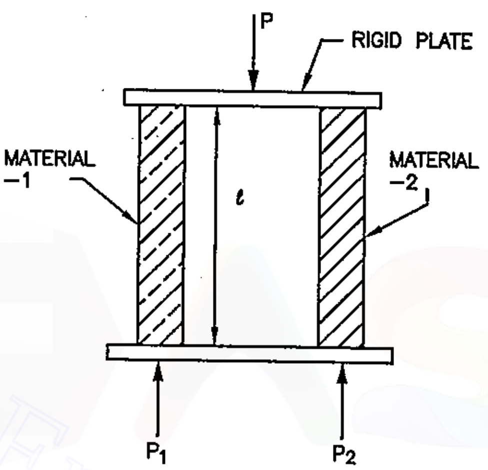

FIG. 2.5

$\therefore \quad \delta l_1 = \delta l_2$ and $l_1 = l_2$

$\therefore$ Strain in material 1 = Strain in material 2

$\therefore \quad \varepsilon_1 = \varepsilon_2$

$$\therefore \quad \frac{\sigma_1}{E_1} = \frac{\sigma_2}{E_2}$$

$$\therefore \quad \sigma_1 = \frac{E_1}{E_2} \cdot \sigma_2 \quad \text{... (1)}$$

Here, $\frac{E_1}{E_2}$ is known as **modular ratio :**

$E_1 > E_2$

Now,

Total load = load on material 1 + load on material 2

$\therefore \quad P = P_1 + P_2 \qquad \because \quad \sigma = \frac{P}{A}$

$\therefore \quad P = \sigma_1 A_1 + \sigma_2 A_2$ .... (2)

2.3 ELASTIC CONSTANTS :

Consider a bar subjected to tensile force "P' as shown in figure.

Due to tensile force P,

Length increases from l to l'

Diameter decreases from d to d'

The direction of foıce is called **linear direction**. The direction of force perpendicular to the linear direction is called lateral direction. length of bar is a **linear dimension.** Diameter of bar is a **lateral dimension.**

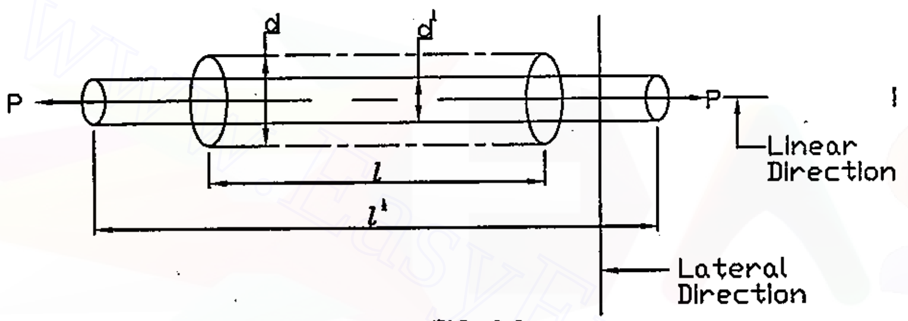

FIG. 2.6

1. Linear strain (ε) :

It is defined as the ratio of change in length to the original length of the member.

$$\therefore \quad \text{Linear strain} = \frac{\text{Change in length}}{\text{Original length}}$$

$$\therefore \quad \boxed{\varepsilon = \frac{\delta l}{l}}$$

Strain has no unit.

Linear strain and strain are same

2. Lateral strain (ε') :

- **For circular cross section :**

$$\text{Lateral strain} = \frac{\text{Change in diameter}}{\text{Original diameter}}$$

$$\therefore \quad \boxed{\varepsilon' = \frac{\delta d}{d}}$$

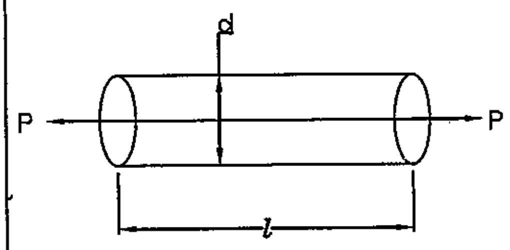

FIG. 2.7

- **For rectangular cross section :**

$$\varepsilon' = \frac{\delta b}{b}$$

or

$$\varepsilon' = \frac{\delta t}{t}$$

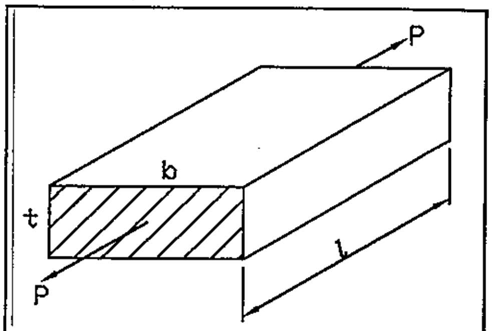

FIG. 2.8

3. **Poisson's ratio (μ or $\frac{1}{m}$) :**

The ratio of lateral strain to linear strain is called **Poisson's ratio.**

$$\text{Poisson's ratio} = \frac{\text{Lateral strain}}{\text{Linear strain}}$$

$$\mu = \frac{1}{m} = \frac{\varepsilon'}{\varepsilon}$$

For steel, μ = 0.25 to 0.33

For concrete, μ = 0.08 to 0.18

4. **Volumetric strain (ε_v) :**

$$\text{Volumetric strain} = \frac{\text{Change in volume}}{\text{Original volume}}$$

$$\varepsilon_v = \frac{\delta V}{V}$$

Equation to find change in volume :

$$\frac{\delta V}{V} = \varepsilon\,(1 - 2\,\mu)$$

5. **Bulk modulus (K) :**

When a body is subjected to three mutually perpendicular stresses of equal intensity, the ratio of direct stress to the corresponding volumetric strain is known as **bulk modulus.**

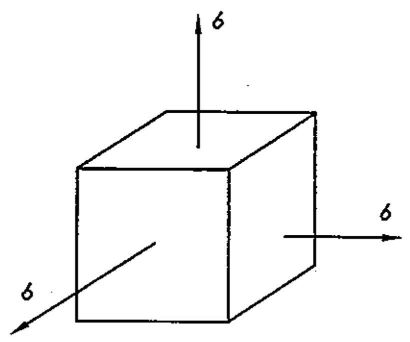

FIG. 2.9

$$\text{Bulk modulus} = \frac{\text{Direct stress}}{\text{Volumetric Strain}}$$

$$\therefore \quad K = \frac{\sigma}{\varepsilon_v} \quad \text{... N/mm}^2$$

- **Shear modulus (Modulus of rigidity) G or N or C :**

$$\text{Modulus of rigidity} = \frac{\text{shear stress}}{\text{Shear strain}} = \frac{\tau}{\phi}\ \text{N/mm}^2$$

6. Shear stress and shear strain :

Shear stress :

When a body is subjected to two equal and opposite forces acting tangetially across the resisting section, as a result of which the body tends to shear off across the section, the stress induced is called **shear stress.**

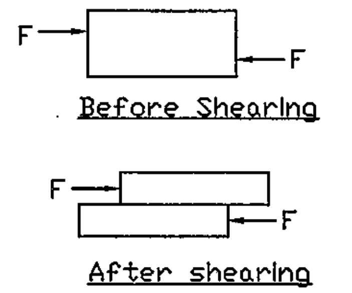

FIG. 2.10

$$\text{Shear stress} = \frac{\text{Shear force}}{\text{shearing Area}}$$

$$\therefore \boxed{\tau = \frac{F}{A_s}}$$

Unit of shear stress is N/mm^2

Shear strain :

Consider a cube of length l fixed at bottom face CD.

Let force F is applied to face DC tangetially to the face AB.

As a result the cube will deformed from ABCD to A'B'CD

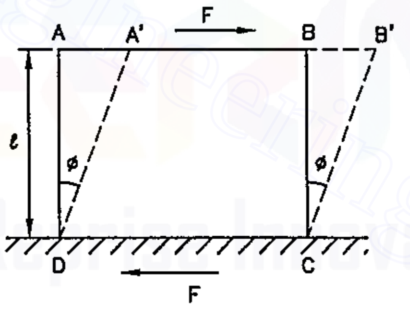

FIG. 2.11

$$\text{Shear strain} = \frac{\text{deformation}}{\text{original length}}$$

$$\tan\phi = \frac{AA'}{AD} = \frac{BB'}{BC}, \text{ but } \phi \text{ is very small}$$

$$\therefore \quad \tan\phi = \phi$$

$$\therefore \quad \phi = \frac{AA'}{AD} = \frac{BB'}{BC}$$

7. Complimentary shear stress :

In order to cause an equilibrium. a shear stress (τ) across a plane, is always accompanied by a balancing shear stress (τ') across the plane and normal to it. This balancing shear stress is called **complimentary shear stress.**

Condiser a block ABCD. shear stress (τ) is acting on faces AD and CB.

$\therefore$ Forces acting on faces AD and CB.

$$P = \tau \times AD = \tau \times CB$$

This forces will form a couple.

$\therefore$ Moment of couple = M_1 = force × distance

$M_1 = (\tau \times AD) \times AB$.... (i)

If the block is in equilibrium, resisting couple with shear stress τ' on faces AB and CD will be set up.

∴ forces acting on faces AB and CD.

$P = \tau' AB = \tau' \times CD$

This forces will also form a couple.

Moment of this couple,

$M_2 = (\tau' \times AB) \times AD$.... (ii)

equating two moments,

$M_1 = M_2$

$\therefore \quad (\tau \times AD) \times AB = (\tau' \times AB) \times AD$

$\therefore \quad \tau = \tau'$

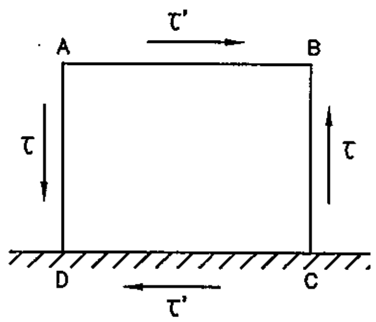

FIG. 2.12

8. Modulus of rigidity or shear modulus (G or N or C)

$$\text{Modulus of rigidity} = \frac{\text{Shear stress}}{\text{Shear strain}}$$

$$\therefore \quad G = \frac{\tau}{\phi} \text{ ... N/mm}^2$$

- **Relation between E and K :**

$$K = \frac{mE}{3(m-2)}, \quad \frac{1}{m} = \text{Poisson's ratio}$$

- **Relation between E and G :**

$$G = \frac{mE}{2(m+1)}$$

- **Relation between E, G and K :**

$$E = \frac{9GK}{G+3K}$$

- **Volumetric strain of a rectangular body subjected to only axial force :**

$$\frac{\delta V}{V} = \varepsilon(1-2\mu)$$

$\mu = \frac{1}{m}$

V = volume of the body

$\varepsilon = \frac{\sigma}{E}$

- **Volumetric strain of a rectangular body subjected to three mutually perpendicular Forces :**

resultant strain in x-direction

$$\varepsilon_x = \pm\frac{\sigma_x}{E} \pm \frac{\sigma_y}{mE} \pm \frac{\sigma_z}{mE}$$

$$\varepsilon_y = \pm\frac{\sigma_y}{E} \pm \frac{\sigma_x}{mE} \pm \frac{\sigma_z}{mE}$$

$$\varepsilon_z = \pm\frac{\sigma_z}{E} \pm \frac{\sigma_x}{mE} \pm \frac{\sigma_y}{mE}$$

Volumetric strain,

$$\frac{\delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

Note :
tension = + Ve
Compression = - Ve
Take normal sign for linear strain (first strain) and opposite to normal sign for two lateral strains.

2.4 THERMAL STRESS :

1. Thermal stress :

With increase in temperature material expands and with decrease in temperature it contracts. If this free expansion or contraction is prevented, Stress will be generated in the material. It is called **thermal stress.**

If temperature of a material is increased or decreased and it is allowed to expand or contract freely, no stress will be produced in the material.

- Free deformation of a material due to change in temperature,

$$\boxed{\delta l = l \times \alpha \times t}$$

where,
l = length of a member,
α = coefficient of thermal expansion,
t = change in temperature

Let,
l = original length of bar

If temperature of bar is increased by t° C,

Increase in length,
$\delta l = l\,\alpha\,t$.

If this expansion is to be prevented, external compressive load P is required.

Hence, if temperature of a bar is increased and expansion is prevented compressive stress will be produced.

If temperature of bar is reduced by t° c,

decrease in length,
$\delta l = l\,\alpha\,t$

If this contraction is to be prevented, external tensile load P, is required.

Hence, if temperature of a bar is decreased and contraction is prevented, tensile stress will be produced.

2. Thermal Strain :

$$\text{Thermal Strain} = \frac{\text{Change in length due to change in temperature}}{\text{Original length}}$$

$$\varepsilon = \frac{l\alpha t}{l}$$

$$\therefore \quad \boxed{\varepsilon = \alpha t}$$

3. Thermal stress for yielding and non–yielding supports :

(a) For supports do not yield :

We know that,

thermal strain, $\boxed{\varepsilon = \alpha t}$

$\therefore$ thermal stress,

$$\sigma = \varepsilon.E \qquad \because \quad E = \frac{\sigma}{\varepsilon}$$

$$\therefore \quad \boxed{\sigma = \alpha t E}$$

(b) For supports are yielding :

let, yielding of supports = δ

$\therefore \quad \delta l = l\,\alpha\, t - \delta$

$$\therefore \quad \frac{\delta l}{l} = \alpha t - \frac{\delta}{l}$$

$$\therefore \quad \boxed{\varepsilon = \alpha t - \frac{\delta}{l}} \text{ ...... Thermal strain}$$

Now,

$\sigma = \varepsilon.E$

$$\boxed{\sigma = \left(\alpha\, t - \frac{\delta}{l}\right) E} \text{ ...... Thermal stress}$$

- **Thermal stress in bars of tapering circular section :**

$$\sigma = \alpha\, tE\,\frac{d_1}{d_2} \text{ ... maximum stress}$$

$$\sigma = \alpha\, tE\,\frac{d_2}{d_1} \text{ .... minimum stress}$$

where, d_1 = dia. at larger end

d_2 = dia. at smaller end

- **Thermal stress in compound bars :**

For compound bar,

$P_1 = P_2$

$\therefore \quad \sigma_1 A_1 = \sigma_2 A_2$ ..... (i)

$\delta l = \delta\, l_1 + \delta l_2$

$$= \frac{\sigma_1 l_1}{E_1} + \frac{\sigma_2 l_2}{E_2} \quad ....(ii)$$

- **Thermal stresses in composite bars :**

For composite bar,

$P_1 = P_2$

$\therefore \quad \sigma_1 A_1 = \sigma_2 A_2$ ....(i)

$\varepsilon_1 + \varepsilon_2 = t(\alpha_1 - \alpha_2)$ ... (ii)

$\varepsilon_1 = \dfrac{\sigma_1}{E_1}$

$\varepsilon_2 = \dfrac{\sigma_2}{E_2}$

2.5 STRAIN ENERGY AND IMPACT LOADING :

1. Strain Energy (u) :

When a body is strained within elastic limit, energy stored in it. This energy is called **strain energy.**

Strain energy = work done on a body.

$$\therefore \quad \boxed{u = \frac{\sigma^2}{2E} \times v}$$

where,

u = Strain energy

σ = Stress

v = Volume of a bar

The unit of strain energy is N.m.

2. Resilience :

Total strain energy stored in a body, within elastic limit is called **resilience.**

$$\text{Resilience} = u = \frac{\sigma^2}{2E} \times v$$

3. proof resilience :

The maximum strain energy that can be stored in a body at elastic limit is called **Proof resilience.**

$$\therefore \quad \text{Proof resilience} = u_p = \frac{(\sigma_E)^2}{2E} \times v$$

where, σ_E = Stress at elastic limit

4. Modulus of resilience (u_m) :

The maximum strain energy that can be stored in a body per unit volume, at elastic limit is called **modulus of resilience.**

$$\text{Modulus of resilience} = \frac{\frac{(\sigma_E)^2}{2E} \times v}{v} = \frac{(\sigma_E)^2}{2E}$$

The unit of modulus of resilience is N.mm/mm^3

5. Instantaneous stress :

When a body is subjected to sudden load or Impact load the stress produced is called instantaneous stress.

6. Methods of applying load :

Method of applying load

↓

↓	↓	↓	↓
Gradual loading	Sudden loading	Impact loading	Shock loading

- **Gradual load :** The load is increasing gradually from zero to P.

  Stress, $\sigma = \frac{P}{A}$

- **Sudden load :** When a body is subjected to total load P at a time, without small increments, it is called sudden load.

  Stress, $\sigma = \frac{2P}{A}$

- **Impact load :** When a load fall on a body from some height, it is called impact load.

$$\sigma = \frac{P}{A}\left[1 + \sqrt{1 + \frac{2EAh}{P.l}}\right]$$

Strain energy is,

u = work done

u = P (h + δl)

$$\therefore \frac{\sigma^2}{2E} \times V = P\,(h + \delta l)$$ ... equation to find impact load.

where,

σ = stress due to impact load

P = Impact load

h = height of fall of load

δl = deformation of a body

2.6 TENSION TEST ON MILD STEEL :

- **Tension test specimen :**
- **Stress–strain curve for tension test on M.S :**

A = Proportional limit

B = Elastic limit

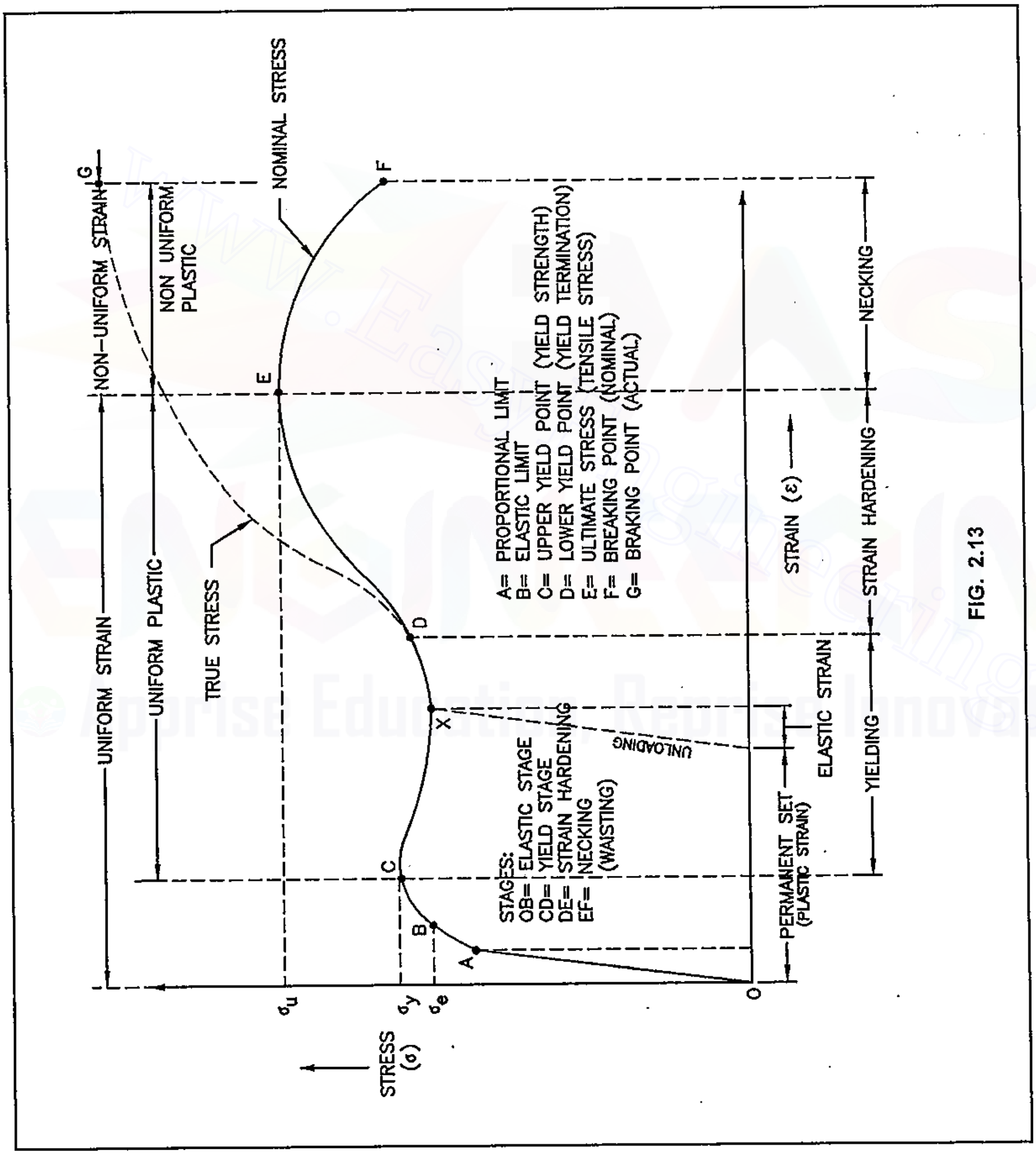

FIG. 2.13

C = Upper yield point

D = Lower yield point

E = ultimate load point

F = Breaking point (Nominal)

G = Breaking point (Actual)

- **Proportional limit :** The limit of stress up to which, stress is proportional to strain is called **proportional limit.**

- **Elastic limit :** The value of force up to and within which, the deformation entirely disappear on removal of the force is called **elastic limit.**

- **Yield stress :** When specimen is stressed beyond elastic limit, Strain increases more rapidly than the stress. Because, sudden elongation of the specimen takes place, without appreciable increase in the stress (or load). This phenomena is known as yielding. The Stress corresponding to point "C" in the graph is called **yield stress.**

$$\text{Yield stress} = \frac{\text{yield load}}{\text{original c/s area}}$$

$$\therefore \boxed{\sigma_y = \frac{P_y}{A_o}}$$

$$A_0 = \frac{\pi}{4} \times (d_o)^2$$

d_o = Original diameter of bar

- **ultimate stress :**

$$\text{ultimate stress} = \frac{\text{ultimate load (Maxi. load)}}{\text{original c/s area}}$$

$$\therefore \boxed{\sigma_u = \frac{P_u}{A_o}}$$

- **Nominal breaking stress :**

$$\text{Nominal breaking stress} = \frac{\text{Breaking load}}{\text{original c/s area}}$$

$$\therefore \boxed{\sigma_b = \frac{P_b}{A_o}}$$

- **Actual breaking stress :**

$$\text{Actual breaking stress} = \frac{\text{Breaking load}}{\text{Final c/s area}}$$

$\therefore$ $\boxed{\sigma_b = \frac{P_b}{A'}}$

$A' = \frac{\pi}{4} \times (d')^2$

d' = Final diameter

- **Percentage elongation :**

$$\% \text{ elongation} = \frac{(\text{Final G.L.} - \text{original G.L.})}{\text{original G.L.}} \times 100\ \%$$

$$= \frac{(L' - L_o)}{L_o} \times 100\ \%$$

For mild steel % elongation is 23 to 25%

- **Percentage reduction in area :**

$$\% \text{ Reduction in area} = \frac{\left(\frac{\text{original c/s}}{\text{area}} - \frac{\text{Final c/s}}{\text{area}}\right)}{\text{original c/s area}} \times 10$$

$$= \frac{(A_o - A')}{A_o}\ 100\%$$

For mild steel % reduction in area is about 40 to 65%

- **Gauge length :** During tension test on mild steel bar, two points A and B are marked at equal distance from centre. This length AB is known as original gauge length.

Minimum gauge length = $L_o = 5.65\sqrt{A_o}$

A_o = Original c/s area

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3 : Shear force and Bending Moment diagrams

3.1 SHEAR FORCE : (SF) :

Algebric sum of unbalanced vertical forces to the left or right side of the section is called **shear force** at that section.

Unit of S.F. is N or kN.

3.2 BENDING MOMENT (B.M.) :

Algebric sum of moments to the left or right side of the section is called **Bending moment** at that section.

Unit of B.M.is N.M. or kN.m

3.3 POINT OF CONTRAFLEXURE :

The point in a B.M. diagram at which, B.M. changes sign from +ve to –ve or –ve to +ve is called **Point of contraflexure.**

At point of contraflexure B.M. is zero.

3.4 RELATION BETWEEN S.F. AND B.M. :

1. The rate of change of S.F. w.r.t. distance (or slope of the S.F. curve) is equal to the intensity of loading.

$$\therefore \quad \frac{\delta F}{\delta x} = w \quad \ldots \text{(i)}$$

2. The rate of change of B.M. w.r.t. distance (or slope of B.M. curve) is equal to the S.F. at the section.

$$\therefore \quad \frac{\delta M}{\delta x} = -F \quad \ldots \text{(ii)}$$

3. The point at which S.F. changes sign, B.M. will be maximum.

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4 : Slope and deflection of Beams

4.1 SLOPE AND DEFLECTION :

- **For cantilever beam :**

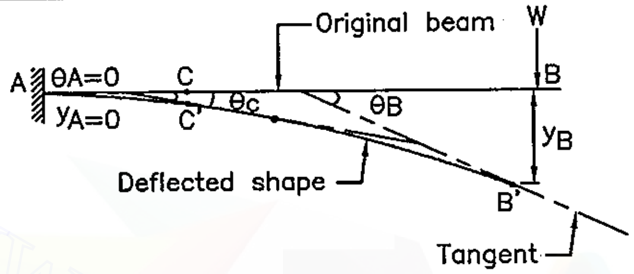

FIG. 4.1

- **For simply supported beam :**

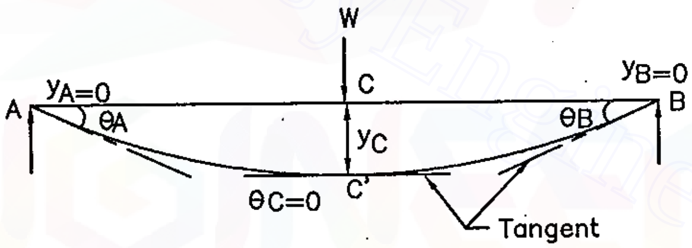

FIG. 4.2

- **Slope (θ) :** At any point, angle made by tangent drawn to the deflected shape of a beam, with horizontal is called slope at that point.

  The unit of slope is radian or degree.

  It is denoted by θ.

$$1 \text{ degree} = \frac{\pi}{180} \text{ radian}$$

OR

$$1 \text{ radian} = \frac{180}{\pi} \text{ degree}$$

- **Deflection (y) :**

  At any point, vertical distance between the axis of original beam and the axis of deflected beam is known as deflection at that point.

unit of deflection is mm or cm.

Flexural rigidity : Modulus of elasticity (E), Moment of inertia (I)

Flexural rigidity = EI

4.2 SLOPE - DEFLECTION EQUATIONS :

1. **Cantilever beam with point load at free end :**

$$\theta_B = \frac{Wl^2}{2EI}$$

$$y_B = \frac{Wl^3}{3EI}$$

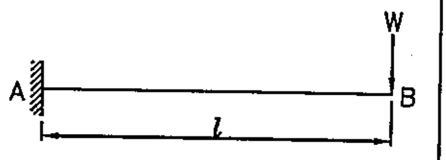

FIG. 4.3

2. **Cantilever beam with u.d.l. on entire span :**

$$\theta_B = \frac{wl^3}{6EI}$$

$$y_B = \frac{wl^4}{8EI}$$

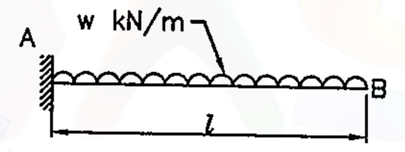

FIG. 4.4

3. **Cantilever beam with point load at free end and u.d.l. on entire span :**

$$\theta_B = \frac{Wl^2}{2EI} + \frac{wl^3}{6EI}$$

$$y_B = \frac{Wl^3}{3EI} + \frac{wl^4}{8EI}$$

FIG. 4.5

4. **Simply supported beam with central point load :**

$$\theta_A = \theta_B = \frac{Wl^2}{16EI}$$

$$y_c = \frac{Wl^3}{48EI}$$

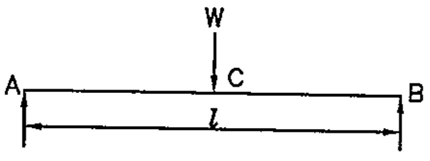

FIG. 4.6

5. Simply supported beam with u.d.l. on entire span :

$$\theta_A = \theta_B = \frac{wl^3}{24EI}$$

$$y_c = \frac{5}{384} \times \frac{wl^3}{EI}$$

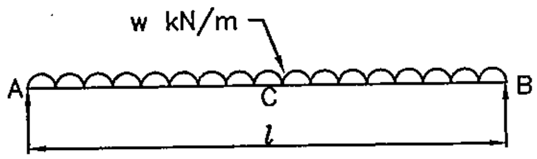

FIG. 4.7

6. Simply supported beam with central point load and u.d.l. on entire span :

$$\theta_A = \theta_B = \frac{Wl^2}{16EI} + \frac{wl^3}{24EI}$$

$$y_c = \frac{Wl^3}{48EI} + \frac{5}{384}\frac{wl^4}{EI}$$

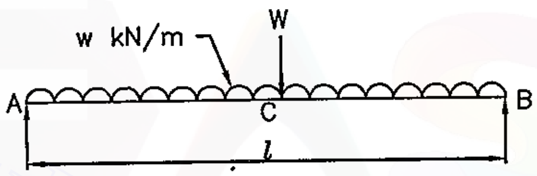

FIG. 4.8

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5 : Bending stresses in Beams and Shear Stresses

5.1 PURE BENDING STRESS :

When a beam length is subjected to a constant amount of bending moment and a zero shear force, the stresses set up across the cross–section of the beam, due to bending, is known as **Pure bending stress.**

5.2 ASSUMPTIONS IN THE THEORY OF PURE BENDING :

The following assumptions are made in the theory of pure bending :

1. The material of the beam is perfectly homogeneous (i.e. of the same kind throughout) and isotropic (i.e. of equal elastic properties in all directions).
2. The beam is stressed within its elastic limit and Hook's law is valid.
3. The transverse sections, which were plane before bending remain plane after bending.
4. Each layer of beam is free to expand or contract, independently.
5. The value of Young's modulus (E) is the same in tension and compression.

5.3 THEORY OF PURE BENDING :

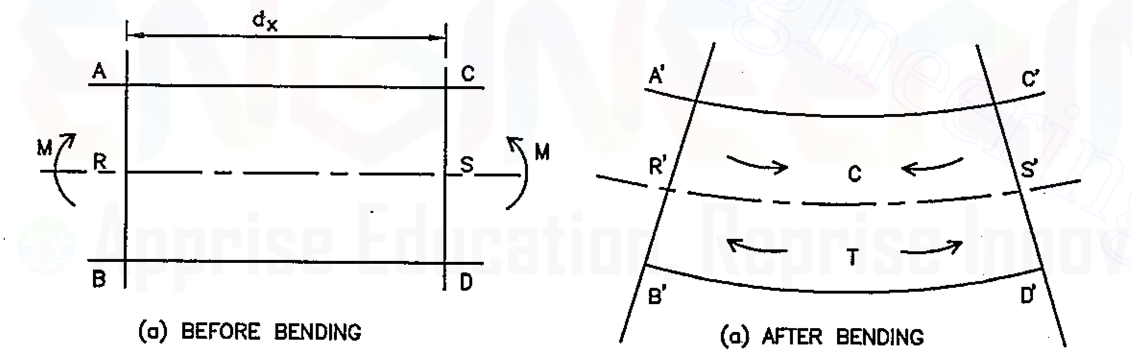

FIG. 5.1

Consider a simply supported beam subjected to a bending moment M.

dx = small length of beam

Due to bending of beam, the top layer AC suffered compression and reduced to A'C'. As we proceed towards the lower layers of the beam, they also suffered compression, but to a lesser degree, until we come across the layer RS which has suffered no change in its length.

As we further proceed towards the lower layers, we find the layers have suffered tension. The layer BD has suffered maximum tension and has been stretched to B'D'.

- **Neutral layer (Neutral plane) :**

Due to bending of beam, all the layers above RS layer are compressed and all the layers below RS layer are stretched. But, layer RS which is neither compressed nor stretched, is known as **neutral layer** or **neutral plane**.

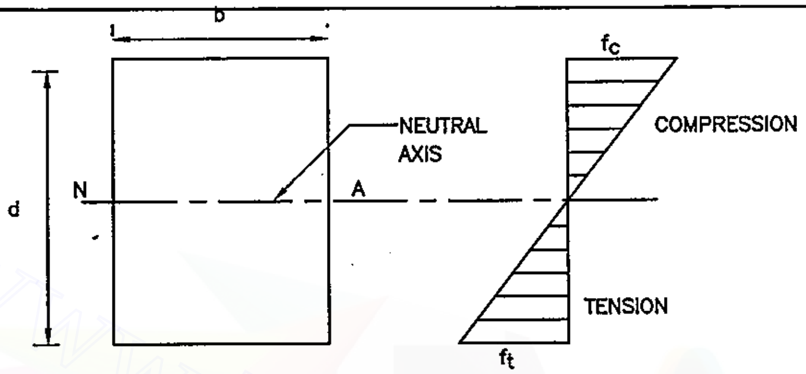

FIG. 5.2 For simply supported beam

- **Neutral Axis :**

The line of intersection of the neutral layer, with any normal cross section of a beam is known as **neutral axis** of that section.

If section of a beam is subjected to pure sagging bending moment, stresses above N.A. are compressive and stresses below N.A. are tensile. At the neutral axis (NA), there is no stress of any kind.

- **Moment of resistance :**

When a beam length is subjected to a constant amount of bending moment, on one side of neutral axis there are compressive stresses and on the other there are tensile stresses. These stresses form a couple, whose moment must be equal to external moment M. The moment of this couple, which resists the external bending moment, is known as moment of resistance.

5.4 BENDING EQUATION :

$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$ ... It is called **bending equation** or **flexure equation.**

where, M = Moment of resistance

I = M.I. of the section about x–x axis

f = bending stress (maxi)

y = distance of extreme fibre from N.A.

E = Modulus of elasticity

R = Radius of curvature of the beam

5.5 MAXIMUM BENDING MOMENT :

Maximum B.M. or Moment of Resistance (M) for some simple beams is given below.

(1) Simply supported beam with central point load :

Maxi. N.M. will occure at C.

$$M = \frac{W}{2} \cdot \frac{l}{2} = \boxed{\frac{Wl}{4}} \text{ (sagging)}$$

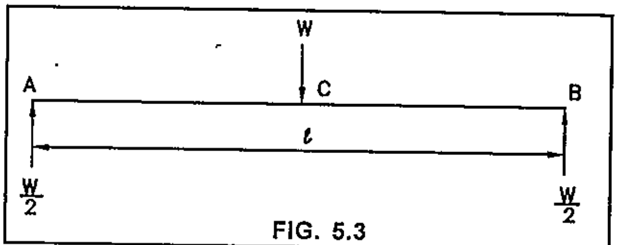

FIG. 5.3

(2) Simply supported beam with eccentric point load :

Maxi, N.M. will occur at C.

$$\therefore \; M = \frac{Wa}{l} \cdot b = \frac{W\,a\,b}{l}$$

OR

$$M = \frac{Wb}{l} \cdot a = \boxed{\frac{W\,a\,b}{l}} \text{ (sagging)}$$

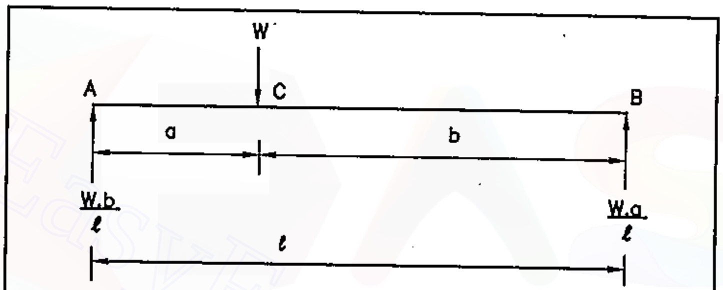

FIG. 5.4

(3) Simply supported beam with U.D.L. on entire span :

Maxi B.M. will occur at the mid span

$$M = \frac{wl}{2} \times \frac{l}{2} - w \times \frac{l}{2} \times \frac{l}{4}$$

$$= \frac{wl^2}{4} - \frac{wl^2}{8}$$

$$= \boxed{\frac{wl^2}{8}} \text{ (sagging)}$$

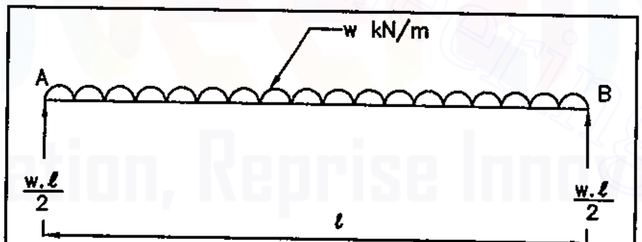

FIG. 5.5

(4) Cantilever beam with point load at free end :

Maxi. B.M. will occur at fixed end A.

$$\therefore \; \boxed{M = W.\ L.} \text{ (hogging)}$$

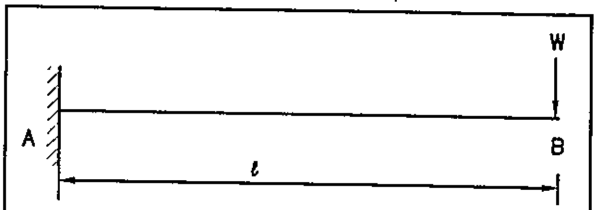

FIG. 5.6

(5) Cantilever beam with U.D.L. on entire span :

Maxi. B.M. will occur at fixed end A.

$$M = w.\ l.\ \frac{l}{2}$$

$$= \frac{wl^2}{2} \quad \text{(hogging)}$$

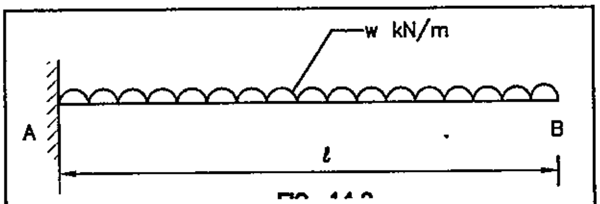

FIG. 5.7

5.6 EQUATION OF SHEAR STRESS :

$$\tau = \frac{FA\bar{y}}{I.b}$$

where,

t = shear stress at a layer

F = Shear force

A = Area of the section above the layer where shear stress is required.

$\bar{y}$ = distance of c.g. of the area above layer from N.A.

I = M.I. about x-x axis

b = width of the layer on which shear stress is required.

5.7 SHEAR STRESS DISTRIBUTION DIAGRAMS :

(a) Rectangular Section :

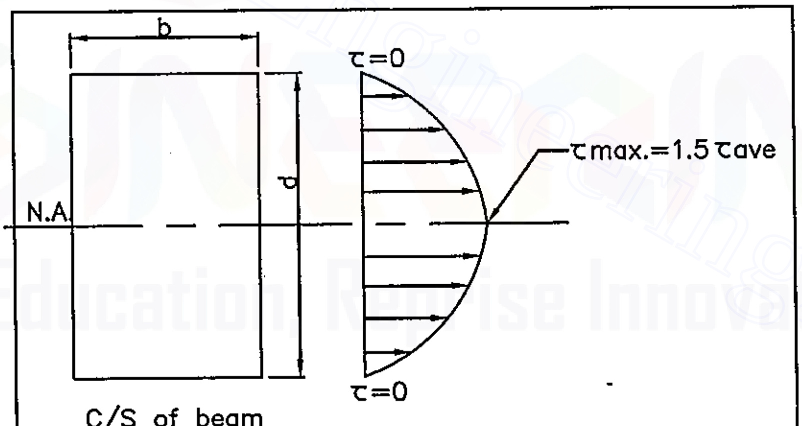

FIG. 5.8

(b) Circular Section :

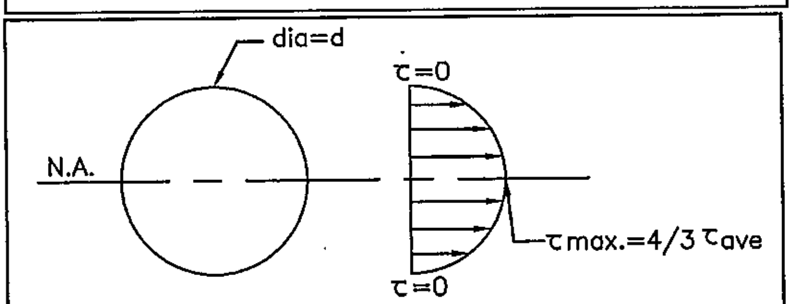

FIG. 5.9

6 : Columns and Struts

6.1 STRUT :

A structural member subjected to axial compressive force is called **strut.**

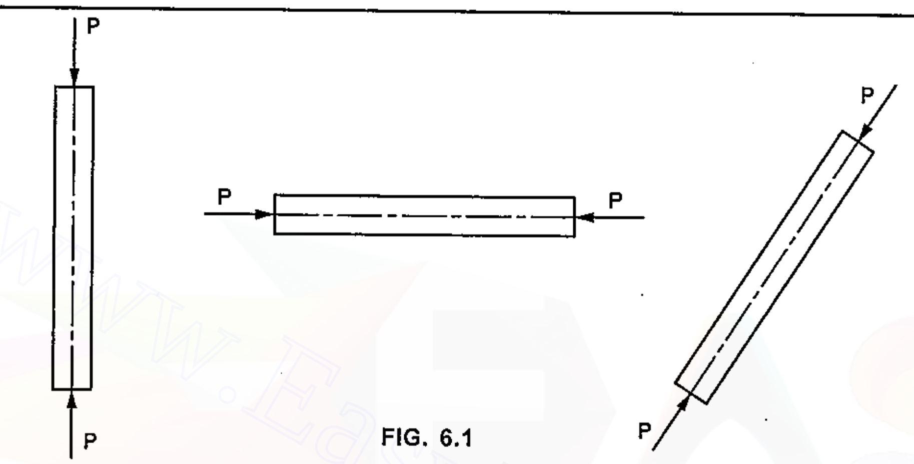

FIG. 6.1

- Strut may be vertical, horizontal or inclined.
- The cross - sectional dimensions of strut are small.
- Normally, struts carry smaller compressive loads.
- Struts are used in roof truss and bridge trusses.

6.2 COLUMN :

- When strut is vertical it is known as column.
- The cross - sectional dimensions of column are large.
- Normally, columns carry heavy compressive loads.
- Columns are used in concrete and steel buildings.

- **Difference between strut and column :**

Strut	Column
• It carry light axial compressive force.	• It carry heavy compressive force.
• It may be vertical, horizontal or inclined.	• It is always vertical.
• The c/s dimensions of strut are small.	• The c/s dimensions of column are large.
• It is used in roof trusses and bridge truss.	• It is used in concrete and steel buildings.

6.3 RADIUS OF GYRATION (k) :

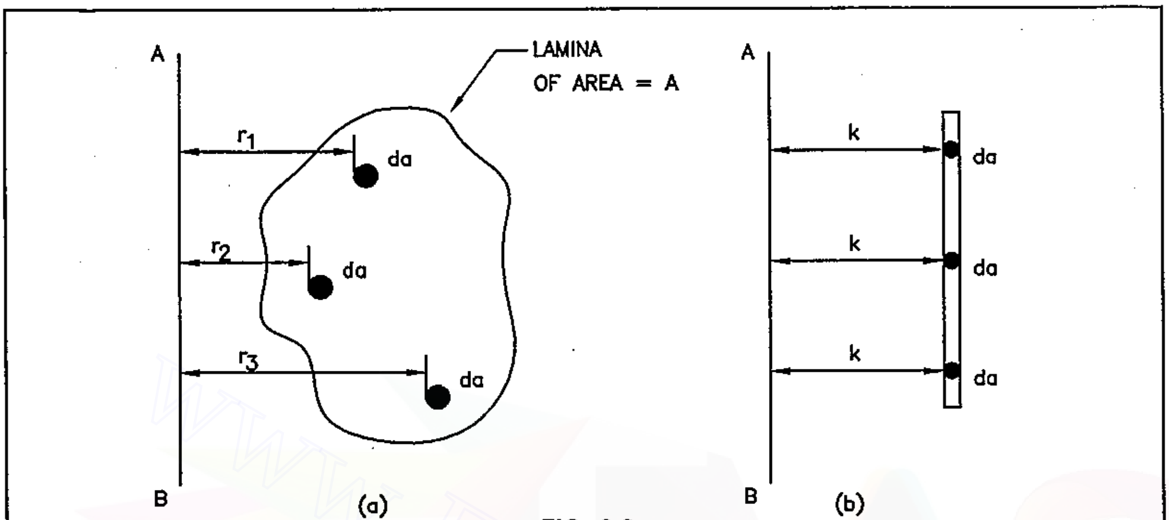

FIG. 6.2

The distance from the given axis at which, if all the small elements of the lamina are placed, the M.I. of the lamina about the given axis does not changes. This distance is called **Radius of gyration.**

Mathematically,

$$k = \sqrt{\frac{I}{A}}$$

where,

k = radius of gyration

I = Moment of inertia

A = c/s area

6.4 SLENDERNESS RATIO : (λ) :

$$\text{Slenderness ratio} = \frac{\text{effective length of Column}}{\text{Minimum radius of gyration}}$$

$$\therefore \quad \lambda = \frac{l_e}{k_{min}}$$

⇨ If λ for column is more, its load carrying capacity will be less.

⇨ If λ for column is less, its load carrying capacity will be more.

6.5 LONG COLUMN :

When length of column is more as compared to its cross - sectional dimension, it is called long column.

For long columns,

$$\frac{l_e}{d} \geq 12$$

OR

$$\lambda = \frac{l_e}{k_{min}} \geq 50$$

where,

l_e = effective length of column

d = least lateral dimension of column.

k_{min} = minimum radius of gyration.

For mild steel if $\lambda \geq 80$, it is called **long column.**

6.6 SHORT COLUMN : When length of column is less as compared to its cross - sectional dimension, it is called **short column.** For **short columns,**

$$\frac{l_e}{d} < 12$$

OR

$$\lambda = \frac{l_e}{k_{min}} < 50$$

where,

le = effective length of column

d = least lateral dimension of column.

k_{min} = minimum radius of gyration.

6.7 CRUSHING LOAD :

In case of short columns, with increase in axial compressive load, compressive stress increases. After some load, the column fails by crushing.

The load at which, short column fails by crushing is called **crushing load.**

The stress corresponding to crushing load is called **crushing stress.**

6.8 CRIPPLING LOAD OR BUCKLING LOAD OR CRITICAL LOAD :

In case of long columns, with increase in axial compressive load, compressive stress increases. After some load, the column starts buckling (bending) and bending stress also produces. Finally, the column fails by buckling.

The load at which, long column starts buckling is called **buckling load or crippling load.**

- **Buckling load is always less than crushing load.**
- Buckling of column depends upon the following factors.
  1. Amount of load
  2. Length of column
  3. End conditions of column
  4. Cross - sectional dimensions of column
  5. Material of column.

6.9 COLUMN END CONDITIONS AND EFFECTIVE LENGTH :

We may consider the following four end conditions.

1. Both ends hinged.
2. Both ends fixed
3. One end fixed and other hinged.
4. One end fixed and other free.

(i) Both ends hinged :

$l_e = l$ where

l_e = effective length of column

l = actual length of column

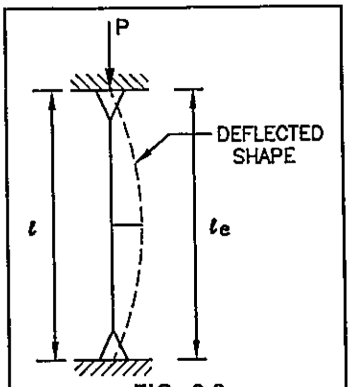

FIG. 6.3

(ii) Both ends fixed :

$$l_e = \frac{l}{2}$$

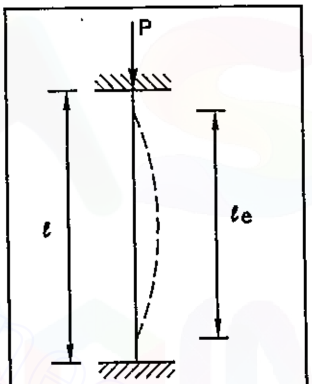

FIG. 6.4

(iii) One end fixed and other hinged :

$$l_e = \frac{l}{\sqrt{2}}$$

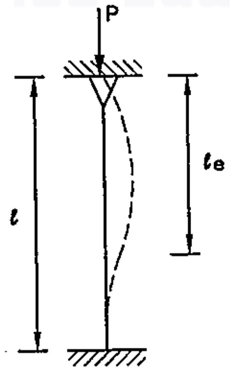

FIG. 6.5

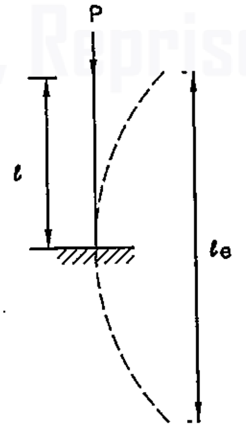

FIG. 6.6

(iv) One end fixed and other free :

$$l_e = 2l$$

6.10 EULER'S FORMULA FOR CRIPPLING LOAD :

$$P_E = \frac{\pi^2 E I}{(l_e)^2}$$

where,

P_E = Euler's crippling load
E = Modulus of elasticity
I = M.I. (Minimum)
l_e = Effective length of column

6.11 ASSUMPTIONS OF EULER'S FORMULA :

1. The material of column is elastic, homogeneous and isotropic.
2. The column is long.
3. The load on column is truely axial.
4. Failure of column is due to buckling.
5. The cross section of column is uniform throughout its length.
6. The Hooke's law is valid.
7. The column is straight before application of load.
8. The shortening of column due to axial compressive load is neglected.

- **Limitation of Euler's formula :**

For mild steel,

If $\lambda \leq 80$ .... short column

If $\lambda > 80$ ...... long column

Euler's formula is valid for long columns only.

- **Rankine Formula :**

$$P_R = \frac{P_c . P_E}{P_c + P_E}$$

where,

P_c = crushing load (for short column)
P_E = Euler's crippling load (for long column)
P_R = Ranking crippling load

$$P_R = \frac{f_c . A}{1 + \alpha \left(\frac{le}{k}\right)^2}$$

where,

le = effective length of column
k = minimum radius of gyration

$\alpha = \dfrac{1}{7500}$ for mild steel

7 : Principal Planes and Principal stresses

7.1 PRINCIPAL PLANE :

The plane on which only direct stress (normal stress) is acting is called principal plane.

σ = direct stress

P.P. = Principal plane

The magnitude of shear stress (τ) on principal plane is zero.

The principal plane may be horizontal, vertical or inclined.

The following planes are principal planes. Fig. 7.1

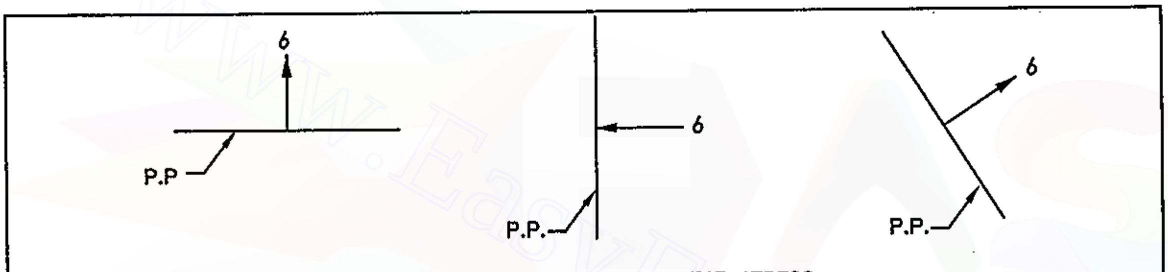

FIG. 7.1

The following planes are not principal planes. Fig. 7.2

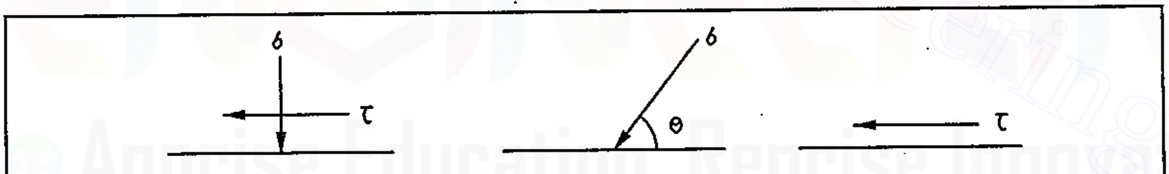

FIG. 7.2

7.2 PRINCIPAL STRESS :

The magnitude of direct stress across a principal plane is known as principal stress.

Principal planes

↓

Major principal plane	Minor principal plane	Intermediate Principal plane
–It carries maximum direct stress	It carries minimum direct Stress.	

7.3 DIFFERENT CASES OF STRESSES IN MATERIALS :

Case – 1 : Only one direct stress (σ_1) is acting :

σ_1 = major direct stress

θ = angle of inclined plane EF with vertical plane.

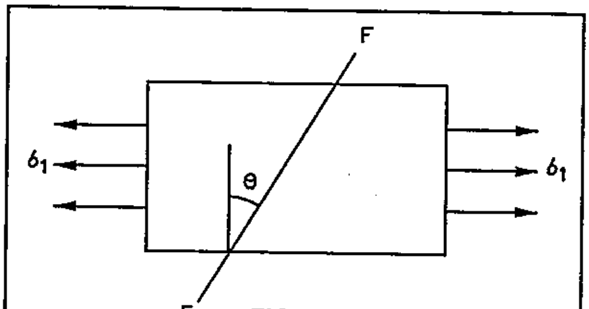

FIG. 7.3

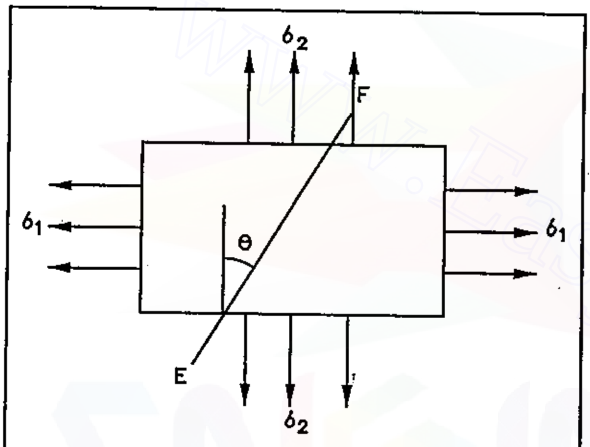

FIG. 7.4

Case – 2 : Two direct stress (σ_1 and σ_2) acting :

σ_1 = major direct stress

σ_2 = minor direct stress

Case – 3 : One direct stress (σ_1) and shear stress (τ) are acting :

σ_1 = major direct stress

τ = shear stress

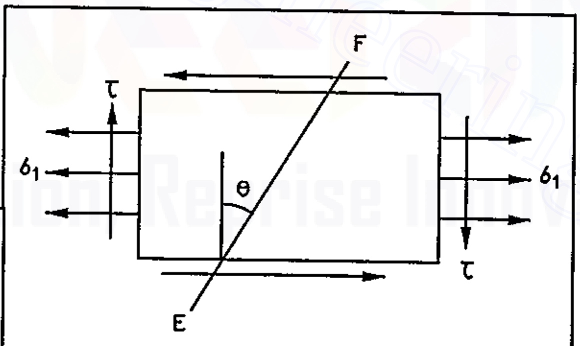

FIG. 7.5

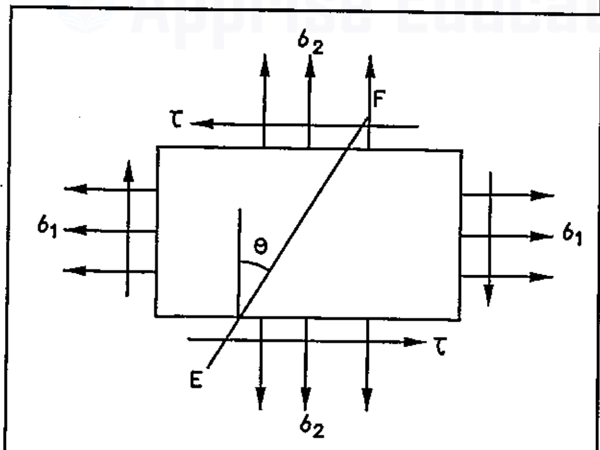

FIG. 7.6

Case – 4 : Two direct stresses and shear stress are acting :

σ_1 = major direct stress

σ_2 = minor direct stress

τ = shear stress

In the above four cases the nature of σ_1 and σ_2 may be tensile or compressive.

7.4 EQUATIONS OF σ_n, σ_t, σ_r :

$$\sigma_n = \frac{(\sigma_1+\sigma_2)}{2} + \frac{(\sigma_1-\sigma_2)}{2} \cdot \cos 2\theta + \tau \sin 2\theta$$

$$\sigma_t = \frac{(\sigma_1-\sigma_2)}{2} \sin 2\theta - \tau \cos 2\theta$$

$$\sigma_r = \sqrt{\sigma_n^2+\sigma_t^2}$$

where,

σ_n = Normal stress on EF plane

σ_t = Tangential stress on EF plane

σ_r = Resultant stress on EF plane

σ_1 = major direct stress (bigger)

σ_2 = Minor direct stress (Smaller)

τ = shear stress

θ = angle of inclined plane EF with vertical plane.

- The above equations of σ_n, σ_t, σ_r can be applied to any of the four cases.
- To use the equations of σ_n, σ_t, σ_r

For case – 1, $\sigma_2 = 0$,
- $\tau = 0$

For case – 2, $\tau = 0$

For case – 3, $\sigma_2 = 0$

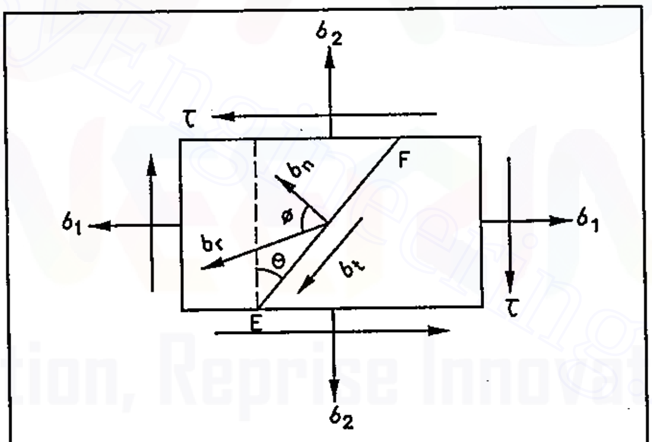

FIG. 7.7

7.5 SIGN CONVENTIONS :

- Take σ_1 as always positive (whether tensile or compressive).

If the nature of σ_2 is similar to σ_1, take σ_2 as positive.

If the nature of σ_2 is opposite to σ_1, take σ_2 as negative.

For example,

If, σ_1 is tensile σ_2 is tensile then take, σ_1 = + ve σ_2 = + ve	If, σ_1 is tensile σ_2 is compressive then take, σ_1 = + ve σ_2 = – ve

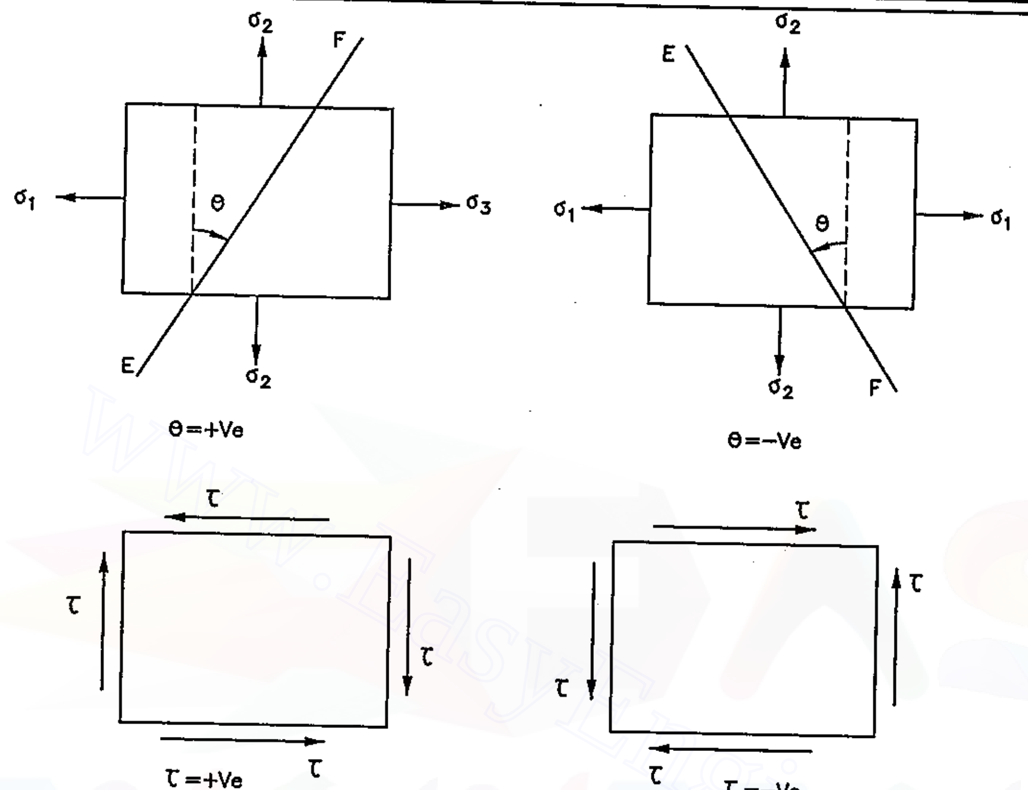

FIG. 7.8

- Angle (θ) of inclined plane EF with vertical measured clockwise is taken positive.
  θ clockwise = +ve
  θ Anticlockwise = –ve
- Clockwise shear stress (τ) on vertical plane is taken +ve.
- Anticlockwise shear stress (τ) on vertical plane is taken –ve.

For Graphical method (Mohr circle Method) :

- Draw σ_1, always on right side of O.
- If nature of σ_2 is similar to σ_1, then draw σ_2 also on right side of O.
- If nature of σ_2 is opposite to σ_1, then draw σ_2 on left side of O.
- If τ = + ve draw below OX line
  If τ = – ve draw above OX line.
- If θ = + ve, measure 2θ above OX line
  If θ = –ve, measure 2θ below OX line
- If shear stress (τ) is acting, CA' line represents vertical plane.
  If θ = + ve, measure 2θ above CA' line

If $\theta = -$ ve, measure 2θ below CA' line.

- If σ_t is above OX line, it is + ve

If σ_t is below OX line, it is – ve

7.6 PRINCIPAL PLANES AND PRINCIPAL STRESSES :

$$\sigma_{n1} = \frac{\sigma_1 + \sigma_2}{2} + \sqrt{\left(\frac{\sigma_1 - \sigma_2}{2}\right)^2 + \tau^2}$$

$$\sigma_{n2} = \frac{\sigma_1 + \sigma_2}{2} - \sqrt{\left(\frac{\sigma_1 - \sigma_2}{2}\right)^2 + \tau^2}$$

$$\sigma_{tmax} = \frac{\sigma_{n1} - \sigma_{n2}}{2}$$

$$\tan 2\alpha_1 = \frac{2\tau}{\sigma_1 - \sigma_2}$$

$$\alpha_2 = \alpha_1 + 90°$$

where,

σn_1 = Major principal stress

σn_2 = Minor principal stress

σ_{tmax} = Maxi. shear stress (Maxi. tangential stress)

α_1 = Angle of major P.P. with vertical plane

α_2 = Angle of minor P.P. with vertical plane.

- **Angle of obliquity (ϕ) :** The angle made by resultant stress with normal stress is called angle of obliquity.

$$\tan\phi = \frac{\sigma_t}{\sigma_n}$$

❖❖❖

8 : Combined Direct and Bending Stress

8.1 AXIAL LOAD AND ECCENTRIC LOAD :

(1) **Axial load :** If load is acting on the longitudinal axis of column, it is called axial load.

For axial load e = 0

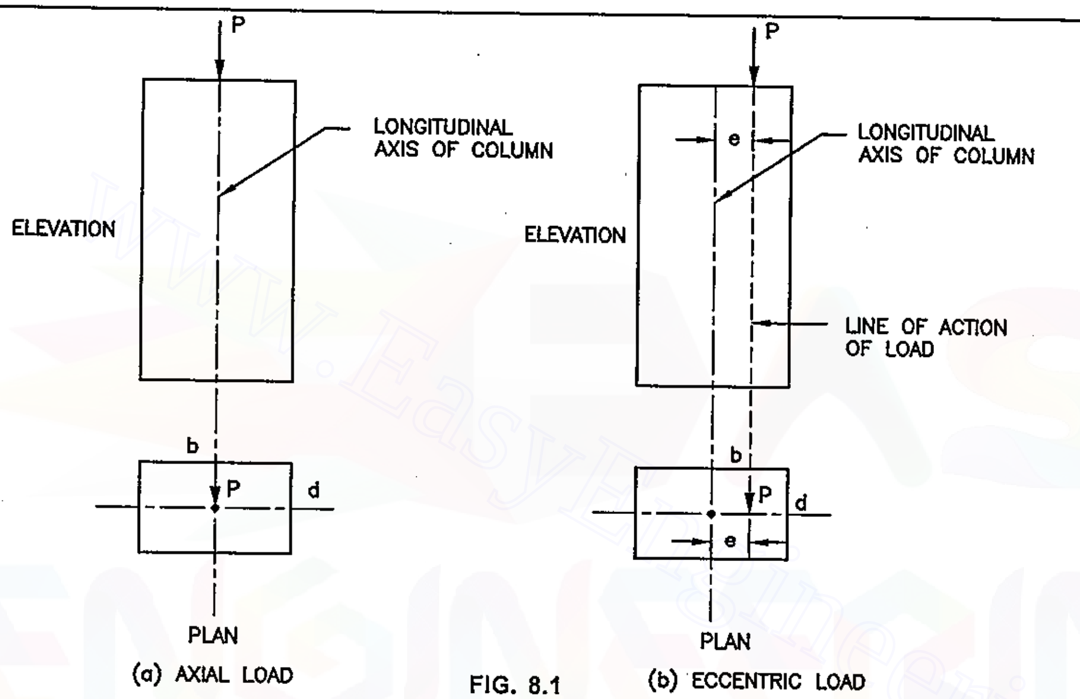

FIG. 8.1

(2) **Eccentric load :**

If load is acting away from the longitudinal axis of column, it is called eccentric load.

(3) **Eccentricity (e) :**

The horizontal distance between the longitudinal axis of column and the line of action of load is called eccentricity.

e = eccentricity.

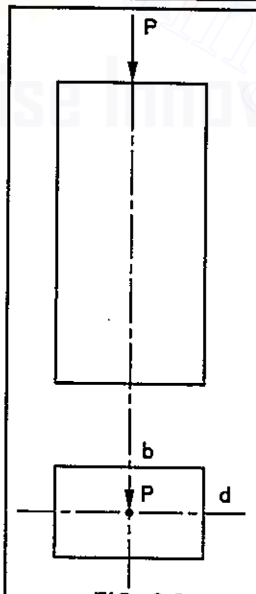

FIG. 8.2

8.2 STRESS DUE TO ECCENTRIC LOAD :

P = axial load

Axial load produces only direct stress

$\sigma_o = \frac{P}{A}$ where, σ_o= direct stress

But, eccentric load produces both direct stress (σ_o) and bending stress (σ_b).

Let us consider the following figure.

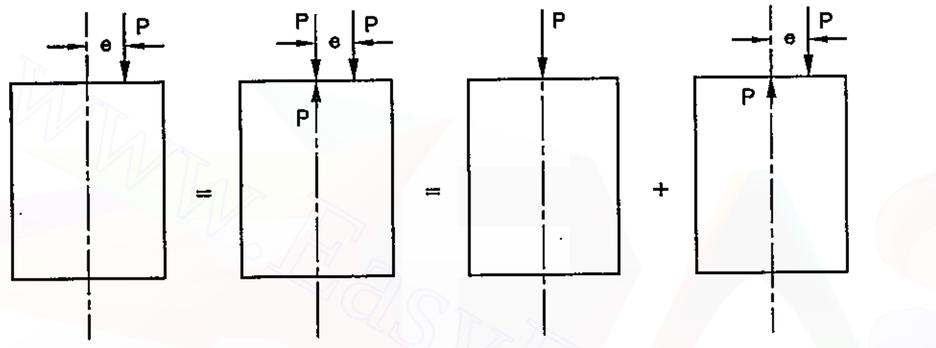

FIG. 8.3

Eccentric load ⟶ **Axial load** + **couple**

It produces direct stress (σ_o) | It produces bending stress (σ_b)

Thus, eccentric load produces both direct stress (σ_o) and bending stress (σ_b).

- **Maximum and minimum stresses in column :**

Maximum stress (σ_{max})

σ_{max} = direct Stress + bending stress

$= \sigma_o + \sigma_b$

$= \frac{P}{A} + \frac{M}{Z}$

$= \frac{P}{A} + \frac{M}{I}.y$

Minimum stress (σ_{min})

σ_{min} = direct stress − bending stress

$= \sigma_o - \sigma_b$

$= \frac{P}{A} - \frac{M}{Z}$

$= \frac{P}{A} - \frac{M}{I}.y$

where,

σ_o = direct stress

σ_b = bending stress

M = Moment = P.e.

e = eccentricity

Z = Section modulus = $\frac{I}{y}$

I = M. I.

y = distance of extreme fibre from c.g.

Sign conventions :

Compressive stress = + ve

Tensile stress = – ve

σ_{max} is always compressive (+)

If $\sigma_o > \sigma_b$, σ_{min} is compressive (+)

If $\sigma_o < \sigma_b$, σ_{min} is tensile (–)

8.3 STRESS DISTRIBUTION IN COLUMN :

For a column, Let's understand how stresses at two edges of column changes as the load moves away from the centre.

(a) When load is axial (e = 0), stresses at both the edges of column will be same and compressive in nature.

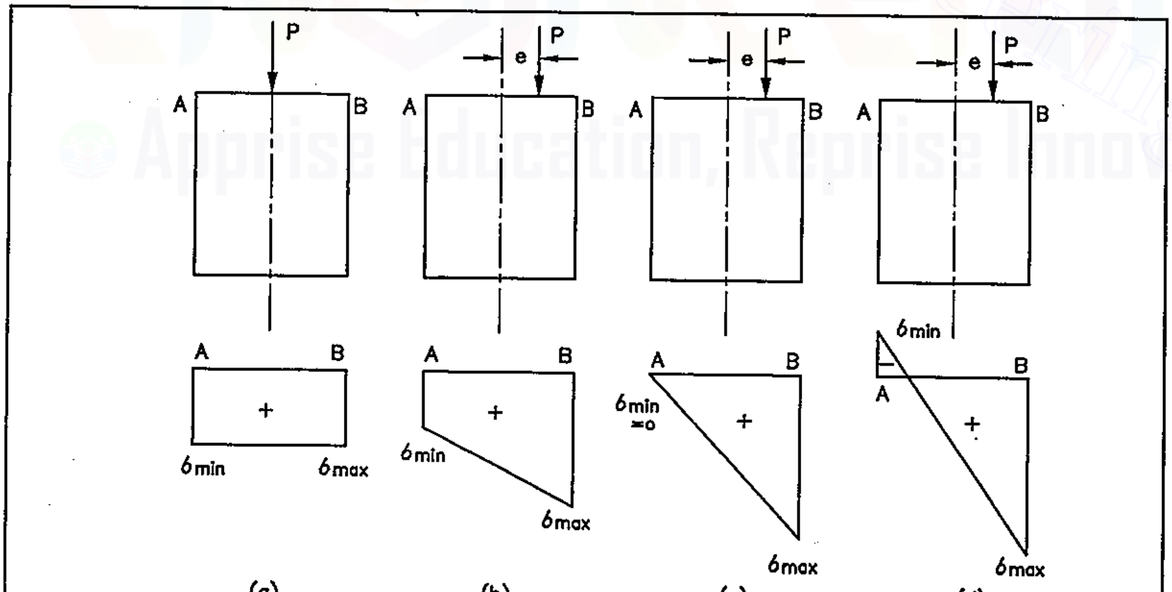

FIG. 8.4

(b) As the load moves away from the centre, compressive stress at B increases and compressive stress at A decreases.

(c) As the load moves away from the centre, σ_{min} gradually decreases and becomes zero. The eccentricity of load when $\sigma_{min} = 0$ is called limit of eccentricity.

(d) If load goes beyond limit of eccentricity, the value of σ_{min} becomes negative i.e. stress at A becomes tensile.

8.4 LIMIT OF ECCENTRICITY :

The maximum distance of load from the centre of column, up to which there is no tensile stress in column, is known as limit of eccentricity.

When load is at limit of eccentricity,

$\sigma_{min} = 0$ or $\sigma_o = \sigma_b$

- **No tension condition :**

Column is a compression member. There should not be tension in the column. If tensile stress produced in the column, it indicates failure of the column.

Hence, for **"no tension"** in column,

- Load must act within limit of eccentricity.
- The value of σ_{min} should not be negative.
- $\sigma_o \geq \sigma_b$

$$\therefore \frac{P}{A} \geq \frac{M}{Z}$$

$$\therefore \frac{P}{A} \geq \frac{P.e}{Z}$$

$$\therefore \frac{Z}{A} \geq e$$

$$\therefore \boxed{e \leq \frac{Z}{A}} \text{ ... No tension condition.}$$

8.5 CORE OF SECTION OR KERNAL :

Core of section : The central part of column joining the points of elimit, is known as core of section or kernal.

If load act within the area of core, there is no tension in the column.

(1) Rectangular section :

$$e \leq \frac{Z}{A}$$

$$Z_{xx} = \frac{I_{xx}}{y} = \frac{\frac{bd^3}{12}}{\frac{d}{2}} = \frac{bd^2}{6}$$

$$A = b.d$$

$$\therefore \quad e \le \frac{Z}{A}$$

$$e \le \frac{\frac{bd^2}{6}}{bd}$$

$$\therefore \quad \boxed{e \le \frac{d}{6}}$$

Similarly $\therefore \quad \boxed{e \le \frac{b}{6}}$

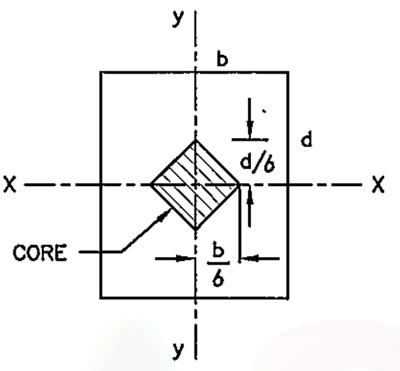

FIG. 8.5

(2) Hollow rectangular Section :

$$e \le \frac{Z}{A}$$

$$Z_{xx} = \frac{I_{xx}}{y}$$

$$= \frac{\frac{BD^3 - bd^3}{12}}{\frac{D}{2}}$$

$$= \frac{BD^3 - bd^3}{6D}$$

$$A = BD - bd$$

$$\therefore \quad e \le \frac{Z}{A}$$

$$\le \frac{\frac{BD^3 - bd^3}{6D}}{BD - bd}$$

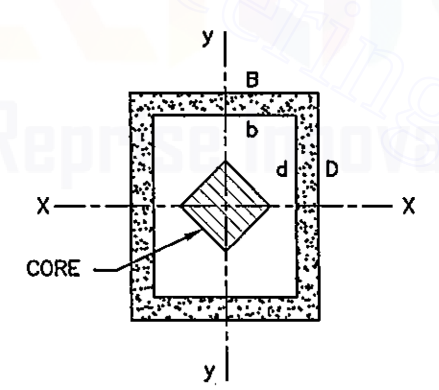

FIG. 8.6

$$e \le \frac{(BD^3 - bd^3)}{6D(BD - bd)} \qquad e = \frac{(DB^3 - db^3)}{6B(BD - bd)}$$

(3) circular Section :

$$e \leq \frac{Z}{A}$$

$$Z_{xx} = \frac{I_{xx}}{y}$$

$$= \frac{\frac{\pi}{64} \times d^4}{\frac{d}{2}} = \frac{\pi}{32} \cdot d^3$$

$$A = \frac{\pi}{4} d^2$$

$$e \leq \frac{Z}{A}$$

$$\leq \frac{\frac{\pi}{32} d^3}{\frac{\pi}{4} d^2} \leq \frac{d}{8}$$

$$\therefore \quad e \leq \frac{d}{8}$$

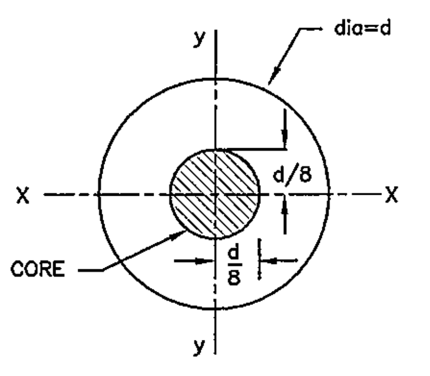

FIG. 8.7

(4) Hollow circular Section :

$$e \leq \frac{Z}{A}$$

$$Z_{xx} = \frac{I_{xx}}{y}$$

$$= \frac{\frac{\pi}{64}\left(D^4 - d^4\right)}{\frac{D}{2}}$$

$$= \frac{\pi}{32} \frac{(D^4 - d^4)}{D}$$

$$A = \frac{\pi}{4} (D^2 - d^2)$$

$$\therefore \quad e \leq \frac{Z}{A} \leq \frac{\frac{\pi}{32} \frac{\left(D^4 - d^4\right)}{D}}{\frac{\pi}{4}\left(D^2 - d^2\right)} = \frac{1}{8D} \frac{\left(D^2 + d^2\right)\left(D^2 - d^2\right)}{\left(D^2 - d^2\right)}$$

$$e \leq \frac{\left(D^2 + d^2\right)}{8D}$$

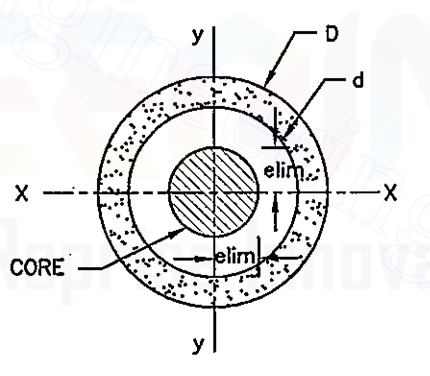

FIG. 8.8

8.6 MAXIMUM AND MINIMUM PRESSURE AT THE BASE OF DAM :

The figure shows a trapezoidal dam section.

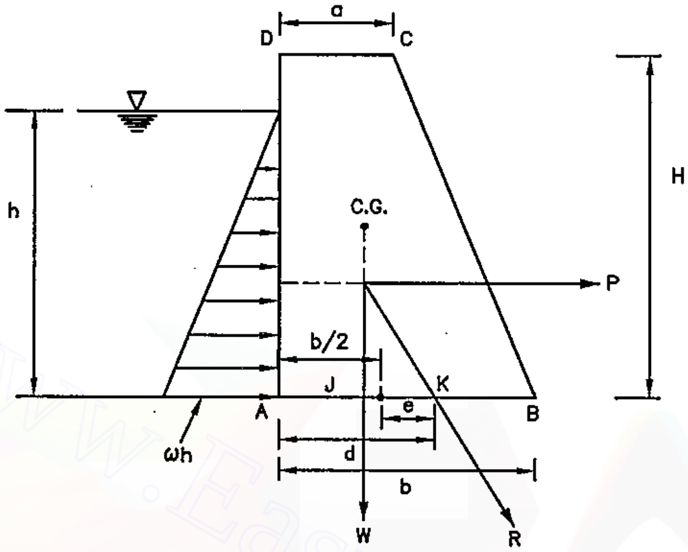

FIG. 8.9

where,

a = top width of dam

b = Bottom width of dam

H = Total height of dam

h = height of water

P = Total water pressure acting on dam

W = Total weight of dam

R = Resultant of P and W

(1) Weight of Dam : (For 1 m length)

Weight = cross sectional area of dam × density of dam material

$$\therefore \quad \boxed{W = (a + b) \times \frac{H}{2} \times \rho}$$

where, ρ = density of dam material in kN/m^3

(2) Total water pressure on dam : (For 1 m length)

Total water pressure = Area of water pressure diagram

$$\therefore \quad P = \frac{1}{2} \times wh \times h$$

$$\therefore \quad P = \frac{wh^2}{2}$$

where, w = density of water
= 1000 kg/m^3
= 10 kN/m^3

(3) Eccentricity (*e*) :

Total water pressure (P) acts horizontally at height $\frac{h}{3}$ from the base of dam.
Total weight of dam (W) acts vertically downwards.
R is the resultant of P and W.

$$R = \sqrt{P^2 + W^2}$$

Resultant (R) cut the base at point K.

$$\text{distance } JK = x = \frac{P}{W} \times \frac{h}{3}$$

$$\text{distance } AJ = \frac{a^2 + ab + b^2}{3\,(a + b)}$$

$$\therefore \quad d = AJ + JK$$

$$\therefore \quad \text{eccentricity} = \boxed{e = d - \frac{b}{2}}$$

(4) Maximum and Minimum Pressure :

Maximum Pressure,

$$\sigma_{max} = \frac{W}{b}\left(1 + \frac{6e}{b}\right)$$

Minimum Pressure,

$$\sigma_{min} = \frac{W}{b}\left(1 - \frac{6e}{b}\right)$$

- **Stability conditions for Dam :**

(i) No tension at base :

$$e \le \frac{b}{6}$$

(ii) No overturning :

Resultant R must cut within base AB.

(iii) No Sliding :

Resisting force > sliding force

$$\mu W > P$$

(iv) No Crushing :

$\sigma_{max} < \sigma_c$

σ_{max} = maximum stress produced at base

σ_c = Permissible crushing stress of dam material.

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9 : Thin Cylindrical Shells

- If $t \leq \frac{d}{10}$ .... thin cylindrical shell

  If $t > \frac{d}{10}$ .... thick cylindrical shell

9.1 FOR THIN CYLINDRICAL SHELL :

(i) Hoop Stress or circumferential stress :

$$\sigma_c = \frac{pd}{2t}$$

p = internal pressure

d = internal dia.

t = wall thickness

(ii) Longitudinal stress :

$$\sigma_l = \frac{pd}{4t}$$

for riveted joints,

$$\sigma_c = \frac{pd}{2t\eta}, \quad \sigma_l = \frac{pd}{4t\eta}$$

η = efficiency of joint

(iii) Circumferential strain :

$$\varepsilon_1 = \frac{\sigma_c}{E} - \frac{\sigma_l}{mE} = \frac{pd}{2tE}\left(1 - \frac{1}{2m}\right)$$

(iv) Longitudinal strain :

$$\varepsilon_2 = \frac{\sigma_l}{E} - \frac{\sigma_c}{mE} = \frac{pd}{2tE}\left(\frac{1}{2} - \frac{1}{m}\right)$$

$\therefore$ Change in dia. $\delta d = \varepsilon_1 \cdot d$

$\therefore$ Change in length $\delta l = \varepsilon_2 \cdot l$

(v) Change in volume :

$\delta v = v\,(\varepsilon_2 + 2\varepsilon_1)$

(vi) Maximum shear stress :

$$\tau_{max} = \frac{\sigma_c - \sigma_l}{2} = \frac{pd}{8t}$$

9.2 THIN SPHERICAL SHELL :

stress, $\sigma = \frac{pd}{4t}$

$$\varepsilon = \frac{\delta d}{d} = \frac{pd}{4tE}\left(1 - \frac{1}{m}\right)$$

change in volume,

$$\delta v = \frac{\pi . p.d^4}{8tE}\left(1 - \frac{1}{m}\right)$$

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10 : Torsion and Springs

10.1 TERMS RELATED TO TORSION :

1. Torsion :

In factories and workshops, shaft is used to transmit energy from one end to the other end.

When turning force (P) is applied on the pulley mounted on the shaft deformation is produced in the shaft. This deformation is called **'torsion'.**

2. Torque or turning moment or twisting moment (T) :

To transmit the energy by shaft, turning force (P) is applied on the shaft. Due to this turning force, moment is produced in the shaft. This moment is known as **'torque'.**

Turning moment = P × 2R

∴ T = P × 2R

Torque is denoted by T.

Unit of torque is N.m or kN.m.

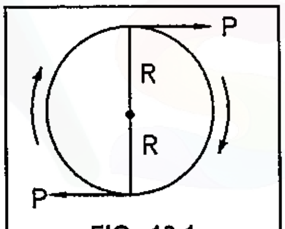

FIG. 10.1

3. Shear strain in shaft (ϕ) :

When shaft is subjected to torque (T), line CA on the surface of the shaft comes to new position CA'. The angular deformation ϕ is known as **shear strain in shaft.**

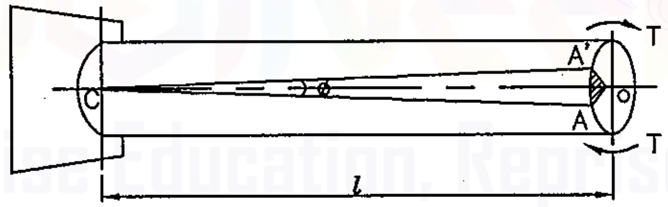

FIG. 10.2

4. Angle of twist (θ) :

When shaft is subjected to torque (T), point A on the surface of the shaft comes to new position A'. The angle AOA' at the centre of the shaft is known as **angle of twist.**

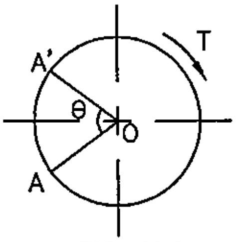

FIG. 10.3

5. Shear stress in shaft (τ) :

When shaft is subjected to torque (T), a stress resisting the torque is produced in the material of the shaft. This stress is known as **shear stress in shaft.**

Shear stress = shear strain × modulus of rigidity

$\tau = \phi \times C$

6. Polar moment of inertia (J) :

The moment of inertia of a plane area, with respect to an axis perpendicular to the plane of the lamina is called **polar moment of inertia.**

For circular shaft :

Polar M.I. $= I_{zz} = I_{xx} + I_{yy}$

$$= \frac{\pi}{64} \times D^4 + \frac{\pi}{64} \times D^4$$

$$\boxed{J = \frac{\pi}{32} \times D^4}$$

unit of J is mm^4

7. Polar section modulus (Z_p) :

$$\text{Polar section modulus} = \frac{\text{Polar M.I.}}{\text{Radius of shaft}}$$

$$\therefore \boxed{Z_p = \frac{J}{R}}$$

unit of Z_p is mm^3

8. Torsional rigidity :

Torsional rigidity = Modulus of rigidity × polar M.I.

$= C \times J$

unit is $N.mm^2$

10.2 EQUATION OF TORSION :

$$\frac{T}{J} = \frac{C.\theta}{l} = \frac{\tau}{R}$$

where, T = Torque (N.mm)

J = Polar M.I. (mm^4)

C = Modulus of rigidity (N/mm^2)

θ = angle of twist (radians)

τ = shear stress in shaft (N/mm^2)

R = radius of shaft (mm)

10.3 ASSUMPTIONS IN THE THEORY OF TORSION :

1. The material of shaft is uniform throughout the length.
2. The twist along the shaft is uniform.
3. The cross section of shaft is uniform throughout the length.
4. The cross sections of the shaft, which are plane before twist, remain plane after twist.
5. All radii which are straight before twist remain straight after twist.

10.4 IMPORTANT EQUATIONS :

Solid circular shaft

(i) Torque (T) :

$$T = \frac{\pi}{16} \times \tau \times D^3$$

(ii) Polar M.I. (J) :

$$J = \frac{\pi}{32} \times D^4$$

(iii) Polar section Modulus (Z_P)

$$Z_P = \frac{\pi}{16} \times D^3$$

Hollow circular shaft

$$T = \frac{\pi}{16} \times \tau \times \left(\frac{D^4 - d^4}{D}\right)$$

$$J = \frac{\pi}{32} \times (D^4 - d^4)$$

$$Z_p = \frac{\pi}{16} \times \frac{(D^4 - d^4)}{D}$$

10.5 EQUATIONS OF POWER :

(a) Power in horse power (h.P.) :

$$\boxed{P = \frac{2\pi NT}{4500} \text{ h.p.}}$$

where, P = Power in h.p.

N = R.P.M.

T = Torque (kg.m)

(b) Power in watt :

$$\boxed{P = \frac{2\pi NT}{60} \text{ watt}}$$

where, T = Torque (N.m)

1 kW = 1000 watt

1 H.P. = 746 watt = 0.746 kW

10.6 SHAFT SUBJECTED TO COMBINED BENDING AND TORSION :

When a shaft is subjected to twisting moment (T) and bending moment (M),

(i) **bending stress produced in shaft :**

$$\sigma = \frac{M}{I} \times y = \frac{M}{\frac{\pi}{64} \times D^4} \times \frac{D}{2} = \frac{32\,M}{\pi\,D^3}$$

(ii) **Shear stress produced in shaft**

$$\tau = \frac{T}{J} \times R = \frac{T}{\frac{\pi}{32} \times D^4} \times \frac{D}{2} = \frac{16T}{\pi D^3}$$

$$\therefore \quad \frac{\sigma}{\tau} = 2$$

$$\frac{\text{Major Principal stress}}{\text{(Maxi. normal stress)}} \qquad \sigma_{n_1} = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$= \frac{16}{\pi D^3}\left[M + \sqrt{M^2 + T^2}\right]$$

Minor principal stress (Mini. normal stress)

$$\sigma_{n_2} = \frac{\sigma}{2} - \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$= \frac{16}{\pi D^3}\left[M - \sqrt{M^2 + T^2}\right]$$

$$\tau_{max} = \frac{\sigma_{n_1} - \sigma_{n_2}}{2} = \frac{16}{\pi D^3}\left[\sqrt{M^2 + T^2}\right]$$

where,

equivalent bending moment (Me)

$$Me = \frac{1}{2}\left(M + \sqrt{M^2 + T^2}\right)$$

equivalent twisting moment (Te)

$$Te = \sqrt{M^2 + T^2}$$

10.7 CLOSED-COIL HELICAL SPRING :

$$W.\ R = \frac{\pi}{16} \times \tau \times d^3$$

d = dia. of spring wire

R = Radius of spring coil

deflection,

$$\delta = \frac{64\ W\ R^3\ n}{C\ d^4}$$

stiffness of spring,

$$S = \frac{W}{\delta} = \frac{C\ d^4}{64\ R^3 n}$$

10.8 LEAF SPRING OR CARRIAGE SPRING :

Maximum bending stress,

$$\sigma = \frac{3Wl}{2nbt^2}$$

deflection,

$$\delta = \frac{3Wl^3}{8Enbt^3}$$

where,

w = load on the spring

l = span of spring

t = thickness of plates

b = width of plates

n = number of plates

E = Young's modulus of plate material

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MCQ'S

1. **Modulus of elasticity is the ratio of**
   (a) Stress to strain (b) Strain to stress
   (c) Force to cross sectional area (d) Stress to original length.
2. **The property by virtue of which a body returns to its original shape after removal of the force is called**
   (a) ductility (b) plasticity (c) Elasticity (d) malleability
3. **Beyond elastic limit, tensile strain**
   (a) increases more quickly. (b) decreases more quickly.
   (c) increase in proportion to stress. (d) decrease in proportion to stress.
4. **The phenomenon of slow extension of materials with time under constant load is called**
   (a) yielding (b) Creeping (c) breaking (d) none of these
5. **Every material obeys Hooke's law within its**
   (a) elastic limit. (b) plastic limit.
   (c) limit of proportionality. (d) None of these.
6. **The stress at which extension of a material take place more quickly as compared to the increase in load, is called**
   (a) elastic point (b) Plastic point (c) breaking point (d) yield point
7. **The maximum stress produced in a bar of tapering section is at**
   (a) Larger end (b) Smaller end (c) middle (d) any where
8. **In a composite section, the number of different materials is**
   (a) one only (b) two only (c) two or more (d) all of these
9. **Which is the correct statement for composite section ?**
   (a) It consists of two or more different materials.
   (b) Strain in each material is same.
   (c) Load on each material may be different.
   (d) all of these.
10. **The rerm 'modular ratio' is the ratio of**
    (a) Stress and strain (b) Strain and stress
    (c) Elasticity of two materials. (d) Change in length to original length
11. **The ratio of the elongations of a conical bar under the action of its own weight and that of a prismatic bar of the same length is**
    (a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{1}{6}$ (d) $\frac{1}{8}$

12. For a uniformly tapering circular bar of length l_1, larger diameter d_1, smaller diameter d_2, elongation is equal to

(a) $\frac{Pl}{AE}$ (b) $\frac{Pl}{A_1 A_2 E}$ (c) $\frac{4Pl}{\pi E d_1 d_2}$ (d) $\frac{Pl}{4\pi E d_1 d_2}$

13. A mild steel bar under tension shows property of

(a) Malleability (b) ductility (c) Tensionability

14. The ability of a material to resist deformation is called as

(a) toughness (b) Hardness (c) Strength (d) brittleness

15. The ability of material to deform without breaking is called as

(a) creep (b) plasticity (c) resilience (d) elasticity

16. The modulus of elasticity of mild steel is approximately equal to

(a) 110 GPa (b) 80 GPa (c) 210 GPa (d) 10 GPa

17. 1 MPa = ... N/mm^2

(a) 1 (b) 10 (c) 10^3 (d) 10^6

18. The steel used for cutting tools is

(a) Mild steel (b) Medium carbon steel

(c) High carbon steel (d) None of these

19. Which of the following is a proper sequence ?

(a) Elastic limit, proportional limit, yielding, failure

(b) Proportional limit, elastic limit, yielding, failure

(c) Yielding, proportional limit, elastic limit, failure

(d) None of these

20. If a material has identical elastic properties in all directions, it is said to be (GATE)

(a) homogeneous (b) elastic (c) isotropic (d) Visco elastic

21. The deterioration of the properties of a material when subjected to repeatedly applied stress is termed as

(a) isotropic (b) creep (c) elasticity (d) fatigue

22. In S.I. Units, the unit of stress is

(a) N/mm^2 (b) N/cm^2 (c) kg/cm^2 (d) kg/mm^2

23. The unit of strain is

(a) N–mm (b) N/mm (c) mm (d) no unit

24. Internal resistance offered per unit area by the body against force is called

(a) Stress (b) Strain (c) resistance (d) friction

25. The deformation per unit length is called

(a) Shear stress (b) tensile stress (c) Compressive stress (d) Strain

26. When a bar of length *l*, and cross sectional area A is rigidly fixed at the upper end and hanging freely, then the total elongation of the bar due to its own weight is,

(a) $\frac{wl}{2AE}$ (b) $\frac{wl^2}{2AE}$ (c) $\frac{wl^3}{2AE}$ (d) $\frac{wl^4}{2AE}$

where, w = weight of bar per unit length

27. The modulus of elasticity is expected to have least value for

(a) aluminium (b) copper (c) wood (d) glass

28. The modulus of elasticity is expected to have highest value for (Civil Services)

(a) Steel (b) copper (c) brass (d) aluminium

29. Which of the following materials is more elastic ?

(a) Rubber (b) Steel (c) Wood (d) Plastic

30. Young's modulus of elasticity for a perfectly rigid body is

(a) Zero (b) unity (c) infinity (d) none of these

31. The area under the stress strain curve represents

(a) Breaking strength of material (b) toughness of material

(c) hardness of material (d) energy required to cause failure

32. The unit of elastic modulus is the same as those of (Civil services)

(a) Stress, shear modulus and pressure (b) Strain, shear modulus and force

(c) Shear modulus, stress and force (d) Stress, strain and pressure

33. A block of steel is loaded by a tangential force on its top surface while the bottom surface is held rigidly. The deformation of the block is due to (GATE)

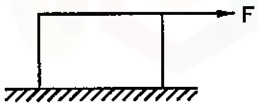


FIG. Q–33

(a) Shear only

(b) bending only

(c) Shear and bending

(d) Torsion

34. The maximum energy stored at elastic limit of a material is called (IES)

(a) resilience (b) Proof resilience

(c) Modulus of resilience (d) bulk resilience

35. During tensile testing of a specimen using a universal testing machine, the parameters actually measured include (IES)

(a) true stress and true strain

(b) Poisson's ratio and Young's modulus

(c) engineering stress and engineering strain

(d) load and elongation

36. The stress at which a material fractures under large number of reversals of stress is called (IES)

(a) endurance limit (b) creep (c) ultimate strength (d) residual stress

37. **Ductile fracture is defined as one for which the plastic deformation before fracture (IES)**

(a) is smaller than the elastic deformation

(b) vanishes

(c) is equal to the elastic deformation

(d) is much larger than the elastic deformation

38. **A test specimen is stressed slightly beyond the yield point is then unloaded. Its yield strength will (GATE)**

(a) decrease (b) increase

(c) remains same (d) becomes equal to ultimate tensile strength

39. **A copper bar 25 cm length is fixed by means of supports at its ends. Supports can yield (total) by 0.01 cm. If temperature of the bar is raised by 100°C, then stress induced in the bar for $\alpha_c = 2 \times 10^{-6}$/°C and $E_c = 1 \times 10^6$ kg/cm². (IES)**

(a) 2×10^2 kg/cm² (b) 4×10^2 kg/cm²

(c) 8×10^2 kg/cm² (d) 16×10^2 kg/cm²

40. **When a bar fixed at ends is cooled to –10°C, it will develop**

(a) no stress (b) shear stress (c) tensile stress (d) Compressive stress

41. **If the ends of a body yield, the magnitude of thermal stress will**

(a) Increase (b) decrease (c) remain the same (d) none of these

42. **A steel rod having ends free is subjected to rise in temperature. As a result,**

(a) tensile stress will be produced

(b) compressive stress will be produced.

(c) no stress will be produced.

43. **When the temprature of a body having rigid ends is increased, the stress induced will be**

(a) Tensile (b) Compressive (c) both (a) and (b) (d) neither (a) nor (b)

44. **If a composite bar is cooled, then the nature of stress in the part with higher coefficient of thermal expansion will be,**

(a) tensile (b) zero (c) compressive (d) none of these

45. **A composite bar made up of steel and copper is subjected to rise in temperature, $\alpha_s < \alpha_c$. The stress induced in copper will be**

(a) Tensile (b) compressive (c) Zero (d) None of these

46. **A steel rail is 15 m long and is laid at a temperature of 20°C. The maximum temperature in summer expected is 45°C. The minimum gap required between two rails is $\alpha = 12 \times 10^{-6}$/°C.**

(a) 4.5 mm (b) 9.0 mm (c) 2.25 mm (d) no gap required.

47. The maximum thermal stress in a circular tapering section is

(a) directly proportional to the smaller diameter.
(b) directly proportional to the bigger diameter.
(c) inversely proportional to the bigger diameter.
(d) both 'a' and 'c'.

48. For a linearly elastic, isotropic and homogeneous material, the number of elastic constants required to relate stress and strain is **(Civil Services)**

(a) two (b) three (c) four (d) six

49. Which one of the following favours brittle fracture in a ductile material ?

(a) elevated temperature (b) Slow rate of straining
(c) Presence of notch (d) Circular cross–section

50. The value of Poisson's ratio for any material can not exceed **(IES)**

(a) 2.0 (b) 1.414 (c) 1.0 (d) 0.5

51. The value of Poisson's ratio for steel varies from

(a) 0.20 to 0.25 (b) 0.25 to 0.35 (c) 0.35 to 0.40 (d) 0.40 to 0.55

52. Which relation does not hold good ? **(GTU, April 2010)**

(a) $\varepsilon_v = \varepsilon(1 - 2\mu)$ (b) $E = 3K(1 - 2\mu)$
(c) $E = \dfrac{G+3K}{9GK}$ (d) $E = 2G(1 + \mu)$

53. The ratio of lateral strain to the linear strain is called

(a) Modulus of elasticity (b) Bulk modulus
(c) Poisson's ratio (d) Modulus of rigidity

54. Volumetric strain of a rectangular body subjected to an axial force is,

(a) $\varepsilon\left(1-\dfrac{2}{m}\right)$ (b) $\varepsilon\left(1+\dfrac{2}{m}\right)$ (c) $\varepsilon\left(2-\dfrac{1}{m}\right)$ (d) $\varepsilon\left(2+\dfrac{1}{m}\right)$

55. When a body is subjected to three mutually perpendicular stresses of equal intensity, the ratio of direct stress to volumetric strain is known as

(a) Young's modulus (b) Shear modulus
(c) Poisson's ratio (d) Bulk modulus

56. When two equal, opposite and parallel forces acting tangentially to the surface of a body, the stress produced is called

(a) Tensile stress (b) shear stress (c) Compressive stress (d) direct stress.

57. Lateral strains are longitudinal strains.

(a) always less than (b) sometimes less than (c) never less than

58. Poisson's ratio is ratio of ______.

(a) longitudinal to lateral strain. (b) lateral to longitudinal strain.
(c) shear stress to shear strain.

59. Maximum possible value of Poisson's ratio is ______.

(a) 0.5 (b) 0.75 (c) 1.0

60. Which material has the highest Poisson's ratio ?

(a) Wood (b) Rubber (c) Steel (d) Copper

61. Poisson's ratio for most of the materials is close to

(a) 0.5 (b) 0.25 (c) 0.33 (d) 0.20

62. The ratio of Young's modulus of elasticity to modulus of rigidity for a material having Poisson's ratio 0.2 is (Civil Services)

(a) $\frac{12}{5}$ (b) $\frac{5}{12}$ (c) $\frac{5}{14}$ (d) $\frac{14}{5}$

63. The relation between Young's modulus (E), modulus of rigidity (G) and Poisson's ratio $\left(\frac{1}{m}\right)$ is given by (Civil Services) (GATE 2007)

(a) $E = 2G\left(1 - \frac{1}{m}\right)$ (b) $E = 2G(1 + m)$

(c) $E = \frac{1}{2}G(1 + m)$ (d) $E = 2G\left(1 + \frac{1}{m}\right)$

64. The rigidity modulus of a material whose $E = 2 \times 10^6$ kg/cm^2 and Poisson's ratio is 0.25 will be (IES)

(a) 0.8×10^6 kg/cm^2 (b) 0.6×10^6 kg/cm^2

(c) 0.5×10^6 kg/cm^2 (d) 2×10^6 kg/cm^2

65. If a material has modulus of elasticity of 2.1×10^6 kgf/cm^2 and modulus of rigidly of 0.8×10^6 kgf/cm^2 then approximate value of the Poisson's ratio of the material would be (IES)

(a) 0.26 (b) 0.31 (c) 0.47 (d) 0.5

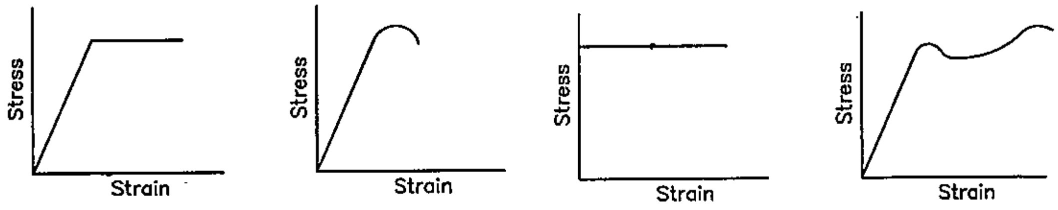
66. A bar 4 cm in diameter is subjected to an axial load of 4t. The extension of the bar over a gauge length of 20 cm is 0.03 cm. The decrease in diameter is 0.0018 cm. The Poisson's ratio is (IES)

(a) 0.25 (b) 0.30 (c) 0.33 (d) 0.35

67. Given that for a element in a body of homogeneous isotropic material subjected to plane stress; ε_x, ε_y and ε_z are normal strains in x, y and z directions respectively and μ is Poisson's ratio, then magnitude of unit volume change of the element is given by (IES)

(a) $\varepsilon_x + \varepsilon_y + \varepsilon_z$ (b) $\varepsilon_x - \mu(\varepsilon_y + \varepsilon_z)$ (c) $\mu(\varepsilon_x + \varepsilon_y + \varepsilon_z)$ (d) $\frac{1}{\varepsilon_x} + \frac{1}{\varepsilon_y} + \frac{1}{\varepsilon_z}$

68. The stress–strain curve for an ideally plastic material is (IES)



(a) (b) (c) (d)

69. When a body is subjected to three mutually perpendicular stresses of equal intensity, the ratio of direct stress to the corresponding volumetric strain is known as

(a) Young's modulus (b) Bulk modulus (c) Shear modulus (d) Poisson's ratio

70. Shear modulus is the ratio of

(a) linear stress to linear strain (b) linear stress to lateral strain

(c) Volumetric strain to linear strain (d) Shear stress to shear strain

71. When shear force at a point is zero, then bending moment at that point will be

(a) Zero (b) Maximum (c) Minimum (d) infinity

72. The rate of change of S.F. w.r.t. distance is equal to

(a) Shear force (b) bending moment

(c) intensity of loading (d) None of these

73. The slope of the curve of B.M. diagram gives

(a) S.F. at the section (b) B.M. at the section

(c) u.d.l. at the section (d) none of these

74. The point of contraflexure is a point where **(GTU April 2010)**

(a) S.F. changes sign (b) B.M. changes sign

(c) S.F. is maximum (d) B.M. is maximum

75. In a B.M. diagram vertical line at a section indicates,

(a) Concentrated load (b) moment

(c) uniformly distributed load (d) uniformly varying load.

76. B.M. at the centre of a simply supported beam carrying a uniformly distributed load is

(a) $\frac{wl}{2}$ (b) $\frac{wl^2}{4}$ (c) $\frac{wl^2}{8}$ (d) $\frac{wl^2}{16}$

77. B.M. at the fixed end of a cantilever beam subjected to u.d.l. throughout span is

(a) wl (b) $\frac{wl^2}{2}$ (c) $\frac{wl^2}{4}$ (d) $\frac{wl^2}{8}$

78. B.M. at the free end of a cantilever beam subjected to any type of load is

(a) Zero (b) minimum (c) maximum (d) equal to load.

79. **Bending moment is _______ at a hinged support.**

(a) always maximum (b) always zero.

80. **The shape of shear force diagram for cantilever beam subjected to couple at free end is _______.**

(a) horizontal straight line (b) zero

(c) parabola (d) inclined straight line

81. **The maximum B.M. of a cantilever beam lies at**

(a) the free end (b) the fixed end

(c) Middle of its length (d) $\frac{1}{4}$ from fixed end

82. **The B.M. diagram for a cantilever beam subjected to bending moment at free end will be**

(a) a triangle (b) a rectangle (c) a parabola (d) a cubic parabola

83. **The B.M. diagram for a cantilever beam carrying uniformly distributed load is**

(a) a triangle (b) a parabola (c) a cubic parabola (d) a rectangle

84. **The number of independent elastic constants for a linear elastic isotropic and homogeneous material is** **(GATE 2010)**

(a) 4 (b) 3 (c) 2 (d) 1

85. **Shear force along the beam will be** **(IES)**

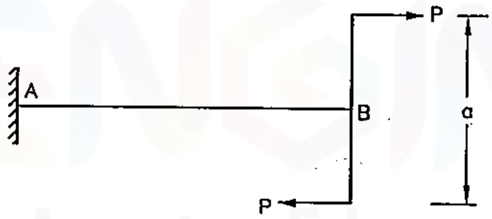


FIG. Q–85

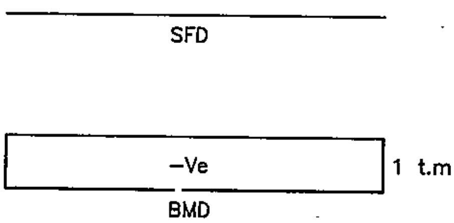
(a) uniformly varying

(b) Uniform

(c) Zero

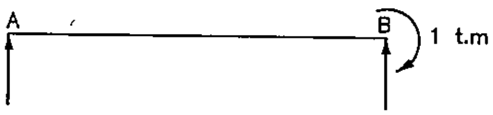
(d) concentrate at A and B only

86. **Shear force diagram (SFD) and bending moment diagram (BMD) are shown in figure.** **(IES)**



The corresponding loading diagram would be

(a)



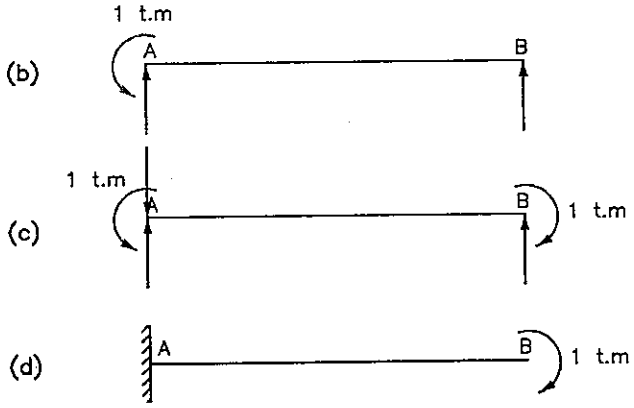


FIG. Q–86

87. Two people weighing W each are sitting on plank of length L floating on water at L/4 from either end. Neglecting the weight of the plank, the bending moment at the centre of the plank is (GATE 2010)

(a) $\frac{WL}{8}$ (b) $\frac{WL}{16}$ (c) $\frac{WL}{32}$ (d) Zero

88. For a simply supported beam of length L, subjected to a uniformly distributed moment M kN–m per unit length as shown in figure, the bending moment (in kN – m) at the mid span of the beam is (Gate 2010)

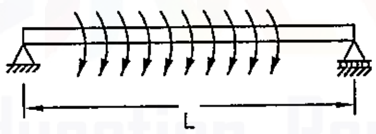


FIG. Q–88

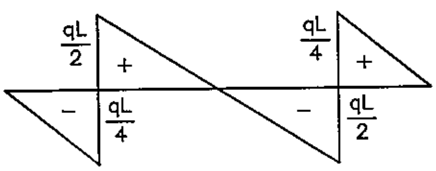
(a) Zero (b) M (c) ML (d) M/L

89. Match List I (shear force diagrams) beams with List II (diagrams of beams with supports and loading) and select the correct answer by using the codes given below the lists. (Gate 2009)

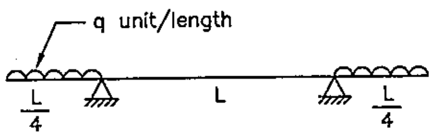
LIST I

LIST II

(A)



(1)



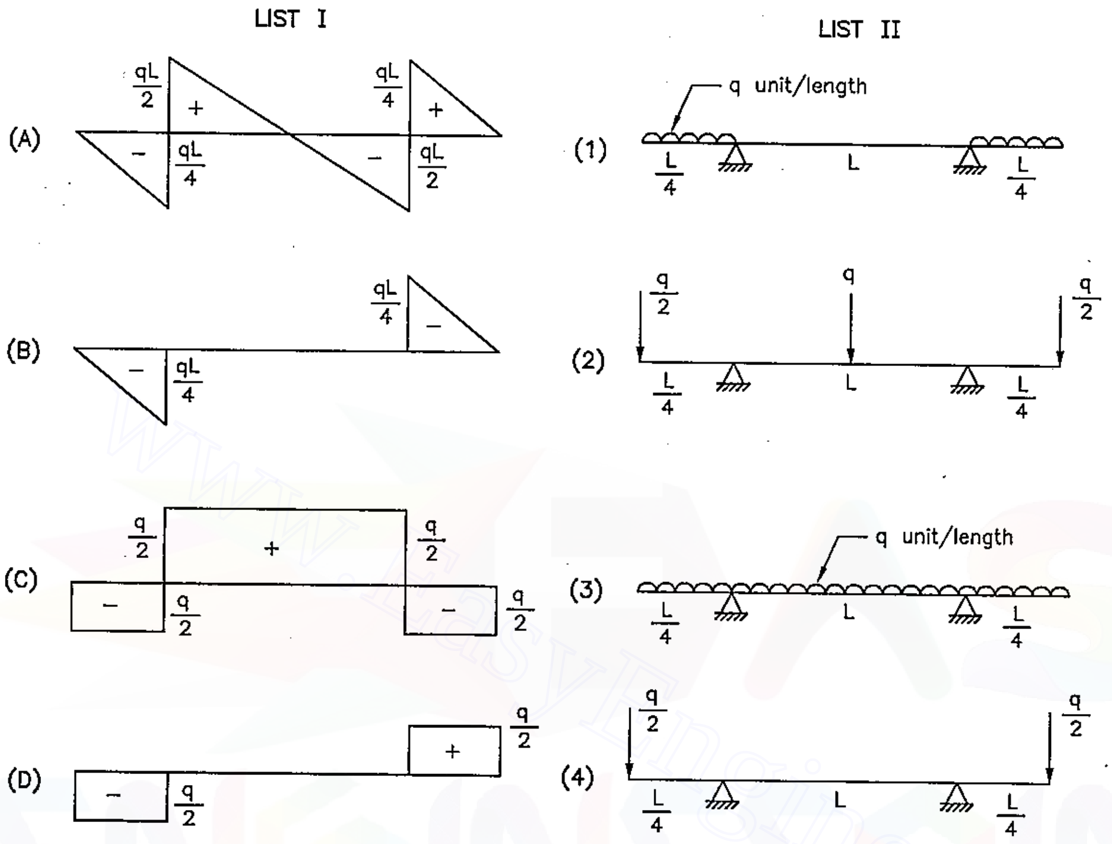


FIG. Q–89

Codes :

	A	B	C	D
(a)	3	1	2	4
(b)	3	4	2	1
(c)	2	1	4	3
(d)	2	4	3	1

90. **A simply supported beam AB has the bending moment diagram as shown in the following figure.** **(GATE 2006)**

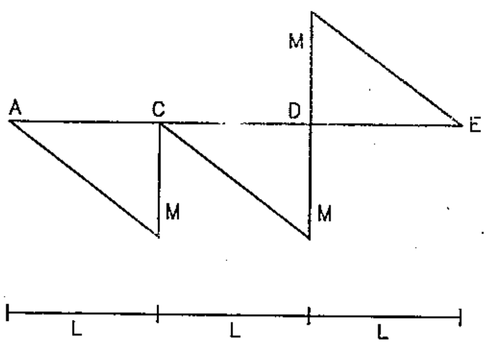


FIG. Q–90

(a) Couple of M at C and 2M at D (b) Couple of 2M at C and M at D

(c) Concentrated loads $\frac{M}{L}$ at C and $\frac{2M}{L}$ at D

(d) Concentrated loads $\frac{M}{L}$ at C and couple of 2M at D

91. List I shows different loads acting on 4 beam and list II shows different bending moment diagrams. Match the load with the corresponding moment diagram.
(GATE 2003)

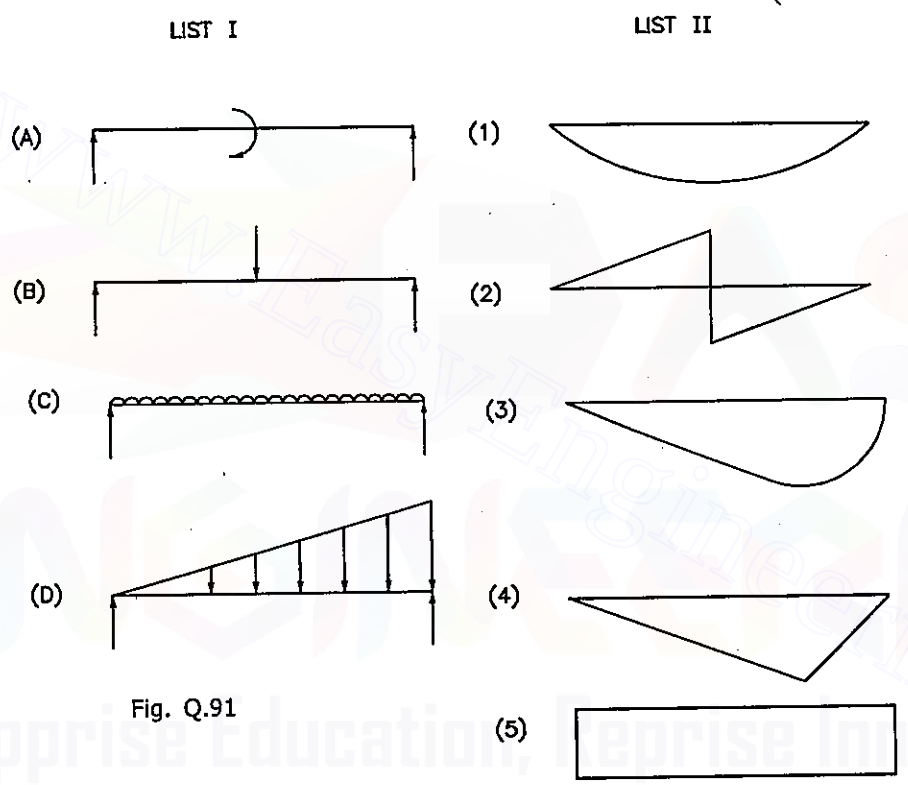


Fig. Q.91

Codes :

	A	B	C	D
(a)	4	2	1	3
(b)	2	5	3	1
(c)	5	4	1	3
(d)	2	4	1	3

92. Match List I with List II and select the correct answer using the codes given below the lists :

LIST I
Beam with loding

LIST II
Bending moment diagram

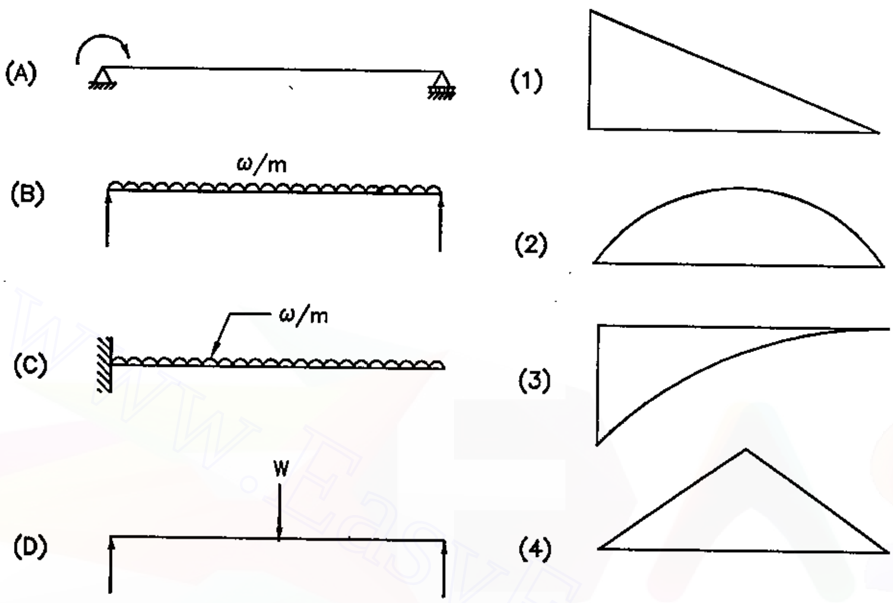


FIG. Q–92

Codes :

	A	B	C	D
(a)	3	4	2	1
(b)	1	2	3	4
(c)	1	3	4	2
(d)	2	1	4	3

93. Figure shows a stress–strain diagram A, B and C represents

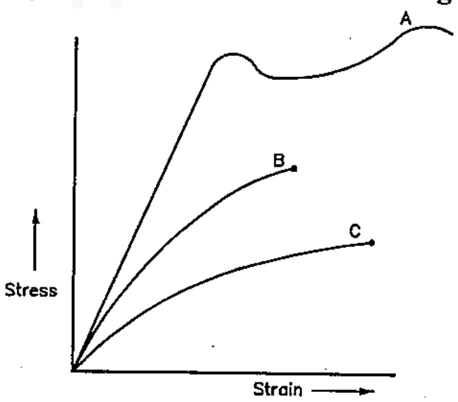


FIG. Q–93

(a) Mild steel, soft brass, glass

(b) Mild steel, glass, soft brass

(c) Soft brass, mild steel, glass

(d) Soft brass, glass, mild steel

94. A beam extending beyond the support is called

(a) Simply supported beam (b) Fixed beam

(c) Overhanging beam (d) Cantilever beam

95. For a beam shown in fig., shear force at B is

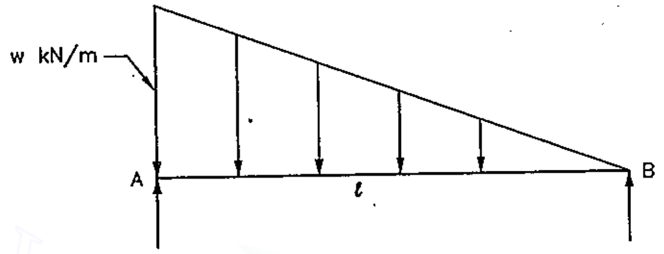


FIG. Q–95

(a) $\frac{wl}{6}$ (b) $\frac{wl}{3}$ (c) wl (d) $\frac{2wl}{3}$

96. For a beam shown in Q. 95, maximum B.M. occur at a distance .... from end B.

(a) $\frac{l}{2}$ (b) $\frac{l}{3}$ (c) $\frac{l}{\sqrt{2}}$ (d) $\frac{l}{\sqrt{3}}$

97. For a beam shown in Q. 95, maximum B.M. is

(a) $\frac{wl^2}{3\sqrt{3}}$ (b) $\frac{wl^2}{6\sqrt{3}}$ (c) $\frac{wl^2}{9\sqrt{3}}$ (d) $\frac{wl^2}{12\sqrt{3}}$

98. For a simply supported beam of span l carrying central point load W, maximum deflection is

(a) $\frac{Wl^4}{8EI}$ (b) $\frac{Wl^3}{6EI}$ (c) $\frac{Wl^3}{48EI}$ (d) $\frac{5}{384}\frac{Wl^4}{EI}$

99. A cantilever beam of span l, carrying u.d.l. on entire span, slope at free end will be

(a) $\frac{Wl^2}{2EI}$ (b) $\frac{Wl^3}{3EI}$ (c) $\frac{Wl^3}{6EI}$ (d) $\frac{Wl^4}{8EI}$

(GATE, IES)

100. For a beam shown in fig. maximum deflection is

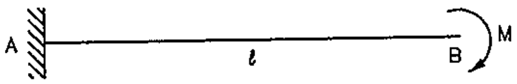


FIG. Q–100

(a) $\frac{ML}{EI}$ (b) $\frac{ML^2}{2EI}$ (c) $\frac{ML^3}{3EI}$ (d) $\frac{ML^3}{6EI}$

101. For a beam shown in Q. 100, maximum slope at B is

(a) $\frac{ML}{EI}$ (b) $\frac{ML^2}{2EI}$ (c) $\frac{ML^3}{3EI}$ (d) $\frac{ML^3}{6EI}$

102. For a beam shown below, deflection below point load is

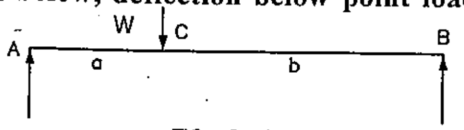


FIG. Q–102

(a) $\frac{Wl^3}{48EI}$ (b) $\frac{Wa^2b^2}{3EIl}$ (c) $\frac{5}{384}\frac{Wl^3}{EI}$ (d) $\frac{Wl^3}{24EI}$

103. The maximum deflection of a fixed beam of length l carrying a central point load W is

(a) $\frac{Wl^3}{48EI}$ (b) $\frac{Wl^3}{96EI}$ (c) $\frac{Wl^3}{192EI}$ (d) $\frac{Wl^3}{384EI}$

104. The maximum deflection of a fixed beam of length l carrying an u.d.l. w kN/m over whole length is

(a) $\frac{Wl^4}{48EI}$ (b) $\frac{Wl^4}{96EI}$ (c) $\frac{Wl^4}{192EI}$ (d) $\frac{Wl^4}{384EI}$

105. Two beams 'A' and 'B' carrying a central point load W are shown below. The deflection of beam A will be .... times the deflection of B.

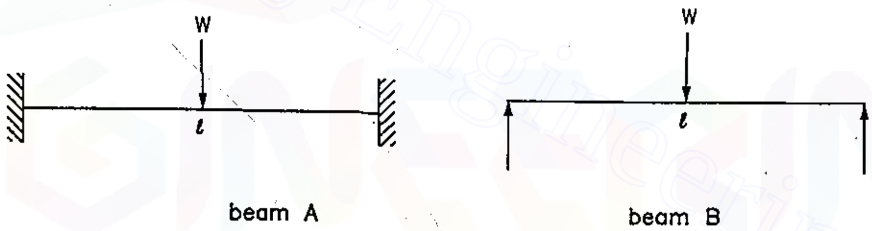


FIG. Q–105

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{1}{4}$ (d) $\frac{1}{8}$

106. Two beams 'A' and 'B' carrying u.d.l. are shown below. The maxi. deflection of B will be .... times the maxi. deflection of A.

FIG. Q–106

(a) 2 (b) 3 (c) 4 (d) 5

107. At neutral axis bending stress is

(a) Minimum (b) maximum (c) zero (d) infinity

108. The purpose of flitched beam is to improve

(a) shear force over the section (b) moment of resistance over the section.

(c) appearance of the section (d) all of these.

109. When a cantilever beam is loaded at its free end, maximum compressive stress shall develop at

(a) bottom fibre (b) top fibre (c) neutral axis (d) centre of gravity.

110. In the theory of simple bending, the bending stress in the beam section varies

(a) linearly (b) parabolically (c) elliptically (d) none of these

111. A beam of uniform strength has constant

(a) Shear force (b) bending moment

(c) Cross - sectional area (d) deflection.

112. The section modulus of a circular section of diameter (d) is

(a) $\frac{\pi}{32}(d)^2$ (b) $\frac{\pi}{32}(d)^3$ (c) $\frac{\pi}{64}(d)^3$ (d) $\frac{\pi}{64}(d)^4$

113. The stepped cantilever is subjected to moments M as shown in figure below. The vertical deflection at the free end (neglecting the self weight) is **(Gate 2008)**

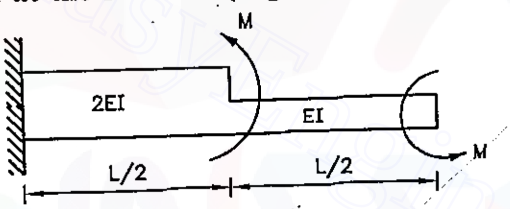


FIG. Q–113

(a) $\frac{ML^2}{8EI}$ (b) $\frac{ML^2}{4EI}$ (c) $\frac{ML^2}{2EI}$ (d) Zero

114. Consider beam AB shown in the figure. Part AC of the beam is rigid while part CB has the flexural rigidity EI. Identify the correct combination of deflection at end B and bending moment at end A, respectively. **(GATE 2006)**

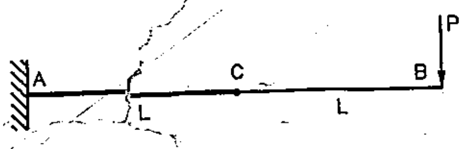


FIG. Q–114

(a) $\frac{PL^3}{3EI}$, 2PL (b) $\frac{PL^3}{3EI}$, PL (c) $\frac{8PL^3}{3EI}$, 2PL (d) $\frac{8PL^3}{3EI}$, PL

115. In the cantilever beam PQR shown below the segment PQ has flexural rigidity EI and the segment QR has infinite flexural rigidity. The deflection at Q is (GATE 2009)

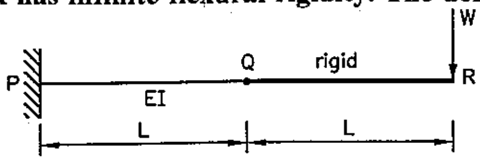


FIG. Q–115

(a) $\frac{5WL^3}{6EI}$ (b) $\frac{WL^3}{3EI}$ (c) $\frac{WL^3}{2EI}$ (d) $\frac{WL^3}{4EI}$

116. The product EI is known as

(a) Polar moment (b) Flexural rigidity
(c) Stiffness (d) Modulus of rigidity

117. When a rectangular simply supported beam is loaded transversely the maximum compressive stress is developed on the

(a) top layer (b) bottom layer
(c) neutral axis (d) every cross section

118. The neutral axis of a beam is subjected to .... stress.

(a) maximum tensile (b) minimum tensile
(c) maximum compressive (d) zero

119. For a beam subjected to pure bending

(a) all fibres experiences uniform stress.
(b) The nature of stress in all fibres is the same.
(c) The stress intensity in any fibre is proportional to the distance of the fibre from N.A.
(d) The stress intensity in any fibre is proportional to the distance of the fibre from supports.

120. Two beam sections, one is circular and other square made from same materials and having same cross–sectional area, when subjected to bending

(a) Moment of resistance for both beams is same.
(b) Circular section has higher M.R.
(c) Square section has higher M.R.
(d) None of these

121. If M is the bending moment, f is bending stress and Z is section modulus, then relation between them is

(a) $f = M.Z$ (b) $f = \frac{M}{Z}$ (c) $f = \frac{Z}{M}$ (d) $Z = \frac{f}{M}$

122. A beam of uniform strength can be obtained by

(a) Keeping the width uniform and varying the depth.
(b) Keeping the depth uniform and varying the width.
(c) Varying the width and depth both.
(d) any one of the above.

123. Castellated beams are used for (GATE)
(a) Light construction
(b) Resisting bending moment only
(c) Loads not passing through the shear centre
(d) Sections subjected to alternate compressive and shear stress

124. The shear in a beam subjected to pure positive bending is
(a) Positive (b) zero (c) negative (d) indeterminate

125. The ratio of flexural strength of two beams of square cross–section, the first beam being placed with its top and bottom sides horizontally and the second beam being placed with one diagonal horizontally is, (IES)
(a) $\sqrt{3}$ (b) 3 (c) $\frac{1}{\sqrt{2}}$ (d) $\sqrt{2}$

126. A propped cantilever beam of span 'l' carries u.d.l. of 'w' per unit run over its entire span. The value of prop reaction to keep the beam horizontal is (IES) (GATE)
(a) $\frac{wl}{3}$ (b) $\frac{3}{8}wl$ (c) $\frac{wl}{2}$ (d) $\frac{5}{8}wl$

127. In a triangular section, the maximum shear stress occurs at,
(a) apex of the triangle (b) mid of the height
(c) $\frac{1}{3}$ of the height (d) base of the triangle.

128. For a rectangular section the ratio of maximum shear stress to the average shear stress is
(a) 2.0 (b) 1.5 (c) 1.25 (d) 1.75

129. For a circular section the ratio of maximum shear stress to the average shear stress is (GTU, April 2010)
(a) 1.13 (b) 1.23 (c) 1.33 (d) 1.43

130. For any section shear stress at the top edge is
(a) Maximum (b) Minimum (c) Zero

131. In case of inverted T - section subjected to shear force F, The maximum shear stress will occur at
(a) top of section (b) Neutral axis
(c) Junction of flange and web (d) bottom of section.

132. The bending equation is
(a) $\frac{M}{I}=\frac{\sigma}{y}=\frac{E}{R}$ (b) $\frac{M}{y}=\frac{\sigma}{I}=\frac{E}{R}$ (c) $\frac{T}{J}=\frac{\tau}{R}=\frac{C\theta}{l}$ (d) $\frac{T}{R}=\frac{\tau}{J}=\frac{C\theta}{l}$

133. The point of contraflexure occurs in
(a) Cantilever beams (b) Simply supported beams
(c) Overhanging beams (d) Fixed beams

134. The basic assumption of plane section normal to the neutral axis, before bending, remaining plane and normal to the axis after bending, leads to

(a) uniform strain over the beam cross–section.

(b) Uniform stress over the cross–section.

(c) linearly varying strain over the cross–section.

(d) stress which are proportional to strains at all cross–sections.

135. The load at which column just starts buckling is called

(a) crippling load (b) buckling load (c) critical load (d) any one of these

136. For long columns, the value of buckling load is .... crushing load.

(a) equal to (b) less than (c) more than

137. A column that fails due to direct stress is called

(a) Short column (b) long column (c) Weak column (d) Slender column

138. Euler's equation for crippling load when both ends of column are hinged is

(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{4\pi^2 EI}{l^2}$ (c) $\frac{\pi^2 EI}{4l^2}$ (d) $\frac{2\pi^2 EI}{l^2}$

139. For a long column with one end fixed and other end hinged, effective length is

(a) L (b) $\frac{L}{2}$ (c) $\frac{L}{\sqrt{2}}$ (d) 2L

140. For a long column with both ends fixed, effective length is

(a) L (b) $\frac{L}{2}$ (c) $\frac{L}{\sqrt{2}}$ (d) 2L

141. The buckling load for a given column depends upon

(a) cross sectional area of column

(b) length and least radius of gyration

(c) modulus of elasticity of column material

(d) all of the above

142. Euler's formula is not valid, for mild steel column when slenderness ratio is

(a) more than 80 (b) less than 80 (c) more than 120 (d) more than 30

143. An electric pole is 5 m high from the ground level. Its effective length for design purpose will be

(a) 2.5 m (b) 3.53 m (c) 5.0 m (d) 10 m

144. If slenderness ratio for a column is 100, then it is said to be

(a) Short column (b) long column (c) medium column

145. The Rankine constant for a mild steel column is

(a) $\frac{1}{750}$ (b) $\frac{1}{1600}$ (c) $\frac{1}{7500}$ (d) $\frac{1}{9000}$

146. For the case of a slender column of length l and flexural rigidity EI built–in at base and free at top, Euler's critical load is (GATE)

(a) $\frac{4\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{\pi^2 EI}{l^2}$ (d) $\frac{\pi^2 EI}{4l^2}$

147. When a column is fixed at both ends then corresponding Euler's critical load is (GATE)

(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{3\pi^2 EI}{l^2}$ (d) $\frac{4\pi^2 EI}{l^2}$

148. If P_E is crippling load given by Euler, P_C is load at failure due to direct compression, P_R is load in accordance with the Rankine's criterion of failure, than P_R is given by (Civil Services)

(a) $\frac{(P_E + P_c)}{2}$ (b) $\sqrt{P_E \times P_c}$ (c) $\frac{P_c \cdot P_E}{P_c + P_E}$ (d) None of these

149. The buckling load will be maximum for a column, if (IES)

(a) one end of column is clamped and other free.
(b) Both ends of the column are clamped.
(c) Both ends of the column are hinged.
(d) One end of the column is hinged and other clamped.

150. For a circular column having its ends hinged the slenderness ratio is 160. The l/d ratio of the column is (IES)

(a) 80 (b) 57 (c) 40 (d) 20

151. The shear stress distribution over a rectangular cross–section of a beam follows (IES)

(a) a straight line path (b) a circular path
(c) a parabolic path (d) an elliptical path

152. The buckling load $P = P_{cr}$ for the column AB in figure, as k_T approaches infinity, becomes $\alpha \frac{\pi^2 EI}{L^2}$, where α is equal to (GATE 2006)

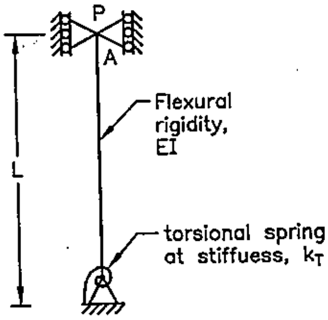


FIG. Q–1.52

(a) 0.25 (b) 1.0
(c) 2.05 (d) 4.0

153. The effective length of column of length L, fixed against rotation and translation at one end is (GATE 2010)

(a) 0.5 L (b) 0.7 L (c) 1.414 L (d) 2 L

154. A steel column pinned at both ends, has a buckling load of 200 kN. If the column is restrained against lateral movement at its mid – height, its buckling load will be (GATE 2007)

(a) 200 kN (b) 283 kN (c) 400 kN (d) 800 kN

155. On a principle plane the magnitude of shear stress will be equal to

(a) Maximum (b) Minimum (c) Zero (d) infinity.

156. When a body is subjected to direct stresses in two mutually perpendicular directions, tangential stress across inclined plane will be maximum when

(a) $\theta = 0°$ (b) $\theta = 45°$ (c) $\theta = 90°$ (d) $\theta = 180°$

157. When a body is subjected to two tensile stresses of equal magnitude on two mutually perpendicular planes, the radius of mohr circle will be

(a) Zero (b) maximum (c) minimum (d) infinity

158. The angle between major principal plane and minor principal plane will be always

(a) greater than 90° (b) Less than 90° (c) equal to 90° (d) equal to 180°

159. The angle of obliquity is equal to

(a) $\tan^{-1}(\sigma_n - \sigma_t)$ (b) $\tan^{-1}(\sigma_n/\sigma_t)$ (c) $\tan^{-1}(\sigma_t/\sigma_n)$ (d) $\tan^{-1}(\sigma_t - \sigma_n)$

160. When a body is subjected to a direct tensile stress (σ) in one plane, then the normal stress on an oblique section of a body inclined at angle (θ) to the normal of the section is equal to.

(a) $\sigma \sin\theta$ (b) $\sigma \cos\theta$ (c) $\sigma \sin^2\theta$ (d) $\sigma \cos^2\theta$

161. The direct stress across a principal plane is known as principal stress.

(a) True (b) False

162. When a body is subjected to a direct tensile stress (σ) in one plane, then maximum normal stress occurs at a section inclined at .... to the normal section.

(a) 0° (b) 30° (c) 45° (d) 90°

163. The maximum shear stress is equal to the radius of Mohr's circle.

(a) True (b) False

164. A steel wire of 20 mm diameter is bent into a circular shape of 10 m radius. If E, the modulus of elasticity is 2×10^6 kg/cm^2, then maximum stress induced in the wire is (IES)

(a) 10^3 kg/cm^2 (b) 2×10^3 kg/cm^2

(c) 4×10^3 kg/cm^2 (d) 6×10^3 kg/cm^2

165. Match list – I and List – II and select correct answer using the codes given below the lists : (IES)

List – I		List II	
A.	Moment of inertia	1.	Tensile stress
B.	Elongation	2.	Modulus of rupture
C.	Neutral axis	3.	Zero shear stress
D.	Top fibre	4.	Zero longitudinal stress

Codes :

	A	B	C	D
(a)	2	1	3	4
(b)	1	2	4	3
(c)	3	4	1	2
(d)	2	1	4	3

166. The shear centre of a section is defined as that point

(a) through which the load must be applied to produce zero twisting moment on the section.

(b) At which shear force is zero.

(c) at which the shear force in maximum.

(d) at which the shear force is minimum.

167. The plane of maximum shear stress has normal stress that is (IES)

(a) maximum (b) minimum (c) zero (d) none of these

168. Consider the following statements :

In a uni–directional stress–system, the principal plane is defined as one on which the (IES)

1. Shear stress is zero
2. Normal stress is zero
3. Shear stress is maximum
4. Normal stress is maximum

of these statements :

(a) 1 and 2 are correct (b) 2 and 3 are correct

(c) 1 and 4 are correct (d) 3 and 4 are correct

169. A Mohr's circle reduces to a point when the body is subjected to (IES)

(a) Pure shear.

(b) Uniaxial stress only.

(c) Equal and opposite axial stresses on two mutually perpendicular planes, the planes being free of shear.

(d) Equal axial stresses on two mutually perpendicular planes, the planes being free of shear.

170. When two mutually perpendicular principal stresses are unequal but alike, then maximum shear stress is represented by **(IES)**

(a) diameter of the Mohr's circle

(b) half the diameter of the Mohr's circle

(c) One–third the diameter of the Mohr's circle

(d) One–fourth the diameter of the Mohr's circle

171. At a point in a strained material, if two mutually perpendicular tensile stresses of 2000 kg/cm^2 and 1000 kg/cm^2 are acting, then intensity of tangential stress on a plane inclined at 15° to the axis of minor stress will be **(IES)**

(a) 125 kg/cm^2 (b) 250 kg/cm^2 (c) 500 kg/cm^2 (d) 1000 kg/cm^2

172. An axially loaded bar is subjected to normal stress of 173 MPa. The shear stress in the bar is **(GATE 2007)**

(a) 75 MPa (b) 86.5 MPa (c) 100 MPa (d) 122.3 MPa

173. Mohr's circle for the state of stress defined by $\begin{bmatrix} 30 & 0 \\ 0 & 30 \end{bmatrix}$ **MPa is a circle with**

(a) Centre at (0, 0) and radius 30 MPa

(b) Centre at (0, 0) and radius 60 MPa

(c) Centre at (30, 0) and radius 30 MPa

(d) Centre at (30, 0) and radius zero

174. Consider the following statements : **(GATE 2009)**

1. On a principal plane, only normal stress acts
2. On a principal phone, both normal and shear stresses act
3. On a principal plane, only shear stress acts
4. Isotropic state of stress is independent of frame of reference

Which of the above statements is/are correct ?

(a) 1 and 4 (b) 2 only (c) 2 and 4 (d) 2 and 3

175. For the section shown, second moment of area about an axis d/4 distance above the bottom of the area is

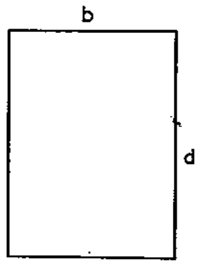


FIG. Q–175

(a) $\frac{bd^3}{48}$ (b) $\frac{bd^3}{12}$

(c) $\frac{7bd^3}{48}$ (d) $\frac{bd^3}{3}$

176. When a column is subjected to eccentric load,

(a) Only direct stress is produced
(b) Only bending stress is produced
(c) Both direct stress and bending stress is produced
(d) None of these

177. For no tension condition in the base of a short column of circular cross section, the limit of eccentricity is

(a) $\frac{d}{2}$ (b) $\frac{d}{3}$ (c) $\frac{d}{4}$ (d) $\frac{d}{8}$

178. For no tension in column

(a) Load must act within elimit
(b) $\sigma_o > \sigma_b$
(c) $e \leq \frac{Z}{A}$
(d) any one of the above

179. A column having moments of inertia I_{xx} and I_{yy}, will fail in the direction of

(a) axis of load
(b) maximum M.I.
(c) Minimum M.I.
(d) Maximum radius of gyration

180. The slenderness ratio is the ratio of

(a) M.I. to area of column
(b) Length of column to least radius of gyration
(c) Least radius of gyration to area of column
(d) Least radius of gyration to length of column

181. A reinforced cement concrete beam is considered to be made of

(a) homogeneous material
(b) heterogeneous material
(c) composite material
(d) isotropic material

182. In engineering materials, the rigidity modulus

(a) is always less than Young's modulus.
(b) is always higher than Young's modulus.
(c) is always less than half the value of Young's modulus.
(d) is nearly equal to Young's modulus.

183. A short column of external diameter D_1 and internal diameter D_2 carries an external load W. For no tension condition the eccentricity will be (IES)

(a) $\frac{D_1^2 - D_2^2}{8D_2}$ (b) $\frac{D_2^2 - D_1^2}{8D_2}$ (c) $\frac{D_1^2 - D_2^2}{8D_1}$ (d) $\frac{D_2^2 - D_1^2}{8D_1}$

184. A column ABCD of rectangular section is subjected to an eccentric load at Z as shown in fig.

Under the compressive load, direct stress is 400 t/m² and bending stresses

$\sigma_{bx} = \pm\ 1200\ t/m^2$, $\sigma_{by} = \pm\ 800\ t/m^2$

The stress at corner A will be **(Civil Services)**

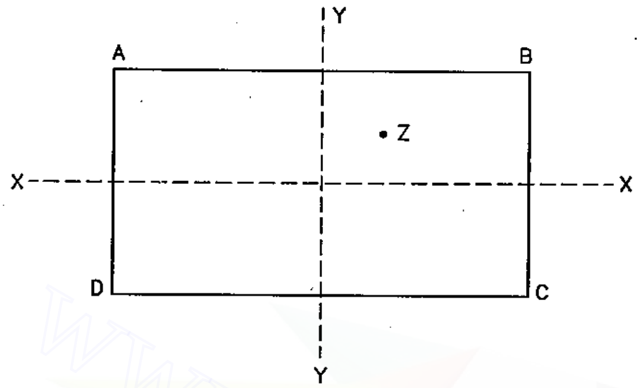


FIG. Q–184

(a) 800 t/m^2 (compressive)

(b) 1600 t/m^2 (tensile)

(c) 800 t/m^2 (tensile)

(d) 2000 t/m^2 (compressive)

185. A simply supported beam of uniform cross section is subjected to maximum bending moment of 2.25 t.m. If it has rectangular cross section, with width 15 cm and depth 30 cm, then maximum bending stress induced in the beam will be **(Civil services)**

(a) 50 kg/cm^2 (b) 100 kg/cm^2 (c) 150 kg/cm^2 (d) 225 kg/cm^2

186. A beam has a solid circular section having diameter d. If a section of the beam is subjected to a shear force F, then maximum shear stress in the cross section is given by **(Civil Services)**

(a) $\frac{4F}{3\pi d^2}$ (b) $\frac{16F}{3\pi d^2}$ (c) $\frac{8F}{3\pi d^2}$ (d) $\frac{3F}{16\pi d^2}$

187. The stress produced by sudden load is .... times that is produced by gradual load.

(a) $\frac{1}{2}$ (b) 1 (c) 2 (d) 4

188. Strain energy is the

(a) Energy stored in a body when strained within elastic limit.

(b) Maximum strain energy which can be stored in a body.

(c) Energy stored in a body when strained up to the breaking of a specimen.

(d) Proof resilience per unit volume.

189. The strain energy stored in a body when load is applied gradually is

(a) $\frac{\sigma^2}{VE}$ (b) $\frac{\sigma^2}{2E} \times V$ (c) $\frac{\sigma^2 E}{2V}$ (d) $\frac{\sigma^2}{2EV}$

190. **The strain energy stored in a body, when suddenly loaded, is .... the strain energy stored when same load is applied gradually.**

(a) equal to (b) one–half (c) twice (d) four times

191. **The strain energy stored in a body due to shear stress is,**

(a) $\frac{\tau^2}{2C} \times V$ (b) $\frac{2C}{\tau V}$ (c) $\frac{\tau^2}{4C} \times V$ (d) $\frac{2C}{\tau^2 V}$

192. **u_1 and u_2 are the strain energies stored in a prismatic bar due to axial tensile forces P_1 and P_2 respectively. The strain energy u stored in the same bar due to combined action of P_1 and P_2 will be** **(GATE 2007)**

(a) $u = u_1 + u_2$ (b) $u = u_1 u_2$ (c) $u < u_1 + u_2$ (d) $u > u_1 + u_2$

193. **A cylindrical pressure vessel is said to be thin walled if 't' is given by :**

(a) $t = \frac{d}{10}$ (b) $t < \frac{d}{10}$ (c) $t > \frac{d}{10}$

194. **For a thin cylindrical shell having diameter (d), pressure (p) length (*l*) and thickness (t), the hoop stress is**

(a) $\frac{pd}{2t}$ (b) $\frac{pd}{4t}$ (c) $\frac{pd}{6t}$ (d) $\frac{pd}{8t}$

195. **The design of thin cylindrical shell is based on**

(a) hoop stress
(b) longitudinal stress
(c) arithmetic mean of hoop and longitudinal stress
(d) none of these

196. **Hoop stress in a thin cylindrical shell is**

(a) longitudinal stress. (b) Compressive stress.
(c) Circumferential tensile stress. (d) radial stress.

197. **The maximum shear stress in a thin cylindrical shell subjected to internal pressure p is**

(a) $\frac{pd}{2t}$ (b) $\frac{pd}{4t}$ (c) $\frac{pd}{6t}$ (d) $\frac{pd}{8t}$

198. **For a thin spherical shell subjected to internal pressure p, stress produced is**

(a) $\frac{pd}{t}$ (b) $\frac{pd}{2t}$ (c) $\frac{pd}{4t}$ (d) $\frac{pd}{8t}$

199. **The longitudinal stress in a riveted cylindrical shell, subjected to internal pressure (p) is**

(a) $\frac{pd}{t\eta}$ (b) $\frac{pd}{2t\eta}$ (c) $\frac{pd}{4t\eta}$ (d) $\frac{pd}{8t\eta}$

200. **For a thin cylindrical shell subjected to internal pressure (p), the volumetric strain is**

(a) $\varepsilon_2 + \varepsilon_1$ (b) $\varepsilon_2 - \varepsilon_1$ (c) $\varepsilon_2 + 2\varepsilon_1$ (d) $\varepsilon_2 - 2\varepsilon_1$

201. A thin cylinder contains fluid at a pressure of 500 N/m^2, internal diameter of the shell is 0.6 m and tensile stress in the material is to be limited to 9000 N/m^2. The shell must have a minimum wall thickness of nearly

(a) 9 mm (b) 11 mm (c) 17 mm (d) 21 mm

202. A thin walled cylindrical pressure vessel having a radius of 0.5 m and wall thickness of 25 mm is subjected to an internal pressure of 700 kPa. The hoop stress developed is (Gate 2009)

(a) 14 MPa (b) 1.4 MPa (c) 0.14 MPa (d) 0.014 MPa

203. The shear stress intensity is minimum at

(a) axis of shaft. (b) surface of the shaft.
(c) any inside layer of the shaft. (d) all the above are correct.

204. The criteria for the design of shaft is the stress at

(a) axis of the shaft. (b) the surface of the shaft.
(c) any inside layer. (d) all the above are wrong.

205. A masonry dam may fail due to

(a) overturning of the dam. (b) tension in the masonry at the base.
(c) crushing of masonry at the base. (d) any one of the above.

206. In the torsion equation $\frac{T}{J}=\frac{\tau}{R}=\frac{C\theta}{l}$, the term $\frac{J}{R}$ is called

(a) shear modulus (b) section modulus (c) polar modulus (d) none of these

207. For a solid shaft of diameter D, torque (T) is given by

(a) $\frac{\pi}{16}\times\tau\times D^3$ (b) $\frac{\pi}{32}\times\tau\times D^3$ (c) $\frac{\pi}{16}\times\tau\times D^4$ (d) $\frac{\pi}{32}\times\tau\times D^4$

208. Polar M.I. of a solid circular shaft of diameter D is given by

(a) $\frac{\pi}{16}D^3$ (b) $\frac{\pi}{32}D^3$ (c) $\frac{\pi}{16}D^4$ (d) $\frac{\pi}{32}D^4$

209. The power transmitted by shaft is given by

(a) $P=\frac{2\pi NT}{60}$ watt (b) $P=\frac{2\pi NT}{4500}$ watt (c) $P=\frac{2\pi NT}{120}$ watt (d) $P=\frac{2\pi NT}{120}$ h.p

210. When a shaft of diameter (D) is subjected to twisting moment (T) and bending moment (M), the equivalent twisting moment (T_e) is given by

(a) $\sqrt{M^2+T^2}$ (b) $\sqrt{M^2-T^2}$
(c) $\frac{1}{2}\left(M+\sqrt{M^2+T^2}\right)$ (d) $\frac{1}{2}\left(M-\sqrt{M^2+T^2}\right)$

211. When a shaft of diameter (D) is subjected to twisting moment (T) and bending moment (M) the equivalent bending moment (M_e) is given by

(a) $\sqrt{M^2+T^2}$ (b) $\sqrt{M^2-T^2}$ (c) $\frac{1}{2}\left(M+\sqrt{M^2+T^2}\right)$ (d) $\frac{1}{2}\left(M-\sqrt{M^2+T^2}\right)$

212. Two shafts A and B are made of the same material. The diameter of shaft B is twice that of shaft A. The ratio of power which can be transmitted by shaft A to that of shaft B is (GATE)

(a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) $\frac{1}{8}$ (d) $\frac{1}{16}$

213. The outside diameter of a hollow shaft is twice its inside diameter. The ratio of its torque carrying capacity to that of solid shaft of the same material and the same outside diameter is (GATE)

(a) $\frac{15}{16}$ (b) $\frac{3}{4}$ (c) $\frac{1}{2}$ (d) $\frac{1}{16}$

214. Bending moment M and torque T is applied on a solid circular shaft. If maximum bending stress equals to maximum shear stress developed than, M is equal to (IES)

(a) $\frac{T}{2}$ (b) T (c) 2T (d) 4T

215. For two shafts connected in parallel, which of the following statement is true ? (IES)

(a) Torque in each shaft is the same
(b) Shear stress in each shaft is the same
(c) Angle of twist of each shaft is the same
(d) Torsional stiffness of each shaft is the same

216. A circular shaft is subjected to torsion undergoes a twist of 1° in a length of 120 cm. If maximum shear stress induced is limited to 1000 kg/cm^2 and modulus of rigidity G = 0.8 × 10^6 kg/cm^2, then radius of the shaft is (IES)

(a) $\frac{\pi}{18}$ (b) $\frac{\pi}{27}$ (c) $\frac{18}{\pi}$ (d) $\frac{27}{\pi}$

217. The load required to produce unit deflection in a spring is called

(a) torsional rigidity. (b) spring stiffness. (c) flexural rigidity. (d) Young's modulus.

218. When a closely–coiled helical spring is subjected to an axial load, it is said to be under

(a) bending (b) shear (c) torsion (d) crushing

219. A spring used to absorb shocks and vibrations is

(a) torsion spring (b) leaf spring (c) helical spring (d) conical spring

220. A closely–coiled helical spring is cut into two halves. The stiffness of the resulting spring will be

(a) same (b) double (c) half (d) one–fourth

221. When a closely coiled helical spring of diameter D is subjected to axial load (W), the deflection of the spring (δ) is given by

(a) $\frac{WD^3n}{Cd^4}$ (b) $\frac{2WD^3n}{Cd^4}$ (c) $\frac{4WD^3n}{Cd^4}$ (d) $\frac{8WD^3n}{Cd^4}$

222. In leaf springs, the maximum bending stress developed in the plates is

(a) $\frac{Wl}{nbt^2}$ (b) $\frac{3Wl}{2nbt^2}$ (c) $\frac{2Wl}{nbt^2}$ (d) $\frac{3Wl}{nbt^2}$

where, W = load
l = span of spring
n = no. of plates
b = width of plate
t = thickness of plate

223. The 'plane section remains plane' assumption in bending theory implies : (GATE 2013)

(a) Strain profile is linear
(b) Stress profile is linear
(c) both strain and stress profiles are linear
(d) shear deformations are neglected

224. An overhang beam AB is having span L between supports and overhang length L/2 beyond support B. If a uDL 'w' is applied on length L/2 on either side of support B, the reaction at support A will be

(a) wL/2 (b) 1.5 wL/2 (c) zero (d) wL

225. The slope of B.M. diagram represents

(a) maximum bending moment. (b) shear force.
(c) maximum shear force. (d) bending moment.

226. Point of contraflexure is where

(a) bending moment is zero. (b) shear force is zero.
(c) shear force diagram changes sign. (d) bending moment diagram changes sign.

227. Maximum B.M. exists where

(a) reaction is zero. (b) shear force is zero.
(c) deflection is minimum. (d) At hinged supports.

228. Radius of Mohr circle of stress represents

(a) Principal stress (b) Shear stress
(c) Normal stress (d) Maximum normal stress

229. A thrust diagram indicates

(a) shear force (b) Transverse force (c) axial force (d) none of these

230. A brittle material exhibits

(a) Large plastic deformation (b) Large elastic deformation

(c) Large yield plateau (d) no plastic deformation

231. A thin walled cylindrical pressure pipe is made by welding two semi circular parts along the length. Under working conditions, the weld shall be under

(a) Direct tension. (b) direct shear. (c) direct compression. (d) Torsional shear.

232. In case of pure shear condition, principal planes lie at

(a) 45° to 135° (b) 90° to 135° (c) 0° to 90° (d) 90° to 180°

233. A cantilever beam carrying UDL over its entire span is to be replaced by a simply supported beam of same span. The maximum bending stress will be

(a) reduced by two times. (b) reduced by four times.

(c) increased by two times. (d) decrease by four times.

234. A circular section of beam having dia D is replaced by square section of side D, the bending stress will

(a) not change (b) increase (c) reduce (d) depend on size D

235. A material under pure shear ultimately leads to

(a) uniaxial stress condition. (b) biaxial stress condition.

(c) Triaxial stress condition. (d) zero stress condition.

236. A propped cantilever will have .... reactions.

(a) 2 (b) 3 (c) 4 (d) 1

237. A simply supported beam is replaced by a fixed beam carrying point load at mid span. The maximum deflection will

(a) increase to 4 times (b) reduce to four times

(c) increase to 5 times (d) reduce to five times

238. A cantilever beam carrying UDL over its entire span is to be replaced by a simply supported beam of same span. Nature of stress at top and bottom fibre of cross section will

(a) reverse (b) no change

(c) depends on intensity of u.d.l. (d) Depend on span length

239. Maximum ordinate of all the points lying on a Mohr's circle represents

(a) Major principal stress (b) Minor principal stress

(c) Maximum shear stress (d) None of the above

240. In biaxial stress condition, principal stresses are

(a) at 45° and 135° (b) applied stress itself

(c) average of applied stress (d) none of the above

241. A point on a Mohr circle represents

(a) Principal stress and shear stress (b) Major and minor principal stresses

(c) Maximum shear and principal stress (d) Normal and shear stress

242. In a diamond shape cross section maximum shear stress lies at

(a) Neutral axis (b) above and below neutral axis

(c) extreme fibre (d) central fibre

243. The self weight of beam will be taken as

(a) point load (b) uniformly distributed load

(c) uniformly varying load (d) None of the above

244. Two shafts are connected by a coupling to transfer torsional moment from one end to another, the connector bolts will be under

(a) Torsion (b) shear (c) bending (d) tension

245. A cantilever beam carrying point moment at free end

(a) can fail in shear stress at support

(b) can not fail in shear any where in the beam

(c) can not fail in bending stress at support

(d) can not fail in bending stress anywhere in the beam

246. A simply supported beam carrying a point load W at L/3 span. The maximum bending moment will be

(a) $\frac{WL}{4}$ (b) $\frac{WL^2}{8}$ (c) 2WL/9 (d) 3WL/4

247. Making hole in paper using punch machine is an example of

(a) Compression failure (b) bearing failure

(c) Shearing failure (d) tearing failure

248. As per the Euler's theory, failure in column will be by

(a) Buckling (b) Crippling (c) crushing (d) Crippling and buckling

249. Euler's crippling load of a square column cross section will be .... if its side is doubled.

(a) $\frac{1}{2}$ times (b) $\frac{1}{4}$ times (c) 2 times (d) 16 times

250. Term EI . $\frac{d^2y}{dx^2}$ represents

(a) shear force. (b) bending moment.

(c) slope of bending moment dia. (d) maxima/minima condition for deflection.

251. The formula which can be used for column load to account combined effect of bending and direct stresses is

(a) Euler's formula (b) Rankine's formula

(c) Perry's formula (d) Straight line formula

252. If yy axis is tangential to Mohr's circle it represents
(a) uniaxial stress condition (b) biaxial stress condition
(c) Pure shear condition (d) Shear and uniaxial stress condition

253. A shaft carrying 3 kN.m bending moment and 4 kN.m torsional moment. Equivalent torsional moment producing same shear stress will be
(a) 3 kN.m (b) 7 kN.m (c) 5 kN.m (d) 1 kN.m

254. A long closed cylindrical pressure vessel is made by joining different cylindrical parts using lap joint along the periphery. The bolts shall be under
(a) bending shear (b) direct compression (c) direct shear (d) Torsional shear

255. Shear centre of symmetrical I section will lie
(a) at centroid (b) outside the section
(c) At bottom most fibre (d) at top most fibre

256. In case of beam having channel section placed as C, the direction of shear flow in flanges shall be
(a) in same direction (b) in opposite direction
(c) dependent on thickness of flange (d) dependent on width of flange

257. The diameter of kern (core) section of a circular cross section column is
(a) d/2 (b) d/3 (c) d/4 (d) d/8

258. In thin spherical shell, the ratio of radial to circumferential stress is
(a) $\frac{1}{2}$ (b) 1 (c) 2 (d) $\frac{1}{4}$

259. In case of two point loading test the bending moment between the loads is
(a) zero (b) constant (c) varying (d) data insufficient

260. Impact test measures .... of material.
(a) Hardness (b) ductility (c) toughness (d) brittleness

261. The S.F. diagram for a cantilever beam subjected to couple at free end is
(a) horizontal straight line (b) zero
(c) parabola (d) inclined straight line

262. Lateral strains are .... longitudinal strains
(a) always equal (b) always greater than
(c) always less than (d) sometimes less than

263. When a simply supported beam with overhangs on both sides is subjected to point loads at free end of both side overhang, the nature of bending stress along top fibres at the central span shall be
(a) flexural compressive (b) flexural tensile
(c) axial compressive (d) axial tensile

264. Which of the following beam is likely to have the point of contraflexure when loaded by u.d.l. over its entire span ?

(a) Simply supported beam (b) cantilever beam

(c) overhanging beam (d) none of the above

265. For a proped cantilever beam carrying UDL w kN/m on entire span, reaction at prop will be

(a) $\frac{5}{6}$wl (b) $\frac{3}{8}$wl (c) $\frac{1}{2}$wl (d) $\frac{3}{4}$wl

266. A cantilever beam of length L has flexural rigidity EI up to length L/2 from the fixed end and EI/2 for the rest. It carries a moment M at the free end. The slope at the free end is given by

(a) $\frac{ML^2}{2EI}$ (b) $\frac{ML^2}{3EI}$ (c) $\frac{3ML}{2EI}$ (d) $\frac{2ML}{3EI}$

267. The rectangular section with sides 3 m and 6 m has a core

(a) Parallelogram of sides 2 m, and 4 m

(b) square diagonal of sizes 1 m and 3 m

(c) circular of radius 3 m

(d) Rhombus diagonal of sizes 1 m and 2 m

268. Principal stress on the plane of maximum shear stress is

(a) Maximum (b) zero (c) Minimum (d) None of the above

269. A rod is enclosed centrally in a tube and assembly is tightened by rigid washers, then

(a) rod is subjected to compressive load

(b) tube is subjected to compressive load

(c) both are subjected to compressive load

(d) rod is subjected to compressive, tube is subjected to tensile

270. A column carries an axial load concentrically. Due to wind, a UDL acts along its height. Due to wind load, the axial load carrying capacity of column will

(a) increase (b) decrease

(c) Remain same (d) Depends on the direction of wind

: ANSWERS :

1. (a)	2. (c)	3. (a)	4. (b)	5. (c)
6. (d)	7. (b)	8. (c)	9. (d)	10. (c)
11. (b)	12. (c)	13. (b)	14. (c)	15. (b)
16. (c)	17. (a)	18. (c)	19. (b)	20. (c)
21. (d)	22. (a)	23. (d)	24. (a)	25. (d)
26. (b)	27. (c)	28. (a)	29. (b)	30. (c)
31. (d)	32. (a)	33. (c)	34. (b)	35. (d)
36. (a)	37. (d)	38. (a)	39. (a)	40. (c)
41. (b)	42. (c)	43. (b)	44. (a)	45. (b)
46. (a)	47. (b)	48. (c)	49. (c)	50. (d)
51. (b)	52. (c)	53. (c)	54. (a)	55. (d)
56. (b)	57. (a)	58. (b)	59. (a)	60. (b)
61. (c)	62. (a)	63. (d)	64. (a)	65. (b)
66. (b)	67. (a)	68. (c)	69. (b)	70. (d)
71. (b)	72. (c)	73. (a)	74. (b)	75. (b)
76. (c)	77. (b)	78. (a)	79. (b)	80. (b)
81. (b)	82. (b)	83. (b)	84. (c)	85. (c)
86. (c)	87. (d)	88. (a)	89. (a)	90. (a)
91. (d)	92. (b)	93. (b)	94. (c)	95. (a)
96. (d)	97. (c)	98. (c)	99. (c)	100. (b)
101. (a)	102. (b)	103. (c)	104. (d)	105. (c)
106. (d)	107. (c)	108. (b)	109. (a)	110. (a)
111. (b)	112. (b)	113. (c)	114. (a)	115. (a)
116. (b)	117. (a)	118. (d)	119. (c)	120. (c)
121. (b)	122. (d)	123. (a)	124. (b)	125. (d)
126. (b)	127. (b)	128. (b)	129. (c)	130. (c)
131. (b)	132. (a)	133. (c)	134. (a)	135. (d)
136. (b)	137. (a)	138. (a)	139. (c)	140. (b)
141. (d)	142. (b)	143. (d)	144. (b)	145. (c)
146. (d)	147. (d)	148. (c)	149. (b)	150. (c)
151. (c)	152. (d)	153. (d)	154. (d)	155. (c)
156. (b)	157. (a)	158. (c)	159. (c)	160. (d)
161. (a)	162. (a)	163. (a)	164. (b)	165. (d)
166. (a)	167. (c)	168. (c)	169. (d)	170. (b)
171. (b)	172. (b)	173. (d)	174. (a)	175. (c)
176. (c)	177. (d)	178. (d)	179. (c)	180. (b)

181. (b)	182. (c)	183. (c)	184. (a)	185. (b)
186. (b)	187. (c)	188. (a)	189. (b)	190. (d)
191. (c)	192. (d)	193. (b)	194. (a)	195. (a)
196. (c)	197. (d)	198. (c)	199. (c)	200. (c)
201. (c)	202. (a)	203. (a)	204. (b)	205. (d)
206. (c)	207. (a)	208. (c)	209. (a)	210. (a)
211. (c)	212. (c)	213. (a)	214. (a)	215. (c)
216. (d)	217. (b)	218. (c)	219. (b)	220. (b)
221. (d)	222. (b)	223. (a)	224. (c)	225. (b)
226. (d)	227. (b)	228. (b)	229. (c)	230. (d)
231. (b)	232. (c)	233. (b)	234. (c)	235. (c)
236. (c)	237. (b)	238. (a)	239. (a)	240. (b)
241. (d)	242. (b)	243. (b)	244. (b)	245. (b)
246. (c)	247. (c)	248. (a)	249. (d)	250. (b)
251. (b)	252. (a)	253. (c)	254. (c)	255. (a)
256. (a)	257. (c)	258. (b)	259. (b)	260. (c)
261. (a)	262. (c)	263. (b)	264. (c)	265. (b)
266. (c)	267. (d)	268. (b)	269. (c)	270. (b)

EXPLANATIONS

39. (a) $\sigma = \left(\alpha t - \frac{\delta}{l}\right)E$

$= (2 \times 10^{-6} \times 100 - \frac{0.01}{25}) \times 1 \times 10^6$

$= -200$ kg.cm^2 (tensile)

46. (a) $\delta l = l\,\alpha\,t$

$= 15000 \times 12 \times 10^{-6} \times 25$

$= 4.5$ mm (gap)

48. (c) Four elastic constants are required

E, K, G and μ

62. (a) $E = 2G\,(1 + \frac{1}{m})$ $\mu = 0.2 = \frac{1}{m}$

$E = 2G\,(1 + 0.2)$

$\frac{E}{G} = 2.4 = \frac{12}{5}$

64. (a) $E = 2G\,(1 + \frac{1}{m})$

$2 \times 10^6 = 2G\,(1 + 0.25)$ $\quad \therefore \quad G = 0.8 \times 10^6$ kg/cm^2

65. (b) $E = 2G\,(1 + \frac{1}{m})$

$2.1 \times 10^6 = 2 \times 0.8 \times 10^6\,(1 + \frac{1}{m})$

$\therefore \quad 1 + \frac{1}{m} = 1.3125$

$\therefore \quad \frac{1}{m} = \mu = 0.3125$

66. (b) $\varepsilon = \frac{\delta l}{l} = \frac{0.03}{20} = 0.0015$

$\varepsilon' = \frac{\delta d}{d} = \frac{0.0018}{4} = 4.5 \times 10^{-4}$

$\therefore \quad \mu = \frac{\varepsilon'}{\varepsilon} = \frac{4.5 \times 10^{-4}}{0.0015} = 0.3$

82. (b)

B. M. dia.

FIG. A–82

83. (b)

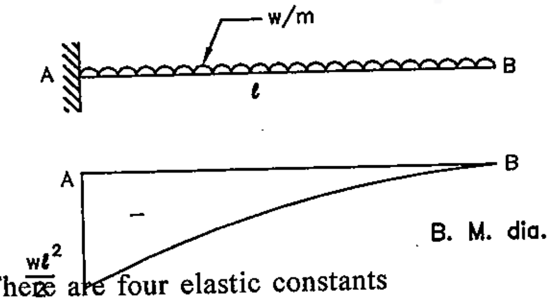


FIG. A–83

84. (c) There are four elastic constants

E, K, G and μ

But only E and μ are independent

87. (d)

$$M_c = \frac{2W}{L} \times \frac{L}{2} \times \frac{L}{4} - W \times \frac{L}{4}$$

$$= \frac{WL}{4} - \frac{WL}{4}$$

$$= 0$$

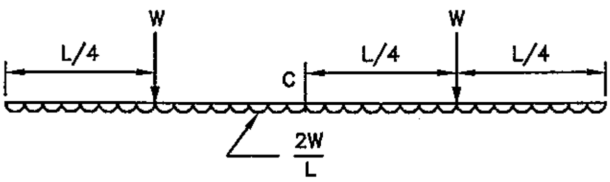


FIG. A–87

88. (a) Taking moment @ A

$R_B \times L = M.L$

$\therefore \quad R_B = M$

B.M. at mid span $= R_B \times \frac{L}{2} - M.\frac{L}{2}$

$= M.\frac{L}{2} - M.\frac{L}{2}$

$= 0$

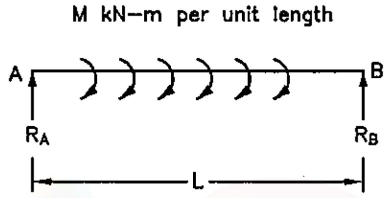


FIG. A–88

95. (a)

$R_B \times l = \frac{1}{2} \times w \,.\, l \times \frac{1}{3} l$

$\therefore \quad R_B = \frac{wl}{6}$ ... SF at B

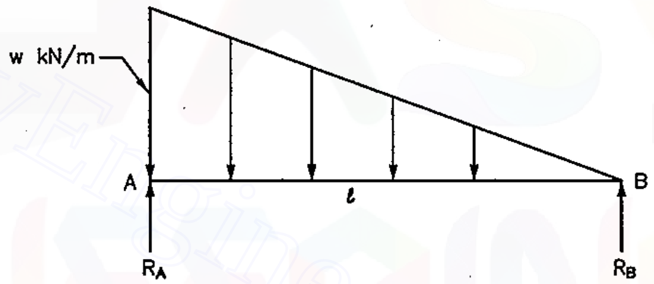


FIG. A–95

105. (c) For fixed beam, $\delta_1 = \frac{Wl^3}{192\,EI}$

For simply supported beam, $\delta_2 = \frac{Wl^3}{48\,EI}$

$\therefore \quad \delta_1 = \frac{1}{4}\delta_2$

106. (d) For fixed beam, $\delta_1 = \frac{wl^4}{384\,EI}$

For simply supported beam, $\delta_2 = \frac{5}{384}\frac{wl^4}{EI}$

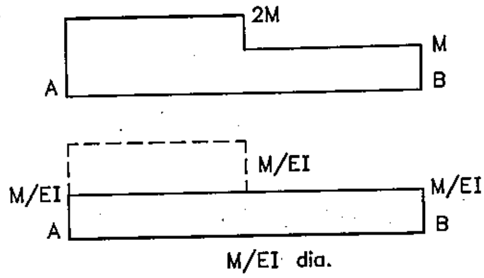
$\therefore \quad \delta_2 = 5\delta_1$

113. (c) Moment area Method :

y_B = moment of $\frac{M}{EI}$ dia

between B and A about B

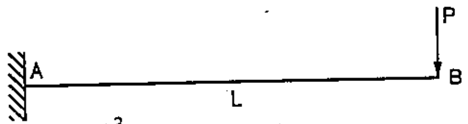
$$= \frac{M}{EI} \times L \times \frac{L}{2} = \frac{ML^2}{2EI}$$



114. (c) Part AC is rigid, $\therefore$ EI $\rightarrow \infty$

Hence for calculation of deflection at B beam can be reproduced as

FIG. A-113



$\therefore$ deflection at B, $y_B = \dfrac{PL^3}{3EI}$

FIG. A-114

B.M. at A = P × 2L (no effect of rigidity of AC)

= 2PL

115. (a) QR is rigid.

Structure can be converted into a cantilever subject to act moment WL at Q, and concentrated load W at Q.

$$\therefore \text{ def. at Q} = \frac{WL^3}{3EI} + \frac{(WL)L^2}{2EI}$$

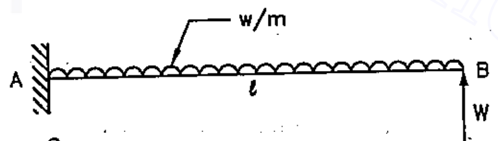
$$= \frac{2WL^3 + 3L^3}{6EI} = \frac{5WL^3}{6EI}$$

FIG. A-115

126. (b) def. at B due to u.d.l. = def. due to point load

$$\frac{wl^4}{8EI} = \frac{Wl^3}{3EI}$$

$$\frac{wl^4}{8} = \frac{Wl^3}{3}$$



$\therefore$ W = $\dfrac{3}{8}$ wl

FIG. A-126

150. (c) $r_{min} = \sqrt{\frac{I}{A}} = \sqrt{\frac{\frac{\pi}{64} \times d^4}{\frac{\pi}{4} \times d^2}} = \frac{d}{4}$

Slenderness ratio, $\lambda = \frac{l_e}{r_{min}}$

$$\therefore \quad 160 = \frac{l_e \times 4}{d}$$

$$\therefore \quad \frac{l_e}{d} = 40$$

152. (d) End A allows only axial deformation which is negligible in case of buckling for long column. At end B, k_T approaches infinity, it will behave as fixed end. So, both ends behave as fixed ends.

$$\therefore \quad P_{cr} = \frac{\pi^2 EI}{\left(\frac{L}{2}\right)^2} = 4\frac{\pi^2 EI}{L^2} \qquad \therefore \ \alpha = 4$$

153. (d) One end is fixed, other free

$\therefore \ l_e = 2L$

154. (d) $P_{cr} = \frac{\pi^2 EI}{l^2} = 200$ kN

For new condition

$$l_e = \frac{l}{2}$$

$$\therefore \quad P_{cr} = \frac{\pi^2 EI}{(l_e)^2} = \frac{\pi^2 EI}{\left(\frac{l}{2}\right)^2} = \frac{4\pi^2 EI}{l^2}$$

$$= 4 \times 200$$

$$= 800 \text{ kN}$$

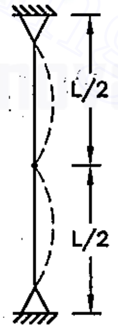


FIG. A–154

164. (b) $\frac{f}{y} = \frac{E}{R}$

$$f = y \times \frac{E}{R} = 1 \times \frac{2 \times 10^6}{10 \times 100} = 2 \times 10^3 \text{ kg/cm}^2$$

171. (b) $\sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \tau \cos 2\theta$ $\tau = 0$

$= \frac{(2000 - 1000)}{2} \sin 30° - 0$

$= 250$ kg./cm^2

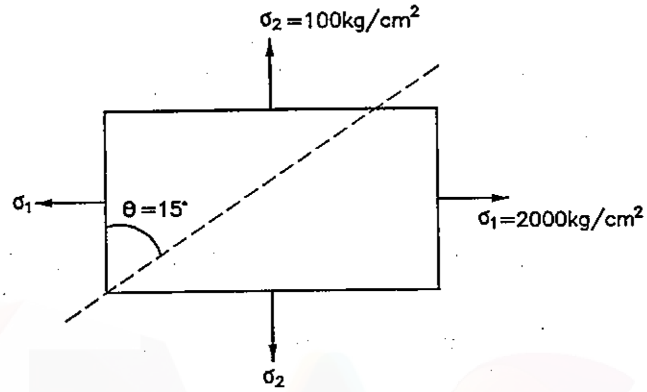


FIG. A–171

172. (b) $\sigma_1 = 173$ mPa

$\sigma_2 = 0$

$\tau = 0$ For τ_{max}, $\theta = 45°$

$\therefore \quad \tau_{max} = \sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta - \tau \cos 2\theta$

$= \frac{173}{2} \sin 90° - 0$

$= 86.5$ MPa

173. (d) $\sigma_{11} = 30, \sigma_{12} = 0, \sigma_{21} = 0, \sigma_{22} = 30$

$\therefore$ Principal stresses are,

$\sigma_{11} = 30, \sigma_{22} = 30$

$\therefore$ radius $= \frac{\sigma_{11} - \sigma_{12}}{2} = \frac{30 - 30}{2} = 0$

centre of Mohr's circle will be (30, 0)

174. (a) Isotropic state means having same material properties in all directions.

iso = same, tropic = direction

175. (c) $I_{AB} = I_g + ah^2$

$= \frac{bd^3}{12} + bd \times \left(\frac{d}{4}\right)^2$

$$= \frac{bd^3}{12} + \frac{bd^3}{16}$$

$$= \frac{7bd^3}{48}$$

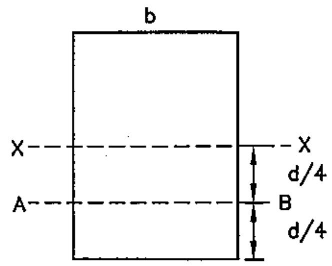


FIG. A–175

184. (a) $\sigma_A = \sigma_0 + \sigma_{bx} - \sigma_{by}$
$= 400 + 1200 - 800$
$= 800$ t/m^2 (compressive)

185. (b) $M = 2.25$ t.m
$= 2.25 \times 1000 \times 100 = 225000$ kg.cm

$$I = \frac{15 \times 30^3}{12} = 33750 \text{ cm}^4$$

$$y = \frac{30}{2} = 15 \text{ cm}$$

$$\frac{M}{I} = \frac{f}{y} \qquad \therefore \quad \frac{225000}{33750} = \frac{f}{15}$$

$$f = 100 \text{ kg/cm}^2$$

186. (b) $\tau_{ave} = \frac{F}{A} = \frac{F}{\frac{\pi}{4} \times d^2} = \frac{4F}{\pi d^2}$

For circular section,

$$\tau_{max} = \frac{4}{3}\tau_{ave}$$

$$= \frac{4}{3} \times \frac{4F}{\pi d^2} = \frac{16F}{3\pi d^2}$$

190. (d) For gradual load, $u = \frac{\sigma^2}{2E} \times v$

for sudden load, $u = \frac{(2\sigma)^2 \times v}{2E}$

$$= \frac{4\sigma^2 \times v}{2E}$$

192. (d) $U_1 = \frac{1}{2} \times P_1 \times \text{elongation}$

$$= \frac{1}{2} \times P_1 \times \frac{P_1 L}{AE} = \frac{P_1^2 L}{2AE}$$

Similarly, $U_2 = \frac{P_2^2 L}{2AE}$

$$\therefore \quad U_1 + U_2 = \frac{L}{2AE}\left(P_1^2 + P_2^2\right) \quad \text{... (i)}$$

Now,

$$U = \frac{1}{2} \times (P_1 + P_2) \times \frac{(P_1 + P_2) L}{AE}$$

$$= \frac{1}{2}\frac{(P_1 + P_2)^2 L}{AE} = \frac{L}{2AE} \times \left(P_1^2 + P_2^2 + 2P_1P_2\right) \quad \text{... (iii)}$$

$$\therefore \quad U > U_1 + U_2$$

201. (c) $f = \frac{pd}{2t}$

$$9000 = \frac{500 \times 0.6}{2t}$$

$\therefore$ t = 0.0166 m = 16.7 mm $\simeq$ 17 mm

202. (a) $f_1 = \frac{pd}{2t} = \frac{(0.7) \times 1000}{2 \times 25}$ = 14 N/mm² (MPa)

p = 700 kPa = 700 kN/m² = 0.7 N/mm²

212. (c) For a shaft P $\propto$ T

shaft A , $T_1 = \frac{\pi}{16} \times \tau \times D^3$

Shaft B, $T_2 = \frac{\pi}{16} \times \tau \times (2D)^3$

$$= \frac{\pi}{16} \times \tau \times D^3 \times 8$$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2} = \frac{1}{8}$$

213. (a) For hollow shaft

$$T_1 = \frac{\pi}{16} \times \tau \times \frac{(D^4 - d^4)}{D} = \frac{\pi}{16} \times \tau \frac{((2d)^4 - d^4)}{2d}$$

$$= \frac{\pi}{16} \times \tau \times \frac{15d^4}{2d}$$

$$= \frac{\pi}{16} \times \tau \times d^3 \times \frac{15}{2} \quad \text{... (i)}$$

For solid shaft,

$$T_2 = \frac{\pi}{16} \times \tau \times D^3$$

$$= \frac{\pi}{16} \times \tau \times (2d)^3 = \frac{\pi}{16} \times \tau \times d^3 \times 8 \quad \text{... (ii)}$$

$$\therefore \quad \frac{T_1}{T_2} = \frac{15}{2 \times 8} = \frac{15}{16}$$

214. (a) bending stress $\sigma = \frac{32\,M}{\pi D^3}$

shear stress $\tau = \frac{16T}{\pi D^3}$

Since, $\sigma = \tau$

$$\frac{32M}{\pi D^3} = \frac{16T}{\pi D^3} \qquad \therefore \qquad M = \frac{T}{2}$$

216. (d) $\frac{\tau}{r} = \frac{G\theta}{l}$

$$\frac{1000}{r} = \frac{0.8 \times 10^6 \times 1 \times \pi}{120 \times 180}$$

$$\therefore \qquad r = \frac{27}{\pi}$$

224. (c) Taking moment @ A

$R_B \times L = w \times L \times L$

$\therefore$ $R_B = wL$

$\therefore$ $R_A = \text{Total load} - R_B$

$= wL - wL = 0$

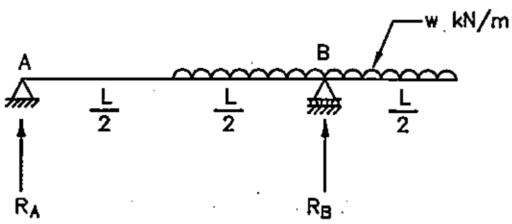


FIG. A–224

233. (b) For cantilever beam, $M = \frac{wl^2}{2}$

For simpli supported beam, $M = \frac{wl^2}{8}$

$$f = \frac{M}{Z} \qquad \therefore \qquad f \propto M$$

234. (c) For circular section, $f = \frac{M}{Z} = \frac{M}{\frac{\pi}{32}D^3} = \frac{19.18\,M}{D^3}$

For square section, $f = \frac{M}{Z} = \frac{M}{\frac{D\,D^2}{6}} = \frac{6\,M}{D^3}$

235. (c)

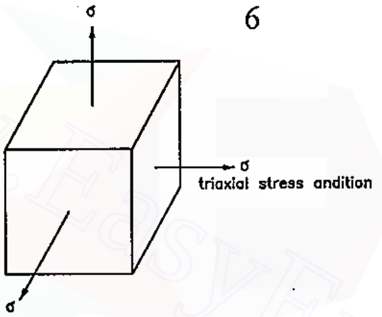


FIG. A–235

237. (b) For simply supported beam, $\delta = \frac{Wl^3}{48\,EI}$

For fixed beam, $\delta = \frac{Wl^3}{192\,EI}$

242. (b)

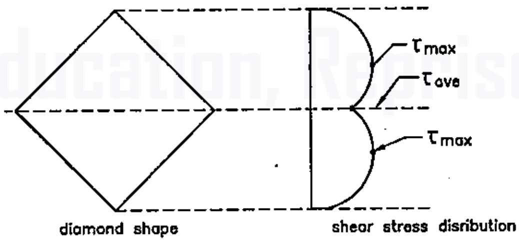


FIG. A–242

245. (b)

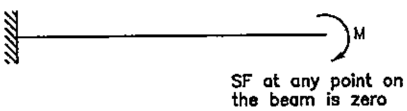


FIG. A–245

SF at any point on the beam is zero.

246. (c) $R_B \times L = W \times \frac{L}{3}$ $\therefore R_B = \frac{W}{3}$

$\therefore M_c = \frac{W}{3} \times \frac{2L}{3} = \frac{2WL}{9}$

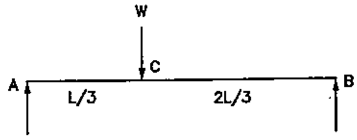


FIG. A–246

249. (d) $P_E = \frac{\pi^2 EI}{(l_e)^2}$ $I_1 = \frac{b.d^3}{12} = \frac{b^4}{12}$

$I_2 = \frac{(2b)^4}{12} = \frac{16b^4}{12}$

252. (a)

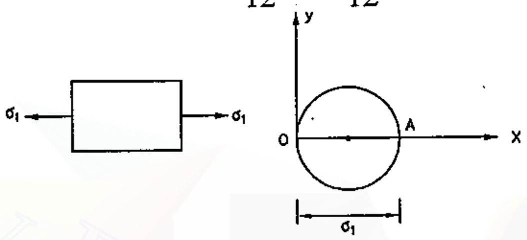


FIG. A–252

253. (c) $T_e = \sqrt{M^2 + T^2}$

$= \sqrt{3^2 + 4^2}$

$= 5$ kN.m

255. (a)

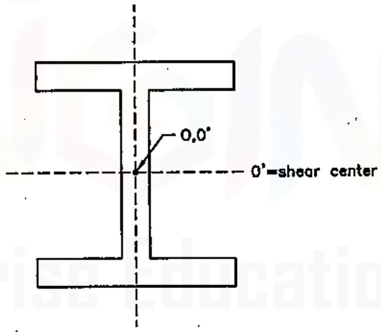


FIG. A–255

256. (a)

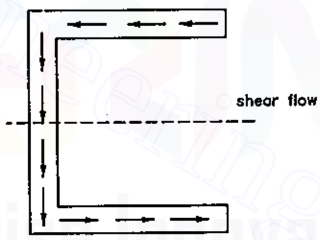


FIG. A–256

257. (c) For circular section

$e_{lim} = \frac{d}{8}$

$\therefore$ dia. of core $= 2 \times \frac{d}{8} = \frac{d}{4}$

258. (b) For thin spherical shell

radial stress = circumferential stress

$= \frac{pd}{4t}$

261. (a)

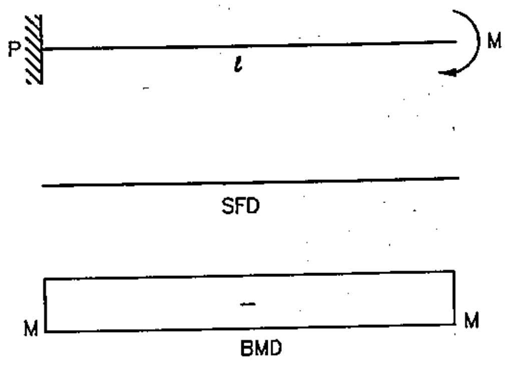


FIG. A–261

263. (b)

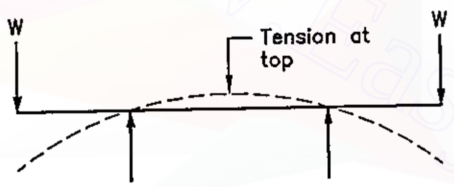


FIG. A–263

265. (b)

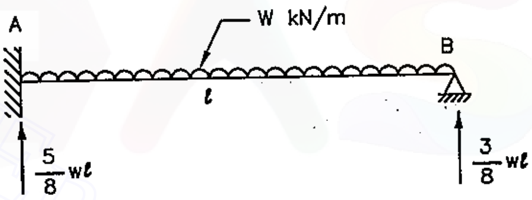


FIG. A–265

266. (c) $\theta_c = \dfrac{M(L/2)}{EI} + \dfrac{M(L/2)}{E\frac{I}{2}}$

$= \dfrac{ML}{2EI} + \dfrac{ML}{EI}$

$= \dfrac{3ML}{2EI}$

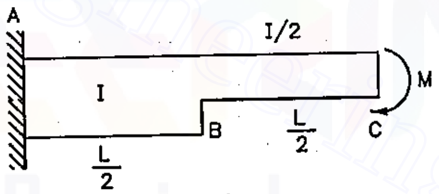


Fig. A-266

267. (d)

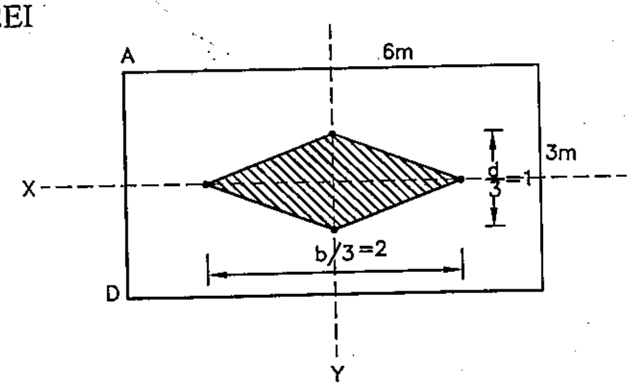


FIG. A–267

❖❖❖

1. The load on a spring per unit deflection, is called

(a) stiffness (b) Proof resilience (c) Proof stress (d) Proof load

2. At yield point of a test specimen, the material

(a) Obey's Hook's law (b) behaves in an elastic manner

(c) regains its original shape (d) undergoes plastic deformation

3. Slenderness ratio of long column is

(a) area of cross section divided by radius of gyration

(b) area of cross section divided by least radius of gyration

(c) radius of gyration divided by area of cross section

(d) length of column divided by least radius of gyration.

4. The greatest eccentricity which a load W can have without producing tension on the cross section of a short column of external diameter D and internal diameter d, is

(a) $\frac{4W}{\pi\left(D^2-d^2\right)}$ (b) $\frac{\pi\left(D^4-d^4\right)}{32\,D}$ (c) $\frac{D^2+d^2}{8D}$ (d) $\frac{D^2-d^2}{8D}$

Explanation :

4. (c) $e_{max}=\frac{Z}{A}$ $\quad Z=\frac{I}{y_{max}}=\frac{\pi}{64}\frac{\left(D^4-d^4\right)}{D/2}$

$$=\frac{\pi}{32\,D}\left(D^4-d^4\right)$$

$$A=\frac{\pi}{4}\left(D^2-d^2\right)$$

$$\therefore \quad e_{max}=\frac{Z}{A}=\frac{\frac{\pi}{32D}\left(D^4-d^4\right)}{\frac{\pi}{4}\left(D^2-d^2\right)}=\frac{1}{8D}\frac{\left(D^2+d^2\right)\left(D^2-d^2\right)}{\left(D^2-d^2\right)}$$

$$=\frac{\left(D^2+d^2\right)}{8D}$$

5. Stress may be expressed in

(a) N/mm^2 (b) N/cm^2 (c) N/m^2 (d) None of the above

6. For a beam of uniform strength if breadth is constant

(a) depth d α $\sqrt{M}$ (b) depth d α M (c) depth d α $3\sqrt{M}$ (d) depth d α $\frac{1}{M}$

7. A beam is said to be of uniform strength if

(a) The shear stress is constant throughout the beam

(b) The extreme fibre stress is the same at every section

(c) bending moment is constant throughout the length of the beam

(d) deflection is the same throughout the length of the beam.

8. The middle third rule applies to the retaining wall for its stability against

(a) Sliding (b) tension (c) Overturning (d) all of the above

9. When a body is in equilibrium undergoes an infinitely small displacement, work imagined to be done is known as

(a) imaginary work (b) negative work (c) Virtual work (d) none of these

10. The effect of number of loads applied simultaneously is the sum of the effect of each load. This statement is the principle of

(a) Superposition (b) complementary load
(c) reciprocal theorem (b) transmissibility

11. The angle of obliquity ϕ, the normal stress σ_n and the tangential shear stress σ_t are related to an oblique plane of an element. The resultant stress σ_r is expressed by :

(a) $\sigma_r = \sigma n^2 + \sigma t^2$ (b) $\sigma_r = \sqrt{\sigma n^2 + \sigma t^2}$ (c) $\sigma_r = \sigma n + \sigma t$ (d) $\sigma_r^2 = \sqrt{\sigma n^2 + \sigma t^2}$

12. For an element in pure shear, principle planes are oriented at

(a) 45° (b) 90° (c) 75° (d) 50°

Explanation :

12. (a) $\tan 2\alpha_1 = \dfrac{2\tau}{\sigma_1 - \sigma_2} = \dfrac{2\tau}{0} = \infty$

$2\alpha_1 = \tan^{-1}\infty$

$= 90° \quad \therefore \ \alpha_1 = 45°$

13. The amount of energy absorbed by the material under impact load is known as

(a) Durability (b) Toughness (c) Ductility (d) Hardness

14. Resistance of a material against reversel of stresses is

(a) tensile strength (b) compressive strength
(c) fatigue strength (d) damping

15. $P = \dfrac{\pi^2 EI}{4L^2}$ is the equation of Euler's crippling load, if

(a) both ends are fixed
(b) both ends are hinged.
(c) one end is fixed and other end is free
(d) one end is fixed and other end is hinged.

Explanation : 15 (c) $P = \dfrac{\pi^2 EI}{le^2} = \dfrac{\pi^2 EI}{(2L)^2} = \dfrac{\pi^2 EI}{4L^2}$

For one end fixed, other free, $le = 2L$

16. Wrough iron contains carbon about

(a) 0.25% (b) 12% (c) 10% (d) 8 %

3.

Structural Analysis

1. **For a perfect truss with j is the number of joints and m is the number of member,**
   (a) $m = 2j - 3$ (b) $m > 2j - 3$ (c) $m < 2j - 3$ (d) $j = 2m - 3$
2. **A truss is said to be deficient if**
   (a) $m = 2j - 3$ (b) $m > 2j - 3$ (c) $m < 2j - 3$ (d) $j = 2m - 3$
3. **A framed structure of a triangular shape is**
   (a) Perfect (b) imperfect (c) deficient (d) redundant
4. **A redundant frame/truss is also called**
   (a) Perfect (b) imperfect (c) deficient (d) none of these
5. **In the analysis of truss the incorrect assumption is,**
   (a) all the joints are pinned joints.
   (b) External forces are acting at the joint only.
   (c) Members are subjected to transverse loads.
   (d) Self weight of the member is neglected.
6. **In a cantilever truss it is very essential to find out the reactions before analyzing it.**
   (a) Agree (b) disagree
7. **The force in member PQ of the truss PQR is**

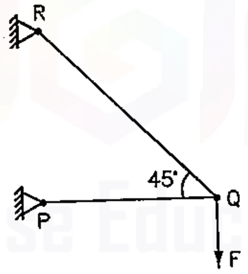


FIG. Q–7

   (a) F (compression)
   (b) $F\sqrt{2}$ (Compression)
   (c) F (tension)
   (d) $F/\sqrt{2}$ (tension)
8. **In the truss shown in figure the forces in members AB and BC will be respectively (plus denotes tension)**
   (a) zero, zero
   (b) $-W/\cos 60°$, $+ W \cos 60°$
   (c) $- W/\cos 60°$, zero
   (d) zero, $+ W \cos 60°$

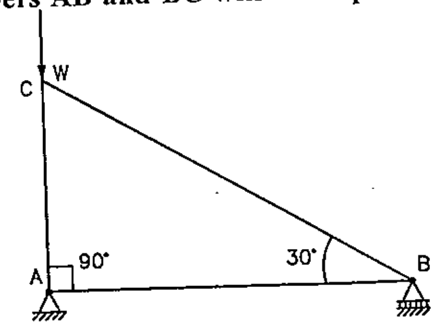


FIG. Q–8

17. For a rectangular foundation of width b, eccentricity of load should note exceed

(a) $b/_2$ (b) $b/_3$ (c) $b/_4$ (d) $b/_6$

18. Two principal planes are located at an angle of

(a) 180° (b) 45° (c) 90° (d) 135°

19. When two equal opposite forces applied to a body tend to elongate it, the stress so produced is called

(a) shear stress (b) compressive stress
(c) tensile stress (d) transverse stress

20. The relationship between bulk modulus K, modulus of elasicity E and modulus of rigidity G is

(a) $E = \frac{6KG}{(2K+G)}$ (b) $E = \frac{9KG}{(2K-G)}$ (c) $E = \frac{6KG}{(3K-G)}$ (d) $E = \frac{9KG}{(3K+G)}$

21. The centre of gravity of the solid hemisphere of radius r is located from the flat base of hemisphere along the centreline at a distance of

(a) $\frac{r}{2}$ (b) $\frac{3r}{8}$ (c) $\frac{4r}{3\pi}$ (d) $\frac{4r}{5}$

22. The magnitude of shear stress due to shear force F on a rectangular section of area A at the neutral axis is

(a) $\frac{3F}{2A}$ (b) $\frac{F}{2A}$ (c) $\frac{2F}{3A}$ (d) $\frac{2F}{A}$

23. Moment of inertia of uniform circular disc about any of its diameter is (d = 2r, mass = m)

(a) Mr^2 (b) $\frac{Mr^2}{2}$ (c) $\frac{Mr^2}{12}$ (d) $\frac{Mr^2}{4}$

Explanation : 23. (d) M.I. about diameter = $\frac{Mr^2}{4}$

M.I. perpendicular to plane = $\frac{Mr^2}{2}$

: ANSWERS :

1.	(a)	2.	(d)	3.	(d)	4.	(c)	5.	(a)
6.	(b)	7.	(b)	8.	(b)	9.	(c)	10.	(a)
11.	(b)	12.	(a)	13.	(b)	14.	(c)	15.	(c)
16.	(a)	17.	(d)	18.	(c)	19.	(c)	20.	(d)
21.	(b)	22.	(a)	23.	(d)				

9. The pin jointed frame shown in fig. is

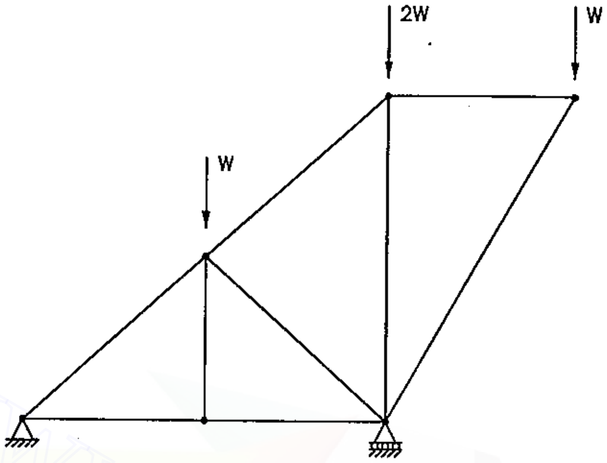


FIG. Q–9

(a) perfect frame

(b) redundant frame

(c) deficient frame

(d) none of these

10. The force in member BD is,

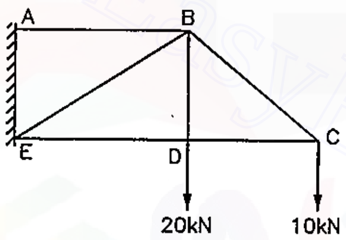


FIG. Q–10

(a) 20 kN (comp.)

(b) 20 kN (Tension

(c) 30 kN (tension)

(d) zero

11. A pin jointed cantilever truss is shown in fig. The force in member ED is,

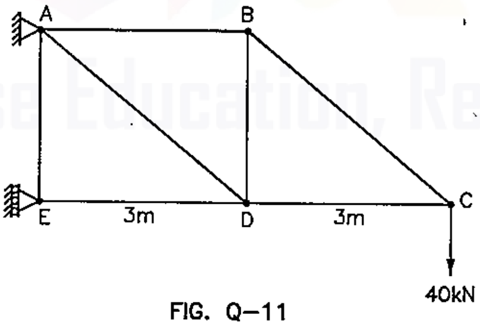


FIG. Q–11

(a) 40 kN (C)

(b) 80 kN (T)

(c) 80 kN (C)

(d) 120 kN (C)

12. Force in member BC of the truss shown in fig. is (Civil / services)

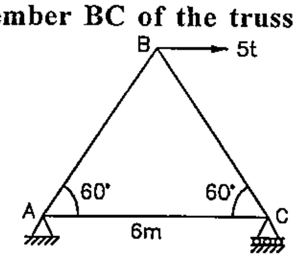


FIG. Q–12

(a) 5 t, tensile

(b) zero

(c) 2.88 t, compressive

(d) 5 t, compressive

13. A truss is shown in fig. below. The cross sectional area of each member is 'A' and modulus of elasticity of the material is 'E'. The strain energy in the member 'XY' is given by (IES)

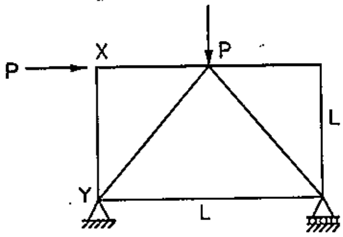


FIG. Q–13

(a) $\frac{P^2L}{2AE}$ (b) $\frac{P^2L}{6AE}$

(c) $\frac{P^2L}{3AE}$ (d) zero

14. A truss is shown in fig. The force in member QR is (GATE 2010)

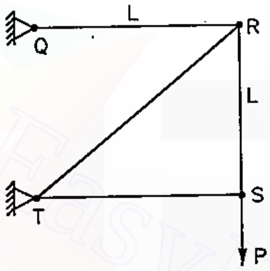


FIG. Q–14

(a) zero

(b) $P/\sqrt{2}$

(c) P

(d) $\sqrt{2}\,P$

15. What is the degree of static indeterminacy of the beam given below ?

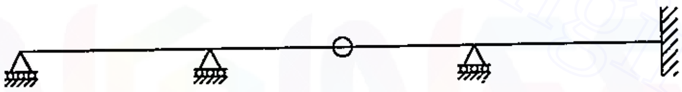


FIG. Q–15

(a) 1 (b) 2

(c) 3 (d) 4

16. What is the degree of static indeterminacy of the beam given below ?

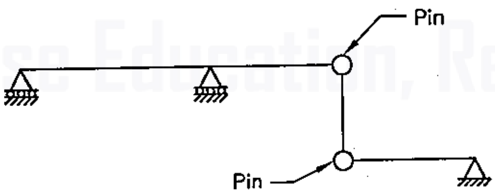


FIG. Q–16

(a) 0

(b) 1

(c) 2

(d) 3

17. What is SI for the truss shown below ?

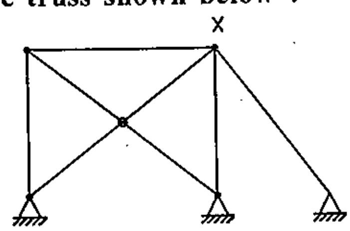


FIG. Q–17

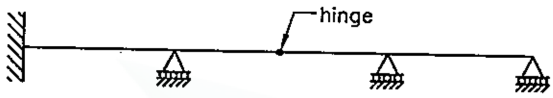
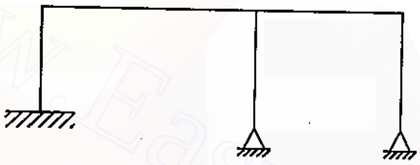
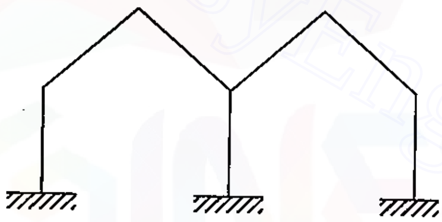
(a) 1

(b) 2

(c) 3

(d) 0

18. Match list I with list II and select correct answer using the codes given below the lists : (Civil Services)

List I (structure)	List II (S.I.)
A. 	1. three
B. 	2. Six
C. 	3. two
D. 	4. Four

Codes :

	A	B	C	D
(a)	1	3	2	4
(b)	3	1	2	4
(c)	3	1	4	2
(d)	1	3	4	2

19. For a plane frame shown in figure below static and kinematic degrees of indeterminacy are respectively, (IES)

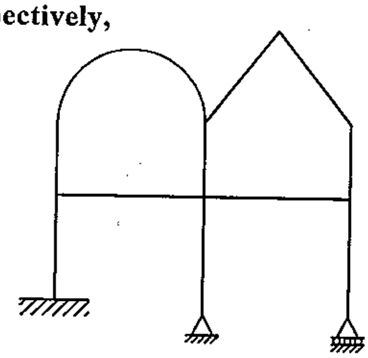


FIG. Q–19

(a) 12 and 27

(b) 12 and 24

(c) 9 and 24

(d) 9 and 27

20. What is degree of kinematic indeterminacy of the frame shown below if axial deformation is neglected ?

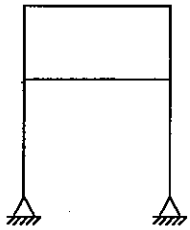


FIG. Q–20

(a) 6

(b) 8

(c) 10

(d) 12

21. What is KI of the beam shown in fig.

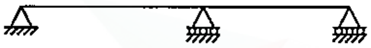


FIG. Q–21

(a) 2 (b) 3

(c) 4 (d) 5

22. The frame shown in fig. has **(Civil Services)**

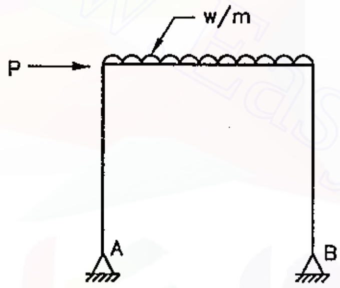


FIG. Q–22

(a) one unknown reaction component

(b) two unknown reaction components

(c) Three unknown reaction components

(d) Six unknown reaction components

23. The degree of static indeterminacy of the rigid frame having two internal hinges as shown in the figure below is **(GATE 2008)**

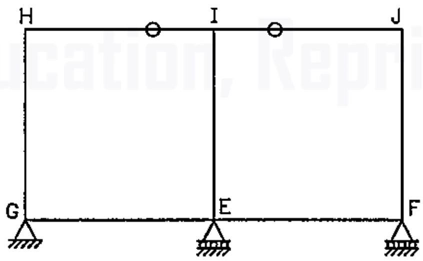


FIG. Q–23

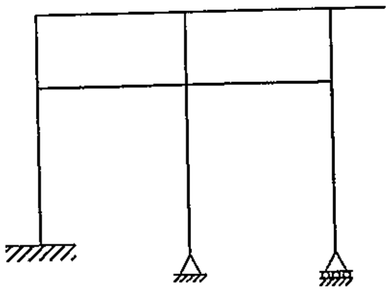
(a) 8

(b) 7

(c) 6

(d) 5

24. For the plane frame with an overhang as shown below, assuming negligible axial deformation, the degree of static indeterminacy d, and the degree of kinematic indeterminacy, k are **(GATE 2004)**



(a) d = 3, d = 10

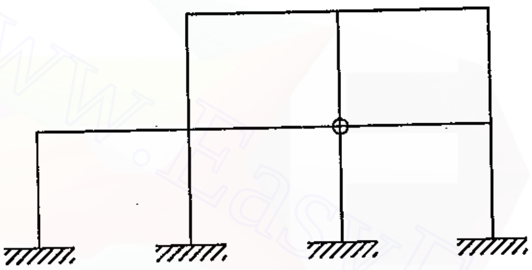
(b) d = 3, k = 13

(c) d = 9, k = 10

(d) d = 9, k = 13

FIG. Q–24

25. **Statical indeterminacy of the given 2D frame is**



(a) 10

(b) 11

(c) 12

(d) 13

FIG. Q–25

26. **The fixed support in a real beam becomes in the conjugate beam a**
    (a) fixed support (b) hinged support (c) roller support (d) free support
27. **The theorem of three moments is applicable only when**
    (a) the beam is prismatic
    (b) the spans are equal
    (c) there is no discontinuity such as hinges within the span
    (d) there are atleast 2 spans
28. **The fixed end of a continuous beam in Clapeyron's equation is replaced by an addition of span of length**
    (a) zero length (b) infinite length
    (c) equal to other span lengths (d) none of the above
29. **The conjugate beam method falls in the category of**
    (a) force method (b) displacement method
    (c) Stiffness method (d) none of these
30. **In the moment area method, the difference in slope between two sections of a beam is equal to the**

(a) area of $\frac{M}{EI}$ diagram between these two sections.

(b) moment of $\frac{M}{EI}$ diagram between these two sections.

(c) $\frac{1}{2} \times$ area of $\frac{M}{EI}$ diagram between these two sections.

(d) $\frac{1}{2} \times$ moment of $\frac{M}{EI}$ diagram between these two sections.

31. In the moment area method, the deflection of point A from a tangent at B is equal to

(a) area of $\frac{M}{EI}$ diagram between A and B.

(b) Moment of $\frac{M}{EI}$ diagram between A and B about A.

(c) Moment of $\frac{M}{EI}$ diagram between A and B about B.

(d) $\frac{1}{2} \times$ area of $\frac{M}{EI}$ diagram between A and B.

32. Shear force at any section in a conjugate beam gives .... in the actual beam.

(a) slope (b) deflection (c) curvature (d) none of these

33. Bending moment at any section in a conjugate beam gives .... in the actual beam.

(a) slope (b) deflection (c) curvature (d) none of these

34. The plane frame shown in fig. is

(a) Stable and statically determinate.

(b) Unstable and statically determinate.

(c) Stable and statically indeterminate.

(d) unstable and statically indeterminate.

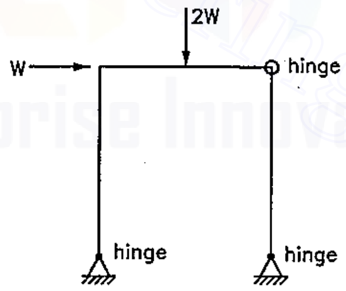


FIG. Q–34

35. The unit load method used in structural analysis is **(GATE 2004)**

(a) applicable only to statically determinate structures.

(b) another name of stiffness method.

(c) an extension of Maxwell's reciprocal theorem.

(d) derived from Castigliano's theorem.

36. **Muller Breslan principle in structural analysis is used for** (GATE 2003)
   (a) drowing influence line diagram for any force function
   (b) writing virtual work equation
   (c) superposition of load effects
   (d) None of the above

37. **Match list I with list II and select the correct answer using the codes given below the lists.** (Gate 2005)

List I	List II
(a) Slope deflection method	1. Force method
(b) Moment distribution method	2. Displacement method
(c) Method of three moments	
(d) Castigliano's second theorem	

Codes :

	A	B	C	D
(a)	1	2	1	2
(b)	1	1	2	2
(c)	2	2	1	1
(d)	2	1	2	1

38. **Castigliano's theorem fall under the category of**
   (a) displacement method (b) equilibrium method
   (c) force method (d) stiffness method

39. **Maximum number of unknown forces that can be determined in concurrent force system under equilibrium is**
   (a) zero (b) 2 (c) 3 (d) 6

40. **Muller Breslan principle for influence line is applicable for**
   (a) simple beam. (b) continuous beam.
   (c) redundant truss . (d) all of these.

41. **Maxwell's reciprocal theorem is valid for all**
   (a) Statically determinate structures.
   (b) Structures.
   (c) Elastic structures.
   (d) Structures with linear force displacement relations.

42. **For a propped cantilever beam with central point load W, B.M. at fixed end is**
   (a) $\frac{Wl}{2}$ (b) $\frac{3}{16}Wl$ (c) $\frac{5}{16}Wl$ (d) $\frac{Wl}{4}$

43. For a propped cantilever beam with u.d.l. on entire span, B.M. at fixed and is

(a) $\frac{wl^2}{2}$ (b) $\frac{wl^2}{4}$ (c) $\frac{wl^2}{8}$ (d) $\frac{wl^2}{12}$

44. Strain energy stored in a bar due to axial load P is

(a) $\frac{P^2L}{AE}$ (b) $\frac{P^2L}{2AE}$ (c) $\frac{PL}{2AE}$ (d) $\frac{P^2L}{4AE}$

45. The equation for strain energy due to bending is given by

(a) $U = \int_0^L \frac{M^2L}{2EI} \cdot dx$ (b) $U = \int_0^L \frac{M^2}{EI} dx$ (c) $U = \int_0^L \frac{M^2}{2EI} dx$ (d) $U = \int_0^L \frac{M}{2EI} dx$

46. According to Castigliano's first theorem partial derivative of strain energy U w.r.t. force P will give

(a) slope (b) deflection (c) moment (d) Shear force

47. According to Castigliano's first theorem partial derivative of strain energy U w.r.t. moment M will give

(a) slope (b) deflection (c) Shear force (d) curvature

48. The fictitious method of finding slope and deflection of beam is

(a) unit load method. (b) Castigliano's first theorem.
(c) castigliano's second theorem. (d) consistent deformation method.

49. The principal of least work is

(a) Castigliano's first theorem (b) Castigliano's second theorem
(c) principle of superposition (d) Muller Breslan principle

50. Fixed end moment for a beam with uniformly distributed load on entire span is

(a) $\frac{wl^2}{8}$ (b) $\frac{wl^2}{12}$ (c) $\frac{wl^2}{16}$ (d) $\frac{wl^2}{24}$

51. For a beam loaded as shown in fig. fixed end moment at A is

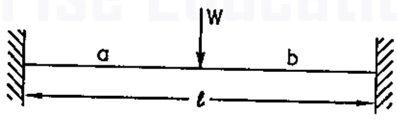


FIG. Q–51

(a) $\frac{Wab}{l}$ (b) $\frac{Wab^2}{l^2}$ (c) $\frac{Wba^2}{l^2}$ (d) $\frac{Wa^2b^2}{l^2}$

52. For a beam loaded as shown in fig. fixed end moment at B is

(a) $\frac{wl^2}{12}$ (b) $\frac{wl^2}{20}$ (c) $\frac{wl^2}{30}$ (d) $\frac{wl^2}{24}$

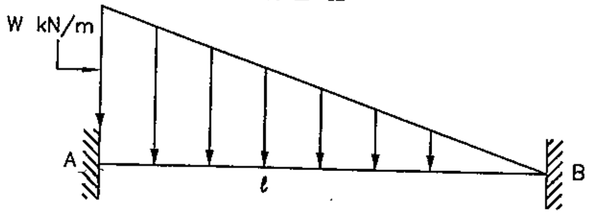


FIG. Q–52

53. For a fixed beam with central point load fixed end moment at each end will be

(a) $\frac{Wl}{4}$ (b) $\frac{Wl^2}{4}$ (c) $\frac{Wl^2}{8}$ (d) $\frac{Wl}{8}$

54. At the fixed end support slope will be

(a) zero (b) maximum (c) minimum

55. Moment required to produce unit rotation is called

(a) Flexibility (b) stiffness (c) rigidity (d) none of these

56. The stiffness value k, for a beam with far end fixed is

(a) $\frac{2EI}{L}$ (b) $\frac{3EI}{L}$ (c) $\frac{4EI}{L}$ (d) $\frac{6EI}{L}$

57. The stiffness value k, for a beam with far end simple is

(a) $\frac{2EI}{L}$ (b) $\frac{3EI}{L}$ (c) $\frac{4EI}{L}$ (d) $\frac{6EI}{L}$

58. For a beam with far end fixed, carry over moment will be

(a) $\frac{2EI}{L}$ (b) $\frac{3EI}{L}$ (c) $\frac{4EI}{L}$ (d) $\frac{6EI}{L}$

59. The distribution factor for member OB shown in fig. is

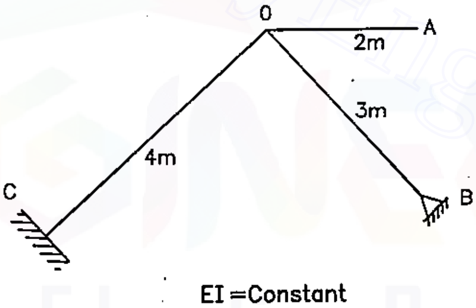


FIG. Q–59

(a) 1

(b) 0.33

(c) 0.5

(d) 0

60. A moment of 6 kN–m is acting at joint O. The relative stiffness of member OA, OB, OC are $\frac{1}{6}, \frac{1}{3}$ and $\frac{1}{2}$ respectively, the moment resisted by member OB is

(a) 1.0 kN.m

(b) 2 kN.m

(c) 3 kN.m

(d) 4 kN.m

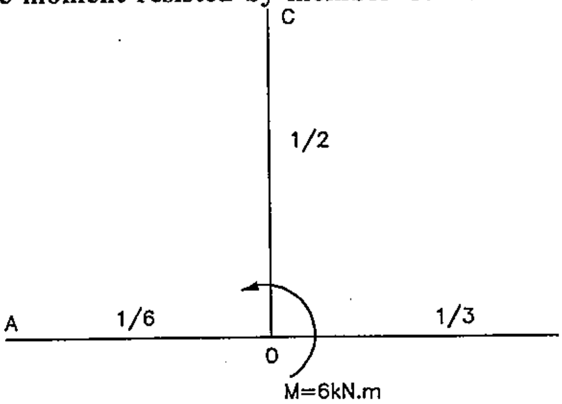


FIG. Q–60

61. Fixed end moment M_{fAB} for a given beam is

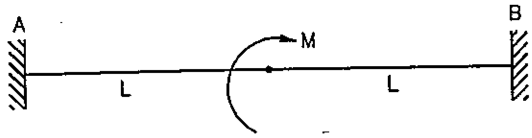


FIG. Q–61

(a) zero (b) $\frac{M}{2}$ (c) $\frac{M}{4}$ (d) $\frac{M}{8}$

62. If a moment M is applied to the hinged end of a prismatic propped cantilever beam, then moment at the fixed end will be

(a) M (b) $\frac{M}{2}$ (c) $\frac{M}{3}$ (d) $\frac{M}{4}$

63. The sum of distribution factors for moment at any joint is

(a) 0 (b) 0.5 (c) 1.0 (d) 1.5

64. The ratio of stiffness of a beam at the near end when far end is hinged to the stiffness when far end is fixed is

(a) $\frac{1}{2}$ (b) $\frac{3}{4}$ (c) 1 (d) $\frac{4}{3}$

65. Consider the propped cantilever shown in fig. (a) and fixed beam shown in fig. (b). Consider the following statements :

Statement – I : Fixed end moment at A for propped cantilever is 12 t.m

Statement – II : Fixed end moment at A of fixed beam is 6 t.m

of these statements : (Civil Services)

(a) both I and II are false

(b) I is correct but II is false

(c) both I and II are correct

(d) I is false but II is correct

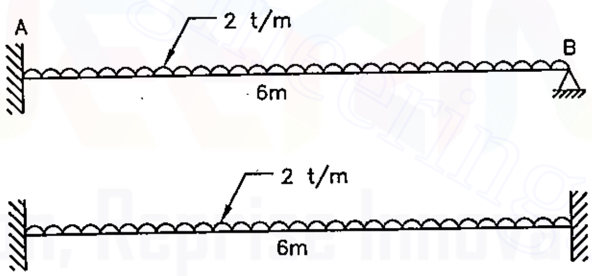


FIG. Q–65

66. A fixed beam AB is subjected to triangular load varying from zero at A to w per unit length at end B. The ratio of fixed end moment at B to A will be (Civil Services)

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{2}{3}$ (d) $\frac{3}{2}$

67. For a fixed beam AB, support B sink by δ downwards. The moment produced at end B will be

(a) $\frac{6EI\delta}{L^2}$ anticlockwise (b) $\frac{6EI\delta}{L^2}$ clockwise

(c) $\frac{12EI\delta}{L^3}$ anticlockwise (d) $\frac{12EI\delta}{L^3}$ clockwise

68. For a propped cantilever beam AB, with end B fixed, sink down by δ. The reaction produced at A will be

(a) $\frac{3EI\delta}{L^3}$ downward (b) $\frac{3EI\delta}{L^3}$ upward (c) $\frac{12EI\delta}{L^3}$ downward (d) $\frac{12EI\delta}{L^3}$ upward

69. For a fixed beam AB, if end B rotate through θ, anticlockwise, reaction at A will be

(a) $\frac{12EI\theta}{L^2}$ upward (b) $\frac{12EI\theta}{L^2}$ downward (c) $\frac{6EI\theta}{L^2}$ upward (d) $\frac{6EI\theta}{L^2}$ downward

70. When a beam is subjected to uniform rise of temperature (t), axial compressive force produced at the ends will be

(a) αtE (b) $\alpha t E A$ (c) $\frac{\alpha tE}{A}$ (d) $\frac{\alpha tA}{E}$

71. The strain energy stored in a simply supported beam of span *l* and subjected to central point load W is

(a) $\frac{W^2 l^3}{48EI}$ (b) $\frac{W^2 l^2}{48EI}$ (c) $\frac{W^2 l^2}{96EI}$ (d) $\frac{W^2 l^3}{96EI}$

72. A steel frame is shown in fig. below. If joint O of the frame is rigid, the rotational stiffness of the frame at point O is given by (IES)

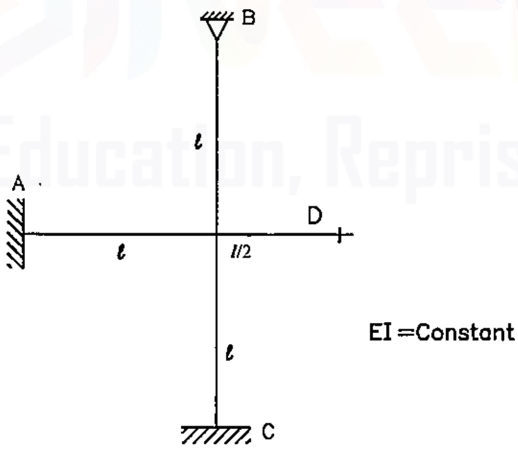


FIG. Q–72

(a) $\frac{11EI}{l}$

(b) $\frac{10EI}{l}$

(c) $\frac{8EI}{l}$

(d) $\frac{6EI}{l}$

73. For the portal frame shown in fig. below the shear equation is (IES)

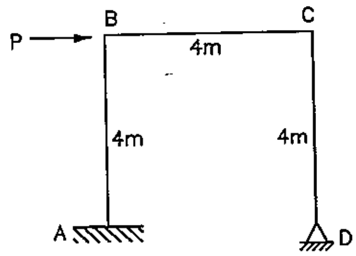


FIG. Q–73

(a) $\frac{M_{BC}+M_{CB}}{4}+P=0$

(b) $\frac{M_{BA}+M_{BC}}{4}+P=0$

(c) $\frac{M_{BA}+M_{BC}}{4}+\frac{M_{CD}}{4}+P=0$

(d) $\frac{M_{CD}}{4}+P=0$

74. A fixed beam of uniform section is carrying a point load at its mid–span. If moment of inertia of the middle half length is now reduced to half its previous value, then fixed end moments will (IES)

(a) increase (b) decrease
(c) remain constant (d) change their direction

75. Due to some point load any where on a fixed beam the maximum free bending moment is M. The sum of fixed end moments is (IES)

(a) M (b) 1.5 M (c) 2.0 M (d) 3.0 M

76. The slope deflection equation at the end B of member BC for the frame shown in fig. below will be (IES)

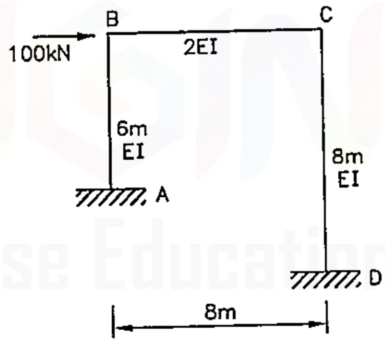


FIG. Q–76

(a) $M_{BC} = \frac{4EI}{8}(2\theta_C - \theta_B)$

(b) $M_{BC} = \frac{4EI}{8}(2\theta_B - \theta_C)$

(c) $M_{BC} = \frac{4EI}{8}(2\theta_B + \theta_C)$

(d) $M_{BC} = \frac{4EI}{8}(\theta_B + \theta_C)$

77. Where the concentrated load 'W' should be kept on simply supported beam AB so that $R_A = 2R_B$?

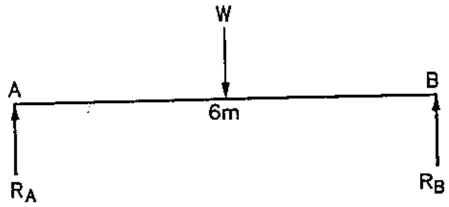


FIG. Q–77

(a) 2 m from A
(b) 1.5 m from A
(c) 1.5 m from B
(d) 2 m from B

78. **The moment distribution method is**

(a) an iterative method (b) an exact method

(c) an approximate method (d) none of these

79. **If M is the external moment which rotates the near end of a prismatic beam without translation, the far end being fixed, then the moment induced at the far end is**

(a) zero (b) $\frac{M}{2}$ in the same direction

(c) $\frac{M}{2}$ in the opposite direction of M (d) None of the above

80. **The portal frame shown below will**

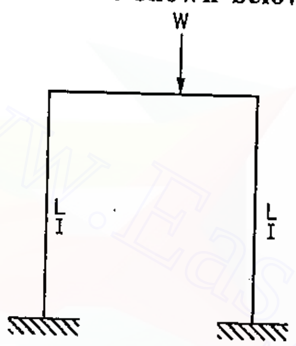


FIG. Q–80

(a) not sway

(b) sway towards left

(c) sway towards right

(d) sway either to left or right

81. **The carry over factor for prismatic member with far end fixed is**

(a) $\frac{-1}{2}$ (b) $\frac{1}{2}$ (c) $\frac{-1}{4}$ (d) $\frac{1}{4}$

82. **All members in the rigid jointed frame are prismatic and have the same flexural stiffness EI. Find the magnitude of the bending moment at Q (in kN–m) due to given loading** **(GATE 2013)**

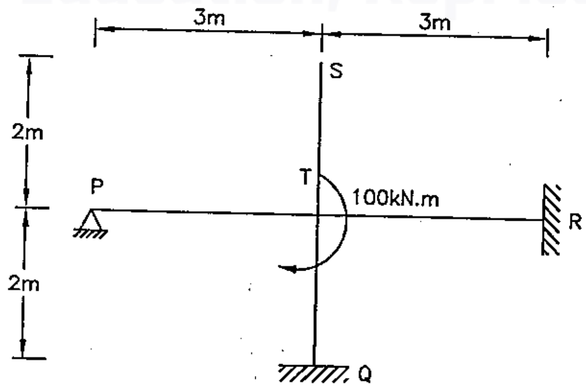


FIG. Q–82

(a) 100 kN.m

(b) 50 kN.m

(c) 25 kN.m

(d) 20 kN.m

83. A three hinged parabolic arch having span l, and central rise r, subjected to u.d.l. on entire span,

(a) horizontal thrust is $\frac{wl^2}{8r}$
(b) S.F. will be zero throughout
(c) B.M. will be zero throughout
(d) all the above

84. A three hinged arch is generally hinged at its supports and

(a) at one quarter span
(b) at the crown
(c) any where in the rib
(d) none of these

85. The equation of parabolic arch of span l and rise r, is given by

(a) $y = \frac{2r}{L^2} x (L - x)$
(b) $y = \frac{4r}{L^2} x (L - x)$
(c) $y = \frac{3r}{L^2} x (L - x)$
(d) $y = \frac{r}{L^2} x (L - x)$

86. In the cable shown in fig. The minimum tension occur at

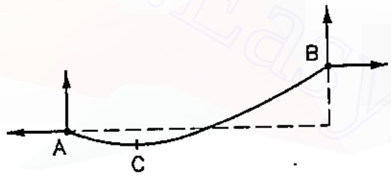


FIG. Q–86

(a) A
(b) B
(c) C
(d) between A and C

87. A three hinged parabolic arch of span 20 m and rise 5 m is loaded as shown in fig. The horizontal thrust H, is

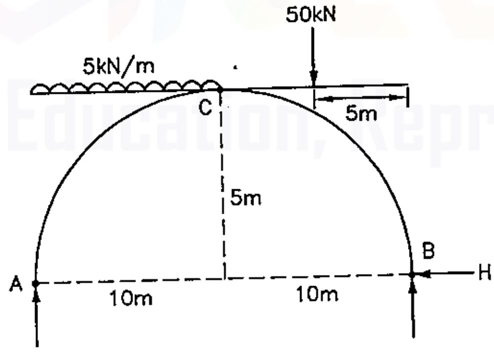


FIG. Q–87

(a) 50 kN
(b) 75 kN
(c) 100 kN
(d) 150 kN

88. A cable of span l and central dip d is subjected to uniform load w per unit horizontal length. The horizontal component of tension in the cable is

(a) $\frac{wl^2}{4d}$
(b) $\frac{wl^2}{8d}$
(c) $\frac{wl^2}{12d}$
(d) $\frac{wl^2}{16d}$

89. Length of parabolic cable of span l and maximum dip d is

(a) $l+\frac{d^2}{3l}$ (b) $l+\frac{4d^2}{3l}$ (c) $l+\frac{8d^2}{3l}$ (d) $l+\frac{16d^2}{3l}$

90. Shape of cable suspended between two points is

(a) parabolic (b) Catenary (c) Circular (d) depends upon loads

91. The cable resists external loads by

(a) tension (b) compression
(c) bending (d) compression and bending

92. The shape of cable under horizontal uniformly distributed load is

(a) parabolic (b) catenary (c) circular (d) triangular

93. An arch resist the external load by

(a) normal thrust (b) normal thrust and B.M.
(c) radial shear and B.M. (d) normal thrust, radial shear and B.M.

94. A line of thrust of a parabolic arch is

(a) Parabolic (b) Funicular polygon (c) triangular (d) circular

95. In case of a simply supported rectangular beam of span L and loaded with a central load W, the length of elasto–plastic zone of the plastic hinge is

(a) $\frac{L}{2}$ (b) $\frac{L}{3}$ (c) $\frac{L}{4}$ (d) $\frac{L}{5}$

96. In plastic analysis, the shape factor for rectangular section is

(a) 1.7 (b) 1.6 (c) 1.5 (d) 1.4

97. In plastic analysis, the shape factor for circular section is

(a) 1.5 (b) 1.6 (c) 1.7 (d) 1.8

98. In plastic analysis, the shape factor for triangular section is

(a) 1.5 (b) 2.34 (c) 1.34 (d) 2.5

99. The shape factor of standard rolled beam section varies from

(a) 1.10 to 1.20 (b) 1.20 to 1.30 (c) 1.30 to 1.40 (d) 1.40 to 1.50

100. Pick up the correct statement from the following

(a) In a loaded beam the moment at which first yield occurs, is called yield moment.
(b) In a loaded beam the moment at which the entire section of the beam becomes fully plastic, is called plastic moment.
(c) In a fully plastic stage of beam, the neutral axis divides the section in to two equal areas.
(d) all the above.

101. The shape factor is the ratio of

(a) Mp and My (b) My and Mp (c) Ze and Zp (d) None of these

102. If Q is load factor, S is shape factor and F is the factor of safety in elastic design, the following is correct.

(a) Q = S + F (b) Q = S – F (c) Q = F – S (d) Q = F × S

103. In the approximate analysis of frames under lateral loads, the point of contraflexure in the beams and columns are assumed at

(a) $\frac{L}{2}$ for beam and $\frac{2}{3}$ H from base for column

(b) $\frac{L}{2}$ for beam and $\frac{H}{3}$ from base for column

(c) $\frac{L}{10}$ for beam and $\frac{H}{2}$ from base for column

(d) $\frac{L}{2}$ for beam and $\frac{H}{2}$ from base for column

104. Moment distribution method is best suited for

(a) Indeterminate pin jointed truss (b) Rigid frames

(c) Space frame (d) Composite structure

105. Total reactions in 3D space frame at fixed end support are

(a) 3 (b) 4 (c) zero (d) 6

106. For a simply supported beam, of span *l* the ordinate for B.M. at distance x from left support is

(a) $\frac{x}{L}$ (b) $\frac{L-x}{L}$ (c) $\frac{x(L-x)}{L}$ (d) x (L – x)

107. B.M. and slope at the end of fixed support of a fixed beam loaded by u.d.l. is .... and .... respectively.

(a) Minimum, zero (b) Maximum, zero (c) zero, maximum (d) zero, minimum

108. STAAD uses .... method of analysis for plate elements.

(a) Finite element method (b) Finite difference method

(c) Stiffness method (d) Flexibility method

109. In a two span continuous beam loaded by UDL, point of contraflexure exist

(a) At mid support (b) In both spans near middle support

(c) near end support (d) At the end support

110. For a fixed beam with span 'L' having plastic moment capacity Mp, the ultimate central concentrated load will be

(a) $\frac{4M_P}{L}$ (b) $\frac{6M_P}{L}$ (c) $\frac{8M_P}{L}$ (d) $\frac{11.7M_P}{L}$

111. For a fixed beam with span 'L' having plastic moment capacity Mp, the total collapse u.d.l. will be

(a) $\frac{6M_P}{L}$ (b) $\frac{8M_P}{L}$ (c) $\frac{12M_P}{L}$ (d) $\frac{16M_P}{L}$

112. For a propped cantilever beam with u.d.l. on entire span, plastic moment capacity will be

(a) $\frac{wl^2}{8}$ (b) $\frac{wl^2}{11.656}$ (c) $\frac{wl^2}{12}$ (d) $\frac{wl^2}{16}$

113. For a simply supported beam of span 16 m, the maximum B.M. at section 4 m from left support, when u.d.l. 2 kN/m longer than span crosses the girder from left to right is

(a) 12 kN.m (b) 24 kN.m (c) 48 kN.m (d) 96 kN.m

: ANSWERS :

1. (a)	2. (c)	3. (a)	4. (b)	5. (c)
6. (b)	7. (a)	8. (a)	9. (a)	10. (b)
11. (c)	12. (d)	13. (d)	14. (c)	15. (b)
16. (a)	17. (b)	18. (d)	19. (c)	20. (b)
21. (d)	22. (d)	23. (d)	24. (d)	25. (c)
26. (d)	27. (c)	28. (a)	29. (a)	30. (a)
31. (b)	32. (a)	33. (b)	34. (a)	35. (d)
36. (a)	37. (c)	38. (c)	39. (c)	40. (d)
41. (d)	42. (b)	43. (c)	44. (b)	45. (c)
46. (b)	47. (a)	48. (b)	49. (b)	50. (b)
51. (b)	52. (c)	53. (d)	54. (a)	55. (b)
56. (c)	57. (b)	58. (a)	59. (c)	60. (b)
61. (c)	62. (b)	63. (c)	64. (b)	65. (d)
66. (d)	67. (a)	68. (b)	69. (c)	70. (b)
71. (d)	72. (a)	73. (c)	74. (a)	75. (a)
76. (c)	77. (a)	78. (a)	79. (b)	80. (c)
81. (b)	82. (c)	83. (d)	84. (b)	85. (b)
86. (c)	87. (a)	88. (b)	89. (c)	90. (d)
91. (a)	92. (a)	93. (d)	94. (b)	95. (b)
96. (c)	97. (c)	98. (b)	99. (a)	100. (d)
101. (a)	102. (d)	103. (d)	104. (b)	105. (d)
106. (c)	107. (b)	108. (a)	109. (b)	110. (c)
111. (d)	112. (b)	113. (c)		

EXPLANATIONS

7. (a) At joint Q,

$\Sigma V = 0,$

$\therefore \quad F = RQ \sin 45° = \frac{RQ}{\sqrt{2}} \qquad \therefore \quad RQ = \sqrt{2}\ F$

$\Sigma H = 0,$

$RQ \cos 45° = PQ$

$\sqrt{2} F \times \frac{1}{\sqrt{2}} = PQ \qquad \therefore \quad PQ = F$ (comp.)

8. (a) $V_B = 0$ and $V_A = W$

Joint A : $\Sigma H = 0, \qquad \therefore \quad F_{AB} = 0$

$\Sigma V = 0, \qquad \therefore \quad F_{AC} = W$ (comp.)

Joint B : $\Sigma H = 0,$

$F_{BC} \cos 30° = F_{AB}$

$F_{BC} \cos 30° = 0 \qquad \therefore F_{BC} = 0$

9. (a) $m = 9$

$j = 6 \qquad m = 2j - r$

$r = 3 \qquad = 2 \times 6 - 3$

$= 9 \qquad \therefore$ Perfect frame

10. (b) At joint D,

$\Sigma V = 0, \qquad \therefore F_{BD} = 20$ kN (T)

11. (c) Taking moment @ A

$H_E \times 3 = 40 \times 6$

$\therefore \; H_E = 80$ kN

At joint E, $\Sigma H = 0$

$\therefore F_{ED} = 80$ kN (C)

12. (d) $\tan 60° \; \frac{BD}{3}$

$\therefore \quad BD = 5.196$ m ... vertical height

taking moment @ A,

$R_C \times 6 = 5 \times 5.196$

$R_C = 4.33$ t

at joint C, $\Sigma V = 0,$

$F_{BC} \sin 60° = R_C$

$F_{BC} = \frac{4.33}{\sin 60°} = 5$ t (compressive)

13. (d) Consider Joint x,

$\Sigma V = 0, \quad \therefore F_{xy} = 0$

Since force in member XY is zero,

strain energy is also zero

14. (c) Taking moment @ T

$R_Q \times L = P \times L$

$\therefore \; R_Q = P$

$\therefore$ Force in member QR = P (Tensile)

15. (b) $D_S = SI = (1 + 1 + 1 + 3) - 4$

$= 2$

Internal hinge provide one extra condition

16. (a) $D_S = SI = (2 + 1 + 2) - 5 = 0$

two extra conditions available at each pin

17. (b) $D_{se} = R - r \qquad R = 6$

$= 6 - 4 \qquad r = 3 + 1 = 4$ ... one extra condition at X

$= 2$

$D_{si} = (m + r) - 2j$

$= (8 + 4) - 2 \times 6 \qquad \therefore D_s = D_{se} + D_{si}$

$= 0 \qquad\qquad = 2 + 0 = 2$

18. (d) **For A :** $SI = (3 + 3) - 3 = 3$

For B : $SI = (3 + 1 + 1 + 1) - 4 = 2$

For C : $D_{se} = R - r$

$= 7 - 3 = 4 \qquad \therefore D_s = 4 + 0 = 4$

$D_{si} = 3C = 0$

For D : $D_{se} = R - r$

$= 9 - 3$

$= 6 \qquad \therefore D_s = 6 + 0 = 6$

$D_{si} = 3C = 0$

19. (c) $D_{se} = R - r \qquad D_{si} = 3\,C$

$= (3 + 2 + 1) - 3 \qquad = 3 \times 2$

$= 3 \qquad = 6$

$\therefore D_s = 3 + 6 = 9$

$D_k = 3j - R$

$= 3 \times 10 - 6$

$= 24$

20. (b) $D_k = 3j - R$
$= 3 \times 6 - 4$
$= 14$

$D_{knad} = D_k - m$
$= 14 - 6$
$= 8$

21. (d) $D_k = 3j - R$
$= 3 \times 3 - 4$
$= 5$

22. (d) Six unknown reaction components
R_A, H_A, M_A and R_B, H_B, M_B

23. (d) $D_{se} = R - r$
$D_{se} = 4 - 3 = 1$

$D_{si} = 3C - rr$
$rr = (2 - 1) + (2 - 1) = 2$
$\therefore D_{si} = 3 \times 2 - 2 = 4$

$\therefore D_s = D_{se} + D_{si}$
$= 1 + 4 = 5$

24. (d) $D_{se} = R - r$
$= 6 - 3 = 3$

$D_{si} = 3C$
$= 3 \times 2 = 6$

$\therefore D_s = 3 + 6 = 9$

$D_{knad} = (3j - R) - m$
$= (3 \times 10 - 6) - 11$
$= 13$

axial deformation is neglected

25. (c) $D_{se} = R - r$
$= (12) - 3 = 9$

$D_{si} = 3C - rr$
$= 3 \times 2 - 3$
$= 3$

$rr = 4 - 1 = 3$

$\therefore D_s = 9 + 3 = 12$

34. (a) $D_{se} = R - r$
$= 4 - 4$
$= 0$

$D_{si} = 3C = 0$

$\therefore$ Stable and determinate

59. (c)

Member	k	Σk	$DF = \frac{k}{\Sigma k}$
OA	0		0
OB	$\frac{3EI}{3} = EI$	2EI	0.5
OC	$\frac{4EI}{4} = EI$		0.5

60. (b)

Member	k	Σk	DF = $\frac{k}{\Sigma k}$
OA	1/6		0.166
OB	1/3	1.0	0.333
OC	1/2		0.50

$$M_{OB} = M \times D.F.$$
$$= 6 \times 0.333$$
$$= 2.0 \text{ kN.m}$$

65. (d) For propped cantilever beam

$$M_{fAB} = \frac{wl^2}{8} = \frac{2\times 6^2}{8} = 9 \text{ kN.m}$$

For fixed beam

$$M_{fAB} = \frac{wl^2}{12} = \frac{2\times 6^2}{12} = 6 \text{ kN.m}$$

66. (d)

$$\frac{M_{fBA}}{M_{fAB}} = \frac{wl^2/20}{wl^2/30} = \frac{3}{2}$$

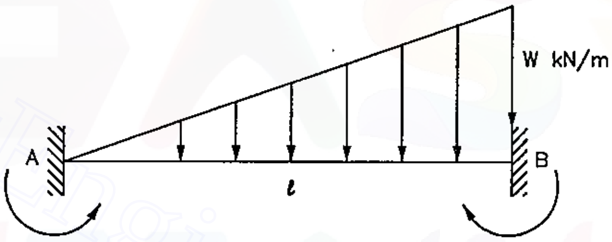


FIG. A–66

67. (a)

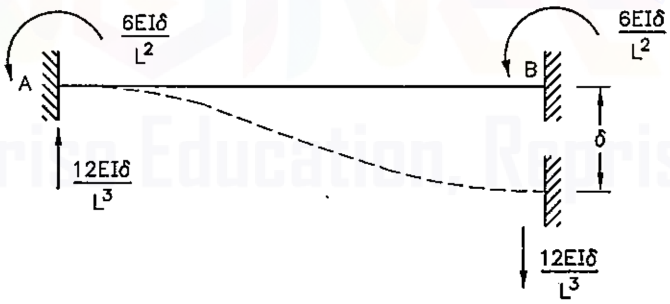


FIG. A–67

68. (b)

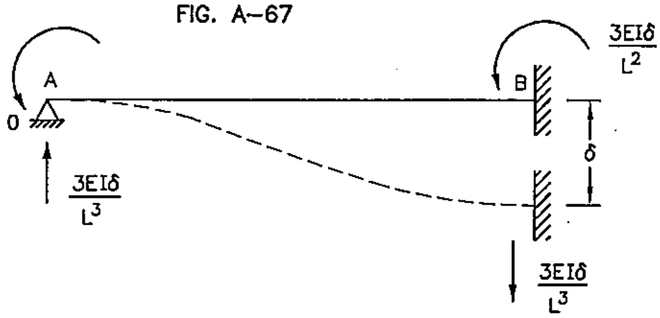


FIG. A–68

69. **(c)**

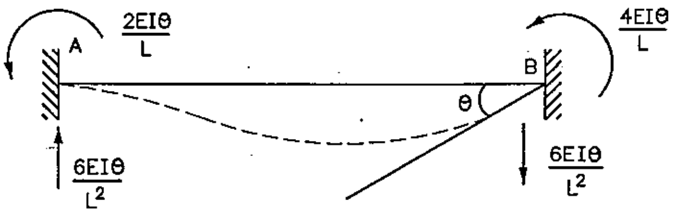


FIG. A–69

71. **(d)** For portion AC

$M_x = \frac{W}{2} . x$

Strain energy stored in AC,

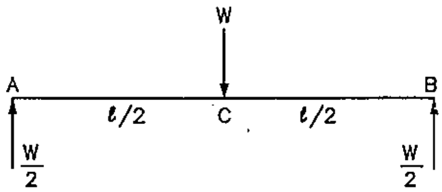


FIG. A–71

$$= \int_0^{l/2} \frac{M^2}{2EI} dx = \int_0^{l/2} \frac{\left(\frac{W}{2}x\right)^2}{2EI} . dx$$

$$= \int_0^{l/2} \frac{W^2x^2}{8EI} dx = \frac{W^2}{8EI}\left[\frac{x^3}{3}\right]_0^{l/2} = \frac{W^2}{8EI}\left[\frac{l^3}{24}\right] = \frac{W^2l^3}{192EI}$$

∴ Total energy stored in entire beam

$$= 2 \times \frac{W^2l^3}{192EI} = \frac{W^2l^3}{96EI}$$

72. **(a)** Total stiffness $= \frac{4EI}{l} + \frac{3EI}{l} + 0 + \frac{4EI}{l}$

$$= \frac{11EI}{l}$$

75. **(a)** Maxi. free B.M. = M = $\frac{Wab}{l}$

Sum of fixed end moments = $\frac{Wab^2}{l^2} + \frac{Wba^2}{l^2}$

$$= \frac{Wab}{l}$$

$$= M$$

76. **(c)** $M_{BC} = M_{fBC} + \frac{2EI}{l}\left(2\theta_B + \theta c - \frac{3\delta}{l}\right)$

$M_{fBC} = 0, \quad \delta = 0$

$$\therefore \quad M_{BC} = \frac{2E(2I)}{8}(2\theta_B + \theta_c) = \frac{4EI}{8}(2\theta_B + \theta c)$$

77. (a) $R_B \times 6 = W.x$ ... (i)

$R_A + R_B = W$

$2R_B \times R_B = W$

$3R_B = W$ ... (ii)

From equation (i)

$R_B \times 6 = 3R_B\, x$

$\therefore \quad x = 2$ m from A

82. (c)

Member	k	Σk	$DF = \frac{k}{\Sigma k}$
TP	$\frac{3EI}{3} = EI$		0.25
TQ	$\frac{4EI}{2} = 2EI$	4EI	0.50
TR	$\frac{4EI}{4} = EI$		0.25

$\therefore \quad M_{TQ} = D.F. \times M$

$= 0.5 \times 100 = 50$ kN.m

$M_{QT} = \frac{50}{2} = 25$ kN.m (half moment is carried over to Q)

87. (a) Taking moment @ A

$V_B \times 20 = (5 \times 10 \times 5) + (50 \times 15)$

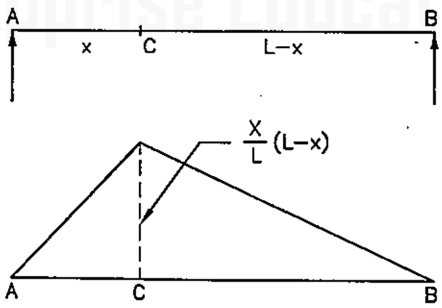
$\therefore \quad V_B = 50$ kN

Taking moment @ C

$V_B \times 10 = 50 \times 5 + H \times 5$

$50 \times 10 = 50 \times 5 + H \times 5$ $\quad \therefore \quad H = 50$ kN

106. (c)



ILD for B.M. at C

FIG. A–106

113. (c) $\therefore$ B.M. maxi = u.d.l. × area of ILD

$= 2 \times \frac{1}{2} \times 16 \times 3$

$= 48$ kN.m

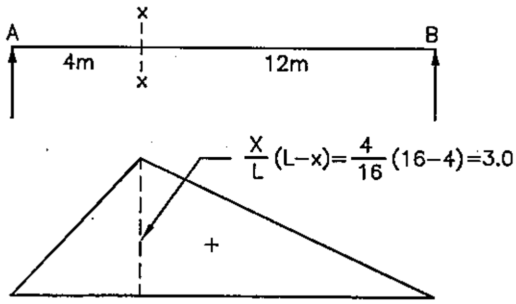


FIG. A–113

❖❖❖

4.

Concrete Technology

• Short Answer Questions

(1) What are the raw materials of OPC ?

A. Raw Materials

- Calcareous Materials
  - Lime Stone
  - Chalk
- Argillaceous Materials
  - Clay
  - Shale

(2) What are the main elements of oxide composition of OPC ?

A. As per IS : 269 – 1989 elements of OPC are :

CaO (Lime) – 60 – 70%

SiO_2 (Silica) – 16 – 25%

Al_2O_3 (Alumina) – 3 – 8%

(3) Give OPC Bogue's compounds and their properties.

A. C_3S – It produces more heat of hydration.
– It is responsible for early strength.

C_2S – It produces less heat of hydration.
– It is responsible for later strength of concrete

C_3A – It causes flash set.
– It does not contribute to the strength of concrete.

C_4AF – It provides resistance to sulphate attack.

(4) What are the different grades of concrete as per IS – 456 – 2000 ?

A. In IS : 456 – 2000, M–10 to M–80 grades of concrete are suggested.

M–7.5 → 1 : 4 : 8

M–10 → 1 : 3 : 6

M–15 → 1 : 2 : 4

M–20 → 1 : 1.5 : 3

M–25 → 1 : 1 : 2

(5) What is M 20 ?

A. M means Mix.

20 means → 15 cm × 15 cm × 15 cm cubes tested after 28 days of curing, compressive strength should not be less than 20 N/mm^2 (MPa).

(6) Why Gypsum is added to cement ?

A. To retard the setting time of cement 2 to 3% Gypsum is added to cement.

(7) Suggest suitable type of cement.

A.

Concrete gravity dam, Retaining wall	– Low heat cement
Marine structures	– Sulphate resisting cement
Road repair, Culverts	– Rapid hardening cement
Waterproofing of dam	– Portland pozzolana cement
Under water construction	– Quick setting cement

(8) How much water is required for full hydration of cement ?

A. 23% water for chemical reaction

\+ 15% to fill up the gel pores

38% water for full hydration of cement.

If less than 38% water is used, hydration will be incomplete. Some of the cement particles will remain dry and strength will be reduced.

If more the 38% water is added, then the excess water will cause undesirable cavities and concrete becomes porous.

(9) What is heat of hydration ?

A. The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat.

The quantity of heat (in joules) per gram of unhydrated cement, evolved upon complete hydration at a given temperature is defined as heat of hydration.

(10) How cement is tested in the field ?

A. (1) Open the bag of cement and take a good look at the cement. There should not be any visible lumps.

(2) The colour of the cement should be greenish grey.

(3) When hand is inserted in cement bag it should give cool feeling.

(4) Take a pinch of cement and feel between the fingers. It should give a smooth feeling and not a gritty feeling.

(5) Take a handful of cement and throw it on a bucket full of water, the particles should float on water for some time before they sink.

(11) Give IS criteria for fineness of cement.

A. Sieve analysis test → Cement retained on 90 μ sieve

For OPC ≯ 10%

For RHC ≯ 5%

Air permeability tests → Specific surface area
For OPC ≮ 2250 cm^2/gm
For RHC ≮ 3250 cm^2/gm

(12) What is consistency of cement paste ?

A. Consistency means degree of fluidity or degree of stiffness or degree of softness.

(13) Explain 'initial and final setting time' of cement.

A. The period elapsing between the time when water is added to the cement and the time at which the cement paste starts losing plasticity is termed as **initial setting time.** For OPC initial setting time should not be less than 30 minutes. During this time period cement paste remains in plastic condition. Various operations in making concrete like mixing, transporting, placing and finishing must be completed within the initial setting time period.

The period elapsing between the time when water is added to the cement and the time at which the cement paste completely loose its plasticity is termed as **final setting time.** For OPC final setting time should not be more than 600 minutes (10 hours).

(14) Give IS criteria for compressive strength of OPC.

	3 days	7 days	28 days (all N/mm²)
A. OPC – 43 grade	23	33	43
OPC – 53 grade	27	37	53

(15) What is 'unsoundness' of cement ?

A. Undesirable expansion of some of the constituents of cement after setting is known as unsoundness.

Unsoundness of cement is due to excess lime, Magnesia or sulphates.

By Le-chatellier apparatus, expansion of cement should not be more than 10 mm.

(16) Give requirement of water for different tests on cement.

A. Initial and final setting time – 0.85 P %

Soundness test – 0.78 P %

Compressive strength of cement – $\left(\frac{P}{4} + 3.0\right)\%$

P = of water for standard consistency

(17) Give list of natural aggregates from different rocks.

A. **Rocks**

↓

Igneous Rocks
- Granite
- Basalt
- Gabbro
- Syenites
- Andesites
- Pegmetites

Sedimentary Rocks
- Sandstone
- Limestone
- Breccia
- Conglomerate
- Shale
- Gypsum

Metamorphic rocks
- Marble
- Slate
- Quartzite
- Gneiss
- Schist
- Pumice
- Scoria

(18) What is 'plum' concrete ?

A. The original idea of the use of aggregate as an inert filler can be extended to the inclusion of large stones up to 300 mm size in a normal concrete; thus the apparent yield of concrete for a given amount of cement is increased. The resulting concrete is called **'plum concrete'** or **'cyclopean concrete'.**

(19) What is maximum size of aggregate in RCC ?

A. (i) Clear cover – 5 mm

(ii) Spacing between Mainbars – 5 mm

(iii) 20 mm

Not more than smaller of three values.

(20) Give different tests on aggregate and their IS criteria.

A.

Tests Name		I. S. Criteria
Aggregate Impact Value	$\ngtr$	30% concrete for Wearing surfaces.
(Passing 2.36 mm Sieve)	$\ngtr$	45% concrete for Buildings.
Aggregate Crushing Value	$\ngtr$	30% concrete for Roads.
(Passing 2.36 mm Sieve)	$\ngtr$	45% concrete for Buildings.
Los Angeles Abrasion Value	$\ngtr$	30% concrete for Roads.
(Passing 1.70 mm Sieve)	$\ngtr$	45% concrete for Buildings.

(21) Give classification of aggregate based on size.

A. **Aggregate**

↓

Coarse Aggregates (C.A.)
Size > 4.75 mm

Fine Aggregates (F.A.)
Size ≤ 4.75 mm

(22) What is bulking of aggregates ?

A. Bulking is the phenomenon of increase in the volume of fine aggregates caused by the presence of free moisture.

Free moisture forms a film around each particle. This film of moisture exerts what is known as surface tension which keeps the neighbouring particles away from it. This causes increase in volume of the mass of fine aggregates.

After addition of certain amount of water in FA, the further addition of water breaks the film around the particles and hence, volume gradually decreases. In CA bulking is negligible.

(23) What is 'alkali-aggregate reaction' ?

A. Normally, aggregates used in concrete are considered as inert materials. But some of the aggregates contains reactive type of silica, which reacts with alkalies present in cement i.e. sodium oxide (Na_2O) and potassium oxide (K_2O). As a result, the alkali silicate gels of unlimited swelling type are formed. This reaction is known as 'alkali aggregate reaction'.

Factors affecting alkali-aggregate reaction are :

- reactive type of aggregate
- High alkali content (more than 0.6%)
- 10 to 38°C temperature
- Availability of moisture
- Fineness of cement particles.

(24) Distinguish between 'good grading' and 'gap grading'.

A. **Good grading :** Aggregate comprising particles of various sizes will give a mass of lesser voids. It is called 'good grading'.

Gap grading : When one or more intermediate size fractions are absent from a particular grading, it is termed as 'gap grading'.

(25) What is fineness modulus ?

A. 'Fineness modulus' is a single factor computed from the sieve analysis, and is defined as the sum of the cumulative percentages of aggregate retained on each of the standard sieves ranging from 80 mm to 150 micron divided by 100.

$\therefore$ Fineness modulus (F.M.) =

$$\frac{\text{Sum of cumulative percentages of Aggregate retained on sieve from 80 mm to 150 micron}}{100}$$

Fineness modulus gives an idea of the mean size of the particles present in the entire body of the aggregate.

F.M. is a measure of coarseness or fineness of the aggregate. The smaller the F.M. value, the finer is the material. The following limits may be taken as guidance.

Sand	F.M.
Fine sand	2.2 – 2.6
Medium sand	2.6 – 2.9
Coarse sand	2.9 – 3.2

(26) Define 'Flakiness index' and 'elongation index'.

A. The flakiness index of aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than 3/5th (0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.

The elongation index of aggregate is the percentage by weight of particles in it whose greatest dimension (length) is greater than 1.8 times their mean dimension. The test is not applicable to size smaller than 6.3 mm.

(27) Give maximum limit of impurities in construction water.

A.

Impurity	Maximum limit
Organic	200 mg/lit.
Inorganic	3000 mg/lit.
Sulphates (as SO_3)	400 mg/lit.
Chlorides (as Cl)	2000 mg/lit. (For PCC) 500 mg/lit. (For RCC)
Suspended Matter	2000 mg/lit.

(28) What is admixtures ?

A. Admixture is defined as a material other than the basic ingredients of concrete cement, aggregates and water, added to the concrete mix immediately before or during mixing to modify some properties of concrete in the fresh or hardened state. They should not adversely affect any property of concrete. Admixtures are no substitute for good concreting practice.

(29) Give list of accelerators and retarders.

A. **Accelerators**
- Calcium chloride
- Sodium nitrate
- Sodium silicate
- Sodium aluminate

Retarders
- Calcium sulphate (gypsum)
- Sugar
- Acids
- Salts, etc.

(30) Give list of air-entraining agents.

A.
- Aluminium Powder
- Hydrogen Peroxide
- Vegetable Oils, Fats
- Alkali Salts

(31) What is Pozzolana ? What are its effects on properties of concrete ?

The pozzolanic materials are essentially a silicious or aluminous materials which itself possessing no cementitious properties, which will, in finely divided form and in the presence of water, react with calcium hydroxide [$Ca(OH)_2$] liberated in the hydration process to form compounds possessing cementitious properties.

Pozzolana
↓

Natural Pozzolana
- Clay
- Shale
- Diatomaceous earth
- Volcanic tuff
- Opaline cherts

Artificial Pozzolana
- Fly ash
- Surkhi
- Blast furnace slag
- Silica fume
- Rice husk ash
- Metakaoline

Effects of Pozzolana :
- Decrease in Permeability
- Increase in workability
- Less heat of hydration
- Less alkali-aggregate reaction
- Decrease in cost

(32) Give importance of w/c ratio.

A. w/c ratio is kept between 0.40 to 0.60.

If w/c ratio is less than 0.40, hydration of cement will be incomplete and strength will be reduced.

If w/c ratio is more than 0.40, excess water will create undesirable capillary cavities and concrete will become porous.

(33) Explain 'Gel space ratio'.

A. $$\text{Gel space Ratio} = \frac{\text{Volume of Gel}}{\text{Space available}}$$

$$= \frac{\text{Volume of hydrated cement paste}}{\text{Volume of hydrated cement + Volume of capillary pores}}$$

(34) What is wokability ?

A. The diverse requirements of partial properties of concrete like mixability, stability, transportability, placeability, mobility, compactibility and finishability are collectiviely referred to as wokability.

Signs of good workability are :
- easy flow
- free from bleeding
- Free from segregation
- homogeneous mix

(35) List factors affecting workability.

A.
(1) Water content
(2) Mix proportions
(3) Size of aggregates
(4) Shape of aggregates
(5) Surface texture of aggregate
(6) Grading of aggregate
(7) Use of admixtures
(8) Time
(9) Temperature

(36) List tests for workability of concrete.

A. – Slump test
– Compacting factor test
– Flow test
– Kelly-ball test
– Vee-Bee consistometer test

(37) Give types of slump.

A. 1. True Slump
2. Shear Slump
3. Collapse Slump

(38) Give relation between compacting factor and workability of concrete.

A. Compacting factors = $\frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$

Workability	Compacting factor
Very Low	0.78
Low	0.85
Medium	0.92
High	0.95

(39) What is segregation ? What are its causes ?

A. Segregation can be defined as separating out of the ingredients of concrete mix, so that the mix is no longer in a homogenous and stable condition.

Causes :

1. Badly proportioned mix
2. Excess water content
3. Insufficient mixing of concrete
4. Dropping concrete from heights
5. Discharging concrete against an obstacle like formwork
6. Conveyance of concrete by wheel borrow, conveyor belts, etc.

(40) What is 'laitance' ?

A. Bleeding water while coming from bottom to top, brings certain quantity of cement to the surface. When the surface is worked up with the trowel and floats, the aggregates goes down and the cement and water come up to the top surface. This formation of cement paste at the surface is known as 'laitance' or 'scum'.

(41) Give methods of transporting concrete.

A. – Mortar Pan
– Wheel Borrow
– Belt Conveyors
– Bucket and Ropeway
– Chute
– Skip & Hoist
– Pumps & Pipeline

(42) Give various methods of curing of concrete.

A. (i) Water curing – Immersion Ponding, Spraying, Wet covering

(ii) Membrane curing

(iii) Application of heat

(iv) Miscellaneous – surface coatings.

(43) What is modular ratio ?

A. Modular ratio $= \dfrac{\text{E for steel}}{\text{E for concrete}}$

$$\therefore \quad m = \frac{E_s}{E_c}$$

where, $E_s = 2 \times 10^5 \text{ N/nm}^2$

$E_c = 5000\sqrt{f_{ck}}$

f_{ck} = grade of concrete in N/mm^2

(44) What is creep ?

A. The increase of strain in concrete with time under sustained (stable) load is termed as creep.

Factors affecting creep :

(1) Aggregate
(2) Water/cement ratio
(3) Age at the time of loading
(4) Moisture content of the concrete
(5) Humidity of the ambient air
(6) Type of cement
(7) Intensity and duration of stress
(8) Size of the specimen
(9) Temperature.

(45) Explain Shrinkage of concrete.

A. With decrease in water content, there is reduction in volume of concrete. It is called Shrinkage.

Types of Shrinkage :

(i) Plastic Shrinkage
(ii) Drying Shrinkage
(iii) Autogenous Shrinkage
(iv) Carbonation Shrinkage.

(46) What is sulphate attack ?

A. Solid salts (sulphates) do not attack concrete, but when present in solution they can react with hardened cement paste. In the hardened concrete, sulphates react with the free calcium hydroxide [Ca $(OH)_2$] to form gypsum (calcium sulphate). Similarly, sulphates react with calcium aluminate hydrate (C–A–H) to form calcium sulphoaluminate, the volume of which is approximately 117% of the volume of the original aluminates. The produce of the reactions, gypsum and calcium sulphoaluminate have a considerably greater volume than the compounds they replace, so that the reactions with the sulphates lead to expansion and disruption of the concrete. Of all the sulphates, magnesium sulphate causes maximum damage to concrete. A characteristic whitish appearance is the indication of sulphate attack.

(1) Use of sulphate resisting cement
(2) Addition of Pozzolana
(3) Quality of concrete
(4) Use of air-entrainment
(5) High-Pressure steam curing
(6) Use of high-alumina cement
(7) Lining of polyethylene sheet

(47) Compare strength obtained by different size of specimens.

A. 15 cm × 15 cm × 15 cm cube – its strength is considered as standard strength.
10 cm × 10 cm × 10 cm cube – strength is reduced by 10%
15 cm dia., 30 cm height cylinder – strength is increased by 20%

(48) Give different methods of testing of hardened concrete.

A.

Destructive Tests	Non-destructive Tests
– Compressive Strength test	– Rebound hammer test
– Flexural strength test	– Penetration & Pull out test
– Tensile Strength test	– Ultrasonic Pulse velocity test
	– Radioactive tests
	– Nuclear tests
	– Acoustic emission tests.

(49) Define the terms.

A. (1) **Mean strength ($\bar{x}$) :**

This is the average strength obtained by dividing the sum of strength of all the cubes by the number of cubes.

$$\therefore \quad \bar{x} = \frac{\sum x_i}{n}$$

where, $\bar{x}$ = mean strength
$\sum x_i$ = sum of strength of all cubes
n = number of cubes.

Mean is a measure of central tendency or tendency of getting grouped about a central value.

(2) Variance :

This is the measure of variability or difference between any single observed data from the mean strength.

$\therefore$ variance $= x_i - \bar{x}$.

(3) Range :

The range is the difference between the largest and the smallest values in a set of observations.

(4) **Standard deviation (s) :**

The standard deviation or root mean square deviation of a set of observations (Population) is defined as :

$$S = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n-1}}$$

where, S = standard deviation
x = particular value of observation
$\bar{x}$ = mean strength
n = no. of cubes.

(50) What is concrete mix design ?

A. Concrete mix design may be defined as the art of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

(51) What are the objectives (purposes) of concrete mix design ?

A. The purpose of concrete mix design is to ensure the most optimum proportions of the constituent materials to fulfill the requirements of the structure being built. Mix design should ensure the following objectives.

(1) To achieve the designed/desired workability in the plastic stage.
(2) To achieve the desired minimum strength in the hardened stage.
(3) To achieve the desired durability in the given environmental conditions.
(4) To produce concrete as economically as possible.

(52) List various methods of concrete mix design.

A. (i) IS Method
(ii) ACI Method
(iii) Road Note No. 4 Method (U.K. Method)
(iv) IRC – 44 Method
(v) F. M. (Fineness Modulus) Method
(vi) Surface Area Method
(vii) Maximum Density Method
(viii) Arbitrary Proportion Method

(53) What is special concrete ?

A. Conventional ordinary concrete has many drawbacks, like,

- Poor tensile strength
- Permeability
- Porosity
- Corrosion of reinforcement
- Less durability

To overcome these drawbacks, concrete with some special characteristics is prepared. It is called special concrete.

(54) List different types of special concrete.

(1) Light weight concrete
(2) High Density concrete
(3) Ready Mixed Concrete (RMC)
(4) Plum concrete
(5) No fines concrete
(6) Aerated concrete
(7) Fibre Reinforced Concrete (FRC)
(8) Polymer concrete
(9) Ferrocement
(10) Fly ash concrete
(11) Pumped concrete

(55) Give types of light weight concrete.

A. – Light Weight Aggregate Concrete
– Aerated Concrete (Foam Concrete)
– No Fine Concrete

(56) Give list of light weight aggregates.

A. **Light Weight Aggregate**

↓

Natural Aggregates
– Pumice
– Scoria
– Rice Husk
– Saw Dust
– Diatomite
– Volcanic Cinders

Artificial Aggregates
– Bloated Clay
– Expanded Shale
– Siutered Flyash
– Foamed Slag

(57) Give advantages of light weight concrete.

A. – Reduction of dead load.
– Smaller sections of structural members can be adopted.
– Lower haulage and handling costs.
– Increase in the progress of work.
– Reduction in foundation costs, particularly in the case of weak soil and tall structures.

(58) How Cellular Concrete or (Foam Concrete) is prepared ?

A. – Producing gas in concrete by chemical reaction
– Adding foam in concrete
– Adding metal powder (Aluminium powder or hydrogen peroxide)

(59) What do you mean by fibre reinforced concrete ?

A. Fibre reinforced concrete (FRC) can be defined as a composite material consisting of concrete and discontinuous, discrete, uniform dispersed fine fibres. The continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres.

(60) Give list of fibres used in fibre reinforced concrete.

A. – Steel
– Carbon
– Glass
– Asbestos
– Polypropelene
– Nylon, etc.

(61) What is polymer concrete ? Give its types.

A. Polymer impregnated concrete is produced by impregnating or infiltrating a hardened Portland cement concrete with a monomer and subsequently polymerizing the monomer in situ. It is one of the widely used polymer composite.

Types of polymer concrete :

(i) Polymer Impregnated Concrete (PIC)
(ii) Polymer Cement Concrete (PCC)
(iii) Polymer Concrete (PC)
(iv) Partially Impregnated and Surface Coated Polymer Concrete.

(62) What are the aggregates used in high density concrete ?

A. Aggregates used in high density concrete :

– Magnetite
– Limonite
– Hematite
– Barytes, etc.

Density of high density concrete ranges from 3400 kg/m^3 to 5500 kg/m^3.

This concrete is used for radian shielding.

(63) What is ferrocement ?

A. Ferro cement is a relatively new material consisting of wire meshes and cement mortar. It consists of closely spaced wire meshes which are impregnated with rich cement mortar mix. While the mortar provides the mass, the wire mesh imparts tensile strength and ductility to the material. The ferro cement possess high resistance against cracking, high fatigue resistance higher toughness and higher impermeability.

(64) What are the applications of ferrocement ?

A. (i) Mobile Homes
(ii) Water tight Structure
(iii) Silos and bins
(iv) Boat hulls
(v) Pipes
(vi) Folded Plates
(vii) Shell roofs, etc.

(65) What is nominal mix ?

A. A concrete mix prepared by using fix proportions, without taking into consideration the properties of constituents of concrete, without any criteria of workability and durability is called nominal mix.

e.g. M 20 – 1 : 1.5 : 3 (nominal mix)

It is used for ordinary concrete.

(66) What is design mix ?

A. The concrete mix produced under quality control, keeping in view the strength, durability and workability is called the design mix. For all important works, concrete mix is designed.

(67) List causes of corrosion of reinforcement steel.

A. (i) presence of cracks in concrete
(ii) presence of moisture
(iii) permeability of concrete
(iv) carbonation
(v) chlorides
(vi) sulphate attack
(vii) alkali aggregate reaction
(viii) inadequate cover to reinforcement.

(68) List remedial measures to prevent corrosion of reinforcement steel.

A. (i) Application of protection coating to steel.
(ii) using concrete of low permeability.
(iii) proper mixing, compaction and curing of concrete.
(iv) providing minimum 20 mm clear cover.
(v) using minimum cement 350 kg/m^3.
(vi) using maximum w/c ratio equal to 0.45
(vii) using PPC cement.

(69) List causes of cracks in concrete.

A. (i) Moisture movent
(ii) Temperature variation
(iii) Plastic Shrinkage
(iv) Creep
(v) Chemical reaction
(vi) Drying Shrinkage
(vii) Weathering

(70) What is 'Shrinkage Crack' ?

A. When moisture evaporates from the surface of freshly placed concrete faster than it is replaced by bleed water, the surface of concrete shrinks. Due to shrinking tensile stress produced in the concrete which causes cracks in the concrete. It is called Shrinkage cracks.

(71) What are the causes of Shrinkage cracks in concrete ?

A. (i) Cement content – Higher the cement content more will be Shrinkage
(ii) Aggregate – More the aggregate content, less will be the Shrinkage
(iii) Temperature – At higher temperature Shrinkage will be more
(iv) Moisture in atmosphere – Lesser the air moisture more will be Shrinkage
(v) Curing – Inadequate curing may increase Shrinkage

(72) List materials used for repair of cracks.

A. (i) Cement Slurry
(ii) Cement mortar
(iii) Epoxy resin
(iv) Polymer resin

(73) List materials used in grouting.

A. For grouting, a mixture of cement + water + Sand is used. Sometimes bentonite clay is also used.

(74) List the methods of application of repair materials.

A. (i) Dry packing

(ii) Concrete replacement

(iii) Mortar replacement

(iv) Grouting

(v) Guniting or Shotcreting

(75) What is 'Guniting' or 'Shotcreting' ?

A. 'Shotcrete' or 'Guniting' is a mortar or a fine concrete that is pneumatically transported through a hose and projected on to a surface at a high velocity. The thickness of layer is small in guiniting while it is thick in shotcreting. In shotcreting small size course aggregate are also used in mortar.

(76) What is full form of PPC, RHC, PSC ?

A. PPC – Portland Pozzolana Cement

RHC – Rapid Hardening Cement

PSC – Portland Slag Cement

(77) What is code number for concrete mix design ?

A. IS : 10262 – 1982

(78) What is standard size of concrete slump mould ?

A. Top diameter – 10 cm

Bottom diameter – 20 cm

Height – 30 cm

❖❖❖

MCQ'S

SET-1

1. **The maximum percentage of chemical ingredient of cement is that of...**
(a) Alumina (b) Silica (c) Magnesium oxide (d) lime
2. **The following material does not belong to calcareous rocks....**
(a) lime stone (b) marl (c) chalk (d) laterite.
3. **Pick up correct proportions of chemical ingredients of ordinary Portland cement.**
(a) lime : silica : Alumina : Iron oxide : : 63 : 22 : 6 : 3
(b) Silica : lime : Alumina : Iron oxide : : 63 : 22 : 6 : 3
(c) Alumina : silica : lime : Iron oxide : : 63 : 22 : 6 : 3
(d) Iron oxide : Alumina : silica : lime : : 63 : 22 : 6 : 3.
4. **Pick up the correct statement from the following.**
(a) Lime in excess, causes the cement to expand and disintegrate.
(b) Silica in excess, causes the cement to set slowly.
(c) Alumina in excess, reduce the strength of cement.
(d) Magnesium oxide in access, remains in free state and causes unsoundness.
(e) all of the above.
5. **Pick up incorrect statement from the following.**
(a) C_3S hydrates rapidly.
(b) C_3S generates more heat of hydration.
(c) C_3S develops early strength.
(d) C_3S has more resistance to sulphate attack.
6. **Pick up incorrect statement from the following.**
Tricalcium aluminate (C_3A)
(a) reacts fast with water
(b) generates less heat of hydration
(c) causes flash setting of cement
(d) does not contribute to develop ultimate strength.
7. **Efflorescence in cement is caused due to an excess of**
(a) Alumina (b) Iron oxide (c) Alkalis (d) Silica.
8. **Pick up incorrect statement from the following.**
Dicalcium silicate (C_2S),

(a) hydrates slowly.
(b) responsible for early strength.
(c) provide more resistance to chemical attack.
(d) generates less heat of hydration.

9. Portland pozzolana cement is used with confidence for,
(a) Dams (b) Abutments (c) Massive foundations
(d) R.C.C. structures (e) All the above.

10. The standard sand nowadays used in India is obtained from,
(a) Jaipur (Rajasthan) (b) Jullandhar (Punjab)
(c) Hyderabad (A.P.) (d) Ennore (Madras)

11. Sand normaly requires a higher w/c ratio belongs to
(a) zone I (b) zone II (c) zone III (d) zone IV

12. Sands of zone I are,
(a) coarse (b) medium (c) fine (d) medium to fine

13. The types of aggregate of same nominal size which contain less voids when compacted are,
(a) Flaky (b) Rounded spherical (c) Irregular (d) Elongated

14. The bulk density of aggregates depends upon
(a) shape (b) grading (c) compaction (d) all of above

15. The bulk density of aggregate is generally expressed as,
(a) tonne/cubic metre (b) kg/cubic metre (c) kg/litre (d) gm/cubic cm.

16. The risk of segregation is more for,
(a) wetter mix (b) coarser grading
(c) large proportion of maximum size of aggregate
(d) all the above.

17. The most useless aggregate is one whose surface texture is
(a) smooth (b) granular (c) glassy (d) honey combed

18. On a grading curve, gap grading is represented by
(a) a horizontal line (b) a vertical line
(c) N-W inclined line (d) N-E inclined line

19. To obtain very high strength concrete, one should use very fine grained,
(a) Magnetite (b) granite (c) Barite (d) volcanic scoria

20. Natural light weight aggregates are obtained from,
(a) Igneous rocks (b) sedimentary rocks
(c) metamorphia rocks (d) volcanic source

21. Saw dust can be rendered chemically inert by boiling it in water containing
(a) Ammonia (b) Potassium chloride (c) Ferrous sulphate (d) Nitric acid

22. For a given water content workability of concrete is good if aggregates used are
(a) rounded (b) irregular (c) angular (d) flaky

23. Pick up the correct statement : An excess of flaky particles in concrete aggregates
(a) Increases the quantity of water and sand. (b) decreases the workability.
(c) affects the durability of concrete. (d) more than 15% are not desirable.
(e) all the above

24. An aggregate which passes through 25 mm IS sieve and is retained on 20 mm IS sieve is said to be flaky if its least dimension is less than,
(a) 22.5 mm (b) 18.5 mm (c) 16.5 mm (d) 13.5 mm

25. A flaky aggregate is said to be elongated if its length is,
(a) equal to the mean size (b) 1.8 times the mean size
(c) thrice the mean size (d) four times the mean size

26. Inert material of a cement concrete mix is
(a) water (b) aggregate (c) cement (d) none of these

27. An aggregate is known as 'cyclopean aggregate' if its size is more than
(a) 20 mm (b) 30 mm (c) 60 mm (d) 75 mm

28. The aggregate containing moisture in pores and having its surface dry, is known as
(a) Dry aggregates (b) moist aggregates
(c) saturated surface dry aggregate (d) very dry aggregate

29. Setting time of cement increases by adding
(a) Gypsum. (b) Calcium chloride. (c) Hydrogen peroxide. (d) Sodium oxide.

30. Which is best accelerator from followings ?
(a) Calcium chloride. (b) Calcium sulphate (Gypsum).
(c) Aluminium powder. (d) Sugars.

31. Commercial brand name Impermo is a
(a) Accelerating admixture. (b) Plasticizer.
(c) Waterproofing admixture. (d) Bonding admixture.

: ANSWERS :

(1) (d);	(2) (d);	(3) (a);	(4) (e);	(5) (d);
(6) (b);	(7) (c);	(8) (b);	(9) (e);	(10) (d);
(11) (a);	(12) (a);	(13) (b);	(14) (d);	(15) (c);
(16) (d);	(17) (c);	(18) (a);	(19) (b);	(20) (d);
(21) (c);	(22) (a);	(23) (e);	(24) (d);	(25) (b);
(26) (b);	(27) (d);	(28) (c);	(29) (a);	(30) (a);
(31) (c).				

SET-2

1. **Pick up the correct statement.**
   (a) Segregation is necessary for a workable concrete.
   (b) Consistency does not affect the workability of concrete.
   (c) If the slump increases, workability decreases.
   (d) If the concrete mix is dry, the slump is maximum.
   (e) None of the above.
2. **If the slump of concrete mix is 60 mm, its workability is**
   (a) very low (b) low (c) medium (d) high
3. **If the compacting factor of concrete mix is 0.88, its workability is**
   (a) very low (b) low (c) medium (d) high
4. **Workability of concrete mix having very low water cement ratio should be ascertained by**
   (a) slump test (b) tensile strength test
   (c) compacting factor test (d) flexural strength test
5. **In slump test, each layer of concrete is compacted by a steel rod 600 mm long and 16 mm diameter for**
   (a) 20 times (b) 25 times (c) 15 times (d) 50 times
6. **Segregation is responsible for,**
   (a) honey combed concrete (b) porous layer in concrete
   (c) surface scaling in concrete (d) sand streaks in concrete
   (e) all the above
7. **Pick up the incorrect statement.**
   (a) An increase in water content must be accompanied by an increase in cement content.
   (b) The slump of concrete mix increases with an increase in temperature.
   (c) Angular and rough aggregates reduce the workability of concrete.
   (d) Large size aggregates increase the workability due to lesser surface area.
8. **The specifications of a cement bag for storage, are**
   (a) weight 50 kg (b) height 18 cm (c) plan area 3000 sq. cm
   (d) volume 35 litres (e) all the above
9. **To prevent segregation, the maximum height for placing concrete is**
   (a) 100 cm (b) 125 cm (c) 150 cm (d) 200 cm
10. **Slump test of concrete is a measure of its**
    (a) compressive strength (b) consistency
    (c) tensile strength (d) impact value

11. **Workability of concrete may be improved by adding**
    (a) fly ash (b) hydrated lime (c) calcium chloride
    (d) bentonite (e) all the above
12. **The cement becomes useless if its absorbed moisture exceeds**
    (a) 1% (b) 2% (c) 3% (d) 5%
13. **Minimum water/cement ratio required for a workable concrete is,**
    (a) 0.30 (b) 0.40 (c) 0.50 (d) 0.60
14. **Grading of aggregate in a concrete mix is necessary to achieve**
    (a) adequate workability (b) higher density
    (c) reduction of voids (d) better durability
15. **Reduction in A/C ratio while keeping w/C ratio constant causes**
    (a) decrease in workability (b) workability is not affected
    (c) increase in workability(d) none of the above
16. **The reasonable slump for mass concrete should be**
    (a) 90 – 180 mm (b) 10 – 30 mm (c) 50 – 75 mm (d) 25 – 50 mm
17. **Workability test most suitable for concrete of very low workability is**
    (a) vee-bee test (b) slump test (c) compaction factor test (d) kelly ball test
18. **Addition of pozzolanas in to concrete mixes improves**
    (a) workability (b) resistance to chemical attack
    (c) both of the above (d) none of the above
19. **For mass concrete works, the degree of workability should be**
    (a) low (b) average (c) high (d) very high
20. **Specific gravity of fly ash falls in the range of**
    (a) 1.0 to 1.6 (b) 1.6 to 1.9 (c) 1.9 to 2.4 (d) 2.4 to 2.8
21. **Portland cement is heavier than water by about,**
    (a) 1.15 times (b) 2.30 times (c) 3.85 times (d) 3.15 times
22. **The phenomenon of bleeding occurs in concrete mix which is**
    (a) lean and wet (b) coarse and wet (c) coarse and dry (d) lean and dry
23. **The capacity of a concrete mixer is expressed in terms of :**
    (a) total volume of concrete produced per day
    (b) total volume of concrete produced in 8 hours
    (c) total volume of concrete produced per hour
    (d) volume of concrete mix handled per batch.
24. **In the batching of materials, the ingredients should be measured to a tolerance (as a percentage of batch quantity) of :**
    (a) ± 1.0 (b) ± 2.0 (c) ± 3.0 (d) ± 5.0

25. A mixer designated 400 NT indicates that

(a) It is a non-tilting type mixer

(b) Its nominal mix batch capacity is 400 litres

(c) both of the above

(d) It is a non-tilting type mixer requiring 400 revolutions for proper mixing.

26. In machine mixing, the recommended minimum mixing time for mixers up to 750 litre capacity reckoned from the time when all the materials have been added is (in minutes)

(a) 1.0 (b) 1.5 (c) 2.0 (d) 5.0

27. While pumping concrete,

(a) care should be taken to reduce the number of bends in the delivery pipe

(b) the pipe should be cleaned immediately after use

(c) initially a 1 : 3 cement sand mortar should be pumped to lubricate the pipe line

(d) all of the above.

28. When concrete is pumped by a pump of 60 h.p. the maximum horizontal distance that can be covered would be,

(a) 150 m (b) 200 m (c) 300 m (d) 400 m.

29. A 90° bend in the pipeline reduces the effective pumping distance by approximately,

(a) 10 m (b) 5 m (c) 3 m (d) 2 m

30. Ready mixed concrete (RMC)

(a) is weigh batched and mixed in a centrally located plant, transported in a truck mixer or agitator and delivered in a condition ready to use

(b) is produced under site conditions

(c) does not require control of all operations of manufacture and transportation of fresh concrete

(d) all of the above

31. The acceleration imposed the particles during compaction of concrete by high frequency vibrations is of the order of,

(a) g to 2g (b) 4g to 7g (c) 7g to 9g (d) none of the above.

32. Which type of vibrator is generally used for compaction of concrete ?

(a) form vibrator (b) needle vibrator (c) surface vibrator (d) screen vibrator

33. For compacting thin reinforced concrete slabs following vibrator is recommended.

(a) Form vibrator (b) Needle vibrator (c) Surface vibrator (d)Vibrating table.

34. Surface vibrator is effectived only when the thickness of concrete member does not exceed,

(a) 100 mm (b) 150 mm (c) 200 mm (d) 500 mm.

35. While using vibrators for compacting concrete mixes

(a) vibrations are used for spreading concrete in the form

(b) vibrations reduce entrained air

(c) prolonged vibrations reduces chances of segregation.

(d) all of the above.

36. Maturity of concrete is the,

(a) 28 day strength of concrete (b) 7 day strength of concrete

(c) Product of period of curing and temperature of curing

(d) 365 day strength of concrete.

37. The following conditions of concrete placement are termed as extreme environmental conditions.

(a) under water concreting

(b) when concreting operations are carried out at temperature beyond 40°C

(c) when concreting operations are done at temperature below 5°C.

(d) any of the above

38. For a concrete slab for a 3.75 × 4.75 m room the stripping time of form should be

(a) 3 days (b) 7 days (c) 14 days (d) 21 days

39. To take care of any sag in the beams, the forms are given a camber of,

(a) 1:200 (b) 1:300 (c) 1:500 (d) 1:650

40. The timber formwork for concrete should be made of

(a) teak wood (b) shisham wood (c) soft wood planks (d) hard wood

41. Membrane curing of the concrete is the

(a) process of providing plastic sheeting as a protective cover for curing concrete.

(b) process of applying a membrane forming compound on the concrete surface.

(c) process of spraying the sodium silicate on the concrete surface.

(d) all of the above.

42. In cold weather curing of concrete should be continued for

(a) 7 days (b) 14 days (c) 21 days (d) 28 days.

43. In hot weather concreting it is recommended for

(a) use of cold mixing water

(b) use of low heat cement

(c) have minimum cement content

(d) reduce period between mixing and placement to a absolute minimum

(e) all of the above.

44. The standard moist curing of concrete for the first 7 to 14 days may result in a compressive strength of ______ per cent of 28 day moist curing

(a) 60 to 70 (b) 70 to 80 (c) 80 to 90 (d) 90 to 95.

45. In steam curing concrete

(a) mixes of high w/C ratio respond more favourably than mixes of low w/C ratio.

(b) the heating of concrete products is caused by steam at low pressure or at high pressure

(c) steam curing is followed by water curing for a period of at least 21 days

(d) all of the above.

46. A mix for under water concreting uses should have,

(a) very low slump (b) low slump (c) high slump (d) none of the above.

47. The water/cement ratio is expressed by

(a) volume (b) weight (c) density (d) none of the above.

48. The freshly prepared concrete mix should be consumed normally within

(a) 24 hours (b) 8 hours (c) $1\frac{1}{2}$ hours (d) 15 minutes

49. The stripping time in case of rapid hardening cement is x times that in ordinary cement, where x is,

(a) $\frac{1}{2}$ (b) $\frac{3}{7}$ (c) $\frac{3}{4}$ (d) $\frac{4}{7}$

50. Tremie is a

(a) bucket (b) water-tight pipe (c) bag (d) prepackd concrete

51. The diameter of tremie pipe for under water concreting should not be less than

(a) 100 mm (b) 150 mm (c) 200 mm (d) 300 mm.

: ANSWERS :

(1) (e);	(2) (c);	(3) (c);	(4) (c);	(5) (b);
(6) (e);	(7) (d);	(8) (e);	(9) (a);	(10) (b);
(11) (e);	(12) (d);	(13) (b);	(14) (c);	(15) (c);
(16) (d);	(17) (a);	(18) (c);	(19) (a);	(20) (c);
(21) (d);	(22) (a);	(23) (d);	(24) (c);	(25) (c);
(26) (a);	(27) (d);	(28) (d);	(29) (d);	(30) (a);
(31) (b);	(32) (b);	(33) (c);	(34) (c);	(35) (b);
(36) (c);	(37) (d);	(38) (c);	(39) (c);	(40) (c);
(41) (b);	(42) (d);	(43) (e);	(44) (b);	(45) (b);
(46) (c);	(47) (b);	(48) (c);	(49) (b);	(50) (b);(51) (c).

SET-3

1. **The strength of concrete is decreased by**
(a) vibration (b) impact (c) fatigue (d) all of the above
2. **The concrete may attain its 100 per cent strength after,**
(a) 7 days (b) 28 days (c) 1 year (d) 3 years
3. **The tensile strength of concrete is approximately what per cent of compressive strength of concrete ?**
(a) 50% (b) 20% (c) 10% (d) 5%
4. **The knowledge of flexural strength is useful in design of,**
(a) reinforced concrete members (b) pavement slabs and air field runways
(c) prestressed concrete structures (d) water retaining structures
5. **The increase in strength of concrete with time is**
(a) linear (b) non-linear (c) asymptotic (d) all of the above
6. **The split tensile strength of M15 grade concrete when expressed as a fraction of its compressive strength is,**
(a) 0.10 to 0.15 (b) 0.15 to 0.20 (c) 0.20 to 0.25 (d) 0.25 to 0.30
7. **Hardened concrete is,**
(a) linearly elastic material till the fracture
(b) non-linearly elastic material till the fracture
(c) linearly elastic up to the level where stress is less than 0.5 times the maximum stress in compression.
(d) non of the above
8. **Rheology of concrete deals with**
(a) deformation (b) compatibility (c) flow properties (d) all of the above
9. **As per IS : 456-2000, the relationship between flexural strength (f_{cr}) and characteristic strength of concrete (f_{ck}) is**
(a) $0.5\sqrt{f_{ck}}$ (b) $0.12\sqrt{f_{ck}}$ (c) $0.7\sqrt{f_{ck}}$ (d) $1.0\sqrt{f_{ck}}$
10. **The approximate ratio of concrete strength at 7 days to its strength at 28 days is**
(a) 3/4 (b) 2/3 (c) 1/2 (d) 1/3
11. **The subject of 'Rheology' is more closely related to**
(a) strength of materials (b) Fluid mechanics
(c) Engineering mechanics(d) none of the above
12. **The shrinkage in concrete is due to**
(a) hydration of cement
(b) loss of water by evaporation from the surface
(c) withdrawal of water stored in unsaturated air voids of concrete
(d) all of the above.

13. The shrinkage of concrete can be reduced by

(a) low water/cement ratio(b) water-tight and non-absorbent formwork
(c) presaturated aggregates (d) all of the above.

14. Creep in concrete is undesirable particularly in

(a) continuous beams (b) reinforced concrete columns
(c) prestressed concrete structures (d) all of the above

15. Shrinkage increases with

(a) increase in the water-cement ratio
(b) increase in cement content
(c) decrease in humidity
(d) decrease in the maximum size of the aggregate
(e) all the above

16. For cement concrete the stress-strain curve is linear approximately up to,

(a) 1/4 of ultimate stress (b) 1/3 of ultimate stress
(c) 1/2 of ultimate stress (d) 3/4 of ultimate stress

17. The modulus used for all design purposes is

(a) Tangent modulus (b) Secant modulus
(c) Initial tangent modulus (d) Chord modulus

18. The modulus of elasticity can be measured in

(a) tension (b) compression (c) shear (d) all the above

19. Pick out the incorrect statement.

(a) Dense aggregates have a high elastic modulus.
(b) Wet concrete will show higher modulus of elasticity.
(c) Modulus of elasticity decreases with age.
(d) Richer mixes shows higher modulus of elasticity.

20. Pick out the incorrect statement.

(a) Increase in water increases shrinkage.
(b) High cement content will reduce shrinkage.
(c) The harder aggregates gives lower shrinkage.
(d) Shrinkage decreases with an increase in the size of the specimen.

21. Pick out the incorrect statement.

(a) Light weight aggregate undergoes lower creep.
(b) Creep increases with increase in water/cement ratio.
(c) Portland blast stag cement results in a higher creep.
(d) Creep decreases with increase in the size of the specimen.

22. Creep coefficient of concrete at 1 year age is approximately

(a) 3.3 (b) 2.2 (c) 4.4 (d) 1.1

23. **The permanent deformation of concrete with time, under sustained load is called**
(a) creep (b) relaxation (c) viscosity (d) visco-elasticity
24. **The shrinkage of concrete is due to change in**
(a) length (b) cross-sectional area (c) volume (d) surface area
25. **Concrete shrinkage is more pronounced in**
(a) rich mix (b) very lean mix (c) lean mix (d) normal mix
26. **Concrete with aggregate of higher modulus of elasticity will shrink**
(a) by same amount (b) less (c) more (d) more or less the same
27. **The time dependent phenomenon in concrete is**
(a) gain of strength (b) shrinkage (c) creep (d) all of the above
28. **Creep of the concrete is influenced by**
(a) strength of concrete (b) age of concrete
(c) water cement ratio (d) all of the above
29. **The ratio of ultimate creep strain to elastic strain is known as**
(a) creep modulus (b) creep coefficient
(c) creep strain ratio (d) tertiary creep
30. **Shrinkage strain in concrete is approximately**
(a) 0.0035 (b) 0.0350 (c) 0.0003 (d) 0.3500
31. **The approximate value of the thermal coefficient of expansion of concrete is**
(a) 9×10^{-5} per °C (b) 10×10^{-6} per °C
(c) 9×10^{-7} per °C (d) 8×10^{-6} per °C
32. **Modulus of elasticity of concrete increases with**
(a) the age (b) the increase in W/C ratio
(c) the decrease in curing period (d) all of the above
33. **The most appropriate method to specify the concrete mix is by**
(a) the nominal mix ratio (b) the designed mix ratio
(c) the degree of control (d) the grade of concrete
34. **The strength of concrete is influenced by**
(a) size of test specimen (b) moisture conditions
(c) rate of loading (d) type of testing machine (e) all of the above.
35. **The concrete may attain its 100 per cent compressive strength after**
(a) 7 days (b) 28 days (c) 14 days (d) 1 year (e) 3 years.
36. **The tensile strength of concrete is approximately _______ of compressive strength of concrete.**
(a) 50% (b) 20% (c) 10% (d) 5%
37. **The standard size of a concrete cube for compressive strength test is**
(a) 50 mm (b) 100 mm (c) 150 mm (d) 200 mm

38. For compressive strength determination the minimum number of cubes required in a sample are

(a) 2 (b) 3 (c) 5(d) 6.

39. Split tensile strength tests are better than the direct tensile strength tests because

(a) the test gives move uniform results

(b) the results give values closer to the actual tensile strength values

(c) same moulds can be used for both tension tests and compression tests

(d) all of the above.

40. With increase in the rate of loading during testing of concrete specimens, the compressive strength of concrete

(a) increases (b) decreases

(c) does not change (d) none of the above.

41. ISI has specified the full strength of concrete after

(a) 7 days (b) 14 days (c) 28 days (d) 1 year.

42. The 100 mm cubes may be provided for the work test of concrete if the maximum nominal size of aggregate does not exceed,

(a) 10 mm (b) 15 mm (c) 20 mm (d) 25 mm.

43. The individual variation in compressive strength results should not exceed _____ of the average.

(a) 5% (b) 10% (c) 15% (d) 20%.

: ANSWERS :

(1) (d);	(2) (d);	(3) (c);	(4) (b);	(5) (b);
(6) (a);	(7) (c);	(8) (d);	(9) (c);	(10) (b);
(11) (b);	(12) (d);	(13) (d);	(14) (c);	(15) (e);
(16) (b);	(17) (b);	(18) (d);	(19) (c);	(20) (b);
(21) (a);	(22) (d);	(23) (a);	(24) (c);	(25) (a);
(26) (b);	(27) (d);	(28) (d);	(29) (b);	(30) (a);
(31) (b);	(32) (a);	(33) (d);	(34) (e);	(35) (e);
(36) (c);	(37) (c);	(38) (b);	(39) (d);	(40) (a);
(41) (c);	(42) (d);	(43) (c).		

SET-4

1. **Efflorescence in cement is caused due to an excess of**
   (a) alkalis (b) iron oxide (c) silica (d) alumina a

2. **Fly ash can be used as**
   (i) Partial replacement of fine aggregate
   (ii) Partial replacement of cement
   (iii) as an admixture.
   The correct answer is
   (a) only (i) (b) only (ii) (c) both (i) and (ii) (d) both (i) and (iii) d

3. **The presence of common salt in sand result in**
   (a) corrosion of reinforcement (b) scaling
   (c) pitting (d) all of the above. a

4. **Carbonation of concrete result into**
   (a) increased shrinkage (b) increased strength
   (c) both of the above (d) increased permeability c

5. **Permeability of concrete reduces**
   (a) with the carbonation of concrete (b) with the strength of cement paste
   (c) with the decrease in the porosity (d) all of the above d

6. **The durability of concrete is due to its resistance to**
   (a) deterioration from environmental conditions
   (b) internal disruptive forces (c) chemical attack (d) all of the above d

7. **The thermal conductivity of concrete decreases with the**
   (a) light weight concrete (b) increase in the water/cement ratio
   (c) decrease in the cement content (d) all of the above d

8. **The concrete for sea water application should not be leaner than**
   (a) 1:2:6 (b) 1:2:4 (c) 1:2:3 (d) 1:1:2 c

9. **In case of plain concrete exposed to sea waves, the grade of concrete should not be lower than**
   (a) M 15 (b) M 20 (c) M 25 (d) M 30 b

10. **For high frost resistance, the concrete should be**
    (a) dense (b) free from Cracks
    (c) air-entrained (d) all of the above d

11. **The total water soluble sulphates as SO_3 in the concrete mix should not exceed**
    (a) 2% (b) 4% (c) 6% (d) 8%
    by the mass of the cement.
12. **Which of the following is the correct ascending order of the aggregates with respect to thermal conductivity of concrete ?**
    (a) Expanded shale, quartzite, granite, basalt
    (b) Expanded shale, granite, quartzite, basalt
    (c) Expanded shale, basalt, granite, quartzite
    (d) Quartzite, basalt, granite, expanded shale
13. **Expansion joints are provided when length of building exceeds**
    (a) 20 m (b) 45 m (c) 60 m (d) 100 m
14. **Chloride enters the concrete from**
    (a) cement (b) mixing water (c) admixtures (d) aggregates
    (e) all of the above
15. **The permeability of cement paste is mainly due to**
    (a) Gel pores (b) capillary pores
    (c) finer cement grains (d) all of the above
16. **The length of time over which the structural concrete preserves structural action is called**
    (a) fire rating (b) thermal conductivity (c) specific heat (d) diffusivity

: ANSWERS :

(1) (a);	(2) (d);	(3) (a);	(4) (c);	(5) (d);
(6) (d);	(7) (d);	(8) (c);	(9) (b);	(10) (d);
(11) (b);	(12) (c);	(13) (b);	(14) (e);	(15) (b);
(16) (a).				

SET-5

1. **The light-weight concrete may be produced by**
   (a) Using light weight aggregate (b) Incorporating air bubbles in concrete
   (c) Omitting sand fraction (d) all of the above
2. **Light-weight concrete is used**
   (a) For reducing the dead weight of structures
   (b) In filler wall panels in highrise buildings
   (c) For improving thermal insulation
   (d) Any of the above
3. **Light weight concrete has all the following beneficial characteristic except,**
   (a) High thermal insulation (b) High sound insulation
   (c) Excellent fire resistance (d) Reduced drying shrinkage
4. **Aerated concrete is produced by addition of**
   (a) Sodium silicate (b) Copper sulphate
   (c) Aluminium powder (d) zinc
5. **Vacuum concrete**
   (a) Is the normally cured hardened concrete involving removal of air from the voids of the concrete by suction.
   (b) Is obtained by vacuum treatment of fresh concrete involving the removal of excess water and air by suction.
   (c) Is no fine concrete.
   (d) Has a low wear and abrasion resistance
6. **In mass concrete**
   (a) A large size aggregate and low slump is adopted
   (b) Heat of hydration is more.
   (c) There is early high strength but lower later strength.
   (d) Mix being harsh and dry requires immersion type power vibrators.
   (e) All of the above
7. **Which of the following fibres give highest improvement in the impact strength of fibre reinforced concrete ?**
   (a) Glass fibres (b) Polypropylene, nylon and other organic fibres
   (c) Carbon fibres (d) Asbestos fibres
8. **Polymer impregnated concrete is obtained by**
   (a) Impregnating low viscosity prepolymer or monomers into the pore structure of hardened concrete and polymerizing it by heating.
   (b) Replacing the cement-water matrix by pre-polymer and polymerizing it.

(c) Incorporating a polymeric material into concrete during the mixing state.
(d) Any of the above processes.

9. In polymer concrete (Resin concrete) the polymerization can be achieved by
(a) thermal-catalytic reaction (b) catalyst-promoter reaction
(c) radiation (d) all of the above

10. Shotcrete
(a) is mortar or very fine concrete deposited by jetting it with high velocity on to the prepared surface
(b) is very useful for repair of fire damaged structures
(c) is economical than conventional concrete
(d) all of the above

11. Shotcrete differs from conventional concrete with regard to
(a) materials, proportions and void system (b) compaction
(c) application procedure (d) all of the above

12. Guniting
(a) is the technique of depositing very thin layers of mortar in each pass of nozzle
(b) mix is 1 : 3 to 1 : 4.5 with a water-cement ratio of about 0.30
(c) requires careful and skilful handling of nozzle
(d) all of the above

13. The cement-sand ratio in the ferrocement matrix should not be leaner than
(a) 1:1.5 (b) 1:2.0 (c) 1:3.0 (d) 1:4.0

14. The volume of reinforcement in ferrocement varies between
(a) 1-2% (b) 2-5% (c) 5-8% (d) 8-10%

15. The sand recommended for ferrocement mixes is
(a) with maximum sizes of 2.36 mm and 1.18 mm with optimum grading zones II and III respectively.
(b) with maximum size 4.75 mm and grading zone I.
(c) with maximum size 0.6 mm and grading zone IV.
(d) none of the above.

16. The water-cement ratio for ferrocement mix should be
(a) less than 0.35 (b) between 0.35 to 0.40
(c) between 0.40 to 0.50 (d) between 0.50 to 0.60

17. Light weight concrete can used in
(a) air-conditioned buildings (b) non-load bearing walls
(c) providing reduced thickness of structure (d) all of the above

18. Concreting in hot weather will result in
(a) increased strength (b) increased cracking
(c) retard setting (d) unevenness

19. Shotcrete is used in the application of

(a) Soil stabilization (b) Waterproofing

(c) Stabilization of rock slopes (d) None of the above

20. Concreting in cold weather

(i) results in cracking due to the temperature differential within concrete mass.

(ii) increase the rate of strength development

(iii) delay the removal of formwork

(a) Only (iii) (b) Only (ii) (c) Both (ii) and (iii) (d) Both (i) and (iii)

21. Concreting in hot weather

(i) increases tendency to cracking

(ii) makes air-content control difficult

(iii) increases strength of hardened concrete.

(a) only (i) (b) both (i) and (ii) (c) both (ii) and (iii) (d) (i), (ii) and (iii)

22. Roller compacted concrete is a

(a) stiff concrete mix (b) zero slump concrete

(c) mix having consistency of damp gravel (d) all of the above

23. Ready mixed concrete (RMC) is

(i) specified in terms of performance parameters

(ii) produced under factory conditions

(iii) produced and supplied by weight

The correct answer is

(a) both (i) and (ii) (b) both (i) and (iii) (c) both (ii) and (iii) (d) (i), (ii), (iii)

24. The RMC producer

(i) guarantees the desired performance

(ii) receives instructions through job specifications

(iii) receives instructions in terms of prescriptive specifications

The correct answer is

(a) only (i) (b) both (i) and (ii) (c) both (i) and (iii) (d) none of these

: ANSWERS :

(1) (d);	(2) (d);	(3) (b);	(4) (c);	(5) (b);
(6) (e);	(7) (a);	(8) (a);	(9) (d);	(10) (d);
(11) (d);	(12) (d);	(13) (c);	(14) (c);	(15) (a);
(16) (b);	(17) (d);	(18) (b);	(19) (c);	(20) (d);
(21) (b);	(22) (d);	(23) (a);	(24) (b).	

SET-6

1. **The approximate strength of concrete at 28 days as a percentage of strength at one year is**
   (a) 98 (b) 90 (c) 80 (d) 75
2. **The ratio of tensile strength of concrete to its compressive strength is,**
   (a) $\frac{1}{10}$ (b) $\frac{1}{20}$ (c) $\frac{1}{25}$ (d) $\frac{1}{33}$
3. **Identify the Incorrect statements.**
   (a) Nominal mix is a mix of fixed proportions which ensure adequate strength.
   (b) Nominal or standard mixes may be used for high performance concrete.
   (c) Nominal mixes may result in under or over rich mixes.
   (d) Standard mixes are useful as off-the self sets of proportions that allow the desired concrete to be produced.
4. **The choice of mix proportions of a concrete is independent of**
   (a) grade designation
   (b) maximum nominal size of aggregate
   (c) minimum w/C ratio
   (d) batching, mixing, placing, compaction techniques.
5. **The maximum nominal size of coarse aggregate is determined by sieve analysis and is designated by the sieve size higher than the largest size on which the material retained is more than**
   (a) 5% (b) 15% (c) 25% (d) 50%
6. **Water-cement ratio in concrete is the ratio of**
   (a) Volume of water to volume of cement
   (b) Volume of water to the weight of cement
   (c) Weight of water to the weight of cement
   (d) Weight of water to the volume of cement.
7. **The common mix design method for medium strength concrete is**
   (a) The trial and adjustment method (b) IS method (c) ACI method
   (d) DOE method (e) all of the above.
8. **In a trial concrete mix, if the desired slump is not obtained, the adjustment in the water content for each 10 mm difference in slump (in per cent) is**
   (a) 0.5 (b) 1.0 (c) 2.0 (d) 5.0
9. **If the trial mix gives a higher 28 days compressive strength value than the design value, then for the next trial,**
   (a) cement content is reduced. (b) water content is reduced.
   (c) w/C ratio is increased. (d) proportion of sand is increased

10. In a concrete mix design, while making adjustments for the air-entrainment of amount e, the quantity of water is reduced by w then the reduction in the solid volume of sand is given by

(a) e – w (b) $\frac{1}{2}$ (e – w) (c) e – $\frac{w}{2}$ (d) $\frac{e}{2}$ – w

11. When water is added in an increasing amount to a fixed mass of dry mortar mix, the volume of mortar

(a) Initially increases then decreases to a minimum value
(b) does not change as water simply fills the voids
(c) decreases (d) Increases

12. The volume of water which corresponds to a minimum volume of mortar is termed as,

(a) Saturation water content (b) hygroscopic water content
(c) basic water content (d) highest water content

13. The nominal mix corresponding to M20 grade concrete is

(a) 1:1:2 (b) 1:1.5:3 (c) 1:2:3 (d) 1:2:4

14. The grade of concrete corresponding to nominal mix proportions of 1:3:6 is

(a) M 20 (b) M 15 (c) M 10 (d) M 25

15. The total number of grades of ordinary concrete stipulated in IS:456 – 2000 are

(a) 10 (b) 8 (c) 3(d) 5

16. For slabs and beams the concrete of nominal mix generally used is

(a) 1:1:2 (b) 1:1.5:3 (c) 1:2:4 (d) 1:3:6

17. For water retaining strenctures the nominal mix generally used is

(a) 1:1:2 (b) 1:1.5:3 (c) 1:1.5:4 (d) 1:2:4

18. For a water-cement ratio of 0.6 the water content per bag of cement is

(a) 10 kg (b) 20 kg (c) 30 kg (d) 40 kg

19. To ensure proper quality control the number of cube specimens to be cast for 5 m^3 of concrete are,

(a) 3 (b) 6 (c) 9(d) 12

20. In which method of mix design there is a provision of design of mix using fly ash ?

(a) Is method (b) ACI method (c) DOE method (d) IRC -44 method

21. Pumpable concrete

(a) is transported through completely filled dilivery pipes
(b) Should have a slump between 50 mm and 100 mm
(c) Should have cement content between 270 kg/m^3 to 460 kg/m^3.
(d) Maximum size of crushed aggregate is limited to one-third of the in side diameter of hose.
(e) all of above

: ANSWERS :

(1) (c);	(2) (a);	(3) (b);	(4) (d);	(5) (b);
(6) (c);	(7) (e);	(8) (b);	(9) (c);	(10) (a); (11) (a);
(12) (c);	(13) (b);	(14) (c);	(15) (c);	(16) (b); (17) (a);
(18) (c);	(19) (a);	(20) (c);	(21) (e).	

SET-7

1. **For sealing the cracks in concrete structures by using epoxy, the minimum width of routing required is**
   (a) 3 mm (b) 6 mm (c) 10 mm (d) 15 mm
2. **Blow holes are caused by**
   (a) Lack of compaction (b) Improper design of formwork
   (c) Poor workability (d) Excess water content
3. **The distress in concrete structure may be due to**
   (a) Errors in design and detailing (b) Corrosion of reinforcement
   (c) Poor construction practices (d) All of the above
4. **The tool available for evaluation of concrete structures is**
   (a) Visual inspection (b) Scrutiny of field date (c) NDT (d) All of the above
5. **Shrinkage cracks can be controlled by**
   (a) Erecting wind breaks (b) Shading concrete from direct sunlight
   (c) Covering the concrete surface by plastics sheet (d) All of the above
6. **The cracking due to corrosion of reinforcement is characterised by**
   (a) Exposed reinforcement (b) Splitting and spalling of concrete
   (c) Longitudinal cracks parallel to the bar (d) All of the above
7. **The most common symptom of distress in a concrete structure is**
   (a) Spalling of concrete (b) Surface crazing
   (c) Cracking of concrete (d) Scaling of concrete
8. **The corrosion of steel reinforcement embedded in concrete is rapid when the member immersed in**
   (a) Acidic solution (b) Water with dissolved oxygen
   (c) Alkaline solution (d) Sea-water
9. **Wide and deep cracks in concrete members may be repaired by**
   (a) Grouting (b) Epoxy injection (c) Shotcreting (d) Mortar replacement

: ANSWERS :

(1) (b);	(2) (c);	(3) (d);	(4) (d);	(5) (d);
(6) (d);	(7) (b);	(8) (a);	(9) (a).	

SET-8

1. The reaction of cement with water is called
(a) segregation (b) bleeding (c) hydration (d) carbonation

2. Why the name 'portland cement' was given.
(a) It was named after the inventor.
(b) It is resembling to a type of limestone occuring at portland in England.
(c) In olden days, it was used at ports.
(d) It contains portland as part of its ingredients.

3. The amount of gypsum, usually added in manufacture of cement is
(a) 0.1 to 0.5 % (b) 0.5 to 1.0 % (c) 1 to 2 % (d) 2 to 3 %

4. Clinkers are formed at a temperature of
(a) 500°C (b) 1000°C (c) 1200°C (d) 1500°C

5. The residue on I.S. sieve No. 9 of ordinary portland cement should not exceed
(a) 5% (b) 10% (c) 15% (d) 20%

6. The residue on I.S. sieve No. 9 of rapid hardening cement should not exceed
(a) 5% (b) 10% (c) 15% (d) 20%

7. The minimum specific surface area for OPC is
(a) 1250 cm^2/gm (b) 2250 cm^2/gm (c) 3250 cm^2/gm (d) 4000 cm^2/gm

8. If P is the % of water required for standard consistency of cement, then % of water required for initial setting time test is
(a) 1.50 P (b) P (c) 0.85 P (d) 0.75 P

9. For 43 grade cement, minimum compressive strength required after 7 days is
(a) 23 N/mm^2 (b) 33 N/mm^2 (c) 43 N/mm^2 (d) 50 N/mm^2

10. In quick setting cement the compound added is called
(a) aluminium sulphate (b) gypsum
(c) Calcium sulphate (d) aluminium silicate

11. Efflorescence in cement is caused due to an excess of
(a) alumina (b) iron oxide (c) silica (d) alkalis

12. For road pavements, the cement generally used is
(a) ordinary portland cement (b) rapid hardening cement
(c) low heat cement (d) blast furnace slag cement

13. Separation of coarse aggregates from mortar during transportation is known as
(a) bleeding (b) creeping (c) segregation (d) shrinkage

14. Separation of water, or water sand cement from a freshly mixed concrete is known as
(a) bleeding (b) segregation (c) creeping (d) flooding

15. **For the construction of thin R.C.C. structures the type of cement to be avoided is**
(a) ordinary portland cement (b) blast furnace slag cement
(c) rapid hardening cement (d) low heat cement
16. **Inert material of a cement concrete mix, is**
(a) water (b) cement (c) aggregate (d) none of these
17. **Pozzolana cement is used with confidence for construction of**
(a) dams (b) abutments (c) massive foundations (d) all the above
18. **The first law of concrete known as**
(a) Newton's law (b) Abram's law (c) Hook's law (d) law of workability
19. **Which is the most desirable property of concrete ?**
(a) bleeding (b) laitance (c) hydration (d) Honeycombing
20. **When the aggregates are of single sized, the grading is termed as**
(a) well graded (b) gap graded
(c) uniformly graded (d) Continuous graded
21. **'Green concrete' can also be referred to as which of the concrete below ?**
(a) hardened concrete (b) Eco-friendly concrete
(c) Few hours old concrete (d) Concrete of green colour
22. **By what percentage the strength of concrete shall get reduced due to the presence of 5 % voids ?**
(a) 30 % (b) 45 % (c) 25 % (d) 5 %
23. **Which of the ingredients below has the least specific gravity ?**
(a) Sand (b) Coarse aggregate (c) water (d) cement
24. **Who developed the first portland cement by burning limestone and clay at high temperature ?**
(a) Newton (b) Duff Abram (c) Aspdin (d) Le-chatellier
25. **Which instrument is used to determine soundness of cement ?**
(a) Vicat apparatus (b) Le-chatelier apparatus
(c) Briquette apparatus (d) cubes
26. **'Snowcem' is**
(a) Powdered lime (b) Chalk powder (c) Coloured lime
27. **A compacting factor of 0.85 for a concrete sample indicates**
(a) Very low workability (b) Low workability
(c) Medium workability (d) high workability
28. **According to IS, the full strength of concrete is achieved after**
(a) 7 days (b) 14 days (c) 21 days (d) 28 days
29. **How can you make concrete set faster ?**
(a) Adding Alcohol (b) Adding calcium chloride
(c) Adding sugars (d) Adding extra cement

30. How can you make concrete set slower ?
(a) Adding Alcohol (b) Adding calcium chloride
(c) Adding sugars (d) Adding water

31. In case of concrete cube testing, the strength of individual cube should not vary more than .... % of average strength.
(a) ± 5 % (b) ± 10% (c) ± 15 % (d) ± 20%

32. If 100 mm × 100 mm × 100 mm cubes are tested for compressive strength of concrete, then standard strength of concrete is
(a) Strength of 100 mm cube × 0.90 (b) Strength of 100 mm cube × 0.80
(c) Strength of 100 mm cube/0.90 (d) Strength of 100 mm cube/0.80

33. If 150 mm dia and 300 mm long concrete cylinders are tested for compressive strength, the standard strength of concrete is
(a) Strength of cylinder × 0.90 (b) Strength of cylinder × 0.80
(c) Strength of cylinder/0.90 (d) Strength of cylinder/0.80

34. Addition of 2 % calcium chloride in concrete results in
(a) lesser strength (b) more voids
(c) Reduction in curing period to $\frac{1}{3}$rd of the normal
(d) Less consumption of cement

35. A setting of cement or concrete which occurs suddenly while being mixed and placed, and prevent further working of the materials is called
(a) quick set (b) flash set (c) knocking (d) initially setting

36. Adding a thin layer of cement mortar to the surface of concrete, is known as
(a) Rendering (b) Rodding (c) admixing (d) punning

37. Slump test is used to measure
(a) Strength (b) durability (c) consistency (d) homogeneity

38. At freezing point of water concrete
(a) Sets slowly (b) Sets rapidly (c) sets freely (d) does not set

39. Generally, the size of test cylinder for compressive strength of concrete is
(a) 100 mm dia, 200 mm height (b) 150 mm dia, 200 mm height
(c) 150 mm dia, 300 mm height (d) 200 mm dia, 300 mm height

40. Concrete in alkali soils and for use in alkaline water should
(a) have low w/c ratio (b) high w/c ratio
(c) use rich mix (d) use high alumina cement

41. The proportions cement : Sand : aggregates for M20 nominal mix is
(a) 1 : 3 : 6 (b) 1 : 2 : 4 (c) 1 : 1.5 : 3 (d) 1 : 1 : 2

42. The proportions cement : Sand : aggregates for M 10 nominal mix is
(a) 1 : 3 : 6 (b) 1 : 2 : 4 (c) 1 : 1.5 : 3 (d) 1 : 1 : 2

43. The number of cement bags required for 1 m^3 of M 20 concrete would be roughly
(a) 4 (b) 6 (c) 8 (d) 10

44. Heat of hydration of cement is determined by an apparatus called
(a) Hydrometer (b) Calorimeter (c) Pycnometer (d) Hygrometer

45. The maximum % of ingredient in cement is that of
(a) lime (b) silica (c) Alumina (d) Iron oxide

46. The type of cement preferred in dam construction is
(a) Ordinary portland cement (b) Rapid hardening cement
(c) low heat cement (d) blast furnace slag cement

47. The standard sand now a days used in India is obtained from
(a) Jaipur (Rajasthan) (b) Jallandhar (Punjab)
(c) Hyderabad (A.P.) (d) Ennore (Madras)

48. For tunnel lining, transportation of concrete is done by
(a) Pans (b) Wheel barrows (c) Pumps (d) Belt conveyors

49. An aggregate is said to be flaky if its least dimension (thickness) is less than
(a) $\frac{1}{5}$th of mean dimension (b) $\frac{2}{5}$th of mean dimension
(c) $\frac{3}{5}$th of mean dimension (d) $\frac{4}{5}$th of mean dimension

50. An aggregate is said to be elongated if its length is more than
(a) 1.5 times their mean dimension (b) 1.8 times their mean dimension
(c) 2.0 times their mean dimension (d) 2.5 times their mean dimension

: ANSWERS :

1. (c)	2. (b)	3. (d)	4. (d)	5. (b)
6. (a)	7. (b)	8. (c)	9. (b)	10. (a)
11. (d)	12. (b)	13. (c)	14. (a)	15. (b)
16. (c)	17. (d)	18. (b)	19. (c)	20. (c)
21. (b)	22. (c)	23. (c)	24. (c)	25. (b)
26. (c)	27. (b)	28. (d)	29. (b)	30. (c)
31. (c)	32. (a)	33. (d)	34. (c)	35. (b)
36. (a)	37. (c)	38. (d)	39. (c)	40. (d)
41. (c)	42. (a)	43. (c)	44. (b)	45. (a)
46. (c)	47. (d)	48. (c)	49. (c)	50. (b)

❖❖❖

5. Design of RCC Structures

• Short Questions with Answers

1. What is limit state ?

The acceptable limit for the safety and serviceability requirements before failure occurs is called a 'limit state.' (IS : 456 – 2000, P.67)

2. List different types of limit states.

Limit state (IS : 456, P. 67)

Limit state of collapse
- Flexure (bending)
- Shear
- Compression
- torsion

Limit state of serviceability
- Deflection
- Cracking
- Vibration

3. What is characteristic strength ?

Characteristic strength means that value of strength of the material below which not more than 5 % of test results are expected to fall.

4. What is characteristic load ?

Characteristic load means that value of load which has a 95 % probability of not being exceeded during the life of the structure.

5. What is design strength ?

Design strength, $f_d = \dfrac{f_{ck}}{\gamma_m}$ ... for concrete

where,

f_{ck} = characteristic strength of concrete

γ_m = Partial safety factor

= 1.5 for concrete

Design strength, $f_d = \dfrac{f_y}{\gamma_m}$ ... for steel

where,

f_y = characteristic strength of steel

γ_m = 1.15 for steel

6. What is design load ?

design load, $F_d = F \times \gamma_f$

where,

F = Characteristic load

γ_f = partial safety factor for loads

7. Characteristic strength for different grades of concrete and steel.

- For concrete, f_{ck} = cha. strength

Grade	f_{ck}
M 20	20 N/mm^2
M 25	25 N/mm^2
M 30	30 N/mm^2

- For steel, f_y = characteristic strength

Grade	f_y
Mild steel, Fe – 250	250 N/mm^2
HYSD bars, Fe – 415	415 N/mm^2
Cold twisted bars, Fe 500	500 N/mm^2

8. What is partial safety factor ?

Due to some reasons, the material strength in actual structure gets reduced. Hence, the design strength of material is obtained by applying suitable partial safety factor, to the characteristic strength.

For concrete, γ_m – 1.5

For steel, γ_m = 1.15

IS : 456 – 2000, P.68

9. What is design compressive strength for M – 20 Concrete ?

$$f_d = \frac{f_{ck}}{\gamma_m} = \frac{20}{1.5} = 13.33 \text{ N/mm}^2$$

10. What is tensile strength (flexural strength) for M 20 grade of concrete ? (IS : 456 – 2000, P. 16)

Flexural strength, $f_{cr} = 0.7\sqrt{f_{ck}}$

$= 0.7\sqrt{20}$

$= 3.13$ N/mm^2

11. What is modulus of elasticity for steel and M 20 grade concrete ?

For mild steel, $E_s = 2 \times 10^5$ N/mm^2

For concrete, $E_C = 5000\sqrt{f_{ck}}$

$= 5000\sqrt{20}$

$= 22360.7$ N/mm^2

12. What is M – 20 ?

M 20 is the grade of concrete

M = Mix

20 = 20 N/mm^2 compressive strength at 28 days

150 × 150 × 150 mm size concrete cubes are tested after 28 days of curing. If compressive strength of concrete is more than 20 N/mm^2, the grade of concrete is referred to as M 20.

13. What is neutral axis (N.A.) ?

The axis which separate compression zone and tension zone in the cross section of a beam is known as neutral axis.

14. What is under reinforced section ?

- Steel content is less as compared to balanced section
- tensile strain in steel reaches limiting value, earlier to compressive strain in concrete reaching the limiting value
- Steel fail before concrete
- $x_u < x_{umax}$
- M_u, calculated w.r.t steel ($M_u = T \times Z$)

15. What is balanced section ?

- Compressive strain in concrete and tensile strain in steel reach their limiting value simultaneously
- Both the materials fail at the same time
- $x_u = x_{umax}$
- M_u, can be calculated w.r.t. steel or concrete.

  $M_u = T \times Z$ or $M_u = C \times Z$

16. What is over reinforced section ?

- Compressive strain in concrete reaches limiting value earlier to tensile strain in steel
- reinforcement is more as compared to balanced section
- concrete fail before steel
- $x_u > x_{umax}$
- M_u can be calculated w.r.t. concrete

  $\therefore \quad M_u = C \times Z$

17. Give equation for x_u.

$$x_u = \frac{0.87\, f_y\, Ast}{0.36\, f_{ck}\, b} \qquad \text{(IS : 456 – 2000, P. 96)}$$

18. What are the values of x_{umax} for different grades of steel ?

(IS : 456 – 2000, p. 70)

f_y, N/mm^2	x_{umax}
250	0.53 d
415	0.48 d
500	0.46 d

19. Write equations for M_{ulim} for different grades of steel.

fy, N/mm^2	M_{ulim}
250	$M_{ulim} = 0.148\ f_{ck}bd^2$
415	$M_{ulim} = 0.138\ f_{ck}bd^2$
500	$M_{ulim} = 0.133\ f_{ck}bd^2$

20. Give equation for total compression force in concrete and total tensile force in steel for singly R.C. beam.

$T = 0.87\ f_y\ A_{st}$

$C = 0.36\ f_{ck}.b.x_u$

21. What is lever arm ?

The distance between force C and force T is called lever arm.

$Z = d - 0.42\ x_u$

22. What is doubly R.C. beam ?

When a beam is provided with tensile steel (A_{st}) in tension zone and compression steel (A_{sc}) in compression zone, it is called doubly R.C. beam.

23. When doubly R.C. beam is provided ?

- When $M_u > M_{ulim}$
- When it is not possible to increase the depth of beam due to architectural reason
- to get more headway in the rooms
- When a beam is subjected to reversal of stresses (during earthquake)
- For precast beams

24. Differentiate between singly R.C. beam and doubly R.C. beam

Singly R.C. beam	Doubly R.C. beam
• A_{st} is provided in tension zone	• A_{st} is provided in tension zone and A_{sc} is provided in compression zone
• $M_u < M_{ulim}$	• $M_u > M_{ulim}$
• M.R. is less	• M.R. is more
• Ductility of beam is less	• Ductility of beam is more
• Not suitable for reversal of stresses	• Suitable for reversal of stresses. (e.g. earthquake)

25. What is minimum and maximum % of tension reinforcement in beams ? (IS : 456 – 2000, P. 46, 47)

Mini. reinforcement, $\dfrac{A_{st}}{bd} = \dfrac{0.85}{f_y}$

For $f_y = 250$ N/mm^2

$$\frac{A_{st}}{bd} \times 100 = p_t = \frac{0.85}{f_y} \times 100$$

$$= \frac{0.85}{250} \times 100 = 0.34\ \%$$

For $f_y = 415$ N/mm^2,

$$p_t = \frac{0.85}{415} \times 100 = 0.205\ \%$$

Maximum reinforcement,

$A_s = 0.04$ bD i.e. 4 % of gross area

26. What is nominal cover requirements ? **(IS : 456, P. 46, 47)**

	Mini. cover
Slab, beam......................	20 mm
Column..........................	40 mm
Footing..........................	50 mm

27. What is maximum spacing of bars in beams ?

f_y, N/mm^2	**Clear distance between bars (IS : 456 – 2000, P. 46)**
250.......................	300 mm
415.......................	180 mm
500.......................	150 mm

28. Write equation for width of flange for T–beam.

$$b_f = \frac{l_o}{6} + b_w + 6D_f$$ (IS : 456, P. 37)

29. Write equation for development length of bars. (IS : 456, P. 42)

$$L_d = \frac{\phi \cdot \sigma_s}{4 \cdot \tau_{bd}}, \qquad \sigma_s = 0.87\ f_y$$

30. What is development length ?

The length of reinforcement bar embedded in concrete, which develop bond stress, is termed as development length (Ld).

31. What is diagonal tension and shear cracks ?

At the simply supported end of a beam, BM = 0

$$SF = \frac{wl}{2} \text{ (maximum)}$$

∴ direct tensile stress $\sigma = 0$

Major principle stress

$$\sigma_{n_1} = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$= \tau \text{ ... diagonal tension}$$

Since concrete is weak in tension, cracks are developed at 45° near supports. These cracks are called shear cracks. Shear reinforcement is provided perpendicular to the direction of cracks

32. What are different types of stirrups in beams ?

(i) vertical stirrups : 2–legged, 4–legged, 6–legged

(ii) inclined stirrups : Normally provided at 45° near the end of a beam

33. Write equation for minimum shear reinforcement.

$$\frac{A_{sv}}{b \cdot S_v} \geq \frac{0.4}{0.87\, f_y}$$ (IS : 456, P. 48)

34. What are IS criteria for maximum spacing of shear reinforcement ?

(IS : 456, P. 48, 73)

(i) 0.75 d

(ii) 300 mm

(iii) $S_v = \dfrac{0.87\, f_y \cdot A_{sv} \cdot d}{V_{us}}$

(iv) $S_v = \dfrac{0.87\, f_y \cdot A_{sv}}{0.4\, b}$

whichever is smaller

35. What is nominal shear stress ?

$\tau_u = \frac{V_u}{b.d}$, V_u = shear force (IS : 456, P. 72)

36. Why shear reinforcement is provided in beams ?

- to resist shear force
- To keep longitudinal bars in position

37. Why deformed bars are used in RCC ?

- To increase bond with concrete

38. List factors affecting shear strength of concrete

(i) Shear strength increases with compressive strength

(ii) increase in % of tensile steel, increases shear strength of concrete

39. Why design bond stress (τ_{bd}) is increased for deformed bars and compression ? (IS : 456, P. 43)

- Deformed bars : τ_{bd} is increased by 60 %, because deformed surface of bars increase bond between steel and concrete
- Compression : τ_{bd} is increased by 25 %, because end bearing increases resistance to compression.

40. Define creep. List two negative effects of creep.

Creep is that property of concrete by which it continues to deform with time under sustained load

Negative effects of creep are :

- deformation of concrete is 2 to 3 times its initial deformation.
- In RCC column, initial stress produces due to creep

41. What steps to be taken to reduce creep ?

- use high strength concrete
- adding reinforcement
- delaying finishes, partition walls, etc.

42. Define effective depth and effective cover.

d = effective depth

= distance between extreme compression fibre to the centre of tensile reinforcement

e = effective cover

= distance between extreme tensile fibre (bottom) to the centre of tensile reinforcement

43. What is balanced design ?

In the balanced design, limiting stresses occur in steel and concrete at the same time and both the materials fail simultaneously.

44. Why over reinforced designed is not preferred ?

In the over reinforced section, concrete fails before steel. Concrete is a brittle material, and fails suddenly without giving any warning signs.

45. Write equation to find load carrying capacity of axially loaded short column.

$P_u = 0.4\ f_{ck} \cdot A_c + 0.67\ f_y\ A_{sc}$ (IS : 456, P. 71)

46. What is minimum eccentricity for column ? (IS : 456, P. 42)

$$e_{min} = \frac{l}{500} + \frac{D}{30}$$

Subjected to minimum of 20 mm

l = unsupported length of column

D = Lateral dimension of column

47. What are IS criteria for pitch and diameter of lateral ties ? (IS : 456, P. 49)

Maxi. Pitch :

(i) Least lateral dimension

(ii) 16 × smaller dia

(iii) 300 mm, which ever is less

diameter :

(i) $\frac{1}{4}$ × dia. of larger bar

(ii) 6 mm, whichever is more

48. What are the IS criteria for longitudinal bars in columns ? (IS : 456, P. 48)

(i) Maxi. p_t = 6%, Mini. p_t = 0.8 %

(ii) Mini. no. of bars = 4 in square column
= 6 in circular column

(iii) Mini. dia. of bars = 12 mm

(iv) Spacing of bars along periphery shall not exceed 300 mm

49. Give location of critical section for B.M., One way shear and two way shear in footing.

For B.M – at the face of column

For oneway shear – at d distance from the face of column

For two way shear – at $\frac{d}{2}$ distance from the face of column

50. Distinguish between one way and two way slab

One way slab	Two way slab
(i) $\frac{l_y}{l_x} \geq 2$	(i) $\frac{l_y}{l_x} < 2$
(ii) Main steel is provided along short span (l_x). Distribution steel is provided along l_y	(ii) In both the directions main steel is provided
(iii) Slab deflect along short span	(iii) Slab deflect along l_x and ly

51. Give IS criteria for maximum spacing between bars in slab.

For main steel : (IS : 456, P.46)

(i) 3d

(ii) 300 mm, whichever is smaller

For distribution steel :

(i) 5d

(ii) 450 mm, whichever is smaller

52. Give IS criteria for mini. reinforcement in slab.

For Fe 250, p_t min = 0.15 % of gross area (IS : 456, P. 48)

For Fe 415, 500 p_t min = 0.12 % of gross area

53. What is maxi. dia. of bar for slabs ?

Maxi. dia. = $\frac{1}{8}$ × D, where, D = total thickness of slab

54. What is minimum dia. of bars for slabs ?

For main bars :

Plain bars .... 10 mmϕ

deformed bars .... 8 mmϕ

For distribution bars :

Plain bars .... 6 mmϕ

Deformed bars..................... 6 mmϕ

55. How effective span for simply supported slab/beam is calculated ?

(IS : 456, P.34)

(i) clear span +d (ii) c/c of supports

whichever is smaller

56. Give $l/_d$ ratios for slab and beam for span up to 10 m, for deflection control.

Cantilever .... $\frac{l}{d} = 7$ (IS : 456, P. 37)

Simply supported .... $\frac{l}{d} = 20$

Continuous .... $\frac{l}{d} = 26$

57. Give $l/_d$ ratio for two way slab for short span up to 3.5 m and live load up to 3 kN/m^2.

Simply supported slab .... 35 (IS : 456, P. 49)

Continuous slab 40

These values are for mild steel

For HYSD bars, these values are multiplied by 0.8

58. In two way slab where torsion reinforcement is provided ?

At the corner where both edges are discontinuous, full torsion steel is provided

At the corner where one edge is discontinuous, 50 % torsion steel is provided

59. How much steel is provided at corners for torsion ?

75 % of the maximum mid span steel, in each of the 4 layers extending up to $\frac{l_x}{5}$ from the edge

60. How much steel is provided in edge strips of two way slab ?

Mini. 0.12 % (For Fe 415)

Mini. 0.15 % (For Fe 250)

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MCQ'S

1. **Minimum amount of HYSD bar reinforcement in slab shall be .... of gross area.**
   (a) 0.12 % (b) 0.15 % (c) 0.20 % (d) 0.08 %
2. **All the axially loaded columns shall be designed for a minimum eccentricity of**
   (a) 10 mm (b) 20 mm (c) 25 mm (d) 40 mm
3. **Basic value of span/depth ratio for limit of deflection for a simply supported slab having span up to 10 m shall be**
   (a) 7 (b) 10 (c) 20 (d) 26
4. **The partial safety factor for material for concrete is**
   (a) 1.5 (b) 1.15 (c) 2.0 (d) 2.5
5. **If the minimum dimension of element to be cast in PCC is 75 mm, the maximum size of aggregate can be**
   (a) 20 mm (b) 10 mm (c) 25 mm (d) 40 mm
6. **A long column is one whose ratio of effective length to its least lateral dimension exceeds**
   (a) 5 (b) 10 (c) 12 (d) 20
7. **Tensile strength of concrete is given by**
   (a) $5000\sqrt{f_{ck}}$ (b) $0.7\sqrt{f_{ck}}$ (c) $0.7 \times f_{ck}$ (d) $0.1 \times f_{ck}$
8. **Props for slab formwork (span up to 4.5 m) can be removed after minimum of**
   (a) 3 days (b) 7 days (c) 14 days (d) 21 days
9. **The minimum eccentricity in columns can be calculated as**
   (a) $\frac{l}{500}+\frac{D}{20}$ (b) $\frac{l}{300}+\frac{D}{20}$ (c) $\frac{l}{500}+\frac{D}{30}$ (d) $\frac{l}{300}+\frac{D}{30}$
10. **The test result of individual concrete specimen should not vary more than**
    (a) ± 5 % (b) ± 10 % (c) ± 15 % (d) ± 20 %
11. **In case of doubt of concrete quality, flexural members are tested by**
    (a) DL + LL (b) 1.5 × (DL + LL)
    (c) DL + 1.5 LL (d) DL + 1.25 LL
12. **Moist curing of concrete in case of concrete made by OPC and PPC shall be .... days and .... days respectively.**
    (a) 7, 14 (b) 10, 14 (c) 7, 10 (d) 14, 21

13. Two way slabs can be analysed using

(a) Pigand's theory (b) Westergaurd's theory
(c) Johnson's theory (d) All the above

14. Deflection of beam is usually limited to

(a) span/350 (b) 20 mm
(c) a or b whichever is less (d) a or b whichever is more

15. Maximum diameter of bar for slab thickness D is

(a) $\frac{D}{4}$ (b) $\frac{D}{5}$ (c) $\frac{D}{6}$ (d) $\frac{D}{8}$

16. Minimum and maximum % of steel in column is

(a) 0.8 %, 6 % (b) 0.6 %, 8 % (c) 0.12 %, 6 % (d) 0.15 %, 8 %

17. Drops are provided in flat slab to resist

(a) bending moment (b) thrust (c) shear (d) torsion

18. In RCC beam, side face reinforcement is provided if depth of web in a beam exceeds

(a) 300 mm (b) 450 mm (c) 750 mm (d) 800 mm

19. The purpose of reinforcement in prestressed concrete is

(a) to resist tensile stresses
(b) To provide adequate bond stress
(c) to impart initial compressive stress in concrete (d) All of these

20. Half of the main steel in a simply supported slab is bent up near the support at a distance of x from the centre of support, where x is equal to

(a) $\frac{l}{3}$ (b) $\frac{l}{5}$ (c) $\frac{l}{7}$ (d) $\frac{l}{10}$

21. As per IS : 1343 – 1980, minimum grade of concrete required for pre–tensioned concrete and post–tensioned concrete shall be respectively

(a) M 20, M 30 (b) M 30, M 20 (c) M 30, M 40 (d) M 40, M 30

22. For pre–stressed concrete, the creep coefficient for 28 days age of concrete is

(a) 2.2 (b) 1.6 (c) 1.1 (d) 1.2

23. As per IS : 456 – 2000, concrete having characteristic strength varying between M 25 to M 55 is known as

(a) Ordinary concrete (b) Standard concrete
(c) Nominal concrete (d) Normal concrete

24. Snow loads are accounted in design as per

(a) IS : 875 (Part – I) (b) IS : 875 (Part II)
(c) IS : 875 (Part IV) (d) IS : 875 (Part V)

25. Fire resistance of RC structural member depends on

(a) Size of member (b) concrete cover
(c) Types of aggregate (d) all of the above

26. A compression member is called pedestal if its effective length is less than .... times its least lateral dimension.

(a) 2 (b) 3 (c) 4 (d) 5

27. The length of torsion reinforcement in two way slab is

(a) $\frac{l_x}{4}$ (b) $\frac{l_x}{5}$ (c) $\frac{l_x}{8}$ (d) $\frac{l_x}{10}$

28. The amount of reinforcement for torsion in each of the four layers shall be equal to .... of the maximum mid span steel.

(a) $\frac{1}{2}$ (b) $\frac{2}{3}$ (c) $\frac{3}{4}$ (d) $\frac{4}{3}$

29. For RCC footing, which of the following statement is correct ?

(a) Critical section for B.M. is taken at the face of column.
(b) Critical section for one–way shear is taken at distance d from the face of column.
(c) Critical section for two–way shear is taken at distance d/2 from the face of column.
(d) all of these.

30. For footing minimum cover thickness is prescribed as

(a) 40 mm (b) 50 mm (c) 75 mm (d) 100 mm

31. The maximum distance between distribution steel (temperature steel) in a slab is limited to

(a) 3d, 300 mm (b) 3d, 450 mm (c) 5d, 300 mm (d) 5d, 450 mm

32. Bond stress of concrete .... when steel is embedded in compression zone.

(a) reduces (b) increases
(c) remains unchanged (d) has no relation with location

33. The development length of reinforcement depends

(a) Strength of concrete (b) diameter of bar
(c) yield stress of steel (d) All of these

34. Anchoring is done by hooks normally in case of

(a) HYSD bars (b) Plain mild steel bars
(c) TMT bars (d) Prestressing steel

35. TMT bars have

(a) High tensile strength (b) higher resistance to corrosion
(c) More ductility (d) All of these

36. Minimum number of bars in circular column shall be

(a) 4 (b) 5 (c) 6 (d) 8

37. Spacing of longitudinal bars along the periphery of a concrete column is limited to

(a) 200 mm (b) 300 mm (c) 16 × dia of bar (d) 150 mm

38. Minimum thickness of flat slab should be

(a) 75 mm (b) 100 mm (c) 125 mm (d) 150 mm

39. In case of flat slab, thickness of slab is increased around the column is known as

(a) column head (b) Drop panel (c) column strip (d) None of these

40. Edge thickness of a rectangular footing resting on soil will not be less than

(a) 100 mm (b) 150 mm (c) 200 mm (d) 300 mm

41. The factor 0.67 introduced in concrete strength to account

(a) Variation in concrete strength (b) Variation in type of steel
(c) Size effect (d) Partial safety factor

42. A column is designed as axially loaded if minimum eccentricity is less than .... times lateral dimension.

(a) 0.1 (b) 0.05 (c) 0.5 (d) 0.01

43. Punching shear strength of concrete in limit state method is taken as

(a) $0.7\sqrt{f_{ck}}$ (b) $0.25\sqrt{f_{ck}}$ (c) $0.20\sqrt{f_{ck}}$ (d) $5000\sqrt{f_{ck}}$

44. The effective height to thickness of RC wall is limited to

(a) 6 (b) 20 (c) 26 (d) 30

45. An over reinforced beam fails by

(a) Crushing of concrete (b) yielding of steel
(c) Crushing of steel (d) None of these

46. The width of middle strip in two way slab is

(a) $\frac{1}{2}$ of the span (b) $\frac{3}{4}$ of the span
(c) $\frac{1}{8}$ of the span (d) $\frac{1}{4}$ of the span

47. Minimum grade of concrete in prestressing is

(a) M 20 (b) M 25 (c) M 30 (d) M 40

48. In case of continuous prestressed beam, the cable is placed as

(a) Straight (b) Parabolic (c) eccentric straight (d) concordant

49. The loss of prestress in prestressed concrete member usually varies between

(a) 2 to 5 % (b) 6 to 12 % (c) 12 to 20 % (d) 20 to 25 %

50. The loss of prestress in pre–tensioned concrete due to shrinkage is
(a) 60 MPa (b) 63 MPa (c) 100 MPa (d) 200 MPa

51. Maximum w/c ratio for RCC is
(a) 0.45 (b) 0.50 (c) 0.55 (d) 0.60

52. Minimum cement content for mild environment using 10 mm size aggregate, shall be .... per m^3 of concrete.
(a) 300 kg (b) 320 kg (c) 340 kg (d) 360 kg

53. In a designed mix, the quantity of concrete ingredients is defined in terms of
(a) Cement by weight and aggregate by volume (b) weight
(c) volume (d) either of weight or volume can be taken

54. As per IS : 456 – 2000, in case of nominal mix proportioning of ingredients is based on
(a) volume (b) weight (c) density (d) specific gravity

55. To get maximum negative bending moment in a multi span continuous beam, live load arrangement shall be
(a) Two adjacent span loaded (b) Spans randomly loaded
(c) Alternate spans loaded (d) Can not be predicted

56. A beam is called a deep beam, if its L/D ratio is .... in simply supported beam and .... in continuous beam.
(a) 2, 2.5 (b) 2, 2 (c) 2.5, 2 (d) 1.5, 2.5

57. Pitch of lateral ties in column shall be not more than
(a) least lateral dimension (b) 16 × smaller dia longitudinal bar
(c) 300 mm (d) all the above

58. Diameter of lateral ties shall not be less than
(a) $\frac{1}{4}$ dia. of largest longitudinal bar (b) 6 mm
(c) $\frac{1}{4}$ × dia. of smallest longitudinal bar (d) both (a) and (b) above

59. Maximum spacing of vertical reinforcement in RCC wall should not exceed
(a) thickness of the wall (b) 1.5 times thickness of wall
(c) 2.0 times thickness of wall (d) 3.0 times thickness of wall

60. The thickness of any part of shear wall shall not be less than
(a) 100 mm (b) 150 mm (c) 175 mm (d) 200 mm

61. The minimum reinforcement % in each direction for a shear wall shall be
(a) 0.12 % (b) 0.20 % (c) 0.25 % (d) 0.30 %

62. As per IS : 13920 – 1993 the lap length of bars in beam shall not be less than
(a) development length (b) 150 mm
(c) both (a) and (b) above (d) 200 mm

63. Lap splice in beam shall not be provided within

(a) Joint (b) a distance of 2d from joint face
(c) within a quarter length of the member (d) all of these

64. M_{ulim} for Fe 415 steel is

(a) $M_{ulim} = 0.148\ f_{ck}\ bd^2$ (b) $M_{ulim} = 0.138\ f_{ck}\ bd^2$
(c) $M_{ulim} = 0.133\ f_{ck}\ bd^2$ (d) $M_{ulim} = 0.130\ f_{ck}\ bd^2$

65. For Fe 415 grade steel x_{umax} is

(a) 0.53 d (b) 0.48 d (c) 0.46 d (d) 0.33 d

66. Maximum compressive stress in top most fibre of a simply supported rectangular beam is

(a) 0.36 f_{ck} (b) 0.446 f_{ck} (c) 0.50 f_{ck} (d) 0.6 f_{ck}

67. Maximum tensile stress in beam is

(a) 0.446 f_{ck} (b) 0.87 f_y (c) 0.67 f_y (d) 0.33 f_y

68. Loss of stress with time at constant strain in steel is called

(a) relaxation (b) Creep (c) Shrinkage (d) Ductility

69. Minimum % of reinforcement in walls, floors and roofs of water tank as per IS : 3370 (Part–II) is

(a) 0.24 % (b) 0.12 % (c) 0.30 % (d) 0.20 %

70. Doubly beam is considered less economical than a singly R.C. beam because

(a) tensile steel required is more (b) Shear reinforcement is more
(c) Concrete is not stressed to its full value (d) Compression steel is under stressed

: ANSWERS :

1. (a)	2. (b)	3. (c)	4. (a)	5. (b)
6. (c)	7. (b)	8. (b)	9. (c)	10. (c)
11. (d)	12. (b)	13. (d)	14. (c)	15. (d)
16. (a)	17. (c)	18. (c)	19. (c)	20. (c)
21. (d)	22. (b)	23. (b)	24. (c)	25. (d)
26. (b)	27. (b)	28. (c)	29. (d)	30. (b)
31. (d)	32. (b)	33. (d)	34. (b)	35. (d)
36. (c)	37. (b)	38. (c)	39. (b)	40. (b)
41. (a)	42. (b)	43. (b)	44. (d)	45. (a)
46. (b)	47. (c)	48. (b)	49. (c)	50. (a)
51. (c)	52. (a)	53. (b)	54. (a)	55. (c)
56. (a)	57. (d)	58. (d)	59. (d)	60. (b)
61. (c)	62. (c)	63. (d)	64. (b)	65. (b)
66. (b)	67. (b)	68. (b)	69. (a)	70. (d)

EXPLANATIONS

5. (b) Maximum size of aggregate $= \frac{1}{4} D$

$= \frac{1}{4} \times 75$ IS : 456 P. 14

$= 18.75$ mm

10. (c) IS : 456 – 2000, P. 29
11. (d) IS : 456 – 2000, P. 31, cl. 17.6.2
12. (b) IS : 456 – 2000, P. 27
13. (d) IS : 456 – 2000, P. 41
14. (c) IS : 456 – 2000, P. 37
15. (d) IS : 456 – 2000, P. 48
16. (a) IS : 456 – 2000, P. 48
18. (c) IS : 456 – 2000, P. 47
22. (b)

Age	Creep Coefficient (θ)
7 days	2.2
28 days	1.6
1 year	1.1

23. (b) IS : 456 – 2000, P. 16
26. (b) IS : 456 – 2000, P. 41
30. (b) IS : 456 – 2000, P. 46
38. (c) IS : 456 – 2000, P. 53
40. (b) IS : 456 – 2000, P. 64
42. (b) IS : 456 – 2000, P. 71
43. (b) IS : 456 – 2000, P. 59
44. (d) IS : 456 – 2000, P. 61
50. (a) $\Delta\sigma = \varepsilon_{sh} \times E_s$

$= 3 \times 10^{-4} \times 2 \times 10^5$

$= 60$ MPa

51. (c) IS : 456 – 2000, P. 20
52. (a) IS : 456 – 2000, P. 20
56. (a) IS : 456 – 2000, P. 51

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6.

Design of Steel Structures

(AS per IS : 800 - 2007)

SET-1

(1) **The minimum pitch of Bolt allowed in the code is**

(a) 1.5 · d (b) 2.0 · d (c) 2.5 · d (d) 3.0 · d

where d - Diameter of Bolt

(2) **Grade of 4.6 Bolt has nominal ultimate stress of**

(a) 400 Mpa (b) 460 Mpa (c) 240 Mpa (d) 600 Mpa

(3) **For M20 Bolt, Diameter of Hole will be of**

(a) 18 mm (b) 22 mm (c) 21.5 mm (d) 23 mm

(4) **In double Cover Butt Joint, bolt will be subjected to**

(a) Single shear (b) 1.5 × single shear

(c) Double shear (d) No shear

(5) **The minimum size of fillet weld is**

(a) 3 mm (b) 4 mm (c) 3.5 mm (d) 4 mm

(6) **Partial safety factor for field welding is**

(a) 2.0 (b) 1.25 (c) 1.50 (d) 2.5

(7) **Minimum end return of weld is**

(a) 2 × size of weld (b) 3 × size of weld

(c) 2.5 × size of weld (d) 4 × size of weld

(8) **The Type of weld used for butt joint is**

(a) Groove Weld (b) Plug Weld (c) Slot weld (d) Fillet Weld

(9) **The maximum slenderness ratio permitted for the member which always remains in tension is**

(a) 180 (b) 240 (c) 350 (d) 400

(10) **The tensile stress in the material adjacent to a hole during the Elastic stage will be**

(a) 1.5 × Average stress (b) 3.0 × Average stress

(c) 2.5 × Average stress (d) 3.5 × Average Stress

(11) **The angle connected to G.P. with longer leg resist more tensile load than if connected by Shorter leg to G.P.**

True/False (Strike out which one is false)

(12) The single angle connected with G.P. by welding resist more Tension Force compare to if the same angle is connected with G.P. by bolt.
True/False (Strike out which one is false)

(13) The Double angles provided on either side of G.P. can resist same tension force even if both angles are provided on same side of G.P.
True/False (Strike out which one is false)

(14) In equation, $T_{dn} = \alpha \cdot A_n \cdot f_u / \gamma_{m1}$, $\alpha = 0.6$ can be taken if
(a) One or two Bolts are provided (b) Three bolts are provided
(c) Four or more bolts are provided (d) Welding is provided

(15) If ISA 75 × 60 × 6 is connected to G.P. by longer leg by welding then area of connected leg will be
(a) 432 mm^2 (b) 450 mm^2 (c) 360 mm^2 (d) 342 mm^2

(16) If five bolts of 20 mm dia. are provided with a pitch of 50 mm then length of connection will be
(a) 100 mm (b) 200 mm (c) 250 mm (d) 170 mm

(17) As per IS 800 : 2007, Effective length of column fixed at one end and hinge at other end is
(a) 0.65 · L (b) 0.8 · L (c) 1.0 · L (d) 1.5 · L

(18) The maximum slenderness ratio permitted for strut is
(a) 180 (b) 250 (c) 350 (d) 400

(19) A compression member in a roof truss is normally treated as
(a) Column (b) Secondary Beam (c) Strut (d) Main Tie

(20) The imperfection factor for buckling class 'c' is
(a) 0.21 (b) 0.34 (c) 0.49 (d) 0.76

(21) The effective length of double angles strut with angles placed back to back on each side of G.P. is
(a) 0.7 L (b) 0.85 L (c) 0.75 L (d) 1.2 L

(22) The slenderness ratio of lacing shall not exceed
(a) 180 (b) 145 (c) 200 (d) 140

(23) The lacing shall be designed to resist transverse shear - Vt equals to
(a) 2.5 % of Axial Load on Column (b) 1.5 % of Axial Load on column
(c) 3.5 % of Axial Load on column (d) 2.0 % of Axial Load on Column

(24) For 20 mm Dia. bolt, minimum width of Lacing Bar shall be
(a) 40 mm (b) 50 mm (c) 60 mm (d) 80 mm

(25) The effective slenderness ratio of battened column shall be ____ times the maximum actual slenderness ratio.
(a) 1.05 (b) 1.10 (c) 1.20 (d) 1.25

(26) The Main beams are always supported on

(a) Secondary Beams (b) One secondary beam and on one other main beam
(c) Columns (d) Cantilever Beams

(27) A beam with a number of regular openings in its web is called

(a) Hybrid Beam (b) Castellated Beam (c) Tapered Beam (d) Latticed Beam

(28) In case of laterally supported beam

(a) Compression flange is restrained (b) Tension flange is restraine
(c) Web is Restrained (d) Web and Tension flange is restrained

(29) Shear buckling of web occurs if d/tw ratio exceeds

(a) 42 ε (b) 67 ε (c) 84 ε (d) 105 ε

(30) Which type of cross section gives an ideal behavior as a beam

(a) Plastic (b) Compact (c) Semi compact (d) Slender

(31) The buckling class of angle section is

(a) a (b) b (c) c (d) d

(32) The partial safety factor for material in resistance, governed by yielding, γ_{m0} is

(a) 1.25 (b) 1.10 (c) 0.9 (d) 1.20

(33) The partial safety factor for material in resistance, governed by ultimate stress, γ_{m1} is

(a) 1.25 (b) 1.10 (c) 0.9 (d) 1.20

(34) Design strength of tension member is taken as greatest of Tdg, Tdn and Tdb.

True/False (Strike out which one is false)

(35) In equation of rupture strength of an angle in tension, the term β will have a value always greater than or equals to 0.7.

True/False (Strike out which one is false)

(36) In the equation of Block shear strength of Tension Member, the term Avg stands for

(a) Minimum gross area of shear (b) Maximum gross area of shear
(c) Minimum Tension area (d) Net area of shear

(37) As per IS - 800 - 2007, fcd stands for

(a) Design Tensile stress (b) Design Compressive stress
(c) Design Bending stress (d) Design Torsion Stress

(38) As per IS - 800 - 2007, Combination of Lacing and Battening in Built up Column is not permitted.

True/False (Strike out which one is false)

(39) In the equation of flexural design of beam, Md = $\beta_b Z_p f_y/\gamma mo$, β_b can be taken equals to ____ for plastic and compact sections.

(a) 0.75 (b) 1.25 (c) 1.1 (d) 1.0

(40) Purlin shall be designed as

(a) Flexural member (b) Tension Member

(c) Compression Member

(41) More Edge Distance is kept if plate is of Machine Cut compare to Hand Cut.

True/False (Strike out which one is false)

(42) In Lap Joint, Bolts will be always in single shear.

True/False (Strike out which one is false)

(43) The partial Safety factor for ultimate stress of shop weld is

(a) 1.20 (b) 1.10 (c) 1.25 (d) 1.5

(44) The partial safety factor for ultimate stress of field weld is

(a) 1.20 (b) 1.10 (c) 1.25 (d) 1.5

(45) Welded connection cannot be designed using end welds.

True/False (Strike out which one is false)

(46) Roof Trusses are not analyzed for load combination of LL + W.L.

True/False (Strike out which one is false)

(47) The maximum slenderness ratio permitted for tension member subjected to reversal stress due to wind or Earthquake forces is

(a) 180 (b) 250 (c) 300 (d) 350

(48) In case of bolted connection when yielding of gross section governs the design strength of an angle, then it is immaterial whether the longer leg or shorter leg is connected to G.P.

True/False (Strike out which one is false)

(49) A compression member oriented in any direction having insignificant bending is designed as strut.

True/False (Strike out which one is false)

(50) Effective length of column when both ends are hinge is

(a) 1.0 L (b) 0.85 L (c) 1.5 L (d) 2.0 L

: ANSWERS :

1. (c)	2. (a)	3. (b)	4. (c)	5. (a)
6. (c)	7. (a)	8. (a)	9. (d)	10. (b)
11. True	12. True	13. True	14. (a)	15. (a)
16. (b)	17. (b)	18. (a)	19. (c)	20. (c)
21. (b)	22. (b)	23. (a)	24. (c)	25. (b)
26. (c)	27. (b)	28. (a)	29. (b)	30. (a)
31. (c)	32. (b)	33. (a)	34. False	35. True
36. (a)	37. (b)	38. False	39. (d)	40. (a)
41. False	42. True	43. (c)	44. (d)	45. False
46. True	47. (d)	48. True	49. True	50. (a)

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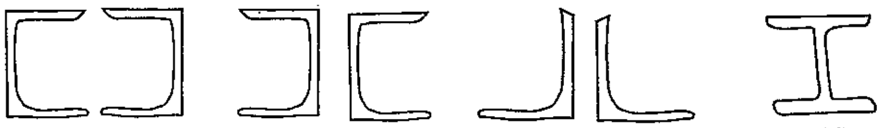
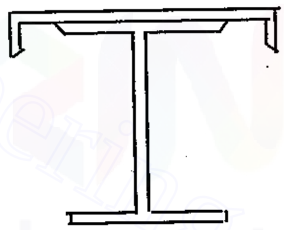
SET-2

1. **'Lug angles' are**
   (a) equal angles
   (b) equal angles with elliptical perforations
   (c) unequal angles with elliptical perforations
   (d) Angle used to reduce the length of connection
2. **In case of lug angles, the strength of lug angle should be .... more than the force in the outstanding leg of the member**
   (a) 10 % (b) 20 % (c) 40 % (d) 50 %
3. **The connection of lug angle to the main angle shall be capable of developing a strength not less than .... in excess of the force in the outstanding leg of the angle member.**
   (a) 10 % (b) 20 % (c) 40 % (d) 50 %
4. **Bolts are most suitable to carry**
   (a) Shear (b) bending (c) axial tension (d) Shear and bending
5. **If the thickness of thinner outside plate is 10 mm, then the maximum pitch of rivets in tension will be taken as**
   (a) 120 mm (b) 160 mm (c) 200 mm (d) 300 mm
6. **When the bolts are subjected to reversal of stresses, the most suitable type of bolt is**
   (a) black bolt (b) ordinary finished bolt
   (c) turned and fitted bolt (d) high strength bolt
7. **Which of the following sections preferably be used at places where torsion occurs ?**
   (a) angle section (b) channel section
   (c) box section (d) Any of above
8. **The capacity of short column depends on**
   (a) yield stress (b) cross-sectional area
   (c) Slenderness ratio (d) both a and b
9. **Density of steel is taken as**
   (a) 2500 kg/m^3 (b) 1600 kg/m^3. (c) 7850 kg/m^3 (d) 800 kg/m^3
10. **Which of the following section is most efficient column section ?**



(a) (b) (c) (d)

11. **For design of compression member**
    (a) Slenderness ratio should be minimum (b) radius of gyration should be large
    (c) both (a) and (b) (d) none of these
12. **The angle of inclination of the lacing bar with longitudinal axis of the column should be between**
    (a) 10° to 30° (b) 30° to 80° (c) 40° to 70° (d) 20° to 70°
13. **The most efficient and economical section used as a beam is**
    (a) I-section (b) H-section (c) angles (d) Circular section
14. **Bearing stiffners are provided to plate girder at**
    (a) Support (b) Point of application of concentrated load
    (c) both (a) and (b) (d) none of these
15. **In case of design of load carrying stiffners the dispersion of the load through web is taken at an angle of**
    (a) 30° (b) 45° (c) 60° (d) 70°
16. **Maximum deflection for simply supported steel beam for elastic cladding is**
    (a) $\frac{L}{150}$ (b) $\frac{L}{180}$ (c) $\frac{L}{240}$ (d) $\frac{L}{300}$
17. **Angle purlin can be used in roof truss when angle of roof truss is**
    (a) less than 30° (b) more than 30° (c) less than 45° (d) between 40° to 70°
18. **Fig. shows the typical section of a gantry girder. The function of top channel is to increase**



    (a) moment of inertia about vertical axis
    (b) torsional stiffness
    (c) Lateral buckling strength
    (d) All of these
19. **The effective slenderness ratio (kL/r) e of laced column shall be taken as .... times the $(kL/r)_0$ the actual maximum slenderness ratio.**
    (a) 1.0 (b) 1.05 (c) 1.10 (d) 1.25
20. **The effective slenderness ratio $(kL/r)_e$ of battened column shall be taken as .... times the $(kL/r)_0$ the actual slenderness ratio.**
    (a) 1.0 (b) 1.05 (c) 1.10 (d) 1.25
21. **A steel beam supporting loads from floor slab as well as from wall is called**
    (a) Stringer beam (b) lintel beam (c) Spandrel beam (d) header beam
22. **In the plastic design the load factor for dead load is**
    (a) 1.5 (b) 1.7 (c) 2.0 (d) 2.5

23. In columns splices should be provided at

(a) Floor levels (b) mid height of columns
(c) beam- column joints (d) One fourth height of column

24. In plastic analysis for flexure, which of the following pairs of shape and shape factors are correctly matched ? **(IES)**

1. I ... 1.4
2. Square ... 1.5
3. Rectangle ... 1.5
4. Circle ... 1.7

Select the correct answer using the codes given below :

(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 3 and 4 (d) 1 and 2

25. Plastic hinge normally formed at

(a) fixed end (b) where B.M. is maximum
(c) below point load (d) all the above

26. A ductile structure is defined as one for which the plastic deformation before fracture **(IES)**

(a) is smaller than the elastic deformation
(b) vanishes
(c) is equal to the elastic deformation
(d) is much larger than the elastic deformation

27. High yield deformed bars have a

(a) definite yield value
(b) Chemical composition different from mild steel
(c) Percentage elongation less than that of mild steel
(d) Percentage elongation more than that of mild steel

28. The height at which wind force acts on a moving vehicle on a bridge deck is **(IES)**

(a) 1.2 m (b) 1.5 m (c) 1.7 m (d) 2.0 m

29. Area of openings for buildings of large permeability is more than

(a) 10 % of wall area (b) 20 % of wall area
(c) 30 % of wall area (d) 50 % of wall area

30. Gantry girders are designed to resist

(a) lateral loads (b) longitudinal and vertical loads
(c) lateral, longitudinal and vertical loads (d) lateral and longitudinal loads

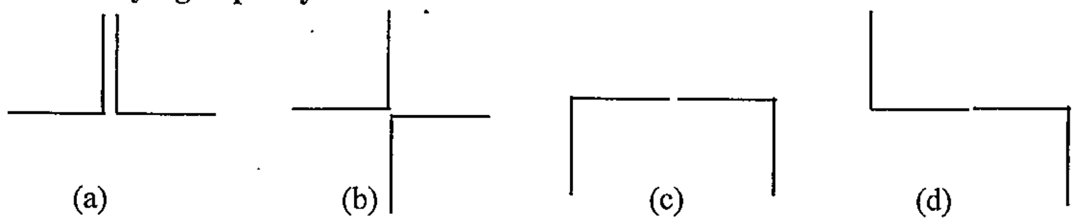
31. As per IS : 875 (part - 3), a structure is classified as class 'A' if greatest horizontal or vertical dimension is

(a) less than 20 m (b) 20 m to 50 m (c) greater than 50 m (d) none of these

32. The topography factor k_3 for site when upwind slope (θ) is less than 3° is

(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5

33. Which of the following four shapes for a compound steel column of the same effective height formed with two equal angles, has highest axial compression load carrying capacity ?



34. If a structure is under fatigue stresses then the welded joints as compared to the riveted joints will fail

(a) earlier (b) later (c) at the same time (d) not at all

35. Generally for structural steel connections, the process of welding adopted is

(a) Carbon arc welding (b) Oxy-hydrogen welding
(c) Pressure welding (d) metal arc welding

36. In roof truss for principal rafter most frequently used section is

(a) Two channels placed at a distance apart
(b) Two channels placed back to back
(c) two angle section placed back to back
(d) four angle section

37. The structure made of rigid curved surfaces are known as

(a) Surface structure (b) framed structure
(c) shell structure (d) Space structure

38. Generally, in a simply supported truss the principal rafter will carry

(a) Compressive forces (b) tensile forces
(c) Sometimes compressive and sometimes tensile forces (d) Shear forces

39. In the fillet weld the weakest section is

(a) Smaller side of fillet (b) throat of the fillet
(c) Side perpendicular to force (d) Side parallel to force

40. In plate girder, a web should be checked for shear buckling if

(a) $\frac{d}{tw} > 67\ \varepsilon$ (b) $\frac{d}{tw} \leq 67\ \varepsilon$ (c) $\frac{d}{tw} > 90\ \varepsilon$ (d) $\frac{d}{tw} > 200\ \varepsilon$

41. For a thickness of a thicker plate t = 12 mm the minimum size of fillet weld required is

(a) 3 mm (b) 5 mm (c) 6 mm (d) 8 mm

42. For fillet weld, minimum throat thickness of weld is taken as

(a) 0.5 S (b) 0.7 S (c) 0.75 S (d) 0.80 S

43. The design strength of fillet weld for f_u = 410 N/mm^2 and shop welding is
(a) 158 N/mm^2 (b) 189 N/mm^2 (c) 150 N/mm^2 (d) None of these

44. The design tensile strength of a member (T_d) is taken as
(a) design strength due to yielding of gross section
(b) design strength due to rupture of critical section
(c) design strength due to block shear
(d) smaller of (a), (b) and (c)

45. The best cross section is
(a) Plastic (b) compact (c) semi-compact (d) slender

46. For gantry girder economic depth of girder is taken as
(a) $\frac{L}{10}$ (b) $\frac{L}{12}$ (c) $\frac{L}{15}$ (d) $\frac{L}{20}$

47. For the same depth, the heaviest I-section is
(a) ISLB (b) ISHB (c) ISMB (D) ISWB

48. In case of rolled steel beams, shear force is resisted by
(a) Web only (b) flange only
(c) Web and flanges together (d) None of these

49. Sag rods are used in a roof truss for connecting
(a) purlins (b) main ties (c) Principal rafters (d) none of the above

50. The batten plates used to connect the components of built up column are designed to resist
(a) longitudinal shear only (b) transverse shear only
(c) bending moments and shear due to transverse shear
(d) none of the above

: ANSWERS :

1. (d)	2. (b)	3. (c)	4. (d)	5. (b)
6. (d)	7. (c)	8. (d)	9. (c)	10. (a)
11. (c)	12. (c)	13. (a)	14. (c)	15. (b)
16. (c)	17. (a)	18. (d)	19. (b)	20. (c)
21. (c)	22. (b)	23. (d)	24. (b)	25. (d)
26. (d)	27. (c)	28. (b)	29. (b)	30. (c)
31. (a)	32. (a)	33. (b)	34. (a)	35. (d)
36. (c)	37. (c)	38. (a)	39. (b)	40. (a)
41. (b)	42. (b)	43. (b)	44. (d)	45. (a)
46. (b)	47. (b)	48. (a)	49. (a)	50. (c)

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7.

Soil Mechanics and Foundation Engineering

MCQ'S

SET - 1 : Origin and Nature of Soil

1. **Water transported soils are termed :**
   (a) Colluvial (b) Aeoline (c) Residual (d) Alluvial
2. **Wind deposited soils are called :**
   (a) Residual (b) Aeoline (c) Lacustrine (d) drift
3. **Cohesionless soils are formed due to :**
   (a) Physical disintegration (b) Chemical decomposition
   (c) Oxidation (d) Hydration
4. **The following type of soil is not glair–deposited :**
   (a) Drift (b) till (c) outwash (d) Loess
5. **Glacier deposited soils are called :**
   (a) Talus (b) Loess (c) Drift (d) None of above
6. **Which soils have higher shrinkage and swelling characteristics ?**
   (a) Cohesionless soils (b) Black cotton soils
   (c) Laterites (d) Residual soils
7. **Soils transported and deposited by gravity are called :**
   (a) Talus (b) drift (c) Loess (d) Aeoline
8. **Major part of Maharashtra is covered by :**
   (a) Alluvial soils (b) Black cotton soils
   (c) Acolian soils (d) Marine soils

: ANSWERS :

(1) (d), (6) (b),	(2) (b), (7) (a),	(3) (a), (8) (b).	(4) (d),	(5) (c),

SET-2 : Index properties and Relationships

1. **Porosity is defined as**
   (a) $n = \frac{V_v}{V_s}$ (b) $n = \frac{V_v}{V}$ (c) $n = \frac{V_s}{V_v}$ (d) $n = \frac{V}{V_v}$

2. **Voil ratio is defined as**
   (a) $e = \frac{V_v}{V_s}$ (b) $e = \frac{V_v}{V}$ (c) $e = \frac{V_s}{V_v}$ (d) $e = \frac{V}{V_v}$

3. **In over drying method for determination of water content the sample is kept at .... temperature for 24 hours.**
   (a) < 80°C (b) 105 – 110°C (c) > 200°C (d) None of these

4. **............... method of determination of water content can be used only when specific gravity of soil solids is known in advance.**
   (a) Pycnometer method (b) Calcium carbide method
   (c) Sand both method (d) Oven drying method

5. **............ is called father of soil mechanics.**
   (a) Rankine (b) Darcy (c) Karl Terzaghi (d) Casagrande

6. **For fully dry soil, degree of saturation is**
   (a) 0 (b) 1 (c) 100 (d) ∞

7. **For fully saturated soil, degree of saturation is**
   (a) 0 (b) 1 (c) 100 (d) ∞

8. **Void ratio 'e' for soils lies between**
   (a) 0 to 1 (b) 1 to 2 (c) 0 to ∞ (d) 0 to 0.1

9. **Higher the specific gravity of soil particles, more .... is the particles.**
   (a) thicker (b) denser (c) lighter (d) none of these

10. **Specific gravity of soil mass is the ratio of**
    (a) γ/γ_w (b) γ_w/γ_s (c) γ_s/γ_w (d) γ_w/γ

11. **Percentage air voids (n_a) is defined as**
    (a) $\frac{V_a}{V_v}$ (b) $\frac{V_a}{V}$ (c) $\frac{V_a}{V_w}$ (d) $\frac{V_v}{V}$

12. **Air content (a_c) is defined as**
    (a) $\frac{V_a}{V}$ (b) $\frac{V_a}{V_v}$ (c) $\frac{V}{V_a}$ (d) $\frac{V_v}{V_a}$

13. Density index is the ratio of

(a) $I_D = \frac{e_{max} - e}{e_{max} - e_{min}}$ (b) $I_D = \frac{e_{max} - e_{min}}{e_{max} - e}$

(c) $I_D = \frac{e - e_{max}}{e_{max} - e_{min}}$ (d) $I_D = \frac{e_{max} - e_{min}}{e_{max} - e}$

14. Generally for soils density index (I_D) lies between

(a) < 0 (b) > 100 % (c) 0 to 100 % (d) ∞

15. On site bulk density of cohesionless soils can be determined by

(a) Core cutter method (b) Sand replacement method

(c) Calcium carbide method (d) Pycnometer method

16. On site bulk density of cohesive soils is determined by

(a) Core cutter method (b) Sand replacement method

(c) Calcium carbide method (d) Pycnometer method

17. Which type of soil is not glacier deposited

(a) Drift (b) bentonite (c) till (d) none of these

18. Cohesionless soils are formed due to

(a) Oxidation (b) hydration

(c) Physical disintegration (d) Chemical decomposition

19. The correct ascending order for following densities is

1. Bulk density
2. Dry density
3. Saturated density
4. Submerged density

(a) 1, 2, 4, 3 (b) 1, 2, 3, 4 (c) 4, 2, 1, 3 (d) 4, 2, 3, 1

20. The value of specific gravity for most of the soils lies around

(a) 1.0 (b) 2.0 (c) 2.68 (d) 3.1

: ANSWERS :

1. (b)	2. (a)	3. (b)	4. (a)	5. (c)
6. (a)	7. (b)	8. (a)	9. (b)	10. (c)
11. (b)	12. (b)	13. (a)	14. (c)	15. (b)
16. (a)	17. (b)	18. (c)	19. (c)	20. (c)

SET - 3 : General

1. **Consistency of soil is used to describe firmness of .... soils related to water content.**
   (a) Coarse grained soils (b) Fine grained soils
   (c) Coarse sand (d) Fine sand
2. **For determination of liquid limit in laboratory the soil sample passing through .... IS sieve is used.**
   (a) 75 μ (b) 150 μ (c) 425 μ (d) 600 μ
3. **In plastic limit test the soil ball is rolled on a glass plate into a thread of .... mm diameter.**
   (a) 2 mm (b) 3 mm (c) 6 mm (d) 10 mm
4. **For uniformly graded soil the uniformity coefficient (C_u) is ....**
   (a) 1 (b) 4 (c) 6 (d) 8
5. **For gravels uniformity coefficient (C_u) should be**
   (a) 1 (b) 2 (c) greater than 4 (d) greater than 6
6. **The ratio of unit weight of soil solids to that of water is called**
   (a) Water content (b) Specific gravity
   (c) degree of saturation (d) Void ratio
7. **The relation between void ratio (e) and porosity (n) is**
   (a) $n = \frac{1+e}{e}$ (b) $n = \frac{e}{1+e}$ (c) $e = \frac{n}{1+n}$ (d) $e = \frac{1-n}{n}$
8. **The relation between the air content (a_c) and degree of saturation (S_r) is**
   (a) $a_c = 1 + S_r$ (b) $a_c = 1 - S_r$ (c) $a_c = 1/S_r$ (d) None of these
9. **The approximate void ratio in sandy soil is**
   (a) 0.2 (b) 0.6 (c) 0.8 (d) 1.2
10. **The .... clay mineral has high swelling and shrinkage characteristics.**
    (a) Kaolinite (b) Illite (c) Montmorillonite (d) None of these
11. **As per Atterberg, if the value of plasticity index is greater than 17, the soil is classified as**
    (a) low plastic (b) non plastic (c) Medium plastic (d) highly plastic
12. **Gravel and sand is a**
    (a) Cohesive coarse grained soil (b) Cohesive fine grained soil
    (c) non–cohesive coarse grained soil (d) non–cohesive fine grained soil
13. **The density of soil mass is expressed in**
    (a) kg/m^2 (b) kg/m^3 (c) N/m^2 (d) N/m^3

14. The unit weight of soil mass is expressed in

(a) kg/m^2 (b) kg/m^3 (c) N/m^2 (d) N/m^3

15. The shape of particle size curve can be represented by

(a) C_u (b) C_c (c) I_P (d) I_f

16. The minimum water content at which soil mass still flows like a liquid is called

(a) liquid limit (b) plastic limit (c) Shrinkage limit (d) flow limit

17. Maximum water content at which reduction in water will not cause decrease in volume of soil mass is called.

(a) liquid limit (b) plastic limit
(c) Shrinkage limit (d) plasticity index

18. In liquid limit test the height of fall of cup is kept as

(a) 1 cm (b) 2 cm (c) 3 cm (d) 5 cm

19. Plasticity index (I_p) is defined as

(a) $I_p = W_L - Wp$ (b) $I_p = W_L - Ws$ (c) $I_p = W_p - W_s$ (d) None of these

20. Toughness index is defined as

(a) $I_T = \frac{I_P}{I_F}$ (b) $I_T = \frac{I_F}{I_P}$ (c) $I_T = \frac{I_C}{I_F}$ (d) $I_T = \frac{I_C}{I_P}$

21. Consistency index is defined as

(a) $I_C = \frac{W_L - w}{I_P}$ (b) $I_C = \frac{w - W_P}{I_P}$ (c) $I_C = \frac{W_L - W_P}{I_P}$ (d) $I_C = \frac{W_L - w}{I_F}$

22. When soil is at liquid limit, I_C = ...

(a) 0 (b) 1 (c) ∞ (d) None of these

23. When soil is at plastic limit, I_C = ...

(a) 0 (b) 1 (c) ∞ (d) none of these

24. When soil is at liquid limit, liquidity index (I_L) = ...

(a) 0 (b) 1 (c) ∞ (d) None of these

25. When soil is at plastic limit, liquidity index I_L = ...

(a) 0 (b) 1 (c) ∞ (d) None of these

26. As per Atterberg, if the value of plasticity index is less than 7, the soil is classified as ....

(a) Non plastic (b) Low plastic (c) Medium plastic (d) highly plastic

27. The sum $I_L + I_C$ is always equal to

(a) 2 (b) 1 (c) 0 (d) 0.5

28. If the value $I_L > 1$, then soil mass is in .... state.

(a) liquid (b) plastic (c) solid (d) semi–solid

29. As per IS soil classification system the sand particles size ranges from

(a) 75 μ – 4.75 mm (b) 4.75 mm – 20 mm
(c) 2μ – 75μ (d) 2 mm – 20 mm

30. A soil having liquid limit 60 % and plasticity index 40 % can be defined as

(a) CL (b) CH (c) SM (d) CL – ML

31. Stoke's law is used to determine the

(a) Specific gravity of soil solids
(b) density of soil suspension
(c) Grain size distribution of those soils whose grain size is finer than 0.075 mm
(a) all of the above

32. The effective size of a soil is

(a) D_{10} (b) D_{20} (c) D_{40} (d) D_{60}

33. The uniformity coefficient of soil is defined as

(a) $Cu = \frac{D_{40}}{D_{10}}$ (b) $\frac{D_{40}}{D_{20}}$ (c) $\frac{D_{60}}{D_{10}}$ (d) $\frac{D_{50}}{D_{10}}$

34. As per IS soil classification system, when liquid limit lies between 35 % and 50 % the given soil is classified as

(a) Soil with low compressibility (b) Soil with medium compressibility
(c) Soil with high compressibility (d) None of these

35. IS plasticity chart is a plot of

(a) I_P v_s W_L (b) I_L v_s W_L (c) I_f v_s W_L (d) W_L v_s W_p

36. Casagrande equation for Ip – A line is

(a) 0.63 (W_L – 20) (b) 0.73 (W_L – 20) (c) 0.63 (W_L – 10) (d) 0.73 (W_L – 10)

37. As per IS classification silt size is

(a) 0.075 to 4.75 mm (b) 0.002 to 0.075 mm
(c) < 0.002 mm (d) > 4.75 mm

38. As per IS classification SM soil is designated as

(a) Silty clay (b) Silty gravel (c) Sandy gravel (d) Silty sand

39. Generally honeycomb structure is observed in .... soils.

(a) Silty (b) Clayey (c) Gravely (d) Sandy

40. Generally flocculated structure and dispersed structure is observed in ... deposits.

(a) Silt (b) Clay (c) Sand (d) gravel

41. Generally the montmorillonite is the primary constituent for .... type of soil.

(a) Gravelly (b) Sandy (c) black cotton (d) Silty

42. Kaolinite is the primary constituent of ....

(a) black cotton soil (b) bentonite (c) china clay (d) gravelly sand

43. Held water is also classified as

(a) Structural water (b) adsorbed water (c) Capillary water (d) all of these

44. Adsorbed water is also referred as

(a) Structural water (b) Free water (c) Hygroscopic water (d) held water

45. .... is the water held by fine grained soil particles due to electrochemical forces of adhesion.

(a) adsorbed water (b) Capillary water (c) Free water (d) None of these

46. Clay particles carry .... charges on their faces.

(a) Positive (b) Negative (c) Neutral (d) None of these

47. A soil having uniformity coefficient C_u more than 15 is known as

(a) uniform soil (b) well graded soil

(c) poorly graded soil (d) coarse soil

48. The activity of clay is defined as ratio of

(a) liquid limit to plastic limit (b) liquidity index to plasticity index

(c) Plasticity index to clay fraction (d) Plasticity index to shrinkage index

49. Which of the following soil is highly permeable ?

(a) gravel (b) sand (c) clay (d) silt

50. Which of the following soil is practically impermeable ?

(a) gravel (b) Sand (c) Clay (d) Coarse sand

51. Which of the following affect permeability of soil ?

(a) Grain size (b) void ratio (c) degree of saturation (d) all of these

52. Quick sand is a

(a) Moist sand containing fine particles (b) Fine sand easily flowing

(c) Condition in which a cohesionless soil loses all its shear strength due to upward flow of water

(d) none of these

53. The critical gradient of seepage of water in a soil mass is given by

(a) $\frac{1-G}{1+e}$ (b) $\frac{G-1}{1+e}$ (c) $\frac{1+e}{1-G}$ (d) $\frac{1+e}{G-1}$

54. Coarse grained soil has a void ratio of 0.75 and G = 2.75. The critical gradient at which quick condition occurs is

(a) 0.75 (b) 1 (c) 0.5 (d) 0.25

55. Maximum size of particle for which Darcy's law is valid is

(a) 0.2 mm (b) 0.5 mm (c) 1 mm (d) 2 mm

56. Permeability of soil varies

(a) inversely as square of grain size (b) as square of grain size

(c) as grain size (d) inversely as void ratio

57. **With increase in water content soil suction**
(a) decreases (b) remains same (c) increases (d) all the above
58. **A flow net is drawn for a dam, the total head loss is 6 m, number of potential drop is 10, and length of flow path for the last field is 1m. The exit gradient is**
(a) 0.7 (b) 0.6 (c) 1 (d) 1.6
59. **In a shear box test the failure plane is**
(a) Weakest plane (b) horizontal plane
(c) Vertical plane (d) Major principal plane
60. **The pressure on phreatic line is**
(a) equal to atmospheric pressure (b) Less than atmospheric pressure
(c) more than atmospheric pressure (d) Not related to atmospheric pressure
61. **The coefficient of permeability of soil**
(a) increases with increase in temperature (b) increases with decrease in temperature
(c) decreases with increase in temperature (d) has no relation with temperature
62. **In soil classification symbol M stands for**
(a) clay (b) silt (c) sand (d) Medium soil
63. **The horizontal permeability is .... than the vertical permeability.**
(a) More (b) less (c) equal to (d) None of these
64. **For a flow net N_f = 5 and N_d = 20, the shape factor is**
(a) 0.5 (b) 80 (c) 5 (d) 0.25
65. **The exit gradient is the ratio of**
(a) Slope of flow line (b) head loss to length of flow field at exit
(c) total head to total length (d) Slope of equipotential line
66. **Capillary water in soils**
(a) Causes negative pore pressure (b) reduces effective stresses
(c) reduces bearing capacity (d) all of these
67. **The ratio of unconfined compressive strength of undisturbed soil to the unconfined compressive strength of remoulded soil is called**
(a) Sensitivity (b) activity (c) thixotrophy (d) consistency
68. **The property of soil which enables to regain its strength lost on remoulding in a short time without change of moisture content is called**
(a) sensitivity (b) Activity (c) thixotrophy (d) relative density
69. **For most clays, sensitivity lies between**
(a) 2 to 4 (b) 4 to 8 (c) 8 to 15 (d) 15 to 20
70. **The critical gradient of the seepage water**
(a) directly proportional to void ratio

(b) increases with decrease in void ratio
(c) inversely proportional to specific gravity
(d) increases with decrease in specific gravity of soil

71. The critical gradient for all soils is normally
(a) 0.5 (b) 1 (c) 1.5 (d) 1.05

72. Flownet is used to determine the
(a) Seepage flow (b) Seepage pressure (c) exit gradient (d) all of these

73. The effective stress on the soil is due to
(a) external load acting on the soil (b) weight of the soil particles
(c) weight of water present in soil pores (d) both (a) and (b)

74. Silt is a
(a) Material deposited by a glacier
(b) Soil composed of two different soils
(c) Fine grained soil with little or no plasticity
(d) Clay with a high percentage of the clay mineral

75. A flow line in seepage through a soil mass is the
(a) Path of particles of water through a saturated soil mass
(b) line joining points of equal head of water
(c) Flow of movement of fine particles of soil
(d) direction of the flow particle

76. The relation between coefficient of consolidation (C_v), coefficient volume change (m_v) and coefficient of permeability (k) is given by
(a) $C_v = \frac{k}{m_v \cdot \gamma_w}$ (b) $C_v = \frac{k \cdot m_v}{\gamma_w}$ (c) $C_v = \frac{\gamma_w}{k \cdot m_v}$ (d) $C_v = \frac{m_v \cdot \gamma_w}{k}$

77. The relation between coefficient of consolidation (C_v), time factor (T_v) and drainage path (H), time (t) is given by
(a) $T_v = \frac{C_v \cdot H}{t}$ (b) $T_v = \frac{C_v \cdot t}{H^2}$ (c) $T_v = \frac{C_v \cdot t^2}{H}$ (d) $T_v = \frac{C_v \cdot t}{H}$

78. The coefficient of consolidation is measured in
(a) cm^2/g (b) cm^2/s (c) $g/cm^2/s$ (d) $cm^2/g/s$

79. The time factor for 25 % degree of consolidation is given by
(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{16}$ (c) $\frac{\pi}{32}$ (d) $\frac{\pi}{64}$

80. The strength of soil is usually identified by
(a) direct tensile stress (b) direct compressive stress
(c) ultimate shear stress (d) effective stress

81. With increase in liquid limit compression index

(a) decreases (b) increases
(c) remain constant (d) May increase or decrease

82. The coefficient of compressibility is the ratio of

(a) Change in void ratio to change in effective stress
(b) Volumetric strain to change in effective stress
(c) Change in thickness to change in effective stress
(d) Stress to strain

83. When drainage is permitted throughout the triaxial test, it is known as

(a) Quick test (b) Drained test
(c) Consolidated undrained test (d) none of these

84. Coulomb's equation for shear strength of sand is

(a) $S = C + \sigma \tan \phi$ (b) $S = \sigma \tan \phi$ (c) $S = C$ (d) None of these

85. Coulomb's equation for shear strength of cohesive soil is

(a) $S = C + \sigma \tan \phi$ (b) $S = \sigma \tan \phi$ (c) $S = C$ (d) None of these

86. The common size of direct shear test box is

(a) 50 × 50 × 60 mm (b) 50 × 50 × 40 mm
(c) 60 × 60 × 40 mm (d) 60 × 60 × 50 mm

87. The relation between undrained cohesion (C_u) and unconfined compressive strength for cohesive soil is

(a) $C_u = 2 q_u$ (b) $C_u = \frac{q_u}{2}$ (c) $C_u = 3 q_u$ (d) $C_u = \frac{q_u}{3}$

88. In triaxial compression test, the deviator stress (σ_d) is given by

(a) $\sigma_d = \sigma_1 + \sigma_3$ (b) $\sigma_d = \sigma_1 - \sigma_3$ (c) $\sigma_d = \sigma_1 \times \sigma_3$ (d) $\sigma_2 = \sigma_1/\sigma_3$

89. The angle of failure plane with major principal plane is given by

(a) $45° + \phi$ (b) $45° + \phi/2$ (c) $45° - \phi$ (d) $45° - \frac{\phi}{2}$

90. Rollers suitable for compacting cohesionless soils are

(a) Smooth wheeled rollers (b) Sheep foot rollers
(c) Pneumatic tyred rollers (d) None of these

91. Pneumatic tyred rollers are useful for compacting

(a) Cohesive soils (b) Cohesionless soils
(c) both (a) and (b) (d) For soils in confined space

92. Vibroflotation technique is best suited for

(a) Clays (b) Silt
(c) Coarse sand and gravel (d) Organic soils

93. The line of optimums generally corresponds to percentage air voids of about

(a) zero percent (b) 5 % (c) 10 % (d) 20 %

94. The range of optimum water contents for the standard proctor test for clayey soils is

(a) 6 to 10 % (b) 8 to 12 % (c) 12 to 15 % (d) 15 to 20 %

95. With increase in compaction energy in compaction test

(a) MDD and OMC both increases (b) MDD increase and OMC decrease
(c) MDD and OMC increase (d) MDD and OMC remains constant

96. For stabilization of heavy clays, the following method is generally most effective

(a) Mechanical stabilization (b) thermal stabilization
(c) electrical stabilization (d) Chemical stabilization

97. For remoulded clays, compression index is given by

(a) $C_c = 0.009\ (W_L - 10)$ (b) $C_c = 0.009\ (W_L - 20)$
(c) $C_c = 0.007\ (W_L - 10)$ (d) $C_c = 0.007\ (W_L - 20)$

98. The coefficient of active earth pressure is given by

(a) $\frac{1-\sin\phi}{1+\sin\phi}$ (b) $\frac{1+\sin\phi}{1-\sin\phi}$ (c) $\frac{1+\cos\phi}{1-\cos\phi}$ (d) $\frac{1-\cos\phi}{1+\cos\phi}$

99. The coefficient of active earth pressure is always .... passive earth pressure coefficient.

(a) more than (b) less than (c) equal to

100. According to Terzaghi's theory, the net ultimate bearing capacity of clay is given by

(a) $C.N_q$ (b) $C.N_\gamma$ (c) $C.N_c$ (d) $1.3\ CN_c$

101. If q_f = ultimate B.C. of footing and q_p = ultimate B.C. of test plate then, for clays

(a) $q_f = q_p$ (b) $\frac{q_f}{q_p} = \frac{B_f}{B_p}$ (c) $q_f > q_p$ (d) $q_f < q_p$

102. For sands, the relation between q_f and q_p is

(a) $q_f = q_p$ (b) $\frac{q_f}{q_p} = \frac{B_f}{B_p}$ (c) $q_f > q_p$ (d) $q_f < q_p$

103. If S_f = Settlement for footing and Sp = Settlement for plate then, for clays

(a) $S_f = S_p \times \frac{B_f}{B_p}$ (b) $S_f = S_p$ (c) $S_f = S_p \times \frac{B_p}{B_f}$ (d) None of these

104. The radius of friction circle or ϕ – circle in friction circle method is (IES)

(a) r (b) r sin ϕ (c) r cos ϕ (d) r tan ϕ

105. For an anistropic soil, permeabilities in x and y directions are kx and ky respectively in a two dimensional flow. The effective permeability keq for the soil is given by **(GATE)**

(a) $k_x + k_y$ (b) k_x/k_y (c) $(k_x^2 + k_y^2)$ (d) $(k_x \cdot k_y)^{\frac{1}{2}}$ (GATE)

106. The soils most susceptible to liquefaction are

(a) Saturated dense sands

(b) Saturated fine and medium sands of uniform particle size

(c) Saturated clays of uniform size

(d) Saturated gravels and cobbles

107. The coefficient of earth pressure at rest is given by

(a) $\frac{\mu}{1+\mu}$ (b) $\frac{1+\mu}{\mu}$ (c) $\frac{\mu}{1-\mu}$ (d) $\frac{1-\mu}{\mu}$ (GATE)

108. The slope of the e– log p curve for a soil mass gives

(a) Coefficient of permeability, k

(b) Coefficient of consolidation, C_v

(c) Compression index, C_c

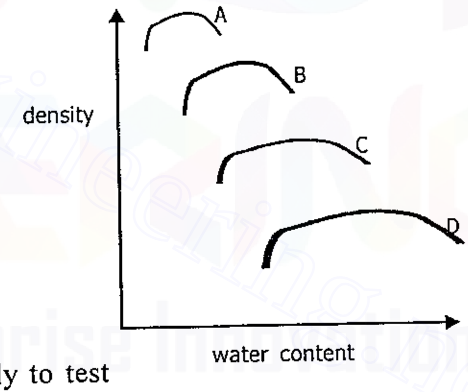
(d) Coefficient of volume compressibility, m_v (IES)

109. Degree of freedom of a block type machine foundation is

(a) 2 (b) 3 (c) 4 (d) 6

110. The results (curves A, B, C, D) of four compaction tests on different soils are shown in figure below : (Civil Services)

1. Silty sand, modified test
2. Silty sand, standard test
3. Fat clay, modified test
4. Fat clay, standard test



Curves A, B, C and D correspond respectively to test

(a) 1, 3, 2, 4 (b) 1, 2, 3, 4 (c) 2, 1, 3, 4 (d) 2, 1, 4, 3

111. A cohesionless soil having an angle of internal friction of ϕ is standing at a slope angle of i. The factor of safety of the slope is

(a) $\frac{\tan i}{\tan \phi}$ (b) $\tan i - \tan\phi$ (c) $\frac{\tan \phi}{\tan i}$ (d) $\tan\phi - \tan i$

112. In consolidation testing, curve fitting method is used to determine (Civil Services)

(a) Compression index (b) Swelling index

(c) Coefficient of consolidation (d) time factor

113. Westergaard's analysis for stress distribution beneath loaded areas is applicable to

(a) Sandy soils (b) Clayey soils (c) Stratified soils (d) Silty soils

114. Match list I and List II :

List I Property of soil		List – II Laboratory equipment	
A.	Grain size	1.	Pycnometer
B.	Specific gravity	2.	Permeameter
C.	Coefficient of permeability	3.	Vane shear apparatus
D.	Cohesion	4.	Pipette
		5.	Sand pouring cylinder

(Civil Services)

Codes :

	A	B	C	D
(a)	4	1	2	3
(b)	4	5	2	3
(c)	5	1	2	4
(d)	1	5	3	2

115. Match list I and List II

List I Property of soil		List – II Test	
A.	Water content	1.	Core cutter method
B.	Field density	2.	Pycnometer bottle method
C.	Shear strength	3.	Calcium carbide method
D.	Specific gravity	4.	Triaxial compression test

	A	B	C	D
(a)	1	3	4	2
(b)	3	1	4	2
(c)	3	1	2	4
(d)	1	3	2	4

116. The upstream slope of an earth dam under steady seepage condition is

(Civil Services)

(a) equipotential line (b) phreatic line (c) Flow line (d) Seepage line

117. For sampling saturated sands and other soft and wet soils satisfactorily, the most suitable soil sampler is (Civil Services)

(a) Open drive thin walled tube sampler (b) Standard split spoon sampler

(c) Stationary piston sampler (d) Rotary sampler

118. Undisturbed soil samples are required for conducting **(Civil Services)**

(a) hydrometer test (b) Shrinkage limit test

(c) Consolidation test (d) Specific gravity test

119. When the degree of consolidation is 50 %, the time factor is about

(Civil Services)

(a) 0.2 (b) 0.5 (c) 1.0 (d) 2.0

120. In context of collecting undisturbed soil samples of high quality using a spoon sampler, following statements are made :

(I) Area ratio should be less than 10 % (II) Clearance ratio should be less than 1 %

With reference to above statements, which of the following applies ?

(a) Both statements are true (b) Statement II is true and I is false

(c) Statement I is true but II is false (d) Both statements are false

121. The net ultimate bearing capacity of a soil is 25 t/m^2 and density 1.7 t/m^3. The safe bearing capacity at 1.0 m below ground surface taking FOS = 2.5 will be

(a) 10 t/m^2 (b) 25 t/m^2 (c) 11.7 t/m^2 (d) 62.5 t/m^2

122. The maximum value of effective stress in the past divided by the present value, is defined as over consolidation ratio (OCR). The O.C.R. of an over consolidated clay is

(a) less than 1 (b) 1 (c) more than 1 (d) none of these

123. In a saturated clay layer undergoing consolidation with single drainage at its top, the pore water pressure would be maximum at its **(Civil Services)**

(a) top (b) middle (c) bottom (d) top as well as bottom

124. Consider the following types of soil tests : **(Civil Services)**

1. California bearing ratio
2. Consolidation
3. Unconfined compression test

The soil tests required to be done in the case of undisturbed samples includes

(a) 1, 2 and 3 (b) 1 and 2 (c) 1 and 3 (d) 2 and 3

125. During seepage through an earth mass, the direction of seepage is

(Civil Services)

(a) Parallel to the equipotential lines

(b) Perpendicular to the stream lines

(c) Perpendicular to the equipotential lines

(d) Along the direction of gravity

126. Which of the following have an influence on the value of permeability ?

(Civil Services)

1. Void ratio
2. Degree of saturation
3. Pressure head
4. Grain size

Select the correct answer using the codes given below :

Codes :

(a) 1, 2 and 4 (b) 1, 2 and 3 (c) 2, 3 and 4 (d) 1, 3 and 4

127. For a damped vibrating system, with single degree of freedom, resonance occurs at a frequency ratio of (Civil Services)

(a) 1 (b) 0 (c) less than 1 (d) greater than 1

128. A clear dry sand sample is tested in a direct shear test. The normal stress and shear stress at failure are both equal to 120 kN/m^2. The angle of shearing resistance of the sand will be (Civil Services)

(a) 25° (b) 35° (c) 45° (d) 55°

129. For undisturbed sampling, the area ratio for thin wall sampler should not normally exceed (IES)

(a) 10 % (b) 15 % (c) 20 % (d) 25 %

130. The ratio of the energies imparted to soil sample in modified proctor test and the standard proctor test is about (IES)

(a) 10 (b) 4.5 (c) 2.2 (d) 1.8

131. A sample of soil has the following properties : (IES)

Liquid limit = 45 %

Plastic limit = 25 %

Shrinkage limit = 17 %

Natural moisture content = 30 %

The consistency index of the soil is

(a) 15/20 (b) 13/20 (c) 8/20 (d) 5/20

132. A stratum of soil consists of three layers of equal thickness. The permeabilities of top and bottom layers are k = 10^{-4} cm/s and that of the middle layer is k = 10^{-3} cm/s. Then the value of horizontal coefficient of permeability k_H for the entire soil layer is (IES)

(a) 2×10^{-3} cm/s (b) 4×10^{-4} cm/s (c) 3×10^{-4} cm/s (d) 1.5×10^{-4} cm/s

133. Match list I and List II and select correct answer :

	List I		List II
A.	Friction Pile	1.	Stiff clay
B.	Batter pile	2.	Loose granular soil
C.	Tension Pile	3.	Lateral load
D.	Compaction pile	4.	Uplift load

Codes :

	A	B	C	
(a)	3	1	2	4
(b)	1	3	4	2
(c)	3	1	4	2
(d)	1	3	2	4

134. The void ratio – pressure diagram is shown in the figure below : (IES)

The coefficient of compressibility is

(a) 0.05 m^2/t

(b) 0.073 m^2/t

(c) 0.20 m^2/t

(d) 0.25 m^2/t

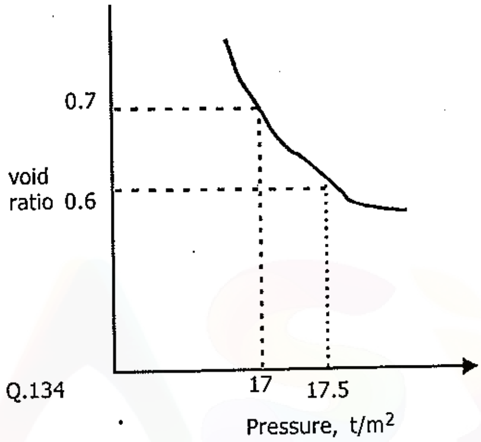


Fig. Q.134

135. Sheep foot rollers are recommended for compacting (IES)

(a) granular soils (b) Cohesive soils (c) hard rock (d) any type of soil

136. A soil has a discharge velocity of 6×10^{-7} m/s and a void ratio of 0.5. Its seepage velocity is (IES)

(a) 18×10^{-7} m/s (b) 12×10^{-7} m/s (c) 6×10^{-7} m/s (d) 3×10^{-7} m/s

137. In Newmark's influence chart for stress distribution there are ten circles and ten radial lines. The influence factor of the chart is (IES)

(a) 0.1 (b) 0.01 (c) 0.001 (d) 0.0001

138. The virgin compression curve for a particular soil is shown in the figure. The compression index of the soil is (IES)

(a) 0.35

(b) 0.50

(c) 1.0

(d) 1.5

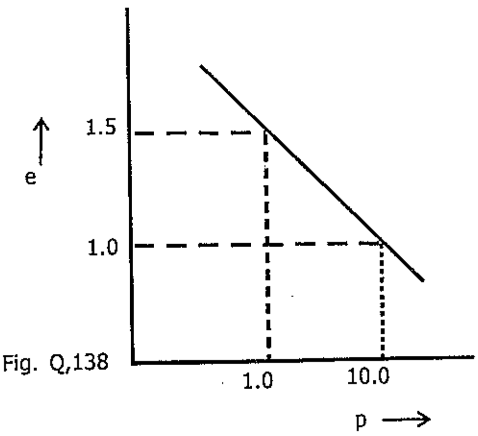


Fig. Q.138

139. Earth pressure and resultant possibilities of wall movement are shown in the figure below. The point marked 'x' in the diagram indicates

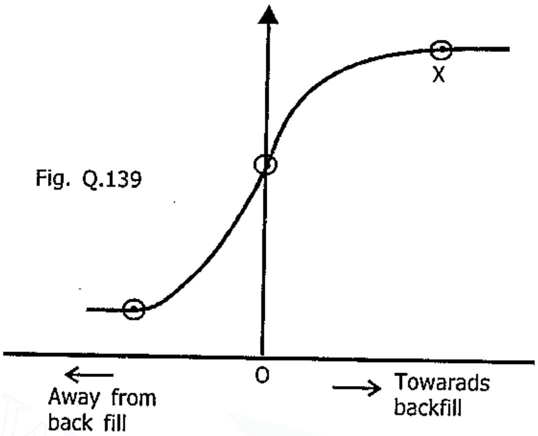


Fig. Q.139

(a) earth pressure at rest
(b) active earth pressure
(c) passive earth pressure
(d) arching active pressure

140. Minimum centre to centre spacing of friction piles of diameter (D) as per BIS code is
(a) 1.5 D (b) 2 D (c) 2.5 D (d) 3 D

141. Which one of the following tests can not be done without undisturbed sampling ? (IES)
(a) Shear strength of sand (b) Shear strength of clay
(c) determination of compaction parameters (d) Atterberg limits

142. If an unconfined compressive strength of 4 kg/cm^2 in the natural state of clay reduces by four times in the remoulded state, then its sensitivity will be (IES)
(a) 1 (b) 2 (c) 4 (d) 8

143. Ratio of bearing capacity of double under reamed pile (U.R.) to that of single U.R. pile is nearly (IES)
(a) 2 (b) 1.5 (c) 1.2 (d) 1.7

144. A soil sample has void ratio of 0.5 and its porosity will be close to (GATE)
(a) 50 % (b) 66 % (c) 100 % (d) 33 %

145. A borrow pit has a dry density of 17 kN/m^3. How many cubic meters of this soil will be required to construct an embankment of 100 m^3 volume with a dry density of 16 kN/m^3 ? (GATE)
(a) 94 m^3 (b) 106 m^3 (c) 100 m^3 (d) 90 m^3

146. The group efficiency of a pile group (GATE)
(a) will be always less than 100 %
(b) will be always greater than 100 %
(c) may be less than 100 % or greater than 100 %
(d) will be more than 100 % for pile group in cohesionless soil and less than 100 % for pile group in cohesive soil

147. The two criteria for the determination of allowable bearing capacity of a foundation are (GATE)
(a) tensile failure and compression failure (b) tensile failure and settlement
(c) bond failure and shear failure (d) Shear failure and settlement

148. The void ratio and specific gravity of a soil are 0.65 and 2.72 respectively. The degree of saturation (in percent) corresponding to water content of 20 % is (GATE)
(a) 65.3 (b) 20.9 (c) 83.7 (d) 54.4

149. The undrained cohesion of a remoulded clay soil is 10 kN/m^2. If sensitivity of the clay is 20, then corresponding remoulded compressive strength is (GATE)
(a) 5 kN/m^2 (b) 10 kN/m^2 (c) 20 kN/m^2 (d) 200 kN/m^2

150. Negative skin friction in a soil is considered when the pile is constructed through a
(a) Fill material (b) Dense coarse sand
(c) Over consolidated stiff clay (d) dense fine sand

: ANSWERS :

1. (b)	2. (c)	3. (b)	4. (b)	5. (c)
6. (b)	7. (b)	8. (b)	9. (b)	10. (c)
11. (d)	12. (c)	13. (b)	14. (d)	15. (b)
16. (a)	17. (c)	18. (a)	19. (a)	20. (a)
21. (a)	22. (a)	23. (b)	24. (b)	25. (a)
26. (b)	27. (c)	28. (a)	29. (a)	30. (b)
31. (c)	32. (a)	33. (c)	34. (b)	35. (a)
36. (b)	37. (b)	38. (d)	39. (a)	40. (b)
41. (c)	42. (c)	43. (d)	44. (c)	45. (a)
46. (b)	47. (b)	48. (c)	49. (a)	50. (c)
51. (d)	52. (c)	53. (b)	54. (b)	55. (b)
56. (b)	57. (c)	58. (b)	59. (b)	60. (a)
61. (a)	62. (b)	63. (a)	64. (d)	65. (b)
66. (a)	67. (a)	68. (c)	69. (a)	70. (b)
71. (b)	72. (d)	73. (d)	74. (c)	75. (a)
76. (a)	77. (b)	78. (b)	79. (d)	80. (c)
81. (b)	82. (a)	83. (b)	84. (b)	85. (c)
86. (d)	87. (b)	88. (b)	89. (b)	90. (a)
91. (c)	92. (c)	93. (b)	94. (b)	95. (b)
96. (d)	97. (c)	98. (a)	99. (b)	100. (c)
101. (a)	102. (b)	103. (a)	104. (b)	105. (d)

106. (b)	107. (c)	108. (c)	109. (d)	110. (b)
111. (c)	112. (c)	113. (c)	114. (a)	115. (b)
116. (a)	117. (b)	118. (c)	119. (a)	120. (a)
121. (c)	122. (c)	123. (c)	124. (d)	125. (c)
126. (a)	127. (a)	128. (c)	129. (a)	130. (b)
131. (a)	132. (b)	133. (b)	134. (c)	135. (b)
136. (a)	137. (b)	138. (b)	139. (c)	140. (d)
141. (b)	142. (c)	143. (b)	144. (d)	145. (b)
146. (a)	147. (d)	148. (c)	149. (c)	150. (a)

EXPLANATIONS

22. (a) $I_c = \frac{W_L - w}{I_p} = \frac{W_L - W_L}{I_p} = 0$

At liquid limit

$w = W_L$

23. (b) $I_c = \frac{W_L - w}{I_p} = \frac{W_L - W_p}{I_p} = \frac{I_p}{I_p} = 1$

at plastic limit

$w = W_p$

24. (b) $I_L = \frac{w - W_p}{I_p} = \frac{W_L - W_p}{I_p} = 1$

at liquid limit

$w = W_L$

25. (a) $I_L = \frac{w - W_p}{I_p} = \frac{W_p - W_p}{I_p} = 0$

at plastic limit

$w = W_p$

26. (b)

I_p	Plasticity
0	non plastic
< 7	low plastic
7 – 17	Medium plastic
> 17	Highly plastic

29. (a)

Clay	0.002 mm	silt	0.075 mm	Sand	4.75 mm	gravel	80 mm	cobble	300 mm	Boulder

30. (b) Ip A – line = 0.73 (W_L – 20)
= 0.73 (60 – 20)
= 29 < 40

∴ The point is above I_p – Aline

∴ soil is CH type

34. (b)

Liquid limit	Compressibility
0 – 35	Low (L)
35 – 50	Medium (M)
> 50	High (H)

54. (b) $i_c = \frac{G-1}{1+e} = \frac{2.75-1}{1+0.75} = 1$

64. (d) Shape factor = $\frac{N_f}{N_d} = \frac{5}{20}$ = 0.25

79. (d) For u < 60 %

$$T_V = \frac{\pi}{4}\left(\frac{u}{100}\right)^2 = \frac{\pi}{4}\left(\frac{25}{100}\right)^2 = \frac{\pi}{64}$$

58. (b) $\Delta h = \frac{6}{10}$ = 0.6, $i = \frac{\Delta h}{L} = \frac{0.6}{I}$ = 0.6

70. (b) $i_c = \frac{G-1}{1+e}$

81. (b) C_c = 0.007 (W_L – 10)

82. (a) $a_v = \frac{e_o - e}{\sigma' - \sigma_0'}$

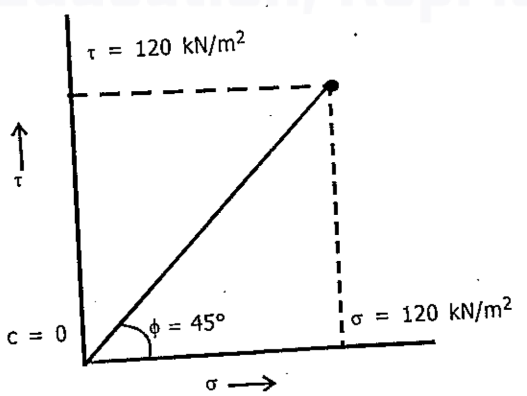
119. (a) $T_V = \frac{\pi}{4}\left(\frac{u}{100}\right)^2 = \frac{\pi}{4}\left(\frac{50}{100}\right)^2$ = 0.196 ≃ 0.20

121. (c) $q_{nu} = q_u - \gamma.D$

$q_{ns} = \frac{q_{nu}}{F} = \frac{25}{2.5}$ = 10 t/m²

$q_s = q_{ns} + \gamma.D$
= 10 + 1.7 × 1 = 11.7 t/m²

128. (c)



130. (b) For modified proctor test, Energy = 2700 kJ/m^3

For standard proctor test, energy = 592 kJ/m^3

$$\therefore \quad \text{Energy ratio} = \frac{2700}{592} = 4.56$$

131. (a) $I_c = \frac{W_L - w}{I_p} = \frac{W_L - w}{W_L - W_p}$

$$= \frac{45-30}{45-25} = \frac{15}{20}$$

132. (b) $k_H = \frac{k_1 d_1 + k_2 d_2 + k_3 d_3}{d_1 + d_2 + d_3}$

$$= \frac{10^{-4}\,d + 10^{-3} d + 10^{-4}\,d}{3d}$$

$$= \frac{12 \times 10^{-4} d}{3d} = 4 \times 10^{-4} \text{ cm/sec}$$

134. (c) $a_v = \frac{e_o - e}{\sigma' - \sigma_0'} = \frac{(0.7-0.6)}{(17.5-17)} = \frac{0.1}{0.5} = 0.2 \text{ m}^2/\text{t}$

136. (a) $V_s = \frac{V}{n} = \frac{V(1+e)}{e} = \frac{6 \times 10^{-7}(1+0.5)}{0.5}$

$= 18 \times 10^{-7}$ m/s

137. (b) Influence factor $= \frac{1}{\text{No. of sub areas}}$

$$= \frac{1}{\text{No. of circles} \times \text{No. radial lines}}$$

$$= \frac{1}{10 \times 10} = 0.01$$

138. (b) Compression index,

$$C_c = \frac{e_o - e}{\log_{10} \frac{\sigma'}{\sigma_0'}} = \frac{0.5}{\log_{10}\left(\frac{10}{1}\right)} = \frac{0.5}{1} = 0.5$$

142. (c) Sensitivity, St $= \frac{q_u\,(\text{undisturbed})}{q_u\,(\text{remoulded})}$

144. (d) $n = \frac{e}{1+e} = \frac{0.5}{1+0.5} = 0.33$

145. (b) $\frac{\gamma_{d_1}}{\gamma_{d_2}} = \frac{V_1}{V_2} \qquad \frac{17}{16} = \frac{V_1}{100} \qquad \therefore V_1 = 106 \text{ m}^3$

148. (c) $e = \frac{wG}{S_r}$ ∴ $S_r = \frac{wG}{e}$

$$= \frac{0.20 \times 2.72}{0.65} = 83.7\ \%$$

149. (c) $C_u = \frac{q_u}{2}$ ∴ $10 = \frac{q_u}{2}$ ∴ $q_u = 20\ kN/m^2$

$$S_t = \frac{q_u \text{ undisturbed}}{q_u \text{ remoulded}}$$

Since compressive strength itself is q_u

∴ remoulded comp. strength = 20 kN/m^2

SET-4 :

1. **The plasticity of clays are due to**
   (a) adsorbed water (b) free water (c) water molecules bond (d) None of above
2. **In fine sands and silts, the most common type structure is**
   (a) single grained (b) flocculated (c) Honey combed (d) Dispersed
3. **The behaviour of sand is governed by**
   (a) Mass energy (b) surface energy (c) both a and b (d) None of the above
4. **The behaviour of clay is governed by**
   (a) Mass energy (b) Surface energy (c) both a and b (d) None of the above
5. **Honey combed structure is found in**
   (a) Gravels (b) Coarse sands (c) Fine sands and silts (d) Clay
6. **The grains of sands and gravels are**
   (a) bulky (b) Flaky (c) Elongated (d) None of the above
7. **The particles with a high value of sphericity are**
   (a) Easy to maniputate in construction (b) Low tendency to fracture
   (c) Both a and b (d) High tendency to fracture
8. **The smallest clay mineral is**
   (a) Kaolinite (b) Illite (c) Chlorite (d) Montmorillonite

: ANSWERS :

(1) (a),	(2) (c),	(3) (a),	(4) (b),	(5) (c),
(6) (a),	(7) (c),	(8) (d).		

148. (c) $e = \frac{wG}{S_r}$ $\therefore$ $S_r = \frac{wG}{e}$

$$= \frac{0.20 \times 2.72}{0.65} = 83.7\ \%$$

149. (c) $C_u = \frac{q_u}{2}$ $\therefore$ $10 = \frac{q_u}{2}$ $\therefore$ $q_u = 20\ kN/m^2$

$$S_t = \frac{q_u \text{ undisturbed}}{q_u \text{ remoulded}}$$

Since compressive strength itself is q_u

$\therefore$ remoulded comp. strength = 20 kN/m^2

SET-4 :

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: ANSWERS :

(1) (a), (6) (a),	(2) (c), (7) (c),	(3) (a), (8) (d).	(4) (b),	(5) (c),

SET-5 :

1. **The minimum water content at which soil starts getting shear strength is termed as,**
   (a) Liquid limit (b) Plastic limit (c) Shrinkage limit (d) Plasticity index
2. **At shrinkage limit, the soil is**
   (a) Dry (b) Partially saturated (c) Saturated (d) None of the above
3. **The liquidity index of a soil indicates the nearness of its water content to its,**
   (a) Liquid limit (b) Plastic limit (c) shrinkage limit (d) None of above
4. **When the soil is at the plastic limit, its I_L is**
   (a) 100 % (b) 50 % (c) 0 (d) 25 %
5. **The consistency index of a soil indicates the nearness of its water content to its,**
   (a) Liquid limit (b) Plastic limit (c) Shrinkage limit (d) None of above
6. **When the soil is at the plastic limit, its I_c is**
   (a) 100 % (b) 50 % (c) 0 (d) 25 %
7. **The toughness is the ratio of**
   (a) Plasticity index to flow index (b) Liquidity index to flow index
   (c) Consistency index to flow index (d) Shrinkage index to flow index
8. **The shrinkage index is equal to**
   (a) Liquid limit minus plastic limit (b) Plastic limit minus shrinkage limit
   (c) Liquid limit minus shrinkage limit (d) None of the above
9. **A stiff class has a consistancy index**
   (a) 50–75 (b) 75 – 100 (c) Greater than 100 (d) Less than 50
10. **The Plasticity index of a highly plastic soil is about**
    (a) 10 – 20 (b) 20 – 40 (c) Greater than 40 (d) Less than 10
11. **For most clays sensitivity is**
    (a) Less than 1.0 (b) 2 to 4 (c) 4 – 16 (d) more than 16
12. **For a soil sample if I_p = 30% and % of particles finer than 2μ size is 20 %, its activity is**
    (a) 0.67 (b) 1.0 (c) 1.50 (d) None of the above

: ANSWERS :

(1) (a),	(2) (c),	(3) (a),	(4) (c),	(5) (b),	(6) (a),
(7) (a),	(8) (b),	(9) (b),	(10) (b),	(11) (b),	(12) (c).

SET-6 :

1. **The maximum particle size for which Darcy's law is valid is,**
   (a) 0.2 mm (b) 0.5 mm (c) 1.0 mm (d) 2.0 mm
2. **The coefficient of permeability of a soil**
   (a) increases with increase in temperature
   (b) increases with decrease in temperature
   (c) increases with a decrease in unit weight of water
   (d) decreases with an increase in void ratio
3. **The constant head permeability test is conducted for**
   (a) coarse grained soils (b) silty soils (c) clayey soils (d) organic soils
4. **A soil has a discharge velocity 9.51 × 10^{-3} cm/s and void ratio of 0.675. It's seepage velocity is**
   (a) 6.426 × 10^{-3} cm/s (b) 14.10 × 10^{-3} cm/s
   (c) 2.36 × 10^{-2} cm/s (d) 3.2 × 10^{-3} cm/s
5. **The permeability of soil varies**
   (a) as square of grain size (b) inversely as square of grain size
   (c) as grain size (d) inversely as void ratio

: ANSWERS :

(1) (b),	(2) (a),	(3) (a),	(4) (c),	(5) (a).

SET-7 :

1. **Which of the following is incorrect for compaction ?**
   (a) Decrease in volume of soil is due to removal of air from voids.
   (b) The load is static
   (c) Process is rapid
   (d) It is an artificial process.
2. **The line of optimum generally corresponds to percentage air voilds of about**
   (a) zero percent (b) 5 % (c) 10 % (d) 20 %
3. **Soil compacted dry of OMC as compared to wet of OMC,**
   (a) has less permeability (b) swells less
   (c) shrinkage less (d) has less resistance to compression
4. **For a Standard Proctor test, the mass of hammer and the drop of hammer are**
   (a) 2.6 kg and 310 mm (b) 2.6 kg and 450 mm
   (c) 4.9 kg and 310 mm (d) 4.9 kg and 450 mm

5. **The zero air void line and 100 % saturation line are identical.**
   (a) True (b) False
6. **Rollers ideally suited for compaction of cohesive soils are**
   (a) smooth wheel roller (b) vibratory roller
   (c) pneumatic roller (d) sheep foot roller

: ANSWERS :

(1) (b),	(2) (b),	(3) (c),	(4) (a),	(5) (a),	(6) (d).

SET-8 :

1. **The angle of failure plane with the major principal plane is given by**
   (a) $45° + \phi$ (b) $45° - \phi$ (c) $45° + \frac{\phi}{2}$ (d) $45° - \frac{\phi}{2}$
2. **Coulomb's equation for shear strength is given by**
   (a) $C = S + \sigma \tan \phi$ (b) $S = C + \sigma \tan \phi$ (c) $C = S - \sigma \tan \phi$ (d) $S = C - \sigma \tan \phi$
3. **The shear strength of plastic undrained clay depends upon**
   (a) Internal friction (b) Cohesion (c) both (a) and (b) (d) Neither (a) and (b)
4. **The shear strength of cohesionless soil is**
   (a) Proportional to the angle of shearing resistance
   (b) Inversely proportional to the angle of shearing resistance
   (c) Proportional to the tangent of the angle of shearing resistance
   (d) None of above
5. **Which of the following is a quick test ?**
   (a) UU test (b) CU test (c) CD test (d) None of above
6. **A soil sample of clay has unconfined compressive strength of 24 kN/m^2. Its cohesion will be**
   (a) 24 kN/m^2 (b) 12 kN/m^2 (c) 0 (d) 48 kN/m^2

: ANSWERS :

(1) (c),	(2) (b),	(3) (b),	(4) (c),	(5) (a),	(6) (b).

SET-9 :

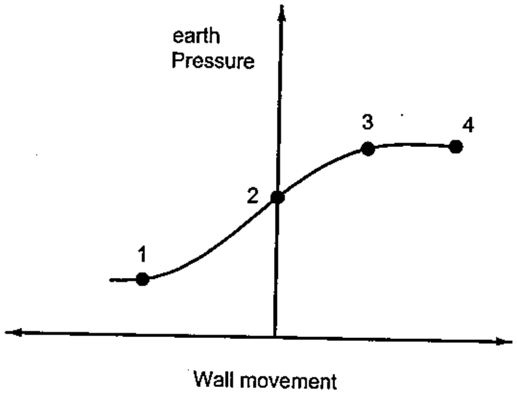
1. **The ultimate settlement of a soil deposit increases with**
   (a) an increase in the compression index
   (b) an increase in the initial void ratio
   (c) decrease in the thickness of clay stratum
   (d) an increase in time
2. **With increase in liquid limit, compression index**
   (a) remains constant (b) decreases
   (c) increases (d) may increase or decrease
3. **The coefficient of compressibility is the ratio of**
   (a) change in void ratio to change in effective stress
   (b) volumetic strain to change in effective stress
   (c) stress to strain
   (d) change in thickness to change in effective stress
4. **A remoulded clay has a liquid limit 50%, its compression index will be**
   (a) 0.18 (b) 0.28 (c) 0.38 (d) 0.48
5. **The recompression index is about _______ of the compression index.**
   (a) 5 times (b) $\frac{1}{5}$ (c) $\frac{1}{2}$ (d) $\frac{1}{20}$

: ANSWERS :

(1) (a),	(2) (c),	(3) (a),	(4) (b),	(5) (b).

SET-10 :

1. **The inclination of the failure plane behind a vertical wall in the passive pressure case is inclined to the horizontal at –**
   (a) $45° - \frac{\phi}{2}$ (b) $45° - \phi$ (c) $45° + \frac{\phi}{2}$ (d) $45° + \phi$
   Ans. (a)
2. **The variation of earth pressure with wall movement is shown in the figure by the points labelled .....** **(IES 1995)**
   (a) 1 and 2 (b) 2 and 3 (c) 3 and 4 (d) 1 and 4
   Ans. (d)



3. **For a sand having an internal friction of 30°, the ratio of passive to active lateral earth pressure will be –** **(IES 2001)**

(a) 1 (b) 3 (c) 6 (d) 9

Ans. : (d)

$$k_a = \frac{1 - \sin 30°}{1 + \sin 30°} = \frac{1}{3}$$

$$k_p = \frac{1}{k_a} = 3$$

$$\therefore \frac{k_p}{k_a} = \frac{3}{\left(\frac{1}{3}\right)} = 9$$

4. **An earth retaining structure may be subjected to the following lateral earth pressures :**

(1) Earth pressure at rest (2) Passive earth pressure (3) Active earth pressure **(IES 2001)**

The correct sequence of the increasing order of the magnitude of these pressures is .....

(a) 3, 2, 1 (b) 1, 3, 2 (c) 1, 2, 3 (d) 3, 1, 2

Ans. (d)

5. **When movement of a wall under the earth pressure from the backfill was prevented the coefficient of earth pressure was recorded as 0.5. The ratio of the coefficients of passive and active earth pressures of the backfill is ......** **(IES 2002)**

(a) $\frac{1}{3}$ (b) 3 (c) $\frac{1}{9}$ (d) 9

Ans. (d)

Coefficient of earth pressure at rest,

$k_a = 1 - \sin\phi = 0.5$

$\therefore \sin\phi = 0.5$

$\therefore \phi = 30°$

$\therefore k_a = \dfrac{1-\sin\phi}{1+\sin\phi} = \dfrac{1-0.5}{1+0.5} = \dfrac{1}{3}$

$k_p = \dfrac{1}{k_a} = 3$

$\therefore \dfrac{k_p}{k_a} = \dfrac{3}{\left(\dfrac{1}{3}\right)} = 9$

6. To have zero active pressure intensity at the top of a wall in cohesive soil, one should apply a uniform surcharge intensity of – **(GATE)**

(a) $2\,c\,\tan\alpha$ (b) $2\,c\,\cot\alpha$ (c) $-2\,c\,\tan\alpha$ (d) $-2\,c\,\cot\alpha$

Ans. (a)

For backfill with surcharge in cohesive soil,

$p_a = \gamma \cdot z\cot^2\alpha - 2c\cot\alpha + q\cot^2\alpha$

For zero active pressure at top,

$z = 0,\ p_a = 0$

$\therefore q\cot^2\alpha = 2c\cot\alpha$

$\therefore q = \dfrac{2c}{\cot\alpha} = 2c\tan\alpha$

7. A retaining wall of height 8 m retain dry sand. In the initial state soil is loose and has a void ratio of 0.5, $\gamma_d = 17.8$ kN/m³ and $\phi = 30'$.

Subsequently, the backfill is compacted to a state where void ratio is 0.4, $\gamma_d = 18.8$ kN/m³ and $\phi = 35°$. The ratio of initial passive thrust, to the final passive thrust according to Rankine earth pressure theory is – **(GATE)**

(a) 0.38 (b) 0.64 (c) 0.77 (d) 1.55

Ans. (c)

Before compaction :

$e = 0.5$

$H = 8$ m

$\gamma_{d_1} = 17.8$ kN/m³

$\phi = 30°$

$k_{p_1} = \dfrac{1+\sin 30'}{1-\sin 30°} = 3$

After compaction :

$e = 0.4$

$\gamma_d = 18.8$ kN/m³

$\phi = 35°$

$$k_{p2} = \frac{1+\sin 35'}{1-\sin 35°} = 3.69$$

$$\frac{p_{p1}}{p_{p2}} = \frac{\frac{1}{2}kp_1 \cdot \gamma_{d_1} \cdot H^2}{\frac{1}{2}kp_2 \cdot \gamma_{d_2} \cdot H^2} = \frac{kp_1 \cdot \gamma_{d_1}}{kp_2 \cdot \gamma_{d_2}} = \frac{3 \times 17.8}{3.69 \times 18.8} = 0.77$$

8. An unsupported excavation is made to the maximum possible depth in a clay soil having $\gamma = 18$ kN/m^3, $c = 100$ kN/m^2, $\phi = 30°$. The active earth pressure, according to Rankine's theory at the base level of the excavation is – (GATE)

(a) 115.47 kN/m^2 (b) 54.36 kN/m^2

(c) 27.18 kN/m^2 (d) 13 kN/m^2

Ans. (a)

Depth of unsupported vertical cut is

$$H_c = \frac{4c}{\gamma}\tan\alpha = \frac{4 \times 100}{18}\tan 60° = 38.49 \text{ m}$$

$$\alpha = 45' + \frac{\phi}{2} = 45° + \frac{30°}{2} = 60°$$

$$p_a = \gamma \cdot H \cot^2\alpha - 2c \cot a$$
$$= 18 \times 38.49 \times (\cot 60°)^2 - 2 \times 100 \cot 60°$$
$$= 230.94 - 115.47$$
$$= 115.47 \text{ kN/m}^2.$$

9. A 3 m high retaining wall is supporting a saturated sand (saturated due to capillary action) of bulk density 18 kN/m^3 and angle of shearing resistance 30′. The change in magnitude of active earth pressure at the base due to rise in ground water table from the base of the footing to the ground surface shall ($\gamma_w = 10$ kN/m^3) (GATE)

(a) increase by 20 kN/m^2 (b) decrease by 20 kN/m^2

(c) increase by 30 kN/m^2 (d) decrease by 30 kN/m^2

Ans. (d)

Change in active earth pressure $= \gamma_w \cdot H$
$= 10 \times 3$
$= 30$ kN/m^2

Usually with rise in water table earth pressure also increases, but due to capillary action it decreases by $\gamma_w \cdot H$.

10. The yield of a retaining wall required to reach plastic equilibrium in active case is

(a) more than that in the passive case (b) less than that in the passive case
(c) equal to that in the passive case (d) None of above

Ans. : (b)

11. The active earth pressure coefficient k_a generally referes to :

(a) effective stresses (b) total stresses (c) neutral stress (d) All the above

Ans. : (a)

12. If a uniform surcharge of 120 kN/m² is placed on the backfill with $\phi = 30°$, the increase in pressure is

(a) 12 kN/m² (b) 30 kN/m² (c) 40 kN/m² (d) 120 kN/m²

Ans. : (c)

Pressure due to surcharge $= k_a \cdot q$

$$= \frac{1}{3} \times 120 \qquad k_a = \frac{1 - \sin 30'}{1 + \sin 30°} = \frac{1}{3}$$

$$= 40 \text{ kN/m}^2$$

13. A wall 8 m high with smooth vertical back retains dry cohesionless sand with $\gamma = 18 \text{ kN/m}^3$, $\phi = 30°$. Determine the total lateral pressure per metre length of wall in passive state. (IES 2004)

(a) 144 kN/m (b) 1728 kN/m (c) 432 kN/m (d) 576 kN/m

Ans. : (b)

$$k_p = \frac{1 + \sin\phi}{1 - \sin\phi} = \frac{1 + \sin 30'}{1 - \sin 30°} = 3$$

$\therefore$ $p_p = k_p \cdot \gamma \cdot H = 3 \times 18 \times 8 = 432 \text{ kN/m}^2$

$\therefore$ Total passive pressure,

$$p_p = \frac{1}{2} \times 432 \times 8 = \boxed{1728 \text{ kN/m}}$$

14. A vertical cut is made clay with c = 15 kN/m², ϕ = 0 and g = 20 kN/m³. What is the theoretical depth to which the clay can be excavated without side collapse ?

(a) 6 m (b) 2 m (c) 2.5 m (d) 3 m

Ans. (d)

$$H_c = \frac{4c}{\gamma} \tan\alpha \qquad \alpha = 45' + \frac{\phi}{2}$$

$$= \frac{4 \times 15}{20} \tan 45° = 3\text{m} \qquad = 45° + 0 = 45°$$

15. Match List-I (Type of structure) with List-II (Type of pressure exerted by sandy backfill) and select the correct answer using the codes given below the lists :

List-I	List-II
(A) A masonary retaining wall founded on compressible clay	(1) Active pressure
(B) Pressure on the back of a cantilever sheet pile wall near the embedded wall	(2) Earth pressure at rest
(C) A masonry retaining wall founded on rock	(3) Passive earth pressure

(IES 1999)

Codes :

	A	B	C		A	B	C
(a)	1	3	2	(c)	3	1	2
(b)	3	2	1	(d)	2	3	1

Ans. (b)

16. For a soil if Poisson's ratio μ = 0.333, the coefficient of earth pressure at rest will be

(a) 0.5 (b) 3 (c) 0.25 (d) 0.333

Ans. (a)

$$k_0 = \frac{\mu}{1-\mu} = \frac{0.333}{1-0.333} = 0.5$$

SET-11 :

1. σ_z is the vertical stress at a depth equal to z in the soil mass due to surface point load Q. The vertical stress at depth equal to $2z$ will be .... (IES 2002)

(a) 0.25 σ_z (b) 0.50 σ_z (c) 1.0 σ_z (d) 2.0 σ_z

Ans. : (a)

$$\sigma_z \propto \frac{1}{z^2} \quad \therefore \ \sigma_z \propto \frac{1}{(2z)^2} \propto \frac{0.25}{z^2}$$

2. A concentrated load of 50 t acts vertically at a point on the soil surface. If Boussinesq's equation is applied for computation of stress, then the ratio of vertical stresses at depths of 3 m and 5 m respectively, vertically below the point of application of load will be ______. (IES 1995)

(a) 0.36 (b) 0.60 (c) 1.66 (d) 2.77

Ans. : (d)

$$\sigma_z = \frac{3Q}{2\pi} \cdot \frac{1}{z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2} \quad \text{since } r = 0$$

$$\therefore \quad \sigma_z = \frac{3Q}{2\pi} \cdot \frac{1}{z^2}$$

$$\therefore \quad \sigma_z \propto \frac{1}{z^2}$$

$$\therefore \quad \frac{\sigma_z(3)}{\sigma_z(5)} = \frac{\frac{1}{3^2}}{\frac{1}{5^2}} = \frac{25}{9} = 2.77$$

3. **Newmark's influence chart can be used for the determination of vertical stress under :**
   (a) circular loaded area only
   (b) rectangular loaded area only
   (c) strip load only
   (d) any shape of loaded area
   Ans. : (d)

4. **Westergaard's analysis is used for :**
   (a) homogeneous (b) cohesive soils (c) sandy soils (d) stratified deposits
   Ans. : (d)

5. **A 25 kN point load acts on the surface of an infinite elastic medium. The vertical pressure intensity in kN/m² at a point 6.0 m below and 4.0 m away from the load will be :** **(GATE)**
   (a) 132 (b) 13.2 (c) 1.32 (d) 0.132
   Ans. : (d)

$$\therefore \quad \sigma_z = \frac{3Q}{2\pi z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2} = \frac{3\times 25}{2\pi\times 6^2} \times \left[\frac{1}{1+\left(\frac{4}{6}\right)^2}\right]^{5/2}$$

$$= 0.132 \text{ kN/m}^2$$

6. **An isobar is a curve which :**
   (a) joins points of equal horizontal stress (b) joins points of equal vertical stress
   (c) joins points of zero vertical stress (d) joins points of maximum vertical stress
   Ans. : (b)

7. **For a strip of width B subjected to a load intensity of q at the surface, the pressure bulb of intensity 0.2 q extends to a depth of :**

(a) 3 B (b) 6 B (c) 1.5 B (d) B

Ans. : (a)

8. If the entire semi-infinite soil mass is loaded with a load intensity of q at the surface, the vertical stress at any depth is equal to :

(a) q (b) $0.5q$ (c) zero (d) infinity

Ans. : (a)

9. The intensity of vertical stress (σ_z) at a depth z due to point load Q acting on the surface of a semi infinite soil mass is :

(a) directly proportional to depth (b) Inversely proportional to depth

(c) directly proportional to square of depth (d) Inversely proportional to the square of depth

Ans. : (d)

10. The change in vertical stress in the soil mass estimated by Boussinesq's equation when Poison's ratio of soil changes from 0.3 to 0.5 will be ______.

(a) reduction by 30% (b) increase by 50%

(c) reduction by 20% (d) no change

Ans. : (d)

SET-12 :

1. Likelihood of general shear failure for an isolated footing in sand decreases with (GATE 2011)

(a) decreasing footing depth

(b) decreasing inter-granular packing of the sand

(c) increasing footing width

(d) decreasing soil grain compressibility

Ans. : (b)

2. Consider the following statements associated with local shear failure of soils :

(1) Failure is sudden with well defined ultimate load

(2) This failure occurs in highly compressible soils

(3) Failure is preceded by large settlement

Which of these statements are correct ? **(IES 1998)**

(a) 1, 2 and 3 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

Ans. : (c)

Sudden failure and well defined ultimate load is the characteristics of general shear failure that occurs in dense sand having relative density, I_D > 70%.

3. Two circular footings of diameter D_1 and D_2 are resting on the surface of a purely cohesive soil. The ratio $\frac{D_1}{D_2} = 2$. If the ultimate load carrying capacity of the footing of diameter D_1 is 200 kN/m^2 then the ultimate bearing capacity (in kN/m^2) of the footing of diameter D_2 will be : [IES 2001]

(a) 100 (b) 200 (c) 314 (d) 571

Ans. : (b)

For purely cohesive soil, bearing capacity does not depend upon the size of footing.

$\therefore \quad q_f = q_p$

But, for footings on sand, bearing capacity also depends upon the width of footing.

$$\frac{q_f}{q_p} = \frac{B_f}{B_p}$$

4. In a plate load test on Sandy soil the test plate of 60 cm × 60 cm, undergoes settlement of 5 mm at a pressure of 12×10^4 N/m^2. What will be the expected settlement of 3 m × 3 m footing under same pressure ? [IES 2002]

(a) 25 mm (b) 20 mm (c) 15 mm (d) 9 mm

Ans. : (d)

For footing on sand,

$$S_f = S_p \left[\frac{B_f\,(B_p + 0.3)}{B_p\,(B_f + 0.3)}\right]^2$$

$$= 5\left[\frac{3.0\,(0.6 + 0.3)}{0.6\,(3 + 0.3)}\right]^2$$

$= 9.29$ mm

5. Two footings, one circular and the other square, are founded on the surface of a purely cohesionless soil. The diameter of circular footing is same as that of the side of the square footing. The ratio of their ultimate bearing capacities is : [GATE]

(a) 3/4 (b) 4/3 (c) 1.0 (d) 1.3

Ans. : (a)

For cohesionless soil, $c = 0$

for surface footing, D = 0

$$\therefore \quad \frac{(q_u)_{cir}}{(q_u)\,s_q} = \frac{0.3 \cdot \gamma \cdot B \cdot N_\gamma}{0.4\,\gamma \cdot B \cdot N_\gamma} = \frac{3}{4}$$

6. The ultimate bearing capacity of a soil is 300 kN/m². The depth of foundation is 1 m and unit weight of soil is 20 kN/m³. Choosing a factor of safety of 2.5, the net safe bearing capacity is **[GATE]**

(a) 100 kN/m² (b) 112 kN/m² (c) 80 kN/m² (d) 100.5 kN/m²

Ans. : (b)

$q_u = 300$ kN/m²

$\gamma = 20$ kN/m³

D = 1.0 m

F = 2.5

$q_{nu} = q_u - \gamma \cdot D = 300 - 20 \times 1 = 280$ kN/m²

$$q_{ns} = \frac{q_{nu}}{F} = \frac{280}{2.5} = 112 \text{ kN/m}^2$$

7. The two criteria for the determination of allowable bearing capacity of a foundation are : **[GATE]**

(a) tensile failure and compression failure (b) tensile failure and settlement

(c) bond failure and shear failure (d) shear failure and settlement

Ans. : (d)

8. The following two statements are made with reference to the calculation of net bearing capacity theory. Identify if they are True or False.

I. Increase in footing width will result in increase in bearing capacity.

II. Increase in depth of foundation will result in higher bearing capacity. **[GATE]**

(a) Both statements are TRUE (b) Both statements are FALSE

(c) I is TRUE but II is FALSE (d) I is FALSE but II is TRUE

Ans. : (b)

9. The width and depth of a footing are 2 and 1.5 m respectively. The water table at the site is at a depth of 3 m below the ground level. The water table correction factor for the calculation of the bearing capacity of soil is : **[GATE]**

(a) 0.875 (b) 1.0 (c) 0.925 (d) 0.5

Ans. : (a)

$$Rw_2 = 0.5\left(1 + \frac{Zw_2}{B}\right) = 0.5\left(1 + \frac{1.5}{2}\right) = 0.875$$

10. Two circular footings of diameters D_1 and D_2 are resting on the surface of the same purely cohesive soil. The ratio of their gross ultimate bearing capacities is : **[GATE]**

(a) $\frac{D_1}{D_2}$ (b) 1.0 (c) $\frac{D_1^2}{D_2^2}$ (d) $\frac{D_2}{D_1}$

Ans. : (b)

$$q_u = 1 \cdot 3\ c \cdot N_c + \gamma \cdot D \cdot N_q + 0.3\,\gamma \cdot B \cdot N_\gamma$$

For clay, $\phi = 0$

$\therefore$ $N_C = 5.7, N_q = 1, N_\gamma = 0$

for surface footing, D = 0

$\therefore$ $q_u = 1 \cdot 3\ cN_c$

$\therefore$ Ratio = 1.0

11. In case of footing on the surface or shallow depth in very dense sand which one of the following types of failure is likely to occur ? **[IES 2006]**

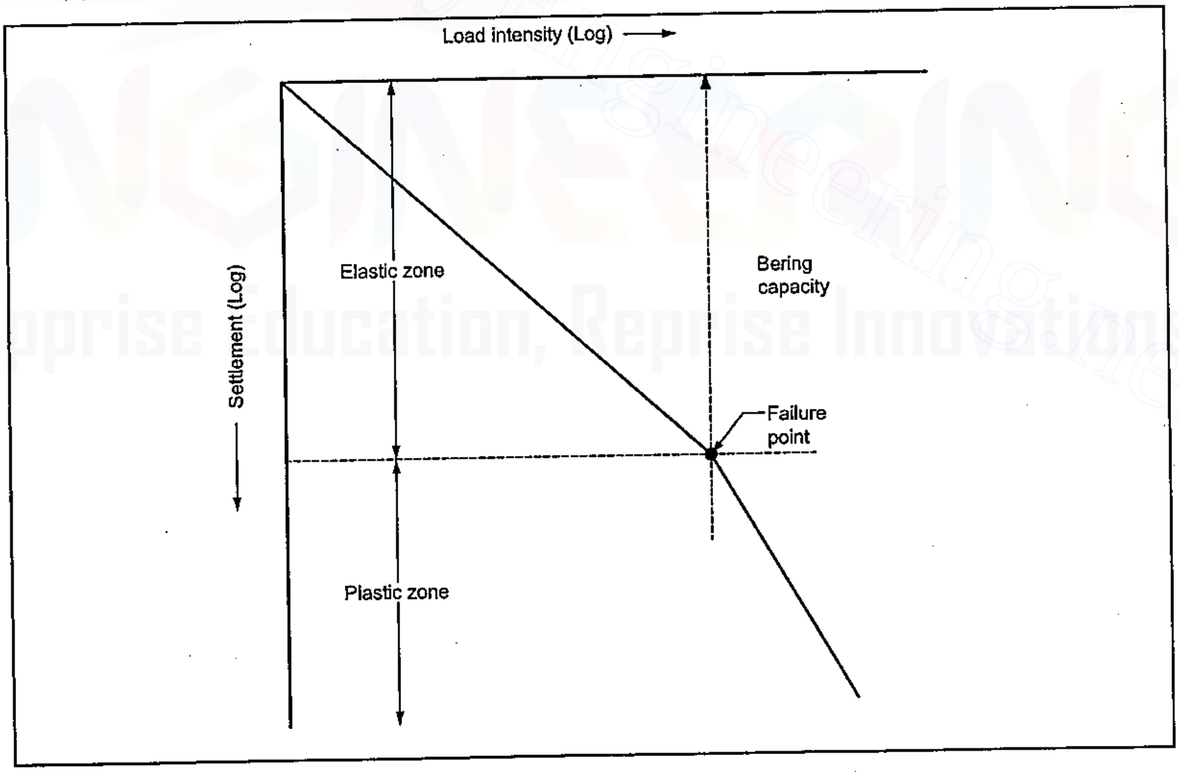
(a) Punching shear failure
(b) local shear failure
(c) General shear failure
(d) Any of the above three

Ans. : (c)

In general shear failure clear and sudden point of failure on the load settlement curve.

12. In a plate load test how is the ultimate load estimated from the load settlement curve on a log log graph ? **[IES 2005]**

(a) directly



(b) By drawing tangents to the curve at the initial and final points

(c) By the secant method

(d) At 0.2 percent of the maximum settlement.

Ans. : (a)

The log log graph of load versus settlement curve distincitly shows the failure point. The pressure corresponding to that point is taken as the bearing capacity.

13. The ultimate bearing capacity of a square footing on surface of a saturated clay having unconfined compression strength of 50 kN/m². (using Skempton's equation) is : **[IES 2003]**

(a) 250 kN/m² (b) 180 kN/m² (c) 150 kN/m² (d) 125 kN/m²

Ans. : (c)

For square footing,

$$q_u = c \cdot N_c$$

$$N_C = 6\left[1 + 0.2\left(\frac{D}{B}\right)\right]$$

$$= 6\,[1 + 0.2\,(0)]$$

$$= 6$$

$$\therefore \quad q_u = c \cdot N_c$$

$$= 25 \times 6$$

$$= 150\ kN/m^2$$

D = 0

for surface footing

$$c = \frac{q_u}{2}$$

$$= \frac{50}{2}$$

$$= 25\ \text{kN/m}^2$$

14. The allowable bearing capacity at 25 *mm* allowable settlement for a footing in a Sandy soil is 15 t/m^2. The allowable bearing capacity for the same footing permitting a settlement of 40 *mm* is :

(a) 24 t/m^2 (b) 30 t/m^2 (c) 35 t/m^2 (d) 40 t/m^2

Ans. : (a)

For Sandy soil

$$\frac{q_2}{q_1} = \frac{S_2}{S_1}$$

$$\therefore \quad q_2 = q_1 \times \frac{S_2}{S_1} = 15 \times \frac{40}{25} = 24\ t/m^2$$

15. If two foundations one narrow and another wide, are resting on a bed of sand carying the same intensity of load per unit area, then which one is likely to fail early ? [IES 2003]

(a) Narrow foundation

(b) Wide foundation

(c) Both will fail simultaneously

(d) Difficult for judge since other conditions are unknown.

Ans. : (a)

For foundation on sand, bearing capacity increase with width of the foundation. So narrow foundation will have lesser bearing capacity and it may fail early.

SET–13 :

1. The maximum net pressure intensity causing shear failure of soil, is known as

(a) Safe bearing capacity

(b) net safe bearing capacity

(c) Net ultimate bearing capacity

(d) Ultimate bearing capacity

Ans : (c)

q_u = ultimate B.C. = gross pressure at the base of foundation at which soil fails in shear.

q_{nu} = net ultimate B.C.

$= qu - \gamma . D$

$$q_{us} = \frac{q_{nu}}{F}$$

$q_s = q_{ns} + \gamma . D$

2. The rario of the volume of water present in a given soil mass to the total volume of its voids, is known as

(a) porosity

(b) void ratio

(c) percentage air voids

(d) degree of saturation

Ans. (d)

Void ratio, $e = \frac{V_v}{V_s}$ % air voids na $= \frac{V_a}{V}$

Porosity, $n = \frac{V_v}{V}$ degree of saturation $S_r = \frac{V_w}{V_v}$

3. **The value of angle of internal friction in cohesive soil is**

(a) 10° (b) negligible (c) 30° (d) 6.5°

Ans. (b)

4. **The fundamental equation of specific gravity (G), dry density (γ_d), unit weight of water (γ_w) and void ratio (e) is**

(a) $e = \frac{G\gamma_w}{(1+\gamma_d)}$ (b) $G = \frac{\gamma_d \gamma_w}{(1+e)}$ (c) $\gamma_d = \frac{G\gamma_w}{(1+e)}$ (d) $\gamma_w = \frac{G\gamma_d}{(1+e)}$

Ans. (c)

5. Coulomb assumed in his theory that

(a) Wall surface is vertical (b) wall surface is smooth

(c) Sliding wedge behaves as rigid body (d) Soil is non–isotropic

Ans. (c)

6. **The value of time factor for 100% consolidation in double drainage is taken as**

(a) ∞ (b) 0.85 (c) 0.94 (d) 1.0

Ans. (a)

When $u \le 60\ \%$, $T_v = \frac{\pi}{4}\left(\frac{U}{100}\right)^2$

when $u > 60\ \%$, $T_v = 1.7813 - 0.933 \log_{10} (100 - U)$

7. **If C is cohesion, F is factor of safety, γ is unit weight of soil and H is maximum height of embankment the stability number is**

(a) $\frac{F}{C\gamma H}$ (b) $\frac{C}{F\gamma H}$ (c) $\frac{H}{CF\gamma}$ (d) $\frac{\gamma}{CFH}$

Ans. (b)

8. **If W is the weight of soil having moisture content w, and V is volume of proctor's mould the dry density of soil is**

(a) $\frac{WV}{(1+w)}$ (b) $\frac{V}{W(1+w)}$ (c) $\frac{W}{V(1+w)}$ (d) $\frac{V(1+w)}{W}$

Ans. (c) $\gamma_d = \frac{\gamma_b}{(1+w)} = \frac{W}{V(1+w)}$

9. **Plate load test is used to estimate**

(a) settlement of foundation (b) Bearing capacity of foundation

(c) Both bearing capacity and settlement of foundation

(d) depth of foundation

Ans. (c)

10. Vibratory rollers are more suitable for compacting which of the following soils ?
(a) clayey (b) silty (c) Sandy (d) mixed
Ans. (c)

11. Ratio of bearing capacity of double under reamed pile to that of single under reamed pile is nearly.
(a) 1.2 (b) 1.5 (c) 1.7 (d) 2.0
Ans. (b)

12. Open pit test is only suitable up to a depth of
(a) 1.5 m (b) 2.0 m (c) 2.5 m (d) 3.0 m
Ans. (a)

13. A partially saturated soil is classified as
(a) one phase soil (b) two phase soil (c) Three phase soil (d) Four phase soil
Ans. (c) Three phases – soil particles, water, air

14. Westergard's analysis for stress distribution beneath loaded area is applicable to
(a) stratified soils (b) sandy soils (c) clayey soils (d) silty soils
Ans. (a)

15. Rankine theory of earth pressure applies to
(a) dry cohesionless soil (b) Cohesive soils
(c) moist cohesionless soil (d) all of the above
Ans. (a)

16. Among the given soils, the specific surface area is highest for
(a) gravel (b) sand (c) silt (d) clay
Ans. (d)

17. Pyenometer method is used to determine
(a) Water content and void ratio (b) specific gravity
(c) Specific gravity and dry density (d) Specific gravity and water content
Ans. (d)

18. Compaction of a soil is measured in terms of
(a) dry density (b) Specific gravity (c) compressibility (d) permeability
Ans. (a)

19. Optimum moisture content is the moisture content at which
(a) Settlement is maximum (b) permeability is more
(c) dry density is maximum (d) Shear strength is less
Ans. (c)

❖❖❖

8.

Highway Engineering

MCQ'S

1. **The grant trunk (G.T.) road was constructed during**
(a) 1440 to 1445 A.D. (b) 1540 to 1545 A.D.
(c) 2000 to 2500 B.C. (d) 2500 to 3000 B.C.

2. **Shershah Suri constructed longest road from**
(a) Delhi to Lahore (b) Delhi to Kolkata (c) Lahore to Kolkata (d) Lahore to Agra

3. **Minimum shoulder width for roads recommended by IRC is**
(a) 2.5 m (b) 2 m (c) 1.5 m (d) 1.85 m

4. **As per IRC standards, minimum width of two-lane carriageway with raised curbs is**
(a) 7.5 m (b) 7.0 m (c) 5.5 m (d) 6.0 m

5. **As per IRC standards, minimum roadway width of single lane ODR in plain and rolling terrain is**
(a) 9 m (b) 12 m (c) 7 m (d) 7.5 m

6. **IRC recommends total reaction time for SSD calculation is**
(a) 2 sec (b) 2.5 sec (c) 2.3 sec (d) 1.8 sec

7. **In PIEV theory, I stands for**
(a) Intention (b) Information (c) Intellection (d) Interpretation

8. **The rate of rise or fall of the road surface along its length is called**
(a) Camber (b) super elevation (c) gradient (d) banking

9. **The equilibrium superelevation is given by**
(a) $\frac{V^2}{R}$ (b) $\frac{V^2}{g.R}$ (c) $\frac{V^2}{127R}$ (d) none of these

10. **As per IRC, super elevation (e) should not exceed**
(a) 5.7 % (b) 6.7 % (c) 0.15 % (d) 0.35 %

11. **In the equation $e + f = \frac{V^2}{127R}$, the maximum value of lateral frictional coefficient (f) is taken as**
(a) 0.10 (b) 0.15 (c) 0.20 (d) 0.25

12. The value of ruling gradient in hills, recommended by IRC is
(a) 1 in 10 (b) 1 in 20 (c) 1 in 30 (d) 1 in 40
13. Exceptional gradient should not be provided in a length more than
(a) 20 m (b) 50 m (c) 75 m (d) 100 m
14. As per IRC, in the calculation of SSD, the height of eye level of driver and the height of object above road surface are taken as
(a) 1.5 m, 0.25 m (b) 1.2 m, 0.15 m (c) 1.5 m, 0.15 m (d) 1.2 m, 0.25 m
15. If L is the length of wheel base of vehicle and R is the mean radius of curve, the width of extra widening of road is
(a) $\frac{nL}{R}$ (b) $\frac{nL^2}{R}$ (c) $\frac{nL^2}{2R}$ (d) $\frac{nL}{2R}$
16. As per IRC, the camber for bituminous road surface for heavy rainfall area is
(a) 1 in 40 (b) 1 in 50 (c) 1 in 60 (d) 1 in 75
17. Minimum length of transition curve as per IRC for plain and rolling terrain is
(a) $\frac{V^2}{R}$ (b) $\frac{2.7\,V^2}{R}$ (c) $\frac{V^2}{2.7\,R}$ (d) none of these
18. A road connecting capitals of states is known as
(a) National Highway (b) Provincial highway
(c) State highway (d) Express highway
19. A road connecting two towns with another is called a
(a) main road (b) highway (c) trunk road (d) Country road
20. A road within a town is called
(a) Trunk road (b) Country road (c) Carriage way (d) Street
21. The highest point on a carriage way is called
(a) Camber (b) Crown (c) gradient (d) Super-elevation
22. As per IRC maximum width of vehicle should be
(a) 2 m (b) 2.44 m (c) 3.8 m (d) 1.58 m
23. As per IRC, the slope of earth in cutting should be
(a) 1 : 1 (b) 1 : 2 (c) 1 : 4 (d) 2 : 3
24. Camber in the road is provided for
(a) proper sight distance (b) Counteracting the centrifugal force
(c) effective drainage (d) all of the above
25. The reduction in load carrying capacity at a gradient of 1 in 20 is
(a) 5 % (b) 10 % (c) 15 % (d) 20 %
26. The thickness of the base in no case should be more than
(a) 10 cm (b) 15 cm (c) 20 cm (d) 30 cm

27. The value of rulling gradient in plains as per IRC is

(a) 1 in 10 (b) 1 in 15 (c) 1 in 20 (d) 1 in 30

28. In earthen roads, the common stabilizer used is

(a) cement (b) lime (c) bitumen (d) all the above

29. The best example of rigid pavement is

(a) bitumen road (b) gravel road (c) Concrete road (d) WBM road

30. Generally the premix carpet laid in India is of thickness

(a) 15 cm (b) 10 cm (c) 4 cm (d) 2 cm

31. In tack coat, bitumen is used at the rate of

(a) 1 kg/m^2 (b) 0.5 kg/m^2 (c) 5 kg/m^2 (d) 10 kg/m^2

32. In gravel road the binding material used is

(a) cement (b) lime (c) clay (d) Surkhi

33. For ordinary earth work in embankment, the allowance for settlement of earth is

(a) 5 % (b) 10 % (c) 25 % (d) 50 %

34. 'Enoscope' is used for measuring

(a) Running speed (b) Time mean speed (c) Spot speed (d) Overall speed

35. In water bound macadam roads, binding material is

(a) Sand (b) cement (c) Stone dust (d) brick dust

36. Camber in pavements is provided by

(a) Straight line method (b) Parabola method

(c) Straight line at edges and parabola at crown (d) all the above

37. Any gradient on a road is said to be an exceptional gradient, if it is

(a) More than rulling gradient

(b) Less than average gradient

(c) More than floating gradient

(d) Less than minimum gradient or more than maximum gradient

38. Raising outer edge of a road with respect to inner edge, is known as

(a) Super elevation (b) Cant (c) banking (d) all the above

39. The distance travelled by a moving vehicle during perception and brake reaction time is

(a) Sight distance (b) stopping distance (c) Lag distance (d) None of these

40. The ideal shape of transition curve is

(a) Clothoid (b) Cubic spiral (c) Cubic parabola (d) lamniscate

41. The shape of a vertical curve is

(a) circular (b) Parabolic (c) elliptical (d) Spiral

42. For comfortable travel on highways, the centrifugal ratio should not exceed

(a) 0.10 (b) 0.15 (c) 0.20 (d) 0.25

43. **Degree of a road curve is defined as the angle in degrees subtended at the centre by an arc of**
(a) 10 m (b) 20 m (c) 25 m (d) 30 m

44. **If degree of a road curve is defined by assuming the standard length of an arc as 30 m, the radius of 1° curve is equal to**
(a) 1046 (b) 1146 (c) 1719 (d) 1619

45. **For clear distinct vision, images of obstructions should fall on the retina with a cone of**
(a) 2° (b) 3° (c) 4° (d) 5°

46. **Along horizontal curves, if centrifugal force exceeds lateral friction, vehicles may**
(a) skid (b) slip (c) not be affected (d) none of these

47. **In multi lane road, overtaking is generally permitted**
(a) from right (b) From left
(c) From both sides right and left (d) not at all

48. **If cross slope of a country is up to 10 % the terrain is classified as**
(a) plain (b) rolling (c) mountainous (d) Steep

49. **If cross slope of a country is 10 to 25 % the terrain is classified as**
(a) plain (b) rolling (c) mountainous (d) steep

50. **Bitumen of grade 80/100 means its penetration value is**
(a) 8 mm (b) 10 mm (c) 8 to 10 mm (d) 8 to 10 cm

51. **Tie bars are provided in cement concrete pavements at**
(a) expansion joints (b) Contraction joints
(c) Warping joints (d) longitudinal joints

52. **Reflection cracking is observed in**
(a) flexible pavement
(b) rigid pavement
(c) bituminous overlays over cement concrete surface
(d) riding overlay over flexible pavement

53. **In the design of highways, expansion and contraction joints should respectively be provided at**
(a) 50 m, 32 m (b) 50 m, 10 m (c) 25 m, 10 m (d) 25 m, 32 m

54. **The main function of prime coat is to**
(a) Provide bond between old and new surfacing
(b) Improving riding quality of pavement
(c) Provide bond between the existing base and surfacing of new construction
(d) Control dust nuisance

55. In a bituminous pavement, aligator cracking is mainly due to

(a) inadequate wearing coarse

(b) Fatigue arising from repeated stress applications

(c) Inadequate thickness of sub-base course

(d) use of excessive bituminous material

56. Intermediate sight distance as per IRC is

SSD : Stropping sight distance

OSD : Overtaking sight distance

(a) 2 SSD (b) 2 OSD (c) $\frac{(SSD + OSD)}{2}$ (d) $\frac{(OSD - SSD)}{2}$

57. Which one of the following binders is recommended for a wet and cold climate ?

(a) 80/100 penetration asphalt (b) tar

(c) cutback (d) emulsion

58. Rapid curing cutback bitumen is produced by blending bitumen with

(a) Kerosene (b) benzene (c) Petrol (d) diesel

59. Match list I with list II and select the correct answer using the codes given below the list : (IES)

	List - I		List - II
A.	Penetration test	1.	Design of bituminous concrete mix
B.	Marshall test	2.	Overlay design
C.	Ring and ball test	3.	Gradation of asphalt cement
D.	Benkelman beam test	4.	Determination of softening point

Codes :

	A	B	C	D
(a)	3	2	4	1
(b)	3	1	4	2
(c)	2	3	1	4
(d)	4	2	3	1

60. Psychological widening on road curves is given by (IES)

(a) $\frac{nL^2}{2R}$ (b) $\frac{0.1V}{\sqrt{R}}$ (c) $\frac{0.1nV}{\sqrt{R}}$ (d) $\frac{0.1V}{\sqrt{R}} + \frac{nL^2}{2R}$

61. Which one of the following pairs is not correctly matched ? (IES)

(a) Horizontal curves - super elevation

(b) Origin and destination studies - desire lines

(c) Los Angeles test - Hardness of aggregates

(d) Soundness test - purity of bitumen

62. For a circular curve of radius 200 m, the coefficient of lateral friction is 0.15 and the design speed is 40 kmph. The equilibrium superelevation would be **(IES)**

(a) 21.3 (b) 7 (c) 6.3 (d) 4.6

Hint : $\frac{V^2}{127\,R} = \frac{(40)^2}{127 \times 200} = 6.3$

63. The general requirement in constructing a reinforced concrete road is to place a single layer of reinforcement **(IES)**

(a) Near the bottom of the slab (b) Near the top of the slab

(c) at the middle (d) equally distributed at the top and bottom

64. It was noted on a section of road, the free speed was 80 kmph and the jam density was 70 vpkm. The maximum flow in vph that could be expected on this road is **(IES)**

(a) 800 (b) 1400 (c) 2800 (d) 5600

Hint : Maxi. flow = 80 × 70 = 5600 vph

65. In desire line diagram **(IES)**

(a) Width of desire line is proportional to the number of trips in one direction

(b) length of desire line is proportional to the number of trips in both directions

(c) Width of desire line is proportional to the number of trips in both directions

(d) Both length and width of desire line are proportional to the number of trips in both directions.

66. A flyover segregates traffic with respect to

(a) speed (b) direction (c) size of vehicle (d) grade of vehicles

67. A dividing strip in the middle of the road is called

(a) Central strip (b) mid strip (c) median strip (d) edging

68. The number of vehicles using the road per hour during peak periods and the average of several peak day is called

(a) traffic volume (b) traffic density (c) traffic concentration (d) traffic rate

69. A road open at one end is called

(a) one way road (b) halfway road (c) blind alley (d) service road

70. As per IRC, the maximum permissible length of a single unit with more than 2 axles is

(a) 11 m (b) 12 m (c) 14.4 m (d) 16 m

71. As per IRC, the maximum permissible load per axle is

(a) 4.55 tonnes (b) 6.165 tonnes (c) 8.165 tonnes (d) 10.273 tonnes

72. The concrete pavement is provided when the daily traffic load per lane exceeds

(a) 3000 tonnes (b) 5000 tonnes (c) 10,000 tonnes (d) 12,000 tonnes

73. **Minimum recommended land width in case of national highway is**
(a) 15 m (b) 20 m (c) 30 m (d) 50 m

74. **In a properly designed vehicle the resistance generally ignored is**
(a) frictional resistance (b) wind resistance
(c) gradient resistance (d) axle resistance

75. **The water absorption of the aggregates used for road making should not exceed**
(a) 0.3 % (b) 0.6 % (c) 1 % (d) 1.5 %

76. **In the CBR test, for 2.5 mm penetration standard load is**
2.5 mm – 13.44 kN, 5.0 mm – 20.16 kN
(a) 13.44 kN (b) 20.16 kN (c) 7.5 kN (d) 10.08 kN

77. **The aggregate crushing value for aggregates to be used for concrete for wearing surfaces of roads should not exceed**
(a) 15 % (b) 20 % (c) 30 % (d) 45 %

78. **Wave like formations on the road are called**
(a) Pot holes (b) zig-zag forms (c) Corrugations (d) Wavy defects

79. **A concrete road which becomes slippery is repaired by**
(a) Pouring hydrocloric acid and washing
(b) Applying hand brush on the surface
(c) Relaying concrete on the defective portion
(d) chipping the surface

80. **A road sign indicating 'speed limit' is**
(a) Warning sign (b) Prohibitory sign (c) Mandatory sign (d) Informatory sign

81. **A road sign indicating 'no parking' is**
(a) Warning sign (b) Prohibitory sign (c) Mandatory sign (d) Informatory sign

82. **A warning sign on a highway is fixed in advance from the point of danger at a distance of**
(a) 25 m (b) 50 m (c) 100 m (d) 120 m

83. **The length of the road ahead of the vehicle visible to the driver is called**
(a) clear distance (b) Sight distance (c) Visible distance (d) Safe distance

84. **The height of lower edge of a road sign from the level of the crown of the road is not less than**
(a) 0.5 m (b) 0.75 m (c) 1 m (d) 2 m

85. **The number of vehicles occupying a unit length of a lane of a road at a given instant, expressed in numbers of vehicles per km length is called**
(a) traffic volume (b) traffic density (c) traffic load (d) track load

86. **The width of broken centre line marked on the road in case of four lane road would be**
(a) 5 cm (b) 10 cm (c) 15 cm (d) 7.5 cm

87. **The percentile cumulative frequency on the basis of which speed regulation on roads is decided is**
(a) 90 (b) 85 (c) 80 (d) 75

88. **While deciding PCU, the standard vehicle considered is a**
(a) car (b) motorcycle (c) bus (d) truck

89. **In the design of highway, the design speed is taken as**
(a) 75^{th} percentile speed (b) 85^{th} percentile speed
(c) 98^{th} percentile speed (d) None of these

90. **The speed such that 50 % vehicles travel at speed less than that and 50 % vehicles travel at speed more than that is called**
(a) design speed (b) modal speed (c) average speed (d) running speed

91. **The colour of light used for visibility during fog is**
(a) white (b) Red (c) blue (d) yellow

92. **Area provided for parking of a car is**
(a) 10 m^2 (b) 20 m^2 (c) 25 m^2 (d) 50 m^2

93. **Match List I and List II correctly :**

List I		List II
(A)		1. Rear and collision
(B)		2. Overturned vehicle
(C)		3. Head on collision
(D)		4. Fatal accident motor vehicle pedestrian

Codes :

	A	B	C	D
(a)	3	4	1	2
(b)	3	4	2	1
(c)	4	3	1	2
(d)	4	3	2	1

94. **Corrugations occur on treated surfaces due to**
(a) instability of base (b) lack of binder (c) Excess rains (d) excess binder

95. **The pavement suitable for heavy traffic load is**
(a) Asphalt concreting (b) Bituminous grouted macadam
(c) Cement concrete (d) Surface dressed macadam

96. **When the distance travelled by a vehicle (when brakes are applied) is more than the circumferential movement of wheels, it is called**
(a) slip (b) skid (c) drag (d) wear

97. The steepest gradient permitted on roads called

(a) Ruling gradient (b) floating gradient
(c) Maximum gradient (d) exceptional gradient

98. A road sign showing hair pin bend is a

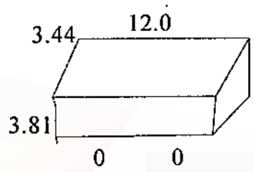
(a) Regulatory sign (b) Warning sign
(c) informatory sign (d) Mandatory sign

99. Which one of the following is not a traffic control device ?

(a) road signs (b) Markings (c) Foot path (d) Islands

100. The height of single decked vehicle is taken as

(a) 3.81 m
(b) 4.11 m
(c) 5.11 m
(d) 5.47 m



: ANSWERS :

1. (b)	2. (c)	3. (a)	4. (a)	5. (d)
6. (b)	7. (c)	8. (c)	9. (c)	10. (b)
11. (b)	12. (b)	13. (d)	14. (b)	15. (c)
16. (a)	17. (b)	18. (a)	19. (b)	20. (d)
21. (b)	22. (b)	23. (a)	24. (c)	25. (b)
26. (d)	27. (d)	28. (d)	29. (c)	30. (d)
31. (b)	32. (c)	33. (b)	34. (c)	35. (c)
36. (d)	37. (d)	38. (d)	39. (c)	40. (a)
41. (b)	42. (d)	43. (d)	44. (c)	45. (d)
46. (a)	47. (c)	48. (a)	49. (b)	50. (c)
51. (d)	52. (c)	53. (b)	54. (c)	55. (b)
56. (a)	57. (d)	58. (c)	59. (b)	60. (b)
61. (d)	62. (c)	63. (b)	64. (d)	65. (c)
66. (d)	67. (c)	68. (a)	69. (c)	70. (b)
71. (c)	72. (a)	73. (c)	74. (d)	75. (b)
76. (a)	77. (c)	78. (c)	79. (a)	80. (c)
81. (c)	82. (d)	83. (b)	84. (d)	85. (b)
86. (b)	87. (b)	88. (a)	89. (c)	90. (b)
91. (d)	92. (c)	93. (b)	94. (a)	95. (c)
96. (b)	97. (c)	98. (b)	99. (c)	100. (a)

1. **Bottom most layer of pavement is known as**
   (a) subgrade (b) base course (c) sub–base course (d) wearing course
   Ans. (a)
   Sequence of layers from top to bottom is
   - surface course (wearing course)
   - base course
   - sub–case course
   - sub grade
2. **Desire lines are plotted in**
   (a) accident studies (b) Traffic volume studies
   (c) origin and destination studies (d) speed studies
   Ans. (c)
3. **Who developed the earliest equations to calculative the wheel load stress at salient locations on a rigid pavement ?**
   (a) Westergaard (b) Boussinesq (c) Rankine (d) Spangler
   Ans. (a)
4. **.......... Presented the theory for calculating stresses in soil mass due to point load on the ground.**
   (a) westergaard (b) Boussinesq (c) Rankine (d) Coulomb
   Ans. (b)
5. **Who developed theory of analysing two–layered soil system which resembled a flexible pavement ?**
   (a) Boussinesq (b) Burmister (c) Spangler (d) Kelly
   Ans. (b)
6. **The basic formula for determination of pavement thickness was first suggested by**
   (a) Kelly (b) Goldbeck (c) Picket (d) Spangler
   Ans. (b)
7. **The number of vehicles moving in a specified direction on a roadway that pass a given point during specified unit of time is called**
   (a) Traffic density (b) Traffic capacity (c) Basic capacity (d) Traffic volume
   Ans. (d)
   Traffic volume is expressed as **vehicles /hr.**
   Traffic volume is also called **flow**
   Maxi. possible traffic volume is called **traffic capacity**
8. **The minimum intermediate sight distance (ISD) shall be provided in terms of stopping sight distance (SSD) is**
   (a) SSD (b) 3 SSD (c) 2 SSD (d) 4 SSD
   Ans. (c)

9. **On urban roads with frequent intersections, maximum superelevation is restricted to**

(a) 4% (b) 5 % (c) 6 % (d) 7 %

Ans. (a)

As per IRC – 73–1980, IRC–86–1983 maximum superelevation recommended is

Plain and rolling terrain : 7 % (0.07)

hilly areas : 10% (0.10)

Urban areas with many intersections : 4 % (0.04)

10. **On a right angled road intersection with two way traffic the total number of conflict points are**

(a) 12 (b) 24 (c) 16 (d) 8

Ans. (c)

11. **As per IRC in heavy rainfall regions, the minimum camber provided on bituminous roads shall be of**

(a) 2 % (b) 3 % (c) 4 % (d) 2.5 %

Ans. (d)

cement concrete road	– 2.0 %
bituminous concrete road	– 2.5 %
WBM road	– 3.0 %
Earthen road	– 4.0 %

12. **As per IRC recommendations, maximum permissible limiting gradient on highways for plain and rolling ground is**

(a) 1:30 (b) 1 : 15 (c) 1 : 16.7 (d) 1 : 20

Ans. (d)

Terrain	Rulling gradient	Limiting gradent
Plain & rolling	1 in 30	1 in 20
Mountainous	1 in 20	1 in 16.7

13. **In a penetration test on bitumen, standard needle shall be released for**

(a) 5 secs (b) 10 secs (c) 15 secs (d) 20 secs

Ans. (a)

14. **In the CBR testing machine, standard diameter of plunger is**

(a) 4 cm (b) 6 cm (c) 3 cm (d) 5 cm

Ans. (d)

Penetration	Standard load (kN)
2.5 mm	13.44 kN
5.0 mm	20.16 kN

$$\text{CBR value} = \frac{\text{load at 2.5 mm/5 mm penetration}}{\text{standard load}}$$

15. 'STOP' sign on highway is a type of

(a) Cautionary sign (b) Information sign
(c) Mandatory sign (d) Warning sign

16. Tests conducted to determine flash and fire points of bitumen are known as

(a) Pansky Marten's test (b) IRC test (c) Brard test (d) API test

Ans. (a)

17. In water bound macadam roads biuding material is

(a) sand (b) broken stones (c) cement (d) brick dust

Ans. (d)

18. According to IRC, the maximum allowable limit of water absorption for any aggregate used for highway pavement construction is

(a) 2 % (b) 3 % (c) 4 % (d) 5 %

Ans. (a)

19. The width of formation of a road means the width of

(a) carriage way (b) Pavement and shoulders
(c) embankment at ground level (d) embankment at top level

Ans. (b) Note : Ans (d) is also correct

20. IRC has specified safe overtaking sight distance assuming overtaking time requied as

(a) 9 to 14 sec (b) 9 to 14 minutes (c) 20 to 40 sec (d) 40 to 50 seconds

Ans. (a)

21. The distane travelled by revolving the wheel of a vehicle more than its circumferential movement is known as

(a) Slip (b) skid (c) neither a or b (d) both a and b

Ans. (b)

Skid – wheel slide without revolving
Slip – wheel revolve without moving

22. The height of low or mountable kerb is kept

(a) 10 cm (b) 15 to 20 cm (c) 23 to 45 cm (d) more than 45 cm

Ans. (a)

Low or mountable kerb – 10 cm
semi – barrier kerb – 15 to 20 cm
Barrier type kerb – 23 to 45 cm

23. The minimum length of overtaking zone in terms of OSD as per IRC is

(a) OSD (b) 2 × OSD (c) 3 × OSD (d) 5 × OSD

Ans. (c)

24. Sign post 'overtaking zone ahead' should be placed in advance of the start of overtaking zone at a distance of

(a) OSD (b) 1.5 × OSD (c) 2 × OSD (d) 3 × OSD

Ans. (a)

25. As per IRC, extra widening required on curved road for radius of 101 to 300 m is

(a) 1.5 m (b) 1.0 m (c) 0.75 m (d) 0.6 m

Ans. (d)

26. The minimum length of transition curve as per IRC is

(a) $\frac{V^2}{R}$ (b) $1.5\frac{V^2}{R}$ (c) $2.7\frac{V^2}{R}$ (d) $3.2\frac{V^2}{R}$

where, V = speed in km/h

Ans. (c)

27. The modulus of subgrade reaction (k) is given by, where p = load intensity, Δ = deflection of standard plate = 1.25 mm

(a) $k = p \times \Delta$ (b) $k = \frac{p}{\Delta}$ (c) $k = \frac{\Delta}{p}$ (d) $k = \frac{2p}{\Delta}$

Ans. (b)

28. In ductility test on bitumen, the cross section at minimum width of specimen is

(a) 10 mm × 10 mm (b) 15 mm × 15 mm

(c) 20 mm × 20 mm (d) 25 mm × 25 mm

Ans. (a)

The test is conducted at 27°C and at a rate of pull of 50 mm per minute.

29. In Marshall method of bituminous mix design, the optimum bitumen content (OBC) is taken as

(a) Bitumen content corresponding to maxi. stability

(b) Bitumen content corresponding to maxi. unit weight

(c) Bitumen content corresponding to 4% air voids

(d) average of above three values.

Ans. (d)

30. The minimum Marshall stability value specified is

(a) 250 kg (b) 340 kg (c) 550 kg (d) 880 kg

Ans. (b)

31. As per IRC the maximum spacing of contraction joints in reinforced concrete slab of thickness 20 cm is

(a) 4.5 m (b) 10 m (c) 14 m (d) 20 m

Ans. (c) For slabs maxi. spacing is 4.5 m

32. In the design of filter material for subsurface drainage of roads D15 filter/D15 of foundation should be

(a) less than 5 (b) greater than 5 (c) less than 10 (d) greater than 10

Ans. (b)

33. While planning plantation of trees along road side, minimum distance of trees should be

(a) 1.5 m from edge, 10 m from centre of road

(b) 1.8 m from edge, 12 m from centre of road

(c) 2.0m from edge, 15 m from centre of road

(d) 2.5 m from edge, 20 m from centre of road

Ans. (b)

34. As per IRC, the axle load of vehicle should not exceed.

(a) 5000 kg (b) 7500 kg (c) 10,000 kg (d) 12000 kg

Ans. (c)

35. As per IRC, maximum width of vehicle is

(a) 2.0 m (b) 2.44 m (c) 2.75 m (d) 3.0 m

Ans. (b)

36. As per IRC, maximum height of single deck vehicle is

(a) 2.44 m (b) 3.2 m (c) 3.82 m (d) 4.72 m

Ans. (c)

37. As per IRC, maximum length of 2 axle vehicle is

(a) 7.5 m (b) 10.67 m (c) 12.19 m (d) 15.24 m

Ans. (b)

38. If l is the wheel base and R is the radius of the curve, the off tracking will be

(a) $\frac{l}{2R}$ (b) $\frac{l^2}{R}$ (c) $\frac{l^2}{2R}$ (d) $\frac{2l^2}{R}$

Ans. (c)

39. The hourly volume considered for design of traffic facilities is

(a) 30^{th} (b) 85^{th} (c) 98^{th} (d) 50^{th}

Ans. (a)

40. On highways safe speed limit is taken as

(a) 30^{th} percentile speed (b) 85^{th} percentile speed

(c) 98^{th} percentile speed (d) 50^{th} percentile speed

Ans. (b)

41. Design speed for highway is taken as

(a) 30^{th} percentile speed (b) 85^{th} percentile speed

(c) 98^{th} percentile speed (d) 50^{th} percentile speed

Ans. (c) 15^{th} percentile speed is the minimum speed

42. For parking the ratio of no. of bays occupied to the number of bays available is called

(a) Parking load (b) parking volume

(c) parking accumulation (d) parking index

Ans. (d)

43. The width and length of segments of centre line marked on divided highway is

(a) 0.1 m, 2 m (b) 0.1 m, 3m (c) 0.15 m, 2 m (d) 0.15 m, 3 m

Ans. (b)

44. Colours used for kerb markings are

(a) white (b) yellow

(c) black (d) alternate bands of white and black

Ans. (d)

45. Colours used for carriage way markings are

(a) white (b) yellow (c) black (d) green

Ans. (a)

46. The Indian practice is to have an amber period of .... in traffic signal.

(a) 10 sec (b) 8 sec (c) 5 sec (d) 2 sec

Ans. (d)

47. The method for signal cycle time design was suggested by

(a) Webster (b) Burmister (c) Westergaard (d) Newmark

Ans. (a)

❖❖❖

9.

Bridge Engineering

1. **An ideal bridge sight has**
   (a) Stream is well defined and narrow
   (b) Square alignment
   (c) Firm and permanent river banks
   (d) all of the above
   Ans. (d)
2. **For a bridge, l = clear span, n = number of spans and b = width of pier, then length of bridge is**
   (a) $L = n \times l + (n + 1)\,b$
   (b) $L = n \times l + (n - 1)\,b$
   (c) $L = nl$
   (d) $L = nl + nb$
   Ans. (b) No. of piers = n – 1
3. **Linear waterway for a river at bridge site is equal to**
   (a) Length of the bridge
   (b) Sum of all clear spans
   (c) Sum of all clear spans + sum of width of piers
   (d) Sum of all clear spans + width of two abutments
   Ans. (b)
4. **Lacey's regime formula for linear water way of alluvial soil is**
   (a) $L = C.\,Q$
   (b) $L = \frac{C}{Q}$
   (c) $L = C\sqrt{Q}$
   (d) $L = \sqrt{C}\,Q$
   Ans. (c)
   Where, C = constant (4.5 to 6.3)
   Q = design flood discharge (m^3/s)
5. **Increase in water level at the bridge site due to obstruction to the flow is called**
   (a) Free board
   (b) afflux
   (c) Scour
   (d) HFL
   Ans. (b)
6. **Minimum free board required for high level bridge is**
   (a) 300 mm
   (b) 500 mm
   (c) 600 mm
   (d) 1000 mm
   Ans. (c)
7. **If Q is the discharge in m^3/s, the regime width of stream is given by**
   (a) 4.8 Q
   (b) $4.8\sqrt{Q}$
   (c) 1.76 Q
   (d) $1.76\sqrt{Q}$
   Ans. (b)
8. **The normal scour depth is given by,**
   (a) $d = 0.473\left(\frac{Q}{f}\right)^{\frac{1}{3}}$
   (b) $d = 0.473\left(\frac{Q}{f}\right)^{\frac{1}{2}}$
   (c) $d = 4.8\left(\frac{Q}{f}\right)^{\frac{1}{3}}$
   (d) $d = 4.8\left(\frac{Q}{f}\right)^{\frac{1}{2}}$

f = Lacey's silt factor

Ans. (a)

9. If P = cost of one pier with its foundation and a_1 = constant for a super structure then the economic span of the bridge is given by :

(a) $l = \frac{2P}{a_1}$ (b) $l = \sqrt{\frac{2P}{a_1}}$ (c) $l = \frac{P}{a_1}$ (d) $l = \sqrt{\frac{P}{a_1}}$

Ans. (d)

10. In a suspension bridge, dip is usually taken as

(a) $\frac{1}{5}^{th}$ of span (b) $\frac{1}{10}^{th}$ of span (c) $\frac{1}{15}^{th}$ of span (d) $\frac{1}{20}^{th}$ of span

Ans. (b)

11. In case of a balanced cantilever bridge, the cantilever span is usually taken as

(a) 5 to 10% of the supported span (b) 10 ti 15% of the supported span
(c) 15 to 20% of the supported span (d) 20 to 25% of the supported span

Ans. (d)

12. 'Viaduct' is a

(a) Small bridge constructed over small stream
(b) long continuous structure supported on trestle bents over a dry valley
(c) bridge structure constructed at the crossing of railway line and road.
(d) tunnel for a roadway

Ans. (b)

13. The bearing which permit horizontal movement as well as rotation is

(a) Rocker bearing (b) Rocker – roller bearing
(c) shallow plate bearing (d) Tar paper bearing

Ans. (b)

14. The width of expansion joint in highway bridges is usually

(a) 10 mm (b) 25mm (c) 40 mm (d) 50 mm

Ans. (b)

15. The minimum width of carriage way for two lane bridge is

(a) 4.25 m (b) 7.5 m (c) 8.4 m (d) 10.0 m

Ans. (b)

16. Which of the following loading class for bridges is the highest loading

(a) class AA (b) class A (c) close B (d) class 70 R

Ans. (d)

Live loads for various loadings are :
class 70 R = tracked vehicle 700 kN and wheeled vehicle 1000 kN
class AA = tracked vehicle 700 kN and wheeled vehicle 400 kN

17. **For IRC loading 70 R and AA, the impact factor is taken as (up to 9m span)**
(a) 10% (b) 20 % (c) 25 % (d) 30%
Ans. (c)
18. **The wind load acting on moving live load will be assumed to act at a height of 1.5 m above the roadway, its value for ordinary bridge is**
(a) 1.5 kN/m (b) 2.0 kN/m (c) 3.0 kN/m (d) 4.0 kN/m
Ans. (c)
19. **Bridge railings and parapets should be designed to resist a lateral horizontal force and vertical force each of .... acting simultaneously.**
(a) 1.0 kN/m (b) 1.5 kN/m (c) 2.0 kN/m (d) 2.5 kN/m
Ans. (b)
20. **Dicken's formula to determine discharge is**
(a) $Q = CA^{3/4}$ (b) $Q = CA^{2/3}$ (c) $Q = CA^{1/4}$ (d) $Q = CA^{1/3}$
Ans. (a)
Ryve's formula is
$Q = CA^{2/3}$ where, Q = discharge (m^3/s)
A = area of catchment in square km.
21. **The length of the d/s portion of the guide bank should be**
(a) $\frac{1}{2}$ × bridge length (b) $\frac{1}{3}$ × bridge length
(c) $\frac{1}{4}$ × bridge length (d) $\frac{1}{5}$ × bridge length
Ans. (c) The top width of guide bank should not be less than 3.0 m
22. **Which of the following is a river training work**
(a) guide banks (b) spurs (c) cutoffs (d) all of theabove
Ans. (d)
23. **The upstream curved head of guide banks generally subtend an angle with the centre line of bridge equal to**
(a) 0 – 45° (b) 45° – 90° (c) 120° – 145° (d) 145° – 180°
Ans. (c)
The d/s curved head make angle 45° to 90° with the centre line of bridge.
24. **On piers, parallel to the direction of current, the intensity of water pressue is,**
(a) $p = kv^2$ (b) $p = 0.5\ kv^2$ (c) $p = 1.5\ kv^2$ (d) $p = kv^3$
Ans. (b)
p in kN/m^2
v in m/s
k = constant
25. **The collision load on bridge piers may be taken parallel to the carriage way equal to**
(a) 250 kN (b) 500 kN (c) 750 kN (d) 1000 kN
Ans. (d) Collision load perpendicular to the carriage way is taken as 500 kN.

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10.

Railway Engineering

MCQ'S

SET-1

1. **In India, the first train was run between**
   (a) Bombay and Calcutta (b) Delhi and Bombay
   (c) Bombay and Thane (d) Delhi and Culcutta
2. **Total number of zones in which Indian Railways is distributed**
   (a) 5 (b) 11 (c) 9 (d) 16
3. **The Broad Gauge is ________ wide.**
   (a) 1.676 m (b) 1.00 m (c) 0.762 m (d) 0.610 m
4. **Railways originated in**
   (a) U.S.A. (b) England (c) U.S.S.R. (d) Germany
5. **The first Indian railway was laid in**
   (a) 1825 (b) 1876 (c) 1853 (d) 1804
6. **Gauge of a permanent way, is**
   (a) Minimum distance between inner faces of rails.
   (b) Minimum distance between outer faces of rails
   (c) Distance between centres of rails
   (d) Width of formation
7. **Now a days, the rail section on Indian Railways is**
   (a) Double headed (b) Bull headed (c) Dumb bell type (d)Flat footed
8. **Generally, in India, the axle load on rail is taken ________ the weight of rail per metre.**
   (a) 100 times (b) 560 times (c) 350 times (d) 460 times
9. **On Indian Railways, standard length of rails for BG track is**
   (a) 12.80 m (42 ft) (b) 11.89 m (39 ft) (c) 10.97 m (36 ft) (d) 10.06 m (33 ft)
10. **On wooden sleepers adzing is done to give a slope of**
    (a) 1 in 10 (b) 1 in 25 (c) 1 in 20 (d) 1 in 35
11. **The height of 60 kg FF rail is**
    (a) 128 mm (b) 172 mm (c) 156 mm (d) 150 mm

12. On B.G. track the standard size of wooden sleeper used is

(a) 150 cm × 18 cm × 11.5 cm (b) 180 cm × 20 cm × 11.5 cm
(c) 275 cm × 25 cm × 12.5 cm (d) none of the above

13. The name of railway station where all four gauges exist is

(a) Sasaram (b) Giridih (c) Shimla (d) Banglore

14. The trade of wheel is provided an outward slope of

(a) 1 in 10 (b) 1 in 15 (c) 1 in 20 (d) 1 in 25

15. Wheels of a rolling stock are provided flanges

(a) on outer side (b) on inner side (c) on both sides (d) on neither side

16. The head quarter of central railway is at

(a) Mumbai Central (b) Mumbai VT (c) Maligaon (d) Gorakhpur

17. The head quarter of Eastern Railway is at

(a) Chennai (b) Kolkata (c) Maligaon (d) Secunderabad

18. The longest platform of the world on B.G. is at

(a) Sonepur (b) Allahabad (c) Kharagpur (d) Sasaram

19. The standard depth of ballast for BG track on Indian Railway is

(a) 22 cm (b) 25 cm (c) 30 cm (d) 35 cm

20. Fish bolts are made up of ________

(a) High carbon steel (b) Low carbon steel (c) Cast Iron (d) Stainless steel

21. Wear of rail is maximum in

(a) Tangent curve (b) Sharp curve (c) Tunnels (d) Coastal area

22. The tracks having gradients more than ________ come under mountain railways.

(a) 10% (b) 8% (c) 5% (d) 3%

23. To connect one pair of fish plates, the number of bolts used are

(a) 2 (b) 4 (c) 6 (d) 8

24. The maximum gradient for B.G. in station yards is

(a) 1 in 1000 (b) 1 in 400 (c) 1 in 200 (d) 1 in 100

25. The minimum gradient permitted for good drainage of water in station yards on B.G. should be

(a) 1 in 1000 (b) 1 in 500 (c) 1 in 400 (d) 1 in 200

26. The relation between the radius of curve (R) and its degree of curve (D) is given by

(a) $D = \frac{1720}{R}$ (b) $D = \frac{1580}{R}$ (c) $D = \frac{1850}{R}$ (d) $D = \frac{1786}{R}$

27. For fixing rails on wooden sleepers, the commonly used spikes are

(a) Screw spike (b) Elastic spike (c) Dog spike (d) Round spike

28. Check rails are provided on inner side of inner rails if sharpness of a B.G. curve is more than
 (a) 3° (b) 5° (c) 6° (d) 8°
29. Between two sleepers, the minimum space for the packing provided is
 (a) 25 to 30 cm (b) 30 to 35 cm (c) 35 to 40 cm (d) 40 to 45 cm
30. On Indian Railways maximum cant deficiency allowed on BG tracks is....
 (a) 76 mm (b) 51 mm (c) 38 mm (d) 30 mm
31. The tongue rail is made up of
 (a) cast iron (b) mild steel
 (c) Low carbon steel (d) High manganese steel
32. Check rail should normally be provided where the radius is ....or less on BG.
 (a) 125 m (b) 200 m (c) 218 m (d) 230 m
33. The longest passenger train is
 (a) Prayag Raj express (b) Kalka express
 (c) Himsagar Express (d) Garib Rath
34. The fastest train on Indian Railways is
 (a) Shatabdi (b) Rajdhani (c) Deccan Queen (d) Kalka mail
35. Maximum height and width to which a wagon can be loaded is expressed by
 (a) Construction gauge (b) Loading gauge
 (c) Dimension gauge (c) None
36. 90 R rails are mostly used in
 (a) BG (b) MG (c) NG (d) All of these
37. On permanent track, points and crossings are provided to change ________
 (a) Gauge (b) Direction (c) Gradient (d) space
38. The thin edge of tongue rail is called as ________
 (a) Heel (b) Switch (c) Toe (d) none of the above
39. The sleeper density of a BG track is (n + 6) in metric units. The number of sleepers per 1.024 km length of track is
 (a) 1520 (b) 1630 (c) 1720 (d) 1800
40. A station having two lines only is called
 (a) Flag station (b) Terminal station (c) Crossing station (d) Junction station
41. Disc signals are provided for
 (a) Goods train (b) Passenger trains
 (c) Shunting operations (d) Marshalling operation
42. Device used for interlocking is called
 (a) Detector (b) Treadler bar (c) Point lock (d) None of the above

43. Advance starter signal is used for
(a) Shunting operations (b) Goods trains
(c) Loco sheds (d) None of the above

44. Rails are generally discarded if
(a) Web or head gets split (b) Gauge side is worn by 3 mm
(c) wear of rail exceeds 5% (d) Any of the above takes place

45. Rail is fixed to concrete sleeper by
(a) Screw spike (b) Pandrol clip (c) lug and key (d) none of the above

46. The ballast below the sleeper is called
(a) Ballast cushion (b) Crib ballast (c) Shoulder ballast (d) Heavy ballast

47. The total frictional resistance independent of the speed can be obtained by
(a) 0.0016 W (b) 0.0000WV
(c) 0.000017 AV^2 (d) none of the above

48. The curve resistance for 50 tonne train on BG track on a 4° curve will be
(a) 0.05 tonnes (b) 0.06 tonnes (c) 0.08 tonnes (d) 0.10 tonnes

49. The absence of signals is usually seen in places where the track is provided with a ________.
(a) Ruling gradient (b) momentum gradient
(c) Pusher gradient (d) Limiting gradient

50. The first warner signal seen by the driver is known as
(a) Home signal (b) Disc signal (c) Routing signal (d) Outer signal

51. Generally, when a train passes through a station without stopping, the driver comes across the signals in the sequence of....
(a) Warner, outer, home, starter (b) outer, warner, home, starter
(c) Warner, outer, starter, home (d) outer, warner, starter, home

52. The recommended ballast width for BG is
(a) 3650 mm (b) 2290 mm (c) 3350 mm (d) 2750 mm

53. Sand may be used as a ballast for
(a) wooden sleepers (b) Steel sleepers (c) CI sleepers (d) all the above

54. The sleepers which satisfy the requirements of an ideal sleeper, are
(a) CI sleeper (b) RCC sleeper (c) Steel sleeper (d) Wooden sleeper

55. Grade compensation on curve on BG is
(a) 0.05% (b) 0.04 % (c) 0.03 % (d) 0.02 %

56. The degree of curvature allowed is more in
(a) BG (b) MG (c) NG (d) All the above

57. The negative superelevation is provided on a

(a) branch line (b) main line (c) transition curve (d) None of the above

58. Rack railway is provided on

(a) Steep gradient (b) Mild gradient

(c) Vertical gradient (d) Horizontal surface

59. Bending of rails for laying curvatures is resorted when the degree of curvature is more than

(a) 3° (b) 4° (c) 5° (d) 6°

60. A hump yard is a type of

(a) Passenger yard (b) Marshalling yard

(c) Goods yard (d) Retarder

: ANSWERS :

1. c	2. d	3. a	4. b	5. c
6. a	7. d	8. b	9. a	10. c
11. b	12. c	13. b	14. c	15. b
16. b	17. b	18. c	19. b	20. a
21. b	22. d	23. b	24. b	25. a
26. a	27. c	28. d	29. c	30. a
31. d	32. c	33. a	34. a	35. b
36. a	37. b	38. c	39. a	40. c
41. c	42. a	43. a	44. d	45. b
46. a	47. a	48. c	49. b	50. d
51. a	52. c	53. c	54. d	55. b
56. c	57. a	58. a	59. a	60. b

SET-2

1. **The toes of both the tounge rails are connected together by means of a plate which is called** (IES)
   (a) Stretcher bar (b) gauge tie bar (c) tie bar (d) tounge rail
2. **If width of sleeper is w, sleeper spacing is S, then depth of ballast D is** (IES)
   (a) $\frac{S-w}{2}$ (b) $\frac{w-S}{2}$ (c) $S-\frac{w}{2}$ (d) $w-\frac{S}{2}$
3. **A turn table on railway is used for** (IES)
   (a) Preventing the lateral movement of wheels
   (b) Reversing the direction of the engine
   (c) reduing the damage to the rails
   (d) reducing the accidents
4. **Cant deficiency is the difference between** (IES)
   (a) actual cant provided at the time of construction and at the time of renewal
   (b) equilibrium cant necessary for the maximum speed and actual cant provided
   (c) Cant required at maximum speed and minimum speed
   (d) two parallel rails after 10 years
5. **Permissible limit of cant deficiency for B.G. is** (IES)
   (a) 50 mm (b) 60 mm (c) 75 mm (d) 88 mm
6. **As per practice of Indian Railways the grade compensation provided for B.G. on curves is** (IES)
   (a) 0.5 % per degree (b) 0.2 % per degree (c) 0.4 % per degree (d) 0.15 % per degree
7. **A railway yard in which wagons are received, sorted and trains are formed is called** (IES)
   (a) goods yard (b) Station yard (c) Marshalling yard (d) Shunting yard
8. **Which of the following signals is provided beyond the trailing points and switches in a railway yard ?** (IES)
   (a) Repeater signal (b) Departure signal (c) advance starter (d) Routing signal
9. **The shape of transition curve used by Indian railways is** (IES)
   (a) cubic parabola (b) Spiral
   (c) Sine curve (d) Lemniscate of Bernoulli
10. **Metal sleepers are superior to wooden sleepers with respect to**
    (a) cost (b) life (c) track circuiting (d) fastening
11. **Wear of rails is maximum in** (IES)
    (a) tangent track (b) sharp curve (c) tunnels (d) coastal area

12. For a sleeper density of (n + 5), the number of sleepers required for constructing a B.G. track of length 650 m is **(IES)**

(a) 975 (b) 918 (c) 900 (d) 880

Hint : Length of B.G. = 12.8 m

$\therefore$ No. of rails required = $\dfrac{650}{12.8} \simeq 50$

Sleeper density = n + 5

= 12.8 + 5 $\simeq$ 18

$\therefore$ total no. of sleepers = 50 × 18 = 900 nos

13. On railway tracks, corrugations normally occur on stretches where

(a) trains stop or start (b) steel sleepers are used

(c) there are horizontal curves (d) there are vertical curves

14. Match List I and List II and select the correct answer using the codes given below the lists : **(IES)**

	List I		**List II**
A.	Shovel	1.	To lift rails
B.	Crow bars	2.	To remove dog spikes out of sleepers
C.	Rail tongs	3.	To correct track alignment
D.	Claw bars	4.	To handle ballast

Codes :

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	2	1
(c)	4	3	1	2
(d)	3	4	1	2

15. The distance between running faces of the stock rail and gauge face of tongue rail measured at the heel of the switch is called ?

(a) flange way clearance (b) throw of switch

(c) heel divergence (d) flare

16. Rail gauge is the distance between

(a) Outer faces of rails (b) running faces of rails

(c) centre to centre of rails (d) none of these

17. Top of rails of a track are placed at an inward slope of

(a) 1 in 10 (b) 1 in 15 (c) 1 in 20 (d) 1 in 25

18. Coning of wheels is provided

(a) to check the lateral movement of rail, (b) to avoid damage to inner faces of rails

(c) to avoid discomfort to passengers (d) all of these

19. **Bull headed rails are generally provided at**
    (a) Curved tracks (b) Points and crossings
    (c) Bifurcation of tracks (d) bridges
20. **The creep in rails is measured in**
    (a) kg/cm^2 (b) kg/cm (c) kg-cm (d) cm
21. **Creep is the**
    (a) longitudinal movement of rail (b) lateral movement of rail
    (c) Vertical movement of rail (d) None of these
22. **Creep is greater**
    (a) on curves (b) in new rails than old rails
    (c) both (a) and (b) (d) None of these
23. **The extra rails provided over a bridge to prevent damage due to derailment on the bridge are called**
    (a) Check rails (b) guard rails (c) torque rails (d) wing rails
24. **When rails go out of their position due to insufficient expansion gap is called**
    (a) hogging (b) creeping (c) buckling (d) none of these
25. **Due to battering action of wheels, over the end of the rail, the rails get bent down and deflected at ends, these rails are called**
    (a) hogged rails (b) guard rails (c) torque rails (d) none of these
26. **Rails are welded by**
    (a) gas welding (b) Arc welding (c) Tig welding (d) Thermit welding
27. **The misalignment of rails due to temperature changes is called**
    (a) hogging (b) Creeping (c) buckling (d) bulging
28. **The Indian practice is to weld maximum of**
    (a) 2 rail lengths (b) 3 rail lengths (c) 4 rail lengths (d) 5 rail lengths
29. **A welded rail joint is generally**
    (a) Supported on sleeper (b) Supported on a metal plate
    (c) left suspended (d) Supported on ballast
30. **When two different rail sections are jointed together by means of fish plates, the joint is called**
    (a) Supported joint (b) Suspended joint (c) Compromise joint (d) Staggered joint
31. **When rail ends rest on a joint sleeper joint is called**
    (a) bridge joint (b) supported joint (c) suspended rail joint (d) Base joint
32. **Ideal sleepers are**
    (a) RCC sleepers (b) Steel sleepers (c) CI sleepers (d) Wooden sleepers
33. **Best wood for wooden sleeper is**
    (a) Chir (b) Sal (c) Teak (d) Seasham

34. Sleepers preferred on joints are
(a) Wooden sleepers (b) Concrete sleepers (c) Steel sleepers (d) CST - 9 Sleepers

35. Standard size of wooden sleeper for B.G. track is
(a) 274 × 25 × 13 cm (b) 183 × 20 × 11 cm
(c) 152 × 15 × 10 cm (d) 250 × 26 × 12 cm

36. Spacing of sleepers is kept
(a) same throughout the length of rail (b) closer near the joints
(c) closer at the middle of rails (d) none of these

37. Sleepers providing best elasticity is
(a) wooden (b) RCC (c) Steel (c) CI

38. Sleepers providing best rigidity of track is
(a) Wooden (b) RCC (c) Steel (d) CI

39. The best suited material for the ballast is
(a) broken stone (b) gravel or river pebbles
(c) ashes or cinders (d) brick ballast

40. Pandrol clip can not be used with
(a) wooden sleepers (b) Concrete sleepers (c) CST-9 sleepers (d) CI sleepers

41. Arrangement made to divert the trains from one track to another is called
(a) railway crossing (b) railway junction (c) turnout (d) none of these

42. The switch giving best performance is
(a) undercut switch (b) Straightcut switch
(c) Over riding switch (d) none of these

43. In a diamond crossing, number of noses are
(a) 3 (b) 4 (c) 5 (d) 6

44. A track adopted when a double track is to be narrowed over a short distance of the track is called
(a) Gauntleted track (b) ladder track (c) double slip track (d) none of these

45. When a number of parallel tracks are branched off from the straight track, it is called
(a) Gauntleted track (b) Ladder track (c) Double slip track (d) Multi track

46. Distance between adjacent faces of the stock rail and check rail is called
(a) heel clearance (b) flangeway clearance
(c) throw of switch (d) flare

47. The type of transition curve used on Indian railway is
(a) Spiral (b) cubic parabola (c) lemniscate (d) S-curve

48. Holes for fish bolts should be
(a) drilled (b) hot-punched (c) Cold-punched (d) Screwed

49. In station the gradient provided is
(a) zero per cent (b) equal to ruling gradient
(c) Steeper than ruling gradient (d) Flatter than ruling gradient

50. Advance starter signal is used for
(a) Shunting (b) goods trains (c) locosheds (d) all of these

51. The reception signal is
(a) outer signal (b) home signal (c) Starter signal (d) both (a) and (b)

52. During foggy and cloudy weather, the signal used is
(a) Semaphore signal (b) warner signal (c) detonating signal (d) colour light signal

53. A station at which a railway line or one of its branches terminates is called
(a) junction station (b) terminal station (c) flag station (d) Halts

54. When semaphore signal is in horizontal position, it is said to be in
(a) 'on' position which indicates 'stop'
(b) 'on' position which indicates 'proceed'
(c) 'off' position which indicates 'stop'
(d) 'off' position which indicates 'proceed'

55. When semaphore signal is inclined at 45° to 60° below horizontal, it is said to be in
(a) 'on' position which indicates 'stop' (b) 'on' position which indicates 'proceed'
(c) 'off' position which indicates 'stop' (d) 'off' position which indicates 'proceed'

56. Pandrol is an example of
(a) Rail spike (b) fish bolt (c) Elastic fastening (d) bearing plate

57. Bearing plate is used below
(a) FF rails (b) BH rails (c) DH rails (d) none of these

58. In a switch, the rail which can move is called
(a) wing rail (b) tongue rail (c) stock rail (d) Splice rail

59. For shunting operations the signal used is
(a) warner signal (b) semaphore signal (c) Disc signal (d) Coloured signal

60. Wheels of train are coned at a slope of
(a) 1 in 20 (b) 1 in 25 (c) 1 in 30 (d) 1 in 15

61. The wheel diameter is generally how many times the gauge ?
(a) 0.50 (b) 0.65 (c) 0.75 (d) 0.80

62. The test conducted on rails is
(a) hammer test (b) tensile test (c) Falling weight test (d) both (a) and (b)

63. **Number of MS keys used in CST - 9 sleepers are**
(a) 4 (b) 3 (c) 2 (d) 5

64. **Slope of platform across its width is**
(a) 1 in 40 (b) 1 in 60 (c) 1 in 30 (d) 1 in 45

65. **The platform height above rail level in BG is provided as**
(a) 0.76 to 0.84 m (b) 0.90 to 1.2 m (c) 0.65 to 0.75 m (d) 1.05 to 1.15 m

66. **Two important constituents in the composition of steel used for rails are**
(a) Carbon and sulphur (b) Carbon and manganese
(c) Carbon and silicon (d) Manganese and phosphorous

67. **The reception signal is**
(a) Outer signal (b) home signal
(c) both (a) and (b) (d) advance starter

68. **Maximum value of 'throw of switch' for B.G. track is**
(a) 89 mm (b) 95 mm (c) 100 mm (d) 115 mm

69. **Generally side slope of embankments for a railway track is taken as**
(a) 1.5 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 1.5

70. **Limitations of superhigh speed is/are**
(a) wave formation (b) adhesion between wheel and rails
(c) vibrations (d) all of these

: ANSWERS :

1. (a)	2. (a)	3. (b)	4. (b)	5. (c)
6. (b)	7. (c)	8. (c)	9. (a)	10. (b)
11. (b)	12. (c)	13. (a)	14. (c)	15. (c)
16. (b)	17. (c)	18. (d)	19. (b)	20. (d)
21. (a)	22. (a)	23. (b)	24. (c)	25. (a)
26. (d)	27. (c)	28. (d)	29. (c)	30. (c)
31. (b)	32. (d)	33. (c)	34. (a)	35. (a)
36. (c)	37. (a)	38. (b)	39. (a)	40. (c)
41. (c)	42. (c)	43. (d)	44. (a)	45. (b)
46. (b)	47. (b)	48. (a)	49. (d)	50. (a)
51. (d)	52. (c)	53. (b)	54. (a)	55. (d)
56. (c)	57. (a)	58. (b)	59. (c)	60. (a)
61. (c)	62. (c)	63. (c)	64. (c)	65. (a)
66. (b)	67. (c)	68. (d)	69. (b)	70. (d)

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11.

Airport Engineering

MCQ'S

1. **According to ICAO, markings on the runways are**
   (a) white (b) yellow (c) black (d) red
2. **Which one of the following is used for servicing and repairs of the aircraft ?**
   (a) Apron (b) hanger (c) Terminal building (d) Holding apron
3. **Where the aircraft is standing (parking), the facility for loading and unloading operation in front of terminal building is called** **(IES)**
   (a) holding apron (b) apron (c) taxiway (d) hanger
4. **The wind rose diagram (WRD) for orientation of airport runway give** **(Civil Services)**
   (a) direction of wind (b) direction and duration of wind
   (c) direction, duration and intensity of wind (d) none of these
5. **Which one of the following imaginary surfaces in airport is circular in plan with centre located at an elevation of 150 m above the airport reference point ? (IES)**
   (a) Conical surface (b) Transitional surface
   (c) Inner horizontal surface (d) Outer horizontal surface
6. **ICAO has recommended that the basic runway length should be increased at the rate of .... per 300 m rise in elevation above mean sea level.(IES)**
   (a) 5% (b) 7% (c) 10% (d) 15%
7. **At a certain station, mean of the average temperature is 25°C and mean of the maximum daily temperature is 40°C. What is the airport reference temperature (ART) ?**
   (a) 46.6°C (b) 45°C (c) 35°C (d) 30°C

   Hint : $T = T_1 + \frac{(T_2 - T_1)}{3}$

   $= 25 + \frac{(40-25)}{3} = 30°C$
8. **A surface longitudinally centred on the extended runway centre line and extending outward and upward is called** **(IES)**
   (a) Primary surface (b) conical surface (c) Horizontal surface (d) approach surface

9. **The total correction percentage for altitude and temperature in calculating the runway length from basic runway length, normally does not exceed (IES)**
(a) 7 (b) 14 (c) 28 (d) 35

10. **The best direction of a runway is** (IES)
(a) along the longest line on the windrose diagram
(b) along the direction perpendicular to the longest line on the windrose diagram
(c) at 30° to the direction of the longest line on the wind rose diagram
(d) along the NW - SW line

11. **Type I windrose diagram used for the orientation of runway shows**
(a) direction of wind (b) direction and duration of wind
(c) direction and intensity of wind (d) direction, duration and intensity of wind (IES)

12. **Consider the following factors**
1. Air traffic control measures 2. Aircraft traffic composition
3. VFR/IFR operation 4. Runway configuration
Which of these factors affect the capacity of a runway ?
(a) 1, 2 and 3 (b) 2 and 3 (c) 1 and 4 (d) 1, 2, 3 and 4

13. **A VOR radio transmitter which emits beam in a vertical plane and gives an indication to the pilot whether he is to the left or right of the correct alignment for approach to the runway is called** (IES)
(a) outer marker (b) localiser antena (c) Glide slope antena (d) Marker beacon

14. **Consider the corrections to be applied to the basic length of runway**
1. Elevation correction 2. Gradient correction 3. Temperature correction
The correct order of aplying the corrections to obtain runway length is (IES)
(a) 1 - 2 - 3 (b) 1 - 3 - 2 (c) 2 - 3 - 1 (d) 3 - 1 - 2

15. **From list I and list II, select the correct answer from the codes :**

List I	List II
A. Localiser antena	1. Gives controller a picture of the descending aircraft both in plan and elevation
B. Glide slope antena	2. Indicates to the pilot whether he is to the left or right of the correct alignment
C. PAR (Precision approach radar)	3. indicates to the pilot the correct angle of descent to the runway
D. ASR (Airport surveillance radar)	4. Provide the control tower operator with an overall picture of airspace surrounding the terminal

Codes :

	A	B	C	D
(a)	3	2	1	4
(b)	3	2	4	1
(c)	2	3	1	4
(d)	2	3	4	1

16. As per ICAO, the minimum basic runway length for A and E type of airport will be

(a) 1500 m and 600 m (b) 2100 m and 750 m
(c) 1500 m and 750 m (d) 2100 m and 600 m

17. Match List I and List II correctly :

	List I		List II
A.	Elevator	1.	It controls yawing
B.	Rudder	2.	It controls rolling
C.	Aileron	3.	It controls pitching

Codes :

	A	B	C
(a)	1	2	3
(b)	2	3	1
(c)	2	1	3
(d)	3	1	2

18. Minimum width of clearway is

(a) 50 m (b) 100 m (c) 150 m (d) 250 m

19. Within 4.5 km distance from the runway end, an object shall be considered an obstruction if its height exceeds

(a) 20 m (b) 30 m (c) 40 m (d) 50 m

20. The engine failure case for determining the basic runway length require

(a) only clearway (b) only stopway
(c) either clearway or a stopway (d) either a clearway or a stopway or both

21. If TOD = Take of distance, LOD = lift off distance, the correct relationship for normal landing case is

(a) TOD = 1.15 LOD (b) LOD = 1.15 TOD (c) TOD = 1.25 LOD (d) LOD = 1.25 TOD

22. **Take of distance (TOD) is 115 % of the distance the aircraft uses to reach a height of**

(a) 15 m (b) 10.5 m (c) 7.5 m (d) 5.0 m

23. **During normal landing, the height of aircraft at the threshod of runway is about**

(a) 10 m (b) 10.5 m (c) 15 m (d) 20 m

24. **The areas which allows to check instruments and engine operation prior to take off and to wait for take off are called**

(a) Hanger (b) apron (c) holding apron (d) terminal area

25. **For determining the basic runway length, the landing case requires that aircraft should come to a stop within p% of the landing distance.**

The value of p is

(a) 40 % (b) 50 % (c) 60% (d) 75 %

26. **The slope of transitional surface for A, B and C type of runway shall be**

(a) 1 : 5 (b) 1 : 7 (c) 1 : 10 (d) 1 : 12

27. **Airport elevation is the reduced level about M.S.L. of**

(A) Control tower (b) highest point of the landing area

(c) Lowest point of the landing area (d) None of these

28. **The taxiway is the strip of pavement which connects**

(a) the city to the airport (b) the runway to the apron

(c) the terminal building to taxi stand (d) none of these

29. **Runway lights are usually spaced at not more than**

(a) 60 m (b) 150 m (c) 200 m (d) 250 m

30. **The taxiway side lights are coloured**

(a) green (b) red (c) blue (d) white

31. **Two single runways on an airport can be arranged in the form of**

(a) T shape (b) L shape (c) X - shape (d) any of the above

32. **Holding aprons are known as**

(a) Warm up pads (b) run-up pads (c) both (a) and (b) (d) None of these

33. **Which of the following is not a landing aid ?**

(a) beacon (b) Airport surveillance rader

(c) Localiser antena (d) Glide slope antena

34. **If L is the basic runway length, the total length of landing strip will be**

(a) L (b) 1.2 L (c) L + 50 m (d) L + 120 m

35. The landing and take off area of heliports are marked with

(a) Letter H (b) Letter P (c) Number 3 (d) None of these

36. The pilot normally takes decision about landing when he is about .... m above the runway.

(a) 100 m (b) 60 m (c) 40 m (d) 20 m

37. Which of the following is not matched correctly ?

(a) runway lighting - white (b) Threshold lighting - yellow
(c) Taxiway lighting - blue (d) End threshold lighting - red

38. The width of threshold markings is

(a) 4 m (b) 10 m (c) 15 m (d) 10 m

39. As per ICAO recommendations all markings on taxiways are painted

(a) white (b) blue (c) black (d) yellow

40. As per ICAO, the maximum longitudinal gradient along the runway is limited to

(a) 1.5 % (b) 3 % (c) 5 % (d) 7 %

: ANSWERS :

1. (a)	2. (b)	3. (b)	4. (c)	5. (d)
6. (b)	7. (d)	8. (d)	9. (d)	10. (a)
11. (b)	12. (d)	13. (b)	14. (b)	15. (c)
16. (d)	17. (d)	18. (c)	19. (b)	20. (d)
21. (a)	22. (b)	23. (c)	24. (c)	25. (c)
26. (b)	27. (b)	28. (b)	29. (a)	30. (c)
31. (d)	32. (c)	33. (a)	34. (d)	35. (a)
36. (b)	37. (b)	38. (a)	39. (d)	40. (a)

12.

Docks and Harbour

MCQ'S

1. **A platform built parallel to the shore for ship to come close to the shore is known as**
(a) Jetty (b) Wharf (c) lock (d) port
2. **A wharf is a platform**
(a) built parallel to the shore (b) having berth on one side only
(c) (a) and (b) both (d) None of these
3. **The 'breakwater' is provided**
(a) in artificial harbour (b) with arm (c) (a) and (b) both (d) None of these
4. **The platform constructed perpendicular to the shore having berth on both sides is called**
(a) Jetty (b) wharf (c) quay (d) lock
5. **The impact of ship while docking is taken up by**
(a) mooring dolphins (b) bresting dolphins
(c) bulkhead (d) fixed mooring berth
6. **The lock gates are always in**
(a) Single number (b) pair (c) quadruple (d) dozen
7. **The tidal range is maximum in India at**
(a) Bombay (b) Madras (c) Paradeep (d) Bhavnagar
8. **Lowest tide of the month is known as**
(a) neap tide (b) tidal bore (c) spring tide (d) diurnal tide
9. **Which is not a type of signal used in harbours ?**
(a) Beacon (b) Semaphore (c) Buoys (d) Moorings
10. **The depth of sea at harbour used in handling of cargo should normally be**
(a) not more than 15 m (b) not less than 15 m
(c) not more than 7.5 m (d) not less than 7.5 m
11. **The lowest tide which occurs in half lunar month is called**
(a) Spring tide (b) neap tide (c) lunar tide (d) tidal bore
12. **The phenomenon of movement and deposition of sand in a zig-zag way due to drifting of sand in the vicinity of coast is called**

(a) Beach drift (b) through action (c) littoral drift (d) Sedimentation

13. Why are moorings provided ?

(a) For anchoring of ships (b) For towing of ships to the sea

(c) For repair of ships (d) For washing of ships

14. Which one of the following is the best method for locating soundings to estimate the dredged material from the harbours ?

(a) Two angles from shore

(b) Two angles from boat

(c) One angle from shore and other from the boat

(d) Fixed intersecting ranges

15. Match List I and List II and select correct answer from the codes :

List I	List II
A. Break water	1. It protects the land from wave erosion
B. Wharf	2. Protects a seashore
C. Fender system	3. Lays vessels alongside, receives and discharges cargo and passengers
D. Revetments	4. Absorbs the energy of mooring vessel

Codes :

	A	B	C	D
(a)	2	3	1	4
(b)	2	3	4	1
(c)	3	2	1	4
(d)	3	2	4	1

16. The percentage of time in a year during which the cross wind component remains within the limit is

(a) wind coverage (b) Head wind (c) Cross wind (d) Prevailing wind

17. What is use of station pointer ?

(a) For making soundings in water bodies

(b) For making tidal observations

(c) For plotting of soundings in harbour area

(d) For marking sunken shipping hazards

18. The approximate height of wave for a given fetch (F) is given by

(a) F (b) $\sqrt{F}$ (c) $0.34\sqrt{F}$ (d) $0.25\sqrt{F}$

19. In maritime works, speed of wind is expressed in

(a) km/hr (b) knots (b) miles/hr (d) none of these

20. 'Beaufort scale' is related to

(a) earthquake magnitude (b) Velocity of water waves
(c) Wind speed (d) None of these

21. The mean low water/mean high water is the average of low/high water over a period of

(a) 10 years (b) 15 years (c) 19 years (d) 25 years

22. Dolphins are used

(a) to absorb the impact force of the ships
(b) to provide mooring facility
(c) to shorten the length of piers and wharves
(d) all of the above

23. Horizontal or vertical wooden members or rubber strips fastended to the deck or face of the dock to absorb the impact of the ship are called

(a) Dolphins (b) fenders (c) moles (d) trestle

24. Rockfills extending out from shores, used for roadways, railway track, side wall, etc. are called

(a) Piers (b) breakwater (c) moles (d) trestle

25. A harbour protected on sides by headlands and requiring protection at the entrance only is known as

(a) Natural harbour (b) Semi-natural harbour
(c) Artificial harbour (d) natural roadstead

26. Bilge blocks are used

(a) to afford sufficient bearing to the ship keel without being crushed
(b) to provide level seat for ship and lateral stability
(c) to keep the harbour water undisturbed
(d) none of these

27. Dolphins are

(a) cluster of closely spaced piles for mooring vessels
(b) light pier designed to withstand vertical force
(c) Constructed at the tip of breakwater near the harbour entrance
(d) heavy pier designed to withstand water pressure

28. The location of a harbour may be guessed by

(a) wave direction (b) wave height (c) fetch (d) all of the above

29. The floating navigational aid is

(a) light ship (b) light house (c) beacon light (d) all of these

30. Which is not a mooring accessory ?

(a) bollard (b) capston (c) fender (d) cleat

31. The concrete armour units used in the construction of

(a) break water (b) pier (c) wharves (d) dry docks

32. The width of entrances of harbours is restricted to

(a) 100 m (b) 125 m (c) 150 m (d) 180 m

33. A dock

(a) is a marine structure for berthing of vessels for loading and unloading cargo and passengers

(b) is provided with a dock gate

(c) is provided with an arrangement to pump out water when required

(d) all the above

34. The dock wall is designed as a gravity retaining wall and is tested for

(a) backfill pressure when the dock is empty

(b) Maximum water pressure from the dock without backfill

(c) The load transmitted to the dock by the movement of loaded vehicles on the way

(d) all of the above

35. Which one of the following lines is used for tying a ship with a dock ?

(a) bow line (b) stern line (c) spring line (d) all the above

36. A low wall built into the sea more or less perpendicular to the coast line, to resist travel of sand and shingle along a beach is called

(a) break water (b) break wall (c) groynes (d) shore wall

: ANSWERS :

1. (b)	2. (c)	3. (c)	4. (a)	5. (b)
6. (b)	7. (d)	8. (a)	9. (b)	10. (b)
11. (a)	12. (c)	13. (a)	14. (c)	15. (b)
16. (a)	17. (b)	18. (c)	19. (b)	20. (b)
21. (c)	22. (d)	23. (b)	24. (c)	25. (b)
26. (b)	27. (a)	28. (d)	29. (a)	30. (c)
31. (a)	32. (d)	33. (d)	34. (d)	35. (d)
36. (c)				

13.

Estimating and Costing

Useful Information

Length, Area, Volume

1m = 3.28 ft.
$1m^2 = 3.28 \times 3.28 = 10.75$ Sq. ft.
$1m^3 = 3.28 \times 3.28 \times 3.28 = 35.28$ cu.ft

Area	1 brass	=	100 Sq. ft.
		=	$\frac{100}{10.75} = 9.3\ m^2$
Volume	1 brass	=	100 cu. ft.
		=	$\frac{100}{35.28} = 2.83\ m^3$
1 bag of cement		=	50 kg mass
		=	$0.035\ m^3$ volume
		=	0.035×35.28
		=	1.23 cu. ft. volume

1 Gallon	=	4.546 Litre
1 Pound	=	0.4536 kg
1 Tonne	=	1000 kg
1 Quintal	=	100 kg

1 Var	=	1 Yard
	=	3 ft. = 90 cm = 0.9 cm
1 Guntha	=	33 ft. × 33 ft
	=	1089 Sq. ft = 101.30 Sq.m
1 Vigha	=	16 Guntha
1 Acre	=	2.5 Vigha
	=	2.5 × 16
	=	40 Guntha
1 Acre	=	4047 Sq. m

100 Sq.m	=	1 Are
100 Are	=	1 Hectare
	=	10000 Sq. m
1 Hectare	=	2.471 Acre

Density of Materials

Material	Density
Cement	1430 kg/m^3
Sand	1500 kg/m3
Aggregates	1600 kg/m3
Steel	7850 kg/m^3
Water	1000 kg/m^3 (10 kN/m^3)
Soil	1600 – 1800 kg/m^3
RCC	2500 kg/m^3 (25 kN/m^3)
PCC	2400 kg/m^3
Brick Masonry	1800 kg/m^3
Wood	800 to 1600 kg/m^3

Nominal Mixes for Concrete :

Grade of Concrete	Cement : Sand : Aggregate
M 7.5	1 : 4 : 8
M 10	1 : 3 : 6
M 15	1 : 2 : 4
M 20	1 : 1.5 : 3 (minimum grade for RCC)
M 25	1 : 1 : 2

SHORT ANSWER QUESTIONS

1. What is weight and volume of 1 bag of cement ?

weight = 50 kg

volume = 0.035 m^3 (1.23 cu.ft) or 35 litres.

2. How many bricks required for 1 m^3 brickwork ?

500 nos.

3. What is actual and nominal size of bricks ?

Actual size of brick = 19 × 9 × 9 cm

Nominal size of brick = 20 × 10 × 10 cm (with mortar joints)

4. What is volume of bricks and mortar in 1 m^3 of brickwork ?

In 1 m^3 brickwork 500 bricks are required

$\therefore$ Volume of bricks = 500 × (0.19 × 0.09 × 0.09)

= 0.77 m^3

$\therefore$ Volume of mortar = 1 − 0.77

= 0.23 m^3 .... wet volume

= 0.33 m^3 ...... dry volume

5. Give quantities of cement, sand and aggregate required for 1 m^3 of M 20 concrete.

Proportion of M 20 concrete = 1 : 1.5 : 3

Volume of wet concrete 1m^3

Volume of dry concrete = 1.52 m^3 (52 % more)

1 : 1.5 : 3 = 5.5

$$\therefore \text{cement} = \frac{1}{5.5} \times 1.52 = 0.2763 \text{ m}^3 = \frac{0.2763}{0.035} = 7.89 \text{ say 8 bags}$$

$$\text{Sand} = \frac{1.5}{5.5} \times 1.52 = 0.414 \text{ m}^3$$

$$\text{Aggregate} = \frac{3}{5.5} \times 1.52 = 0.829 \text{ m}^3$$

6. Give current market rates for following materials

Cement (1 bag)	=	Rs. 280
Steel	=	45 Rs. per kg
Bricks	=	4000 Rs. per 1000 nos.
Sand	=	Rs. 800 /m^3
Aggragate	=	Rs. 1000 /m^3

7. Give current market rates for following items.

Excavation up to 1.5 m = 85 Rs./m^3

B.B.C.C. (1 : 4 : 8) = 2700 Rs./m^3

P.C.C. (1 : 4 : 8) = 3000 Rs./m^3

R.C.C. (1 : 1.5 : 3) = 10,000 Rs./m^3

Brickwork in foundation (1 : 6) = 3200 Rs./m^3

Brickwork in superstructure (1 : 6) = 3500 Rs./m^3

12 mm thick cement plaster (1 : 4) = 150 Rs./m^2

8. Give task work for labour and mason.

Partition wall - 5m^2

Labour ⟶ excavation in ordinary soil = 3 m^3

Delivary of concrete = 3 m^3

Mason ⟶	Brickwork in foundation	= 1.25 m^3
	Brickwork in superstructure	= 1.0 m^3
	12 mm thick Plaster (1 : 3)	= 10 m^2
	P.C.C. (1 : 4 : 8)	= 5 m^3
	R.C.C. (1 : 1.5 : 3)	= 3 m^3

9. **For earthwork, what is standard lead and lift ?**

Lead = 30 m

Lift = 1.5 m

10. **What is surface excavation ?**

Excavation exceeding 1.5 m in width as well as 10 sq.m on plan with a depth not axceeding 30 cm shall be described as surface excavation.

It is measured in m^2.

11. **If it is not possible to take the measurements from borrow pit or cutting, excavation shall be worked out from filling. How deductions are made for voids ?**

10% deduction for normally consolidated fills.

5% deduction for consolidation by heavy machinery.

12. **Give deduction rules for brickwork as per IS : 1200**

No deduction shall be made for :

– Opening up to 0.1 Sq.m area
– Pipes up to 30 cm diameter
– ends of beams, lintels, joists, etc.

13. **Give deduction rules for concrete as per IS : 1200.**

No deduction shall be made for :

– Opening up to 0.1 Sq.m area
– Volume of steel reinforcement
– Volume of pipes not exceeding 100 Sq.cm in cross sectional area.
– Ends of beams, joists, girders, etc. up to 500 sq.cm in cross sectional area.

14. **Give deduction rules for plastering as per IS : 1200.**

No duduction shall be made for :

– Opening up to 0.5 m^2 area
– ends of beams, joists, steps not exceeding 0.5 m^2 in area.
– For openings exceeding 0.5 m^2 and less than 3 m^2 deduction shall be made for one face only if both faces are plastered with the same plaster.

15. **In centre–line method how net centre line length is calculated ?**

Net centre line length

$$= \text{total centre line length} - \left(\frac{1}{2} \times \text{width of wall} \times \text{number of junctions}\right).$$

- At the corner of a building, no junction is formed.
- At T–joint there will be one junction.
- At cross walls, there will be two junctions.

16. Give formula to calculate weight of 1m long steel bar.

Weight of reinforcement bar for 1 m length

$$= \frac{d^2}{162} \text{ kg.}$$

where d = diameter of bar in mm.

For example,

If d = 16 mm

$$\text{wt. of bar per m} = \frac{d^2}{162} = \frac{16^2}{162} = 1.58 \text{ kg/m}$$

17. How number of bars can be calculated if distance and spacing of bars is given.

$$\text{No. of bars} = \frac{(L - 2 \times \text{end cover})}{\text{c/c spacing of bars}} + 1$$

where,

L = distance within which bars are to be provided.

18. What is length of hook provided at the end of bar ?

hook length = 9 × diameter of bar.

19. What is minimum hook length for stirrups ?

Minimum hook length = 12 × dia. of bar

or

75 mm which ever is more.

For 2–hooks,

hook length = 24 ϕ or 0.15 m

20. For 45° bent up bar, extra length of bar is taken as,

extra length = $0.45x$

where, x = vertical distance between centres of top and bottom portion of bent up bar.

21. What is size of standard gauge box (Farma) for mixing sand and aggregate ?

Vol. of 1 bag of cement = 35 litres.

Size of standard gauge box

= 33.3 cm × 30 cm × 35 cm = 0.035 m^3

= 35 litres

22. For 1:1.5:3 mix proportion, if bulking of sand is 20%, actual volume of moist sand required is ?

For 1 : 1.5 : 3

35 lit : 52.5 lit : 105 lit

Volume of moist sand required

$= 52.5 + 0.20 \times 52.5 = 63$ litres.

23. What is EMD ?

The purpose of Earnest money Deposit (EMD) is to punish the contractor who refuse to take up the work or to prevent the financially weak contractor from entering into the contract.

The EMD amount is about 1 to 2% of the estimated cost of the work.

The EMD of the tenderer whose tender has not been accepted is refunded. The EMD of the successful contractor is converted into security deposit.

24. What is security deposit ?

The security amout is required to be deposited by a successful contractor whose tender has been accepted.

The SD amount is about 10% of the tendered amount.

In case of delay in work or incomplete work or poor quality work, the SD is forfeited fully or partially.

After satisfactory completion of work, usually after one rainy season, SD is refunded to the contractor.

25. What is technical sanction ?

Technical sanction means the sanction of the detailed estimate, design calculations, quantities of works, rates and cost of the work by the competent authority of the engineering department (PWD).

Powers for technical Sanction

	P.W.D. officer	Power for technical sanction
1.	Chief engineer	Full powe
2.	Superintending engineer	up to Rs.15 lakhs
3.	Executive engineer	up to Rs.5 lakhs

26. What is liquidated damages ?

Liquidated damages is an amount of compensation payable by a contractor to the owner or Government due to delayed construction. It has no relation with the real damage.

27. What is arbitration ?

The process by which the parties under a contract get their disputes and differences settled through the intervention of an impartial person or a committee of experts in a judicial manner is known as arbitration.

The impartial person chosen by the parties themselves to whom the disputes and differences are referred to, is called an arbitrator.

28. List methods of calculating depreciation.

(i) Straight line method $D = \frac{C - S}{n}$

(ii) Constant percentage method, $p = 1 - \left(\frac{S}{C}\right)^{\frac{1}{n}}$

where p = % rate of annual depriciation

(iii) Sinking fund method

$$p = \frac{i}{(1+i)^n - 1}, \quad q = \frac{(1+i)^n - 1}{i}$$

Rate of depreciation in 'n' years = p × q %

29. If, i is the rate of interest, annual sinking fund installment (p) to accumulate 1 Rs. in n years is ?

$$p = \frac{i}{(1+i)^n - 1}$$

30. If i is the rate of interest, and 1 Rs. is deposited every year, total sinking fund accumulated at the end of n years will be ?

$$q = \frac{(1+i)^n - 1}{i}$$

❖❖❖

MCQ'S

1. **The volume of 1 bag of cement is**
   (a) 0.025 m^3 (b) 0.035 m^3 (c) 0.045 m^3 (d) 0.055 m^3
2. **The actual size of standard brick is**
   (a) 19 × 9 × 9 cm (b) 20 × 10 × 10 cm
   (c) 20 × 12 × 8 cm (d) 20 × 10 × 8 cm
3. **The nominal size of standard brick is**
   (a) 19 × 9 × 9 cm (b) 20 × 10 × 10 cm
   (c) 20 × 12 × 8 cm (d) 20 × 10 × 8 cm
4. **Number of bricks of size 20 cm × 10 cm × 10 cm required for 1 m^3 of masonry wall is**
   (a) 300 (b) 400 (c) 450 (d) 500
5. **In analysis of rates, contractor's profit is taken as**
   (a) 5 % (b) 10 % (c) 15 % (d) 20 %
6. **In analysis of rates, water charges are added on those items which require water, these charges are added at the rate of**
   (a) 1 % (b) 1.5 % (c) 2 % (d) 2.5 %
7. **In measuring plastering, no deduction is made for opening up to**
   (a) 0.25 m^2 (b) 0.50 m^2 (c) 1.0 m^2 (d) 1.5 m^2
8. **The ratio of cost of labour to the total cost of the building is about**
   (a) 1 : 10 (b) 1 : 1 (c) 1 : 4 (d) 1 : 2
9. **In preparing cement concrete by volume the size of gauge box (farma) for measuring sand and aggregate is**
   (a) 35 × 30 × 40 cm (b) 33.3 × 30 × 35 cm
   (c) 30 × 30 × 30 cm (d) 35 × 25 × 30 cm
10. **In specification of earthwork in foundation, lift and lead specified are, respectively**
    (a) 1.0 m, 20 m (b) 1.5 m, 20 m (c) 1.5 m, 30 m (d) 1.0 m, 25 m
11. **Which estimate is least accurate ?**
    (a) Detailed estimate (b) Plinth area estimate
    (c) Supplementary estimate (d) Revised estimate
12. **Thickness of plastering is usually**
    (a) 6 mm (b) 12 mm (c) 25 mm (d) 40 mm
13. **1 m^3 of mild steel weighs about**
    (a) 3800 kg (b) 1000 kg (c) 7850 kg (d) 12560 kg
14. **For 1 m^3 of M 20 (1 : 1.5 : 3) concrete, no. of cement bags required are**
    (a) 6.4 bags (b) 8 bags (c) 10 bags (d) 12 bags

15. **The weight of 16 mm dia. steel bar per m length is**
    (a) 0.89 kg (b) 1.58 kg (c) 2.0 kg (d) 2.46 kg
16. **In analysis of rate, for 1 m^3 of brick work the quantity of dry mortar required is**
    (a) 0.20 m^3 (b) 0.25 m^3 (c) 0.30 m^3 (d) 0.35 m^3
17. **In a detailed estimate the provision for contingencies is usually**
    (a0 1 % (b) 3 to 5 % (c) 10 % (d) 15 %
18. **Number of bricks usually carried by a truck is**
    (a) 2000 (b) 4000 (c) 5000 (d) 7500
19. **The expected taskwork for earthwork in equation in ordinary soil per mazdoor per day is**
    (a) 1.0 cu.m (b) 2.0 cu.m (c) 3.0 cu.m (d) 4.0 cu.m
20. **The expected taskwork (turnout) of brick work in C:M in foundation and plinth per mason per day is**
    (a) 1.25 m^3 (b) 1.50 m^3 (c) 2.0 m^3 (d) 2.5 m^3
21. **The expected taskwork of RCC (1 : 1.5 : 3) per mason per day is**
    (a) 2.0 m^3 (b) 2.5 m^3 (c) 3 m^3 (d) 4 m^3
22. **The expected taskwork of 12 mm c.m. (1 : 3) plaster by mason per day is**
    (a) 6 m^2 (b) 8 m^2 (c) 10 m^2 (d) 15 m^2
23. **Length of hook provided at the end of bar is**
    (a) 7.5 × dia (b) 9 × dia (c) 10 × dia (d) 12 × dia
24. **Length of hook for stirrup is**
    (a) 7.5 × dia (b) 9 × dia (c) 10 × dia (d) 12 × dia
25. **Volume of sand carried in a truck is approximately**
    (a) 4 cu.m (b) 6 cu.m (c) 8 cu.m (d) 10 cu.m
26. **The unit of measurement of brick partition wall is**
    (a) per m length (b) sq.m (c) cu.m (d) numbers
27. **While doing earthwork in filling in foundation trenches the thickness of each layer should not exceed**
    (a) 10 cm (b) 20 cm (c) 30 cm (d) 50 cm
28. **As per IS : 1200, while doing measurements, the dimension shall be measured to the nearest**
    (a) 0.01 m (b) 0.01 mm (c) 0.01 cm (d) 0.1 m
29. **Number of bricks required for constructing a partition wall 10 m long, 1 m high and 10 cm thick is**
    (a) 200 (b) 300 (c) 500 (d) 600
30. **The salvage value of a building is usually taken as .... of the total cost of construction.**

(a) 5 % (b) 10 % (c) 15 % (d) 20 %

31. The EMD amount to be deposited with the tender is about .... of the estimated cost of the work.

(a) 2 to 3 % (b) 1 to 2 % (c) 5 % (d) 10 %

32. The security deposit amount to be deposited by a successful contractor whose tender has been accepted is .... of the tendered amount.

(a) 2 to 3 % (b) 5 % (c) 10 % (d) 15 %

33. The amount of compensation to be paid by the contractor to the owner due to delayed work is called

(a) Penalty (b) Compensation (c) liquidated damages (d) Fine

34. The process by which the parties under a contract get their disputes settled through the impartial person is called

(a) discussion (b) arbitration (c) court case (d) technical sanction

35. The value of a property building after its working tenure without being dismentled is known as

(a) Scrap value (b) book value (c) Salvage value (d) market value

36. The unit of measurement for steel works in trusses and its parts is in

(a) quintal (b) cm (c) numbers (d) kg

37. The unit of payment for fixing glass panels is in

(a) sq.m (b) number (c) cu.m (d) kg

38. Thickness of 25 gauge sheet is

(a) less than 1 mm (b) 1 mm

(c) between 1 mm and 1.5 mm (d) 2 mm

39. Damp proof course (D.P.C.) is measured in

(a) running meter (b) sq.m (c) cu.m (d) None of these

40. While mixing cement mortar by volume, the volume of a cement bag is specified as

(a) 50 litres (b) 35 litres (c) 0.050 m^3 (d) 0.35 m^3

41. As a thumb rule, the percentage of steel in RCC column is taken as

(a) 1 to 5 % (b) 5 to 10 % (c) 10 to 15 % (d) 15 to 20 %

42. Generally for analysis of rates, the reduction in volume of wet mixed mortar over the sum total volume of ingredients is taken as

(a) 5 % (b) 10 % (c) 25 % (d) 50 %

43. The useful part of liveable area of a building is called

(a) carpet area (b) circulation area (c) plinth area (d) built up area

44. The expected taskwork of half brick partition wall per mason per day is

(a) 1.5 m^3 (b) 1.25 m^3 (c) 3 m^2 (d) 5 m^2

45. Original cost of property minus depriciation is
(a) book value (b) Salvage value (c) rateable value (d) market value

46. The total estimated cost of a building electrification usually accounts for
(a) 1 % (b) 2 % (c) 8 % (d) 12 %

47. The standard width of asbestos cement corrugated sheet is
(a) 0.9 m (b) 1.0 m (c) 1.05 m (d) 1.25 m

48. The number of corrugations per sheet in case of asbestos cement corrugated sheet is
(a) 3 (b) 5 (c) 7 (d) 10

49. For 100 sq.m of roof surface, the area of A.C. sheets required will be
(a) 80 m^2 (b) 100 m^2 (c) 115 m^2 (d) 128 m^2

50. The value of a property that can be obtained at any particular time from the open market if the property is put for sale, is called
(a) book value (b) market value (c) current value (d) obsolence value

51. Multiplying factor for painting of fully glazed steel door/window for each side is
(a) 1.2 (b) 1.0 (c) 0.5 (d) 0.25

52. Multiplying factor for painting of flush door for each side is
(a) 1.8 (b) 1.2 (c) 1.0 (d) 0.8

: ANSWERS :

1. (b)	2. (a)	3. (b)	4. (d)	5. (b)
6. (b)	7. (b)	8. (c)	9. (b)	10. (c)
11. (b)	12. (b)	13. (c)	14. (b)	15. (b)
16. (c)	17. (b)	18. (b)	19. (c)	20. (a)
21. (c)	22. (c)	23. (b)	24. (d)	25. (a)
26. (b)	27. (b)	28. (a)	29. (c)	30. (b)
31. (b)	32. (c)	33. (c)	34. (b)	35. (c)
36. (a)	37. (b)	38. (a)	39. (b)	40. (b)
41. (a)	42. (c)	43. (a)	44. (d)	45. (a)
46. (c)	47. (c)	48. (c)	49. (c)	50. (b)
51. (c)	52. (b)			

❖❖❖

14.

Irrigation Engineering

MCQ'S

1. **The relation between duty (D) in hectares/cumec, delta (Δ) in metres and base period (B) in days is**
   (a) $D = 8.64\frac{B}{\Delta}$ (b) $D = 86.4\frac{B}{\Delta}$ (c) $D = 864\frac{B}{\Delta}$ (d) $D = 8640\frac{B}{\Delta}$
2. **The total depth of water required by a crop during entire base period of crop is known as**
   (a) Duty (b) Delta (c) base period (d) Crop period
3. **The duty is largest**
   (a) at the head of main canal (b) at the head of water course
   (c) on the field (d) at all place
4. **The irrigating capacity of a unit of water is called**
   (a) duty (b) delta (c) cumec-day (d) capacity factor
5. **The useful soil moisture for plant growth is**
   (a) gravitational water (b) Capillary water
   (c) hygroscopic water (d) all of these
6. **The amount of water required to fill up the pore spaces in soil particles by replacing all air held in pore spaces is known as**
   (a) field capacity (b) available moisture
   (c) saturation capacity (d) Permanent wilting coefficient
7. **The moisture content of the soil, after free drainage has removed most of the gravity water is known as,**
   (a) Field capacity (b) Saturation capacity
   (c) Wilting coefficient (d) Available moisture
8. **The water content at which plants can no-longer extract sufficient water from the soil for its growth is called**
   (a) Field capacity (b) Permanent wilting point
   (c) Saturation capacity (d) Available moisture
9. **Available moisture may be defined as**
   (a) Moisture content at permanent wilting point

(b) difference in water content of the soil between field capacity and permanent wilting
(c) Maximum moisture holding capacity
(d) all of above

10. Consumptive use of water of a crop is equal to
(a) depth of water consumed by evaporation
(b) depth of water consumed by transpiration
(c) depth of water consumed by evaporation and transpiration, including water consumed by weed growth
(d) None of the above

11. The maximum depth in soil strata, in which the crop spreads its root system, and derives water from the soil is called
(a) Kor depth (b) delta (c) root zone depth (d) overlap allowance

12. The first watering before sowing the crop is called
(a) kor watering (b) paleo (c) delta (d) duty

13. The area in which crop is grown at a particular time or crop season is called
(a) gross commanded area (b) culturable cultivated area
(c) culturable uncultivated area (d) none of these

14. The total area lying between drainage boundaries which can be irrigated by a canal system is called
(a) gross commanded area (b) culturable commanded area
(c) culturable cultivated area (d) None of these

15. The first watering after the plants have grown few centimetres high is known as
(a) Paleo (b) kor watering (c) delta (d) duty

16. The ratio between the area of a crop irrigated and the quantity of water required during its entire period of growth is known as
(a) delta (b) duty (c) base period (d) crop period

17. Crop ratio is defined as
(a) $\frac{\text{area irrigated during rabi season}}{\text{area irrigated during kharif season}}$ (b) $\frac{\text{area irrigated during kharif season}}{\text{area irrigated during rabi season}}$
(c) $\frac{\text{Total area of land}}{\text{total area under crop}}$ (d) None of these

18. Total quantity of water flowing for one day at the rate of 1 cumec is known as
(a) time factor (b) outlet factor (c) capacity factor (d) cumec-day

19. The time in days, that a crop takes from the instant of its sowing to that of its harvesting is known as
(a) Crop period (b) base period (c) time factor (d) none of these

20. The period between the first watering and the last watering supplied to the land is called

(a) Crop period (b) base period (c) time factor (d) None of these

21. Gravitational water is also called

(a) Capillary water (b) Super-fluous water
(c) hygroscopic water (d) all of these

22. The water requirement in terms of delta is maximum for

(a) rice (b) tobacco (c) potatoes (d) sugarcane

23. The average delta of rice crop is nearly

(a) 30 cm (b) 60 cm (c) 120 cm (d) 150 cm

24. If duty (D) is 1428 hectores/cumec and base period (B) is 120 days, for an irrigated crop, then delta (Δ) in meters is given by (GATE)

(a) 102.8 (b) 0.73 (c) 1.38 (d) 0.01

Hint : $\Delta = 8.64 \dfrac{B}{D} = \dfrac{8.64 \times 120}{1428} = 0.726\,\text{m}$

25. A sprinkler irrigation system is suitable when (GATE)

(a) land gradient is steep and the soil is easily erodible
(b) Soil is having low permeability
(c) water table is low
(d) Crops to be grown have deep roots

26. On which of the canal systems, R.G. Kennedy executive engineer in Punjab irrigation department made his observations for proposing his theory on stable channels ? (GATE)

(a) Krishna Western Delta canals (b) Lower Bari Doab canals
(c) Lower Chenab canals (d) Upper Bari Doab canals

27. Water logging may result from

(a) Over irrigation (b) Inadequate drainage
(c) Seepage from adjoining reservoirs, etc (d) all of these

28. Ratio of the total volume of water delivered to a crop to area on which it has been spread is called

(a) duty (b) delta (c) critical depth (d) None of these

29. The operation, which washes out salts from the upper zone of the soil is called

(a) washing (b) leaching (c) Separation (d) none of these

30. For the diversion of flood water of rivers, the type of canal constructed is

(a) ridge canal (b) perennial canal (c) inundation canal (d) canal

31. **The difference in level between the top of the bank and supply level in a canal is called**
(a) berm (b) free board (c) height of bank (d) none of these

32. **Borrow pits should preferably be located in**
(a) field on the left side of the canal
(b) field on the right side of the canal
(c) fields on both sides of the canal
(d) central half width of the section of the canal

33. **Disposal of extra excavated earth of canals is utilised to provide a spoil bank on**
(a) left side (b) right side (c) both sides (d) all the above

34. **A watershed canal**
(a) is most suitable in hilly areas (b) avoids the cross drainage work
(c) irrigates only on one side (d) all of these

35. **A contour canal**
(a) irrigates on both sides
(b) is most suitable in hilly areas
(c) is generally aligned parallel to the contour of the area
(d) all of these

36. **The most desirable alignment of an irrigation canal is along**
(a) a contour line (b) the ridge line (c) the valley line (d) none of these

37. **A canal which is aligned at right angles to the contour is called**
(a) Contour canal (b) branch canal (c) side slope canal (d) none of these

38. **The most serious type of water loss from a canal is**
(a) evaporation (b) Seepage (c) absorption (d) none of these

39. **Berms are provided to**
(a) Strengthen the canal bank (b) Check the seepage
(c) remove silt from the canal (d) both (a) and (b)

40. **A lined canal is in**
(a) initial regime (b) permanent regime (c) final regime (d) none of these

41. **Kennedy in his silt theory, assumed that the silt is kept in suspension due to eddies generated from the**
(a) bed only (b) sides only (c) whole perimeter (d) any one of these

42. **The relation given by Kennedy for critical velocity is**
(a) $V = 0.55\ m\ D^{0.64}$ (b) $V = 0.64\ mD^{0.55}$
(c) $V = 0.74\ mD^{0.84}$ (d) $V = 0.84\ m\ D^{0.74}$

43. If m_r is the mean particle diameter of the silt in mm, the Lacey's silt factor (f) is given by

(a) $f = 1.76\ m_r^{3/2}$ (b) $f = 1.76\ m_r^{1/2}$ (c) $f = 1.76\ m_r^2$ (d) $f = 1.76\ m_r^{5/2}$

44. The perimeter - discharge (P - Q) relationship is given by

(a) $P = 2.25\sqrt{Q}$ (b) $P = 4.75\sqrt{Q}$ (c) $P = 3.75\sqrt{Q}$ (d) $P = 1.75\ \sqrt{Q}$

45. Distributary head regulator is provided

(a) to control the supplies to the off-taking canal
(b) to control the silt entry in the off-taking canal
(c) both (a) and (b)
(d) none of these

46. A structure constructed in an irrigation canal for the purpose of wasting some of its water is known as

(a) fall (b) escape (c) regulator (d) none of these

47. .... are known as safety valves for canals.

(a) escapes (b) regulators (c) falls (d) outlets

48. The Sarda canal has

(a) glacis type fall (b) vertical drop fall (c) ogee fall (d) rapid fall

49. A parabolic glacis type fall is commonly known as

(a) Inglis fall (b) Sarda fall (c) Montague fall (d) Vertical type fall

50. Average normal size of a rain drop may be of the order of

(a) 0.5 - 4 mm (b) 5 - 10 mm (c) 10 - 50 mm (d) None of these

51. Outlet discharge factor is the duty at the head of

(a) main canal (b) branch canal (c) Water course (d) distributary

52. As per Lacey's theory, the silt factor is

(a) Directly proportional to average particle size
(b) directly proportional to square root of average particle size
(c) inversely proportional to average particle size
(d) not related to average particle size

53. Garret's diagrams are based on

(a) Lacey's theory (b) Kennedy's theory (c) Khosla's theory (d) Bligh's theory

54. According to Bligh's Creep theory the percolation water creeps

(a) in a straight line under the floor
(b) along the contact of the base profile of the apron with the subsoil
(c) in a straight path under the foundation
(d) none of the above

31. The difference in level between the top of the bank and supply level in a canal is called

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(a) $V = 0.55 \; m \; D^{0.64}$ (b) $V = 0.64 \; mD^{0.55}$
(c) $V = 0.74 \; mD^{0.84}$ (d) $V = 0.84 \; m \; D^{0.74}$

43. If m_r is the mean particle diameter of the silt in mm, the Lacey's silt factor (f) is given by

(a) $f = 1.76\ m_r^{3/2}$ (b) $f = 1.76\ m_r^{1/2}$ (c) $f = 1.76\ m_r^{2}$ (d) $f = 1.76\ m_r^{5/2}$

44. The perimeter - discharge (P - Q) relationship is given by

(a) $P = 2.25\sqrt{Q}$ (b) $P = 4.75\sqrt{Q}$ (c) $P = 3.75\sqrt{Q}$ (d) $P = 1.75\sqrt{Q}$

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(a) 0.5 - 4 mm (b) 5 - 10 mm (c) 10 - 50 mm (d) None of these

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54. According to Bligh's Creep theory the percolation water creeps

(a) in a straight line under the floor
(b) along the contact of the base profile of the apron with the subsoil
(c) in a straight path under the foundation
(d) none of the above

55. Weirs designed and constructed on Bligh's theory failed due to undermining of

(a) sub-soil (b) floor (c) foundation work (d) all of these

56. A check dam is a

(a) Flood control structure (b) Soil conservation structure
(c) river training structure (d) Water storage structure

57. In a canal siphon the flow is under

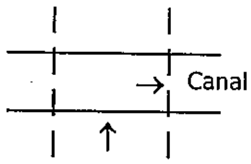
(a) atmospheric pressure (b) negative pressure
(c) positive pressure

58. Superpassage is a structure in which

(a) Canal flows over a drainage channel

(b) drainage channel flows over a canal

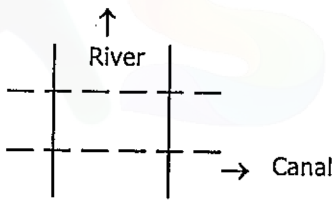
(c) both flow at the same level



- Aquaduct
- Syphoa aquaduct

59. A structure in which canal flows over the drain and bed of the canal is above H.F.L. of the drain, it is called

(a) aqueduct
(b) syphon aquaduct
(c) Super passage
(d) canal syphon



- Super Passage
- Canal syphon

60. A structure in which canal flows over the drain and HFL of the drain is above the bed of canal, it is called

(a) aqueduct (b) syphon aquaduct (c) Super passage (d) canal syphon

61. The cutoff in the earthdam is provided to

(a) reduce seepage (b) Prevent piping (c) both (a) and (b) (d) none of these

62. The stability of the downstream slope of an earthdam is checked for

(a) Sudden drawdown (b) steady seepage
(c) construction pressure (d) both (b) and (c)

63. For the design of lined canal, the formula commonly used is

(a) Kennedy's formula (b) Lacey's formula
(c) Manning's formula (d) Lindley's formula

64. A submerged pipe outlet is a

(a) rigid module (b) Semi-modular outlet
(c) non-modular outlet (d) both (b) and (c)

65. A cross regulator on a canal is used to

(a) increase the water level u/s of the off take canal
(b) control the sediment entering the off take canal
(c) dispose off excess supply in the parent channel
(d) increase discharge on the downstream

66. In a Sarda type fall, the energy dissipation is mainly due to

(a) Water cushion (b) hydraulic jump (c) baffle blocks (d) Chute blocks

67. For silt whose average size is 0.18 mm, Lacey's site factor will be about

(a) 0.65 (b) 0.85 (c) 0.75 (d) 0.95

Hint :

$f = 1.76\ m_r^{1/2} = 1.76 \times (0.18)^{1/2} = 0.746$

68. Match list I and list II correctly.

	List I		List II
A.	Arch dam	1.	Rock foundation
B.	Gravity dam	2.	Strong abutment
C.	Earth dam	3.	Any type of foundation
D.	Buttress dam	4.	Multiple arch

Codes :

	A	B	C	D
(a)	2	1	3	4
(b)	2	1	4	3
(c)	1	2	4	3
(d)	4	2	3	1

69. Match list I and list II correctly.

	List I		List II
A.	Dams	1.	Flood control
B.	Weirs	2.	Large gates
C.	Spillways	3.	Storage of water
D.	Barrage	4.	Diversion of water

Codes :

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	2	1
(c)	3	4	2	1
(d)	4	3	1	2

70. Match list I and list II and select the correct answer using the codes given below :

	List I		List II
A.	Divide wall	1.	Flood control
B.	Wing wall	2.	Diversion headworks
C.	Breast wall	3.	Cross drainage works
D.	Flood wall	4.	Head regulator

Codes :

	A	B	C	D
(a)	2	3	1	4
(b)	3	2	4	1
(c)	2	3	4	1
(d)	3	2	1	4

71. The following structures exist in an irrigation project :

1. Diversion head works
2. Head regulator
3. Silt extractor
4. Cross regulator

Write the correct sequence of the structures.

(a) 1, 4, 3, 2 (b) 1, 4, 2, 3 (c) 1, 3, 4, 2 (d) 1, 2, 3, 4

72. Cavitation is not likely to occur in the following type of spillway.

(a) ogee spillway (b) siphon spillway (c) shaft spillway (d) chute spillway

73. A lysimeter is used to measure

(a) infiltration (b) evaporation (c) evapotranspiration (d) surface run-off

74. The volume of water that can be released by gravitational flow from a unit volume of aquifer is called

(a) porosity (b) specific yield
(c) specific retention (d) specific capacity

75. Match list I and list II and select the correct answer using the codes given below the lists :

	List I		List II
A.	Aquifer	1.	Stores and yields sufficient water
B.	Aquiclude	2.	Stores but yields very little water
C.	Aquitard	3.	Neither stores nor yields water
D.	Aquifuge	4.	Stores but does not yield water

Codes :

	A	B	C	D
(a)	1	4	2	3
(b)	1	3	4	2
(c)	1	2	4	3
(d)	1	2	3	4

76. The discharge per unit drawdown at a well is called

(a) specific yield (b) specific capacity (c) storage coefficient (d) transmissibility

77. For an earthdam, least suited spillway is

(a) Ogee spillway (b) Chute spillway (c) Shaft spillway (d) none of these

78. The overfall of a spillway in the shape of a double or S-curve, which is convex at the top and concave at the bottom is called

(a) Ogee spillway (b) S-spillway (c) oval spillway (d) zig-zag spillway

79. Due to topography, if space is not available, the most suitable spillway is

(a) ogee spillway (b) chute spillway
(c) shaft spillway (d) straight drop spill way

80. According to Khosla's theory, the undermining of the floor starts from the

(a) tail end (b) starting end (c) intermediate point (d) foundation bed

81. A balancing reservoir is one which

(a) balances the peak and minimum flows
(b) balances the distribution
(c) Balances the flow rates of supply and demand
(d) Stores water for emergencies

82. Specific yield for an unconfied aquifer is

(a) greater than porosity (b) less than porosity
(c) equal to porosity (d) unrelated to porosity

83. Guide banks are provided to

(a) train the flow of river along a specified course
(b) reduce the peak flood discharge
(c) confine the width of river
(d) increase the water way

84. In a river, silt excluder and silt ejector are constructed at

(a) a location after the head regulator and at the head of the canal, respectively
(b) the head of the canal and at a location after the head regulator, respectively
(c) the location of which is independent of the command to be served
(d) designed to secure raising of water surface on its upstream

85. Balancing depth of cutting of canal is

(a) half the total depth of canal
(b) half of full supply depth
(c) Maximum cut that an excavator can take
(d) where volume of cutting is equal to the volume of filling

86. **Penman's equation for evapotranspiration is based on**
    (a) energy budget only
    (b) energy budgeting and water budgeting
    (c) energy budgeting and mass transfer
    (d) Water budgeting and mass transfer
87. **Bhakra dam is built on**
    (a) Beas river (b) Sutlej river (c) Ganga river (d) Sindhu river
88. **Over irrigation results in**
    (a) water logging (b) wilting (c) Fertility (d) None of these
89. **In arid region with uneven land surface, the most suitable method of irrigation is**
    (a) Basin method (b) check flooding (c) Sprinkler irrigation (d) Furrow irrigation
90. **Best method of assessment of irrigation water is**
    (a) Crop rate (b) betterment levy (c) Seasonal rate (d) Volumetric rate
91. **Rabi crop pertain**
    (a) Winter season (b) Summer season (c) Monsoon season (d) None of these
92. **Intensity of irrigation means**
    (a) Total depth of water applied to a crop (b) percent area irrigated of C.C.A.
    (c) Percent area irrigated of G.C.A (d) Area left uncultivated during year
93. **Plants develop their root and derive moisture mostly from**
    (a) upper portion (b) middle portion
    (c) lower portion of the root zone (d) all of them
94. **Soil is called saline when pH value is**
    (a) 10 (b) 7 (c) less than 7 (d) 8
95. **Duty of canal water is expressed in**
    (a) cumec (b) centimeters (c) Hectare/cumec (d) None of these
96. **Gravity dams can be constructed with**
    (a) Concrete (b) Soil (c) Sand (d) soil and sand
97. **Echo sounder is used to measure**
    (a) Width of river (b) Velocity of flow
    (c) depth of flow (d) discharge of flow
98. **Gallery is**
    (a) a passage left in a body of dam (b) an observation tower
    (c) water exit from a dam (d) None of these
99. **Which is the foundation seepage control measure**
    (a) impervious cut off (b) D/S seepage berms
    (c) relief wells (d) all of them

100. Gravity dam is most suitable when foundation is

(a) Weak (b) strong

(c) with heavy over burden (d) rocky but cracked

101. Arch dams are constructed in

(a) Narrow valley with strong abutments (b) narrow valley with sound foundation

(c) wide valley with weak foundation (d) none of them

102. Shape of elementary profile of gravity dam is roughly

(a) triangular (b) square (c) Trapezoidal (d) Rectangular

103. Economic height of dam is the one for which

(a) Cost of dam is minimum (b) Cost of dam per unit storage is minimum

(c) Storage is maximum (d) Storage is minimum

104. Silting of reservoir

(a) reduces efficiency of dam (b) reduces storage capacity

(c) raises reservoir water (d) increase storage capacity

105. A reservoir is constructed for

(a) irrigation (b) flood control

(c) generating hydro power (d) all of these

106. Rock fill dam is

(a) rigid type (b) non-rigid type (c) high dam (d) None of these

107. Blanket in earthdam is provided

(a) at the ground on the u/s side (b) at the ground in the body of the dam

(c) at the ground on the d/s side of dam (d) on the d/s slope

108. The spillway in which water spills over the body of the dam are

(a) solid gravity spillway (b) siphon spillway

(c) shaft spillway (d) chute spillway

109. Spillway performs the function of a

(a) Flow measuring device (b) safety valve for the dam

(c) observation opening (d) all of them

110. The provision of filter zone in the d/s side of earthen dam serves the function of

(a) to drain off water seeping through earth dam safely

(b) to reduce the pore water pressure in the d/s portion of the dam

(c) to keep phreatic line within the body of dam

(d) all of above

111. For filter in earthen dam, D_{15} of filter material / D_{85} of base material should be

(a) ≥ 5 (b) ≥ 8 (c) ≤ 5 (d) ≤ 8

112. Common method of protection of stream bed below spillways are

(a) Grouting of stream bed (b) Grouting of body of dam

(c) Creation of hydraulic jump on the d/s face (d) Provision of sluices

113. Sluices are provided in a dam to

(a) Supply water to d/s area (b) reduce flood

(c) remove sediment from reservoir (d) all of these

114. In the earthdams spillways are provided

(a) in the body of the dam (b) in the foundation of the dam

(c) by the side of the dam structure (d) all of them

115. Crest of an emergency spillway is fixed at

(a) F.R.L. (b) M.W.L. (c) dead storage (d) top of dam

116. Main canal take off from

(a) a head regulator (b) a cross regulator (c) a reservoir (d) a well

117. Bhandara irrigation is

(a) runoff the river scheme (b) minor scheme

(c) unproductive scheme (d) the only effective scheme

118. Okhla weir on river Yamuna in Delhi is an example of

(a) Vertical drop weir (b) dry stone slope weir

(c) concrete slope weir (d) parabolic weir

119. In barrage, crest level is kept

(a) low with large gates (b) high with large gates

(c) high with small gates (d) low with small gates

120. According to Khosla's theory, the critical hydraulic gradient for alluvial soils is approximately

(a) 1 (b) 1.5 (c) 2 (d) 2.5

121. According to Khosla's theory, the exit gradient in the absence of a d/s cut off is

(a) zero (b) unity (c) infinity (d) none of these

122. Gibb's module is a type of

(a) non-modular outlet (b) semi-modular outlet

(c) rigid-modular outlet (d) Open flume outlet

123. Berms are provided to

(a) remove the silt from the canal (b) Strengthen the canal bank

(c) to increase the seepage from canal (d) allow traffic along canal

124. Dowla on the canal bank serves the purpose of

(a) a drainage (b) a foot path (c) a road curb (d) none of these

125. 'Spoil bank' is a term used to designate
(a) a canal bank constructed wrongly
(b) damaged canal bank
(c) additional embankment constructed to dispose of excess excavated material
(d) none of these

126. When excavated soil is in excess it is deposited in spoil banks. When extra amount of earth is required it is obtained from
(a) Berms (b) dowla (c) borrow pits (d) side strips

127. Sand core is provided in the canal banks to
(a) make the bank porous to allow quick drainage of seepage water
(b) plug the rat holes
(c) reduce clay content in the banks
(d) all of these

128. A headwork is an assemblage of the following hydraulic structures
(a) A dam, embankments, spillway (b) A weir, guide banks, head regulator
(c) A syphon, spurs, bank revetment (d) none of these

129. Minor irrigation scheme serves
(a) CCA less than 2000 ha (b) CCA less than 10,000 ha
(c) CCA less than 500 ha (d) CCA less than 200 ha

130. Bhakra Nangal project is
(a) Multi purpose project (b) located in Punjab
(c) The highest gravity dam in India (d) all of the above

131. The side slopes of Narmada main canal is
(a) 1 : 1 (b) 2 : 1 (c) 1.5 : 1 (d) 1 : 2

132. The length of Narmada main canal is
(a) 258 km (b) 458 km (c) 600 km (d) 655 km

133. Water table is
(a) the top of the zone of saturation below ground
(b) water surface of a reservoir
(c) depth of water standing on the ground
(d) all of these

134. A deep well
(a) draw water from top pervious layer
(b) draw water from pervious layer below mota layer
(c) draw water from mota layer
(d) none of these

135. A mota layer is

(a) a pervious layer
(b) an impervious layer of clay
(c) a layer of sand
(d) none of these

136. An open well is called shallow when

(a) the depth of well is small
(b) the water table is high
(c) it does not encounter mota layer
(d) none of these

137. Chezy's equation gives velocity of flow. Chezy's constant is given by

(a) Manning's formula
(b) Kutter's formula
(c) Bazin's formula
(d) Lacey's regime formula

138. Protective project is generally taken up in

(a) Hilly areas where communications are difficult
(b) desert areas where water is scanty
(c) Periods of famine to provide employment to the people
(d) None of these

139. A 'damstone' is

(a) A type of stone
(b) The material with which dam is constructed
(c) is a stone pillar embeded on top of bund
(d) All of them

140. Fish ladder is a structure in the body of the weir used for

(a) Catching fish
(b) Providing free passage to migrating fish
(c) restricting movement of fish
(d) all of these

141. 'Divide wall' is a structure constructed

(a) to separate the floor of the scouring sluices from that of weir proper
(b) to provide still pocket in front of the canal head regulator
(c) to prevent cross currents and flow parallel to weir
(d) all of the above

142. Weir and barrage are both low barriers built across the river to raise the water but

(a) Barrage has gates to control flow
(b) Weir has gates to control flow
(c) In weir no solid construction is required
(d) none of these

: ANSWERS :

1. (a)	2. (b)	3. (c)	4. (a)	5. (b)
6. (c)	7. (a)	8. (b)	9. (b)	10. (c)
11. (c)	12. (b)	13. (b)	14. (a)	15. (b)
16. (b)	17. (a)	18. (d)	19. (a)	20. (b)
21. (b)	22. (a)	23. (c)	24. (b)	25. (a)
26. (d)	27. (d)	28. (b)	29. (b)	30. (c)
31. (b)	32. (d)	33. (d)	34. (b)	35. (c)
36. (b)	37. (c)	38. (b)	39. (d)	40. (b)
41. (a)	42. (a)	43. (b)	44. (b)	45. (c)
46. (b)	47. (a)	48. (b)	49. (c)	50. (a)
51. (c)	52. (b)	53. (b)	54. (b)	55. (a)
56. (b)	57. (c)	58. (b)	59. (a)	60. (b)
61. (c)	62. (d)	63. (c)	64. (c)	65. (a)
66. (a)	67. (c)	68. (a)	69. (a)	70. (c)
71. (d)	72. (d)	73. (c)	74. (b)	75. (a)
76. (b)	77. (a)	78. (a)	79. (c)	80. (a)
81. (c)	82. (b)	83. (c)	84. (b)	85. (d)
86. (c)	87. (b)	88. (a)	89. (c)	90. (d)
91. (a)	92. (b)	93. (a)	94. (a)	95. (c)
96. (a)	97. (c)	98. (a)	99. (d)	100. (b)
101. (a)	102. (a)	103. (b)	104. (b)	105. (d)
106. (b)	107. (a)	108. (a)	109. (b)	110. (d)
111. (c)	112. (c)	113. (d)	114. (c)	115. (b)
116. (c)	117. (a)	118. (b)	119. (a)	120. (a)
121 (c)	122. (c)	123. (b)	124. (c)	125. (c)
126. (c)	127. (b)	128. (b)	129. (a)	130. (d)
131. (b)	132. (b)	133. (a)	134. (b)	135. (b)
136. (c)	137. (c)	138. (c)	139. (c)	140. (b)
141. (d)	142. (a)			

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15.

Hydrology and Water Resources EngineEring

MCQ'S

SET-1

1. **Horton equation is used to estimate**
   (a) Amount of evaporation (b) Infiltration
   (c) Soil water content (d) Runoff
2. **Lysimeter is used to measure**
   (a) Infiltration (b) evaporation
   (c) evapotranspiration (d) surface run–off
3. **A rainfall of 1.5 cm occured in a 6 hr storm. If the ϕ–index was 0.2 cm/hr, the rainfall excess was**
   (a) 0.0 (b) 0.30 cm (c) 1.20 cm (d) –0.30 cm
4. **A double mass curve is used to**
   (a) check the consistency of rain gauge record.
   (b) determine the reservoir capacity
   (c) determine the number of rain gauges required.
   (d) determine the maximum probable precipitation
5. **Evapotranspiration is confined to**
   (a) daylight hours (b) night time only (c) land surface only (d) none of these
6. **ϕ–index is always**
   (a) less than W–index (b) more than W–index
   (c) equal to W–index (d) equal to 1
7. **The highest value of annual potential evapotranspiration (PET) in India is at Rajkot, Gujarat. Here the annual PET is**
   (a) 150 cm (b) 150 mm (c) 210 cm (d) 310 cm
8. **The infiltration capacity of a soil was measured under fairly identical conditions by a flooding type infiltratometer as f_f and by a rainfall simulator as f_r, one can expect**
   (a) $f_f = f_r$ (b) $f_f > f_r$ (c) $f_f < f_r$ (d) no fixed pattern

9. The chemical that is found to be most suitable as water evaporation inhibitor is
(a) ethyl alcohol (b) methyl alcohol (c) cetyl alcohol (d) butyl alcohol

10. Which one is the most accurate method of finding the average depth of rainfall over a catchment area ?
(a) Arithmetic mean method (b) Isohyetal method
(c) Thiessen polygon method (d) all the above

11. 1 mm water on an area represents
(a) 1 g/m^2 (b) 10 kg (c) 1 mm/m^2 (d) 1 dm^3/m^2

12. For identical conditions, evaporation from sea water is
(a) 2 – 3% more than that from fresh water
(b) 2 – 3% less than that from fresh water
(c) equal to that from fresh water
(d) None of these

13. Dalton's law of evaporation is given by
(a) $E = C (e_s/e_a)$
(b) $E = C (e_s + e_a)$
(c) $E = C (e_s - e_a)$
(d) $E = C (e_a - e_s)$

where,
e_s = saturation vapour pressure
e_a = vapour pressure in the air
E = evaporation

14. Orographic lifting results in
(a) Topographical dependence of precipitation
(b) Lifting of soil surface after freezing
(c) Higher ocean water level
(d) A warmer climate

15. The average pan coefficient for the Standard US Weather Bureau class A pan A is
(a) 0.85 (b) 0.70 (c) 0.90 (d) 0.20
IS standard Pan Coeff = 0.80

: ANSWERS :

1. (b)	2. (c)	3. (b)	4. (a)	5. (a)	6. (b)
7. (c)	8. (b)	9. (c)	10. (b)	11. (c)	12. (b)
13. (c)	14. (a)	15. (b)			

EXPLANATIONS

3. (b) $\phi = \dfrac{P-R}{t_r}$ cm/hr

$0.2 = \dfrac{1.5 - R}{6}$ $\therefore$ $R = 0.3$ cm

Winder = $\dfrac{P - R - S_R}{t_r}$ cm/hr

S_R = surface retention

SET-2

1. The infection point on the recession limb of the hydrograph indicates the end of
(a) base flow (b) direct runoff (c) overland flow (d) Rainfall

2. The concept of unit hydrograph was first introduced by
(a) Dalton (b) Sherman (c) Horton (d) Thiessen

3. UH is the graphical representation between the time distributions of
(a) Total rainfall and total runoff (b) Total rainfall and direct runoff
(c) effective rainfall and total runoff (d) effective rainfall and direct runoff

4. Unit hydrograph theory cannot be applied to catchment areas greater than
(a) 1000 km^2 (b) 2000 km^2 (c) 5000 km^2 (d) 8000 km^2

5. The word 'unit' in unit hydrograph refers to the
(a) unit depth of runoff (b) unit duration of the storm
(c) unit base period of the hydrograph (d) unit area of the basin

6. The S–curve hydrograph is the summation of the
(a) unit hydrograph (b) total runoff hydrograph
(c) effective rainfall hydrograph (d) base flow recession curve

7. A unit hydrograph is a hydrograph representing
(a) 1 cm of runoff (b) 10 cm of runoff
(c) 100 cm of runoff (d) 1000 cm of runoff

8. A hydrograph is a plot between
(a) discharge versus time (b) intensity versus time
(c) depth versus time (d) none of the above

9. A hyetograph is a plot between
(a) Duration of rainfall against time (b) Intensity of rainfall against time
(c) frequency of rainfall against time (d) none of these

10. The S–Curve hydrograph is used to
(a) estimate peak flood flow of a basin resulting from a given storm.
(b) develop synthetic unit hydrograph.
(c) convert the UH of any given duration into a UH of any other desired duration.
(d) derive the UH from complex storms

11. The area under a hyetograph represents
(a) the total volume of runoff received in that period
(b) the total rainfall received in that period
(c) the total infiltration received in that period
(d) total surface runoff

12. **A rainfall of 1.5 cm occured in 6–hr storm. If ϕ–index was 0.1 cm/hr, the rainfall excess was**

(a) 0.0 (b) 0.90 cm (c) 1.20 cm (d) –0.30 cm

13. **A 6–hr UH of a catchment has a peak discharge of 15 m^3/s. If 3 cm rainfall excess occurs in 6–hr and the base flow is 2 m^3/s the peak discharge of the storm hydrograph is**

(a) 45 m^3/s (b) 47 m^3/s (c) 43 m^3/s (d) 15 m^3/s

14. **In a synthetic unit hydrograph the width of 75% peak is 20 hr. The width of 50% peak value will be approximately**

(a) 20 hr (b) 30 hr (c) 35 hr (d) 12 hr

Hint : $W_{75} = \dfrac{W_{50}}{1.75}$

15. **For a catchment of 40 km^2, the equilibrium discharge of an S–curve obtained by 3–hr unit hydrographs summation is about**

(a) 37.0 m^3/s (b) 47.0 m^3/s (c) 27.0 m^3/s (d) 57.0 m^3/s

Hint : $Q_{eq} = 2.78 \dfrac{A}{t_r}$ m^3/s

16. **Match list–I with list–II :**

List–I	List–II
A. Flow duration	1. Unit hydrograph
B. Mass inflow curve	2. Available water power
C. Frequency curve	3. Storage capacity
D. S–curve	4. Return period

Codes :

	A	B	C	D
(a)	2	3	1	4
(b)	3	2	4	1
(c)	2	3	4	1
(d)	1	4	3	2

17. **A 1–hr unit hydrograph of a catchment is triangular in shape with a base width of 48 hr and a peak discharge of 25 m^3/s. The catchment area is about**

(a) 21.6 sq.km (b) 216 sq.km (c) 21600 sq.km (d) 432 sq.km

Hint : Area of UH = A × 1 cm

$$\frac{1}{2} \times 48 \times 60 \times 60 \times 25 = A \times \frac{1}{100} \quad \therefore A = 216 \times 10^6 \ m^3/s$$

: ANSWERS :

1. (c)	2. (b)	3. (d)	4. (c)	5. (a)	6. (a)
7. (a)	8. (a)	9. (b)	10. (c)	11. (b)	12. (b)
13. (b)	14. (c)	15. (a)	16. (c)	17. (b)	

SET-3

1. **Confined aquifer is one in which**
   (a) Water surface under the ground is at atmospheric pressure.
   (b) Water is confined under pressure less than atmospheric pressure between impermeable strata.
   (c) Water is confined at atmospheric pressure between impermeable strata.
   (d) Water is confined under pressure greater than atmospheric pressure between impermeable strata.

2. **An unconfined aquifer is one in which**
   (a) Water surface under the ground is at atmospheric pressure.
   (b) Water is confined under pressure less than atmospheric pressure between impermeable strata.
   (c) Water is confined at atmospheric pressure between impermeable strata.
   (d) Water is confined under pressure greater than atmospheric pressure between impermeable strata.

3. **For a well penetrating an unconfined aquifer having permeability k = 4 × 10^{-4} m/s, the radius of influence for a drawdown of 5 m is about**
   (a) 100 m (b) 200 m (c) 300 m (d) 400 m
   Hint. $R = 3000\ s\sqrt{k}$

4. **The specific capacity of a well is defined as**
   (a) Drawdown per unit discharge
   (b) Discharge per unit drawdown
   (c) Drawdown per certain given discharge
   (d) Discharge per certain given drawdown

5. **The ratio of volume of water drained to the volume of soil sample is**
   (a) Porosity (b) Specific yield
   (c) Specific retention (d) Storage coefficient

6. **An aquifer is a geological formation which**
   (a) does not contain water (b) Contains water but does not transmit
   (c) Contains water and also transmit it (d) None of these

7. **Which geological formations neither contain water nor transmits it ?**
(a) Aquifer (b) Aquifuge (c) Aquiclude (d) Aquitard

8. **An unconfined aquifer is also called**
(a) Water table aquifer (b) artesian aquifer
(c) leaky aquifer (d) perched aquifer

9. **In case of flowing well, the piezometric surface is**
(a) above ground W.T. (b) below ground W.T.
(c) Between ground level and ground W.T. (d) Coincides with ground W.T.

10. **The discharge per unit drawdown at a well is called**
(a) Specific yield (b) Specific capacity
(c) Storage coefficient (d) Transmissibility

11. **Match list – I and list – II.**

List–I		List–II
A. Aquifer	1.	Store and yield sufficient water
B. Aquiclude	2.	Stores but yields very little water
C. Aquitard	3.	neither store nor yields water
D. Aquifuge	4.	Stores but does not yields water

Codes :	A	B	C	D
(a)	1	4	2	3
(b)	1	3	4	2
(c)	1	2	4	3
(d)	1	2	3	4

12. **The volume of water that can be released by gravitational flow from a unit volume of aquifer is called**
(a) Porosity (b) Specific yield
(c) Specific retention (d) Specific capacity

13. **If T is transmissivity conductivity and b is the width of aquifer, the hydraulic conductivity (k) is**
(a) $k = T \times b$ (b) $k = T/b$ (c) $k = T + b$ (d) $k = T - b$

14. **Transmissibility has the dimensions as**
(a) m/s (b) m/s^2 (c) m^2/s (d) dimensionless

: ANSWERS :

1. (d)	2. (a)	3. (c)	4. (b)	5. (b)
6. (c)	7. (b)	8. (a)	9. (a)	10. (b)
11. (a)	12. (b)	13. (b)	14. (c)	

SET-4

1. **Multipurpose reservoir is the one which is constructed**
   (a) to be used in combination of other reservoirs.
   (b) to serve one main purpose and other purposes are served incidentally.
   (c) to serve more than one purpose.
   (d) to supply water for more than one year.

2. **The ordinate of mass-inflow curve at any time is equal to**
   (a) the ordinate of the flood hydrograph at that time.
   (b) the area under the flood hydrograph upto that time.
   (c) the sum of the ordinates of the flood hydrograph upto that time.
   (d) the ordinate of the demand curve at that time.

3. **Due to valley storage the peak discharge of an outflow hydrograph is**
   (a) increased (b) reduced
   (c) not affected (d) sometimes increased

4. **The water stored in the reservoir below the minimum pool level is called**
   (a) usefull storage (b) sucharge storage (c) dead storage (d) valley storage

5. **Trap efficiency of a reservoir is a function of**
   (a) capacity/inflow ratio (b) capacity/outflow ratio
   (c) outflow/inflow ratio (d) only outflow and inflow

6. **The maximum water level which can be stored in a reservoir during normal conditions is known as**
   (a) Maximum pool level (b) Minimum pool level
   (c) Normal pool level (d) None of these

7. **The volume of water which flows through the river before the construction of a dam is known as**
   (a) Live storage (b) dead storage (c) bank storage (d) valley storage

8. **The percentage of the total flowing sediment load in a stream retained by a reservoir is called**
   (a) density current (b) trap efficiency
   (c) sediment load (d) capacity/inflow ratio

9. **With the reduction in the reservoir capacity over the passage of time, the trap efficiency**
   (a) increases (b) decreases
   (c) remains unaffected (d) may increase or decrease

10. **Capacity-inflow ratio for a storage reservoir is defined as**
    (a) reservoir capacity/average annual flood inflow

(b) reservoir capacity/average annual sediment inflow
(c) dead storage of reservoir/average annual sediment deposited
(d) None of the above

11. With the increase in its capacity-inflow ratio, the trap efficiency of a reservoir
(a) increases (b) decreases
(c) remains unchanged (d) may increase or decrease

12. The capacity-inflow ratio for a reservoir
(a) is a constant factor over time (b) increases with time
(c) decreases with time (d) may increase or decrease with time

13. The dead storage zone in a reservoir is provided for the storage of
(a) water for firm power (b) sand and silt
(c) water for water supplies (d) none of these

14. Trap efficiency of a reservoir indicates the
(a) sediment volume trapped in the reservoir
(b) sediment volume let out from the reservoir
(c) sediment volume trapped in relation to the sediment volume entering the reservoir
(d) none of these

15. With the reduction in the reservoir capacity the quantum of the sediment trapped by it
(a) increases (b) decreases (c) does not get affected

: ANSWERS :

1. (c)	2. (b)	3. (b)	4. (c)	5. (a)
6. (c)	7. (d)	8. (b)	9. (b)	10. (a)
11. (a)	12. (c)	13. (b)	14. (c)	15. (b)

SET-5

1. Match list I and List II.

List - I	List - II
A. Load factor	1. Actual power/Apparent power
B. Power factor	2. Average output/Plant capacity
C. Capacity factor	3. Peak power/Installed capacity
D. Utilisation factor	4. Average load/Peak load

Codes :

	A	B	C	D
(a)	1	4	3	2
(b)	4	1	2	3
(c)	4	1	3	2
(d)	1	4	2	3

2. A run-of-river plant is one which
(a) has a limited pondage (b) has no pondage at all
(c) is a pumped storage plant (d) is a high head plant

3. A pumped storage plant is one which
(a) is used as a base load plant (b) is same as run-of-river plant
(c) is used as peak load plant (d) is a high head plant

4. A high head plant uses a head
(a) more than 15 m (b) more than 30 m (c) more than 60 m (d) more than 100 m

5. A forebay is an enlarged body of water which is provided just in front of the
(a) power house (b) penstocks (c) draft tube (d) turbines

6. The hydro power plant located on a perennial river is
(a) Run-of-river plant (b) Storage plant
(c) Pumped storage plant (d) High head plant

7. A surge tank is usually provided at the
(a) upstream end of the long penstock (b) downstream end of the long penstock
(c) begining of canal (d) begining of tail race

: ANSWERS :

1. (b) 6. (a)	2. (a) 7. (b)	3. (c)	4. (c)	5. (b)

SET-6

1. The earth embankments constructed parallel to the river for flood protection, are called :
(a) Guide banks (b) Levees (c) Terraces (d) Groynes

2. The only structural flood control measure included below is
(a) Dikes (b) Terraces (c) Cutoffs (d) Flood plain zoning

3. Floodways are
(a) embankments (b) Concrete walls
(c) Ponds (d) Low lying areas

4. The flood may be caused due to
(a) Breach of dam (b) Heavy precipitation
(c) Failure of river embankment (d) all of the above

5. A detension basin for flood control is the one which is provided with
(a) Uncontrolled outlet and spillways
(b) Uncontrolled outlet but controlled spillway
(c) Controlled outlet but uncontrolled spillway
(d) Controlled outlet and spillway

6. The retarding reservoir for flood control is the one which is provided with
(a) Uncontrolled outlet and spillways
(b) Uncontrolled outlet but controlled spillway
(c) Controlled outlet but uncontrolled spillway
(d) Controlled outlet and spillway

7. Following are the ill-effects of flood except
(a) Inundation of low lying areas
(b) Flood provide laminar flow to the river in a straight line
(c) Change in river course
(d) Erosion of river banks

8. In the flood damage analysis, the marginal benefit - cost ratio should be
(a) less than 1 (b) equal to 1 (c) greater than 1 (d) anything

9. The river _____ is known as 'tears of Bihar.'
(a) Kosi (b) Brahmaputra (c) Ganga (d) Sindhu

10. The river infamous for devastating floods in the Eastern India is
(a) Ganga (b) Brahmaputra (c) Hugli (d) Kemong

: ANSWERS :

1. (b)	2. (a)	3. (d)	4. (d)	5. (d)
6. (a)	7. (b)	8. (b)	9. (a)	10. (b)

SET-7

1. In Dicken's empirical formula, Q = C.A^n where, n is
(a) 0.25 (b) 0.50 (c) 0.67 (d) 0.75

2. Ryve's formula, to predict maximum flood discharge. Q = C.A^n, where n is
(a) 0.25 (b) 0.50 (c) 0.67 (d) 0.75

3. **If the frequency of flood (T) having a rank m and, total record of n years, is given by $T = \frac{n+1}{m}$ then this relation is known as**
   (a) California formula (b) Weibul formula
   (c) Hazen formula (d) Beard formula flood

4. **The probability that a T year flood frequency occurs in any given year is**
   (a) $\frac{100}{T}$ (b) $\frac{1}{T}$ (c) $\log_e T$ (d) e^{-T}

5. **According California formula, the return period is**
   (a) $T = \frac{n}{m}$ (b) $T = \frac{2n}{2m-1}$ (c) $T = \frac{n+1}{m}$ (d) $T = \frac{n}{m+c-1}$

6. **The most commonly used formula for computing return period is**
   (a) California formula (b) Weibul formula
   (c) Hazen formula (d) Gumbel's method

7. **The governing equation given by Ven Te Chow is**
   (a) $X = \overline{X} + K\sigma$ (b) $X = \overline{X} + \frac{K}{2}\sigma$
   (c) $X = \overline{X} + K^n \cdot \sigma$ (d) $X = \overline{X} + 2K \cdot \sigma$

8. **The rational formula is restricted to the catchment area of size less than**
   (a) 50 ha (b) 500 ha (c) 5000 ha (d) 50,000 ha

9. **The most commonly adopted probability distribution to fit the flood data is**
   (a) Normal distribution (b) Gumbel's extreme value distribution
   (c) Log–Normal distribution (d) Log–Pearson distribution

10. **The continuity equation used for flood routing is**
   (a) $I + O = \Delta S$ (b) $O - I = \Delta S$ (c) $I - O = \Delta S$ (d) $O + I = \Delta S$

: ANSWERS :

1. (d)	2. (c)	3. (b)	4. (b)	5. (a)
6. (b)	7. (a)	8. (c)	9. (b)	10. (c)

SET-8

1. **Multi–purpose project is the one which is constructed to :**
   (a) be used in combination of other reservoirs
   (b) Supply water for more than one year
   (c) Serve more than one purpose
   (d) Serve one main purpose always

2. **The estimated life of an earthen or a mesonary dam is of the order of**
   (a) 20 years (b) 50 years (c) 150 years (d) 500 years
3. **In a multipurpose reservoir, the requirements of flood control is**
   (a) Most compatible with other requirements
   (b) Compatible with water power requirements
   (c) Compatible with requirements for irrigation and drinking water
   (d) Non–compatible with other requirements.
4. **Which one of the following is usually not included as a function of multi–purpose dam :**
   (a) Flood control (b) Irrigation (c) Hydropower (d) Fish and wild life
5. **Which one of the following objectives of a multi–purpose water resources project is most compatible with other desired objectives ?**
   (a) Flood mitigation (b) Irrigation (c) Hydropower (d) Navigation
6. **Which one of the following objectives of a multi purpose water resources project is least compatible with other desired objectives ?**
   (a) Flood control (b) Irrigation (c) Hydro power (d) Navigation
7. **A high dam or a multipurpose water resources project will cause on the surrounding environment**
   (a) Only harmful effects (b) Only beneficial effects
   (c) Both harmful and beneficial effects (d) No effects at all

: ANSWERS :

1. (c)	2. (c)	3. (a)	4. (d)	5. (c)
6. (a)	7. (c)			

SET-9

1. **If D is depth of scour below original bed, then width of launching apron is generally taken as** **(IES)**
   (a) 1.2 D (b) 1.5 D (c) 2.0 D (d) 2.5 D
2. **Ratio of the quantity of water stored in the root zone of the crops to the quantity of water actually delivered in the field is called** **(IES)**
   (a) Water conveyance efficiency (b) Water application efficiency
   (c) Water use efficiency (d) none of these
3. **The leaching requirement of a soil is 10 %. If consumptive use requirement of the crop is 90 mm, then depth of water required to be applied to the field is** **(IES)**
   (a) 80 mm (b) 90 mm (c) 100 mm (d) 110 mm

4. For medium silt whose average grain size is 0.16 mm, Lacey's silt factor is likely to be (IES)

(a) 0.30 (b) 0.45 (c) 0.70 (d) 1.32

5. Mean precipitation over an area is best obtained from gauged amounts by (IES)

(a) Arithmetic mean method

(b) Thiessen method

(c) Linearly interpolated isohyetal method

(d) Orographically weighted isohyetal method

6. Probability of a 10-year flood to occur at least once in the next 4 years is (IES)

(a) 25 % (b) 35 % (c) 50 % (d) 65 %

7. Match list I and list II. (IES)

List I		List II	
A.	Conservation reservoirs	1.	Uncontrolled outlets
B.	Retarding basins	2.	Flood fighting
C.	Flood plains	3.	Temporary storage of flood water
D.	Flood walls	4.	Controlled outlets

Codes :

	A	B	C	D
(a)	1	4	3	2
(b)	1	4	2	3
(c)	4	1	3	2
(d)	4	1	2	3

8. The following four hydrological features have to be estimated or taken as inputs before one can compute the flood hydrograph at any catchment outlet :

1. Unit hydrograph
2. Rainfall hydrograph
3. Infiltration index
4. Base flow

The correct order in which they have to be employed in computations is **(IES)**

(a) 1, 2, 3, 4 (b) 2, 1, 4, 3 (c) 2, 3, 1, 4 (d) 4, 1, 3, 2

9. The standard project flood is (IES)

(a) derived from the probable maximum precipitation in the region

(b) derived from the severe most meteorological conditions anywhere in the country

(c) The flood with return period of 1000 years

(d) Same as the maximum probable flood

10. Isopleths are lines on a map through points having equal depth of (GATE)

(a) rainfall (b) infiltration (c) evapotranspiration (d) total runoff

11. A linear reservoir is one in which storage varies (GATE)
    (a) linearly with time
    (b) linearly with outflow rate
    (c) linearly with inflow rate
    (d) linearly with elevation

12. When there is an increase in the atmospheric pressure, then water level in a well penetrating in a confined aquifer (GATE)
    (a) increases
    (b) decreases
    (c) may increase or decrease depending on the nature of the aquifer
    (d) does not undergo any change

13. Rainfall mass curve shows the variation of (Civil Services)
    (a) rainfall intensity with time
    (b) rainfall intensity with cumulative rainfall
    (c) rainfall excess with time
    (d) cumulative rainfall with time

14. The rainfall during three successive 2 hour periods are 0.5, 2.8 and 1.6 cm. The surface runoff resulting from this storm is 3.2 cm. The ϕ-index value of this storm is (GATE)
    (a) 0.20 cm/hr
    (b) 0.28 cm/hr
    (c) 0.30 cm/hr
    (d) 0.80 cm/hr

15. A watershed got transformed from rural to urban over a period of time. The effect of urbanization on storm run-off hydrograph from the watershed is to (GATE)
    (a) decrease the volume of run off
    (b) increase the time to peak discharge
    (c) decrease the time base
    (d) decrease the peak discharge (GATE)

16. Match List I and List II.

List I	List II
A. Evapotranspiration	1. Penman method
B. Infiltration	2. Snyder's method
C. Synthetic unit hydrograph	3. Muskingun method
D. Channel routing	4. Horton's method

(GATE)

Codes :

	A	B	C	D
(a)	1	3	4	2
(b)	1	4	2	3
(c)	3	4	1	2
(d)	4	2	1	3

17. The intensity of rainfall and time interval of typical storm are : **(GATE)**

Time interval (min)	Intensity of rainfall (mm/min)
0 - 10	0.7
10 - 20	1.1
20 - 30	2.2
30 - 40	1.5
40 - 50	1.2
50 - 60	1.3
60 - 70	0.9
70 - 80	0.4

The maximum intensity of rainfall for 20 min duration of the storm is

(a) 1.5 mm/min (b) 1.85 mm/min (c) 2.2 mm/min (d) 3.7 mm/min

18. A sprinker irrigation system is suitable when **(GATE)**

(a) The land gradient is steep and the soil is easily crodible

(b) The soil is having low permeability

(c) The water table is low

(d) The crops to be grown have deep roots

19. Ordinates of a 1h unit hydrograph at 1h intervals, starting from t = 0 are 0, 2, 6, 2, 1 and 0 m^3/s.

Catchment area represented by this unit hydrograph is **(GATE)**

(a) 1.0 km^2 (b) 2.0 km^2 (c) 3.2 km^2 (d) 5.4 km^2

20. A 1h triangular unit hydrograph of a watershed has the peak discharge of 60 m^3/s at 10h and time base of 30h. The ϕ-index is 0.4 cm/hr and base flow is 15 m^3/s. **(GATE)**

The catchment area of the watershed is

(a) 3.24 km^2 (b) 32.4 km^2 (c) 324 km^2 (d) 3240 km^2

21. 1 cumec of water is pumped into a farm distribution system. If 0.8 cumec is delivered to a turnout, 0.9 km from the well, then conveyance efficiency is

(a) 75 % (b) 60 % (c) 80 % (d) 65 %

22. If S-curve hydrograph is desired for a basin of 540 km^2 from a 6h unit hydrograph then equilibrium discharge in the S-curve is

(a) 277.8 m^3/s (b) 250 m^3/s (c) 540×10^6 m^3/s (d) 3240 m^3/s

: ANSWERS :

1. (b)	2. (b)	3. (c)	4. (c)	5. (d)
6. (b)	7. (c)	8. (c)	9. (a)	10. (c)
11. (b)	12. (d)	13. (d)	14. (b)	15. (c)
16. (b)	17. (d)	18. (a)	19. (d)	20. (c)
21. (c)	22. (b)			

EXPLANATIONS

3. **(c)** Leaching requirement %

$$= \frac{D_i - C_u}{D_i} \times 100\ \%$$

D_i = total depth of water applied

C_u = consumptive use

$$10 = \frac{(D_i - 90)}{D_i} \times 100$$

$\therefore\ D_i = 100$ mm

4. **(c)** Lacey's silt factor

$= 1.76\sqrt{m_r}$

$= 1.76\sqrt{0.16} = 0.70$

6. **(b)** $p = 1 - \left(1 - \frac{1}{T}\right)^n$

$= 1 - \left(1 - \frac{1}{10}\right)^4 = 1 - (0.9)^4$

$= 0.35 = 35\ \%$

14. **(b)** $\phi = \frac{P - R}{t_r}$

$= \frac{4.9 - 3.2}{6}$

$= 2.83$ cm/hr

$P = 0.5 + 2.8 + 1.6$

$= 4.9$ cm

$t_r = 2 + 2 + 2$

$= 6$ hours

17. **(d)** Maxi. intensity for 20 min duration

$= 2.2 + 1.5 = 3.7$ mm/min

19. **(d)** For unit hydrograph rainfall depth $= 1$ cm

$= 1 \times 10^{-2}$ m

total vol. of water $=$ Area under unit hydrograph

$= 60 \times 60 \times 1 \times (0 + 2 + 6 + 4 + 2 + 1 + 0)$

$= 54000 \text{ m}^3$

$\therefore$ Area of catchment $= \dfrac{\text{volume}}{\text{depth}} = \dfrac{54000}{1 \times 10^{-2}} = 5.4 \times 10^6 \text{ m}^2$

$= 5.4 \text{ km}^2$

20. **(c)** For 1h unit hydrograph,

rainfall depth $= 1$ cm $= 1 \times 10^{-2}$ m

Total quantity of rainfall $=$ area of unit hydrograph

$= \dfrac{1}{2} \times 60 \times 30 \times 60 \times 60$

$= 3.24 \times 10^6 \text{ m}^3$

$\therefore$ Area of water shed $= \dfrac{\text{Volume}}{\text{depth}}$

$= \dfrac{3.24 \times 10^6}{1 \times 10^{-2}}$

$= 3.24 \times 10^8 \text{ m}^2$

$= 3.24 \times 10^2 \text{ km}^2 = 324 \text{ km}^2$

21. **(c)** $\eta_c = \dfrac{0.8}{1.0} \times 100 = 80\ \%$

22. **(b)** Equilibrium discharge

$$q_e = 2.778 \frac{A}{D} = 2.778 \times \frac{540}{6}$$

$= 250 \text{ m}^3/\text{s}$

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16.

Surveying

MCQ'S

SET-1 : Introduction

1. **The main principle of surveying is to work from**
   (a) The centre to the boundary (b) The whole to the part
   (c) The part to the whole (d) Higher to lower level
2. **The curvature of the earth is ignored in**
   (a) Geodetic surveying (b) Plane surveying
   (c) Hydrographic surveying (d) Aerial survey
3. **The curvature of the earth is taken into account when the extent of area is more than**
   (a) 50 km^2 (b) 100 km^2 (c) 250 km^2 (d) 350 km^2
4. **If scale of map is 1 cm = 50 m, R.F. is**
   (a) $\frac{1}{50}$ (b) $\frac{1}{500}$ (c) $\frac{1}{5000}$ (d) $\frac{1}{50,000}$
5. **Surveys which depict natural features like mountains, valleys, rivers, forests, etc. are known as**
   (a) cadastal surveys (b) Topographical surveys
   (c) Engineering surveys (d) Mine surveys
6. **The plain scale is used to read**
   (a) One unit (b) Two units
   (c) Three consecutive units (d) None of above
7. **The diagonal scale is used to read**
   (a) One unit (b) Two units
   (c) Three consecutive units (d) None of above
8. **Vernier scale is used to measure**
   (a) Fractional part of a graduated scale
   (b) Fractional part of a plain scale
   (c) Fractional part of a diagonal scale
   (d) None of above

9. **The branch of surveying which deals with the measurements in a vertical plane is known as**
   (a) Plane tabling (b) Levelling (c) Traversing (d) None of above
10. **In surveying the measurements are taken in**
   (a) Horizontal plane (b) Vertical plane
   (c) Inclined plane (d) Both horizontal and vertical plane
11. **The object of surveying is to prepare a**
   (a) Drawing (b) Cross–section (c) Sketch (d) Map

: ANSWERS :

1. (b)	2. (b)	3. (c)	4. (c)	5. (b)
6. (b)	7. (c)	8. (a)	9. (b)	10. (a)
11. (d)				

SET-2 : Linear Measurement

1. **A 20 m chain is divided into**
   (a) 60 links (b) 100 links (c) 150 links (d) 200 links
2. **The length of Gunter's chain is**
   (a) 100 ft (b) 50 ft (c) 66 ft (d) 75 ft
3. **The chainman who drags the chain is called the**
   (a) Captain (b) Leader (c) follower (d) Labour
4. **In chain survey the area is divided into**
   (a) Rectangles (b) Triangles (c) Squares (d) Circles
5. **Chain survey is recommended when the area is**
   (a) Crowded (b) Undulating (c) Simple and fairly level.
6. **Cross staff is used for**
   (a) Setting out right angles (b) Measuring horizontal angles
   (c) Both (a) and (b) (d) None of above
7. **For ranging a line, the number of ranging rods required is**
   (a) Atleast two (b) At least three (c) Atleast four
8. **Correction for slope is given by**
   (a) $h^2/2L$ (b) h/L (c) $h/2L$ (d) $2h^2/L$
9. **In an optical square, the mirrors are fixed at an angle of**
   (a) 30° (b) 60° (c) 45°
10. **The correction for sag is always**
   (a) additive (b) Substractive (c) Zero

11. If θ be the angle of slope and l be the sloping distance, slope correction is given by
(a) l (1 – sin θ) (b) l (1 – cos θ) (c) l (1 – sec θ)

12. Which one is used for the measurement of base line ?
(a) Invar tape (b) Steel tape (c) Engineer's chain

13. Which of the following is an obstacle to chaining but not to ranging ?
(a) Hill (b) Building (c) Forest (d) River

: ANSWERS :

1. (b)	2. (c)	3. (b)	4. (b)	5. (c)	6. (a)	7. (b)
8. (a)	9. (c)	10. (b)	11. (b)	12. (a)	13. (d)	

SET-3 : Compass Survey

1. In a prismatic compass, the zero is marked on the
(a) North end (b) South end (c) East end (d) West end

2. A triangle is said to be well conditioned when its angles lie between
(a) 30° and 120° (b) 20° and 150° (c) 15° and 135° (d) 45° and 90°

3. In a surveyor's compass, the ring is gradnated
(a) From 0° to 360° (b) From 0° to 180°
(c) In quadrants 0° to 90° (d) None

4. The angle of dip at a point on equator is
(a) 0° (b) 45° (c) 30° (d) 90°

5. In the WCB system, a line is said to be free from local attraction if the difference between the FB and BB is
(a) 0° (b) 90° (c) 180° (d) 360°

6. A line joining points of zero declination is called
(a) agonic line (b) isogonic line (c) isoclinic line (d) Survey line

7. The angular error in a closed traverse should not exceed
(a) $15\sqrt{N}$ min (b) $30\sqrt{N}$ min (c) $10\sqrt{N}$ min (d) $\sqrt{N}$ min

8. The horizontal angle between the true meridian and the magnetic meridian is called
(a) Dip (b) Azimuth (c) Declination (d) None of above

9. If FB of a line is zero degree, its BB is
(a) 0° (b) 90° (c) 180° (d) 360°

10. The BB of a line is S 30° W, its FB is
(a) N 30° E (b) N 30° W (c) S 30° W (d) S 30° E

11. The magnetic bearing of a line AB is 120° and the magnetic declination is 4° E, its true bearing is
(a) 116° (b) 124° (c) 120° (d) 4°
12. The true bearing of a line is 60° and the magnetic declination is 3° W, its magnetic bearing is
(a) 60° (b) 3° (c) 63° (d) 57°
13. The WCB of a line is 320°, its QB is
(a) N 40° W (b) N 40° E (c) W 40° N (d) E 40° N
14. The sum of interior angles of a closed traverse is
(a) (N – 4) 90° (b) (2N – 4) 90° (c) 2 (N – 4) 90° (d) (2N + 4) 90°

: ANSWERS :

1. (b)	2. (a)	3. (c)	4. (a)	5. (c)
6. (a)	7. (a)	8. (c)	9. (c)	10. (a)
11. (b)	12. (c)	13. (a)	14. (b)	

SET-4 : Levelling

1. Levelling deals with measurement in
(a) Horizontal plane (b) Vertical plane
(c) Inclined plane (d) Both horizontal and vertical plane
2. The datum adopted in India is the MSL at
(a) Bombay (b) Kolkata (c) Karachi (d) Chennai
3. B.M. in surveying designates
(a) Bombay mark (b) Bending moment (c) Bench mark (d) British mark
4. The staff reading taken on a point whose elevation is known is called
(a) Fore sight (b) Back sight (c) Intermediate sight
5. The station on which both back sight and fore sight are taken is called
(a) Change point (b) Bench mark (c) Intermediate point
6. The operation of levelling across any river is termed
(a) Profile levelling (b) Reciprocal levelling
(c) Compound levelling (d) Fly levelling
7. The line joining the points of equal elevation on the surface of the earth is known as
(a) agonic (b) Contour (c) isohytes
8. At what angle does a ridge line intersect contours ?
(a) 90° (b) 45° (c) 30° (d) 60°

9. **The vertical distance between two adjacent contour lines is called a**
(a) Contour gradient (b) Vertical equivalent (c) Contour interval

10. **In a contour map, when lower values are inside the loop, it indicates**
(a) Level ground (b) Depression (c) Hill (d) Ridge

11. **A fixed point of reference, whose elevation is known is called**
(a) Station (b) Bench mark (c) reduced level (d) Change point

12. **The height of instrument (HI) in levelling is the**
(a) Elevation of line of sight with respect to a datum
(b) Elevation of line of sight with respect to MSL
(c) Height of telescope axis above the ground
(d) None of above

13. **When contours of different elevations cross each other it indicates**
(a) Vertical cliff (b) Saddle (c) Overhanging cliff

14. **The surface of still water is considered to be**
(a) Level (b) Horizontal (c) Smooth (d) Curved

15. **The correction for curvature of earth is given by**
(a) $0.0785\ d^2$ (b) $0.01122\ d^2$ (c) $0.0673\ d^2$

: ANSWERS :

1. (b)	2. (d)	3. (c)	4. (b)	5. (a)
6. (b)	7. (b)	8. (a)	9. (c)	10. (b)
11. (b)	12. (a)	13. (c)	14. (a)	15. (a)

SET-5 : Plane Table Survey

1. **The process of keeping the plane table into a fixed direction so that a line representing a direction on the plan is parallel to its direction on the ground is called**
(a) Centering (b) Orientation (c) Levelling (d) Resection

2. **In setting up a plane table, the operation which is done first is**
(a) Levelling (b) Centering (c) Orientation (d) Resection

3. **The principle of plane tabling is**
(a) Traversing (b) Triangulation (c) Parallelism (d) None of above

4. **Which of the following instrument is used for marking north direction in plane tabling**
(a) Spirit level (b) Trough Compass (c) u–fork (d) alidade

5. **Inaccessible points may be located by**
   (a) Radiation (b) Intersection (c) Traversing (d) Resection
6. **Two point and three point problems are methods of**
   (a) Resection only (b) Orientation only
   (c) Resection and orientation (d) Traversing
7. **The two point problem as compared to three point problem is**
   (a) more accurate (b) quicker (c) more laborious (d) all of above
8. **Three point problem can be solved by**
   (a) Lehmann's method (b) Bessel's method
   (c) Tracing Paper method (d) All the above
9. **The working edge of the alidade is known as**
   (a) Fiducial edge (b) Parallel edge (c) Drawing edge (d) Straight edge
10. **The u–fork and plumb bob are required for**
    (a) Levelling (b) Centring (c) Orientation (d) Bisecting
11. **Which method is most preferred for orientation in plane tabling ?**
    (a) By traversing (b) By magnetic needle
    (c) by backsighting (d) None of above
12. **The instrument which is used in plane table surveying for determining the horizontal distances without tape or chain is called**
    (a) Plane alidade (b) Telescopic alidade
    (c) Tacheometer (d) Clinometer
13. **In plane tabling details are obtained by drawing rays from the station to objects, the method is called**
    (a) Radiation (b) Intersection (c) Traversing (d) Resection
14. **The process of determining the plotted position of the station occupied by the plane table by means of sights taken towards points of known location is called**
    (a) Resection (b) Intersection (c) Orientation (d) None of the above

: ANSWERS :

1.	(b)	2.	(a)	3.	(c)	4.	(b)	5.	(b)
6.	(c)	7.	(c)	8.	(d)	9.	(a)	10.	(b)
11.	(c)	12.	(b)	13.	(a)	14.	(a)		

SET-6 : Theodolite Traversing

1. **Turning the telescope in the vertical plane about the horizontal axis is called**
   (a) Transiting (b) Plunging (c) Swinging (d) both (a) and (b)
2. **The operation of revolving the telescope in the horizontal plane about its vertical axis is called**
   (a) Swinging (b) Transiting (c) Plunging (d) None of the above
3. **Approximate bisection in a theodolite is done by the**
   (a) Focussing screw (b) Tangent screw (c) Clamp screw (d) Foot screw
4. **Fine adjustment in a theodolite is done by the**
   (a) Clamp screw (b) Tangent screw (c) Focussing screw (d) Foot screw
5. **The upper plate of a theodolite is fixed to**
   (a) outer spindle (b) Inner spindle (c) Levelling head (d) None of above
6. **For improved accuracy in the measurement of horizontal angle the method used is**
   (a) General method (b) Reiteration method
   (c) Repetition method (d) Vernier method
7. **If N is the number of sides in a closed traverse, then the sum of interior angles should be equal to**
   (a) $(2N + 4) \times 90°$ (b) $(2N \times 4) \times 90°$ (c) $(2N - 4) \times 90°$ (d) $(N - 4) \times 90°$
8. **The direction of closing error is given by**
   (a) $\tan\theta = \frac{\Sigma D}{\Sigma L}$ (b) $\tan\theta = \frac{\Sigma L}{\Sigma D}$
   (c) $\tan\theta = \Sigma L \times \Sigma D$ (d) $\sin\theta = \frac{\Sigma D}{\Sigma L}$
9. **If θ be the RB of a line of length '*l*' then the latitude of a line is given by**
   (a) $l \sin\theta$ (b) $l \cos\theta$ (c) $l \tan\theta$ (d) $l \cot\theta$
10. **If θ be the RB of a line of length '*l*' then the departure of a line is given by**
    (a) $l \sin\theta$ (b) $l \cos\theta$ (c) $l \tan\theta$ (d) $l \cot\theta$
11. **While taking a backsight, the screw used is**
    (a) Lower clamp (b) Upper clamp (c) Upper tangent (d) None of above
12. **The Parallax can be removed by**
    (a) Focussing the objective (b) Focussing the eye piece
    (c) Focussing both the eye piece and objective (d) None of above
13. **The size of a theodolite is designated by**
    (a) The length of the telescope
    (b) The diameter of the telescope

(c) The height of the theodolite

(d) The diameter of the graduated circle on the lower plate.

14. The horizonatl angle between two lines is generally measured

(a) Clockwise from the forward station

(b) Clockwise from the back station

(c) Counter–clockwise from the forward station

(d) Counter–clockwise from the backward station

15. The difference between face left and face right observations of a theodolite is 2'. The error is

(a) 2' (b) 4' (c) 1' (d) 0'

16. A theodolite can measure

(a) diference in lel (b) bearing of a line

(c) zenith angle (d) all the above

17. The error in the horizontal circle readings, is due to

(a) the late axis bubble not being parallel to the line of collimation.

(b) the line of sight not being parallel to the telescope axis.

(c) the line of collimation not being perpendicular to the trunion axis.

(d) none of the above

18. If the departure and latitude of a line are + 78.0 and –135.1 m respectively, the length of the line is

(a) 213.1 m (b) 57.1 m (c) 156.0 m (d) none of above

19. If the departure and latitude of a line are + 78.0 m and –135.1 m, respectively, the whole circle bearing of the line is

(a) 150° (b) 30° (c) 60° (d) 120°

20. Transit rule of balancing a traverse is applied when

(a) the linear and angular measurements are of same precision.

(b) the linear measurements are more precise than the angular measurements.

(c) the angular measurements are more precise than the linear measurements.

(d) none of above

21. In a closed traverse, the algebric sum of the latitudes and departures must be equal to

(a) 0° (b) 90° (c) 180° (d) 360°

22. The independent co–ordinates of all points in a Gale's traverse table are in

(a) first quadrant (b) second quadrant (c) third quadrant (d) fourth quadrant

23. The face left position is also called

(a) Telescope reversed (b) Telescope inverted

(c) Telescope normal (d) None of above

24. A theodolite in which the telescope can be revolved through a complete revolution in a vertical plane is known as a

(a) Vernier theodolite (b) Tilting theodolite

(c) Non–transit theodolite (d) Transit theodolite

25. When the vertical circle is to the right side of the observer, it is called

(a) Telescope inverted (b) Telescope normal

(c) Telescope reversed (d) none of above

: ANSWERS :

1. (d)	2. (a)	3. (c)	4. (b)	5. (b)
6. (c)	7. (c)	8. (a)	9. (b)	10. (a)
11. (a)	12. (c)	13. (d)	14. (b)	15. (c)
16. (d)	17. (c)	18. (c)	19. (a)	20. (c)
21. (a)	22. (a)	23. (c)	24. (d)	25. (a)

SET-7 : Trigonometric Levelling

1. Which corrections are neglected in plane trigonometric levelling ?

(a) earth's curvature (b) refraction (c) both (a) and (b) (d) None of above

2. The combined correction for earth's curvature and refraction in linear measurement is given by

(a) $0.0673\ D^2$ (b) $0.0785\ D^2$ (c) $0.0112\ D^2$ (d) None of above

3. When the base of the objectis accessible, the horizontal distance between the instrument and object is D, the elevation h is given by

(a) $D \sin \alpha$ (b) $D \cos \alpha$ (c) $D \tan \alpha$ (d) $D \cot \alpha$

4. When the base of the object is inaccessible, the instrument stations in the same vertical plane and instrument axes at the same level, the distance between object and the station nearer to object is

(a) $\dfrac{b \tan \alpha_1}{(\tan \alpha_1 - \tan \alpha_2)}$ (b) $\dfrac{b \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$ (c) $\dfrac{b \tan \alpha_1}{(\tan \alpha_2 - \tan \alpha_1)}$ (d) $\dfrac{b \tan \alpha_2}{(\tan \alpha_2 - \tan \alpha_1)}$

5. For angle of elevation, the correction for earth curvature is

(a) $+\dfrac{\theta}{2}$ (b) $-\dfrac{\theta}{2}$ (c) $+2\theta$ (d) -2θ

: ANSWERS :

1. (c)	2. (a)	3. (c)	4. (b)	5. (a)

SET-8 : Curves

1. A circular curve is most suited for connecting
(a) Two straights in horizontal plane only
(b) Two straights in vertical plane only
(c) Two straights, one in horizontal plane and the other in vertical plane
(d) Two straights in horizontal plane or vertical plane

2. The shortest distance between the point of curve (P.C.) and the point of tangency (P.T.) is
(a) Normal chord (b) Long chord (c) Sub chord (d) Half chord

3. The curve preferred for vertical curve is a
(a) circular (b) spiral (c) parabola (d) hyperbola

4. The degree of a circular curve of radius 1719 m is approximately equal to
(a) 100° (b) 10° (c) 1° (d) None of the above

5. The radius of a 1° curve is (length 30 m)
(a) 1719 m (b) 1917 m (c) 1918 m (d) 1819 m

6. For an ideal transition curve, the relation between radius r and distance l from begining is
(a) $l \propto r$ (b) $l \propto r^2$ (c) $l \propto \frac{1}{r}$ (d) $l \propto \frac{1}{r^2}$

7. The length of transition curve is given by
(a) $L = \frac{n}{e}$ (b) $L = ne$ (c) $L = \frac{e}{n}$ (d) $L = n - e$

8. The length of long chord and tangent length of a circular curve of radius R will be equal if the deflection angle is
(a) 60° (b) 30° (c) 150° (d) 120°

9. The tangent length of a simple circular curve of radius R and deflection angle Δ is given by
(a) $R \tan \frac{\Delta}{2}$ (b) $R \tan \Delta$ (c) $\frac{R}{\tan \Delta}$ (d) $\frac{R}{\tan \frac{\Delta}{2}}$

10. For a transition curve, the shift of a circular curve is given by
(a) $\frac{L}{24R}$ (b) $\frac{L^2}{24R}$ (c) $\frac{L^3}{24R}$ (d) $\frac{L^3}{24R^2}$

11. Apex distance is also called
(a) Mid ordinate (b) Normal chord (c) External distance (d) tangent length

12. The centrifugal ratio is given by
(a) $\frac{P}{W}$ (b) $\frac{W}{P}$ (c) $P \times W$ (d) $P - W$

13. The long chord of a circular curve of radius R and deflection angle Δ is given by

(a) $2R \sin \frac{\Delta}{2}$ (b) $2R \cos \frac{\Delta}{2}$ (c) $2R \tan \frac{\Delta}{2}$ (d) $2R \sec \frac{\Delta}{2}$

14. The deflection angle from the tangent is given by

(a) $\delta = 1718.9 \frac{R}{C}$ minutes (b) $\delta = 1817.9 \frac{R}{C}$ minutes

(c) $\delta = 1718.9 \frac{C}{R}$ minutes (d) $\delta = 1817.9 \frac{C}{R}$ minutes

15. The superelevation required on curve is

(a) $e = \frac{bv^2}{gR}$ (b) $e = \frac{b \cdot R}{gv^2}$ (c) $e = \frac{bv}{gR^2}$ (d) $e = \frac{b^2v^2}{gR}$

16. If the chainage of point of tangency (P.T.) of a circular curve for a normal chord of 20 m is 2303.39 m, the length of the last subchord is

(a) 16.61 m (b) 3.39 m (c) 23.39 m (d) None of the above

17. If the chainage of point of curve of a simple circular curve for a normal chord of 20 m is 2002.48 m the length of the first sub–chord is

(a) 2.48 m (b) 17.52 m (c) 20 m (d) 22.48 m

18. Overturning of vehicles on a curve can be avoided by providing a

(a) Reverse curve (b) Compound curve (c) transition curve (d) Vertical curve

19. A parabola is used for

(a) Summit curves only (b) Sag curves only

(c) Both summit and sag curves (d) None of the above

20. Reverse curve is preferred on high ways and railways defined for

(a) Low speed (b) High speed (c) Both (a) & (b) (d) None of the above

21. The degree of curve for 20 m arc length is given by

(a) $D = \frac{1719}{R}$ (b) $D = \frac{1146}{R}$ (c) $D = \frac{1917}{R}$ (d) $D = \frac{1416}{R}$

22. The radius of a 1° curve for 20 m arc length is

(a) 1146 m (b) 1416 m (c) 1719 m (d) 1917 m

23. The radius of a 4° curve (30 m arc length) is

(a) 719 m (b) 1146 m (c) 430 m (d) 287 m

24. To avoid inconvenience to passengers on highways the recommended value of centrifugal ratio is

(a) 1 (b) 1/2 (c) 1/4 (d) 1/8

25. If an upgrade is 2% is followed by a downgrade 2% and the rate of change of grade is 0.4% per 100 m, the length of vertical curve will be

(a) 200 m (b) 100 m (c) 400 m (d) 1000 m

26. The following curve has a property that the rate of change of curvature is same as the rate of change of increase in superelevation.

(a) Reverse curve (b) Transition curve (c) Compound curve (d) Vertical curve

27. The most widely used transition curve for small deflection angles for simplicity in setting out is

(a) Cubic parabola (b) Lemniscate (c) Cubic spiral (d) hyperbola

28. The offset from long chord is given by

(a) $O_x = \sqrt{R^2 - x^2} - (R - O_o)$ (b) $O_x = \sqrt{R^2 + x^2} - (R - O_o)$

(c) $O_x = \sqrt{R - x^2} + (R - O_o)$ (d) $O_x = \sqrt{R^2 - x^2} + (R + O_o)$

29. Radial offsets from tangent is given by

(a) $O_x = \sqrt{R^2 - x^2} - R$ (b) $O_x = \sqrt{R^2 - x^2} + R$

(c) $O_x = \sqrt{R^2 + x^2} - R$ (d) $O_x = \sqrt{R^2 + x^2} + R$

30. Perpendicular offsets from tangent is given by

(a) $O_x = R - \sqrt{R^2 + x^2}$ (b) $O_x = R - \sqrt{R^2 - x^2}$

(c) $O_x = R + \sqrt{R^2 + x^2}$ (d) $O_x = R + \sqrt{R^2 - x^2}$

: ANSWERS :

1. (a)	2. (b)	3. (c)	4. (c)	5. (a)
6. (c)	7. (b)	8. (d)	9. (a)	10. (b)
11. (c)	12. (d)	13. (a)	14. (c)	15. (a)
16. (b)	17. (b)	18. (c)	19. (c)	20. (a)
21. (b)	22. (a)	23. (c)	24. (c)	25. (d)
26. (b)	27. (a)	28. (a)	29. (c)	30. (b)

SET-9 : Area and Volume

1. The area of zero circle is equal to

(a) M (b) C (c) M × C (d) M – C

2. Simpson's rule can be used for computations of areas when the number of ordinates is

(a) even (b) odd (c) any number (d) 3

3. The area of any irregular figure can be determined accurately by

(a) pentagraph (b) planimeter (c) cross–staff (d) Prismatic compass

4. The area of a parabolic segment of base b and height h is given by

(a) $\frac{1}{2}bh$ (b) $\frac{2}{3}bh$ (c) $\frac{3}{4}bh$ (d) $\frac{1}{3}bh$

5. **Prismoidal correction is requied to correct the volume calculated**
   (a) Using contours (b) Using spot levels
   (c) for a curved section (d) by end–areas rule
6. **In Simpson's rule the line joining the top of the ordinates is considered to be**
   (a) sraight (b) elliptical (c) parabolic (d) curved
7. **In trapezoidal rule, the line joining the top of the ordinates is considered to be**
   (a) straight (b) elliptical (c) parabolic (d) curved
8. **When the anchor point is out the figure the area of zero circle is**
   (a) Added (b) Substracted (c) taken zero (d) None of above
9. **When the tracing point is moved along a circle without rotation of the wheel then the circle is known as**
   (a) Zero circle (b) Prime circle (c) circum circle (d) ortho circle
10. **In trapezoidal formula, the number of ordinates must be**
    (a) odd (b) even
    (c) either odd or even (d) None of the above

: ANSWERS :

1. (c)	2. (b)	3. (b)	4. (b)	5. (d)
6. (c)	7. (b)	8. (c)	9. (a)	10. (c)

SET-10 : Hydrographic Survey

1. **For navigation purposes, generally the datum used is**
   (a) M.S.L. (b) T.B.M. (c) G.T.S. (d) Tidal datum
2. **Sounding in hydrography means**
   (a) distance travelled by sound waves in water body
   (b) depth of water body at the point of measurement
   (c) Velocity of water waves
   (d) None of the above
3. **The observations to establish M.S.L. are recorded for about**
   (a) 9 years (b) 19 years (c) 29 years (d) 39 years
4. **In ocean where depth of water is great, the instrument used is**
   (a) Sounding poles (b) lead lines (c) Fathometer (d) Sounding machine
5. **The branch of surveying which deals with the measurement of bodies of water is called**
   (a) Hydrology (b) Fluid mechanics (c) Hydraulics (d) Hydrographic surveying

6. **In hydrographic surveying**
   (a) Only horizontal control is required
   (b) Only vertical control is required
   (c) Both horizontal and vertical controls are required.
   (d) No such controls are required.
7. **The purpose of soundings is**
   (a) To determine sea bed profile
   (b) Preparation of navigation charts
   (c) to locate areas from where material can be dredged
   (d) all of the above
8. **The purpose of hydrographic survey is**
   (a) To make nantical charts for navigation (b) To establish M.S.L.
   (c) To determine shore lines (d) all of the above

: ANSWERS :

1. (d)	2. (b)	3. (b)	4. (c)
5. (d)	6. (c)	7. (d)	8. (d)

SET-11 : Setting out Works

1. **The accessory used in setting out works is**
   (a) boning rod (b) traveller (c) batter board (d) all of the above
2. **Setting out works involves**
   (a) transferring plans onto the actual site.
   (b) establishing lines and levels of work
   (c) Making measurements to verify the location of completed parts
   (d) all of the above
3. **The accessory used for controlling the side slopes in embankments and in cutting**
   (a) batter board (b) traveller (c) boning rod (d) cross head
4. **Setting out of bridge involves**
   (a) determination of length of the centre line
   (b) determination of the location of piers
   (c) (a) and (b) both
   (d) determination of height of piers
5. **Setting out of tunnels involves**
   (a) Surface setting out

(b) Determination of exact length of the tunnel
(c) Underground survey
(d) all of the above

: ANSWERS :

1. (d)	2. (d)	3. (a)	4. (c)	5. (d)

SET-12

1. **What is the angle of intersection of a contour and a ridge line ?** **(IES)**
(a) 30° (b) 0° (c) 180° (d) 90°

2. **The process of determining the locations of the instrument station by drawing resectors from the locations of the known stations is called** **(IES)**
(a) radiation (b) intersection (c) resection (d) traversing

3. **Which of the following methods of plane table surveying is used to locate the position of an inaccessible point ?** **(IES)**
(a) Radiation (b) Intersection (c) Traversing (d) Resection

4. **Which one of the following methods estimates best the area of an irregular and curved boundary ?** **(IES)**
(a) Trapezoidal method (b) Simpson's method
(c) Average ordinate method (d) Mid ordinate method

5. **A 100 m tape is held 1 m out of line. The true length is** **(Civil Services)**
(a) 100.0050 m (b) 99.9950 m (c) 100.0100 m (d) 99.9800 m

6. **To determine the length of a bridge proposed to be built across a wide river, the surveying method of choice would be** **(Civil Services)**
(a) tacheometry (b) chain surveying
(c) hydrographic surveying (d) Triangulation

7. **Heliograph is a type of** **(Civil Services)**
(a) Instrument used for recording the movement of sun
(b) Instrument used for contouring an area
(c) electronic distance measuring device
(d) sun signal used in triangulation work

8. **For air borne application and materialization of GPS receiver and easy construction, which is the most frequently used antena ?** **(IES)**
(a) Microstrip (b) Micropole (c) Spiral helix (d) Chock ring

9. Diurnal variation is greater

(a) in winter than in summer (b) at smaller latitudes than at higher latitudes
(c) at magnetic equator points (d) in summer than in winter

10. Which of the following figures are equal to one acre ? **(IES)**

1. 43560 sq.ft
2. 40 gunthas
3. 10 sq. Gunter's chain
4. 4850 sq. yards

Select the correct answer using the code given below :

(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 1, 2 and 4 (d) 1, 3 and 4

11. What is the minimum number of satellites required from which signals can be recorded to enable a global positioning system receiver to determine latitude, longitude and altitude ? **(IES)**

(a) One (b) two (c) three (d) four

12. Which of the following pairs are correctly matched ? **(IES)**

1. Telemeter .... measurement of distance
2. Price meter .... measurement of difference in elevation
3. Sounding .... measurement of sextant horizontal angles
4. Clinometer .... measurement of vertical angles

Select the correct answer using codes given below :

(a) 2, 3 and 4 (b) 1, 3 and 4 (c) 1, 2 and 4 (d) 1, 2 and 3

13. The standard measurement of the Geodimeter 510 is **(IES)**

(a) $\pm$ 1 cm (b) $\pm$ 5.1 mm (c) $\sqrt{5.1}$ mm (d) $\pm$ 1 mm

14. On which of the following are the third generation electro–optical instruments based ? **(IES)**

(a) Microwave (b) infrared (c) uv light (d) He–laserlight

15. If g_1 and g_2 are the two gradients, r is the rate of change of grade (%) per chain, the length of the vertical curve will be **(IES)**

(a) $\frac{(g_1+g_2)}{r^2}$ (b) $\frac{(g_1+g_2)}{\sqrt{r}}$ (c) $\frac{(g_1+g_2)}{r}$ (d) $\frac{(g_1+g_2)}{r^3}$

16. Theory of errors and adjustment deals with minimising the effects of **(IES)**

(a) instrumental errors (b) mistakes
(c) systematic errors (d) personal and accidental errors

17. Triangulation station selected close to the main station for avoiding intervening obstruction is called **(IES)**

(a) Eccentric station (b) Pivot station (c) Satellite station (d) tie station

18. The method of orienting a plane table with two inaccessible points is called **(IES)**

(a) intersection (b) resection (c) back sighting (d) two–point problem

19. Which one of the following surveys is required in observations of stars ?

(a) Astronomical survey (b) Cadastal survey

(c) Aerial survey (d) Photogrammetric survey

20. Match List I and List II with respect to aerial photogrammetry and select the correct answer using the codes given below the lists. (Civil Services)

List I (Name)	List II (Explanation)
A. Principal point	1. The angle formed between flight line and edges of photograph in the direction of flight
B. Isocentre	2. Failure of the aeroplane to stay on the predetermined flight line
C. Crab	3. The point where a perpendicular dropped from the front nodal point strikes the photograph
D. Drift	4. The point at which bisector of the angle of tilt meets the photograph

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	4	3	1	2
(c)	3	4	1	2
(d)	3	4	2	1

21. If declination is 5° 40' W, then which one of the following magnetic bearing would represent true bearing of S 25° 20' E ? (IES)

(a) S 19° 20'E (b) S 31° 0'E (c) S 20° 0' E (d) S 19° 20'W

22. Given that for a triangulation survey (Civil Services)

D = Distance in km

h = visible horizon from a station of known elevation above the datum (in metres)

If there is no obstruction due to intervening ground, then h is equal to

(a) 0.6735 D^2 (b) 6.735 D^2 (c) 0.06735 D^2 (d) 0.006735 D^2

23. Mean sea level at any place is the average datum of hourly tide height observed over a period of nearly (Civil Services)

(a) 5 years (b) 10 years (c) 20 years (d) 50 years

24. How high should a helicopter pilot rise at a point 'A' just to see the horizon at point 'B' if the distance AB is 40 km ? (IES)

(a) 10.75 m (b) 110.50 m (c) 107.75 m (d) 105. 50 m

25. If two triangulation signals of 6.75 m height each are to be just visible over ground mutually, what is the maximum distance between their locations on the ground surface ? (IES)

(a) 10 km (b) 20 km (c) 30 km (d) 40 km

26. Match list I and list II and select the correct answer using the code given below the lists : (IES)

List I	List II
A. Vertical cliff	1. Contour lines of different elevations unit to form one line
B. Steep slope	2. Contour lines of different elevations cross one another
C. Hill	3. Contour lines are closely spaced
D. Overhanging cliff	4. Closed contour lines with higher values inside them

Codes :

	A	B	C	D
(a)	4	3	1	2
(b)	1	3	4	2
(c)	1	2	4	3
(d)	4	2	1	3

27. Which one of the following methods of levelling eliminates the error due to curvature and refraction ? (IES)

(a) Fly levelling

(b) Levelling by equalizing the distance of backsight and foresight

(c) Check leveling

(d) Precise levelling

28. A road section of length 1 km scales 8 cm on a vertical photograph. If focal length of camera is 160 mm and the terrain is fairly level, then flying height will be (IES)

(a) 20 m (b) 2000 m (c) 20 km (d) 200 km

29. Given that for a planimeter (Civil Services)

L = Length of the tracing arm

R = Radius of the anchor arm

a = distance between roller and hinge

If wheel is beyond the hinge, then area of zero circle will be

(a) $\pi (L^2 - 2aL + R^2)$ (b) $\pi (L^2 + 2aL + R^2)$ (c) $\pi (L^2 + aL + R^2)$ (d) $\pi (a^2 - aL + R^2)$

(Civil Services)

30. Given that

f = focal length of camera

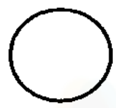
H = Height of exposure station above MSL

h = Height of ground above MSL

The scale of vertical photograph is given by :

(a) $S_h = \frac{f}{H}$ (b) $S_h = \frac{f}{(H-h)}$ (c) $S_h = \frac{H}{(f-h)}$ (d) $S_h = \frac{f}{(H-h)}$

31. Which one of the following is a conventional sign for North line in surveying ? **(Civil Services)**

(a)  (b)  (c)  (d) 

32. In photogrammetric surveying, the relief displacement **(Civil Services)**

(a) decreases with increase in flying height

(b) is negative for a point above datum

(c) decreases as the distance at the object from the principal point increases.

(d) of the point is not affeted by the tilt of the photograph

33. If cross section areas of an embankment at 30 m intervals are 20, 40, 60, 50 and 30 m^2 respectivery, then volume of the embankment on the basis of prismoidal rule is, **(Civil Services)**

(a) 5300 m^3 (b) 8300 m^3 (c) 9300 m^3 (d) 9400 m^3

34. A 3000 m long line lying at elevation of 450 m measures 10 cm on a vertical photograph. The focal length of the camera is 21 cm. The scale of the photograph for the area lying at an elevation of 1000 m will be **(Civil Services)**

(a) 1:27381 (b) 1:25008 (c) 1:20606 (d) 1:30421

35. The representative fraction $\frac{1}{2500}$ means that the scale is 1cm equal to (Civil Services)

(a) 0.25 m (B) 2.5 m (c) 25 m (d) 2.5 km

36. In photogrammetric surveying, image of the top of the hill is 90 mm from the principal point of the photograph. If elevation of top of the hill is 500 m and flying height is 5000 m above datum, then relief displacement is **(Civil Services)**

(a) 0.9 mm (b) 9 mm (c) 90 mm (d) 900 mm

37. **Which one of the following gives the corret distance between light house and a ship, when the light house whose height is 100 m is visible just above horizon from ship ?** **(Civil Services)**

(a) 30.68 km (b) 36.50 km (c) 38.54 km (d) 40.54 km

38. **Which one of the following closely represents shape of the earth ? (Civil Services)**

(a) Spheroid (b) Ellipsoid (c) Oblate spheroid (d) Prolate spheroid

39. **Contour interval on map sheet denotes** **(Civil Services)**

(a) vertical distance of contour lines above the datum line
(b) vertical distance between two successive contour lines
(c) slope distance between two successive contour lines
(d) horizontal distance between two successive contour lines

40. **ABCD is a regular parallelogram plot of land, whose angle BAD is 60°. If bearing of the AB is 30°, then bearing of the line CD is** **(Civil Services)**

(a) 90° (b) 120° (c) 210° (d) 270°

41. **The true length of a line is know to be 200 m, when this is measured with a 20 m tape, the length is 200.80 m. The correct length of the 20 m tap is** **(IES)**

(a) 19.92 m (b) 19.98 m (c) 20.04 m (d) 20.08 m

42. **It is required to produce a small–scale map of an area in a magnetic zone by directly plotting and checking the wrok in the field itself. Which one of the following surveys will be most appropriate for this purpose ?** **(IES)**

(a) Chain (b) Theodolite (c) Plane table (d) Compass

43. **A 30 m metric chain is found to be 0.1 m too short throughout the measurement. If the distance measured is recorded as 300 m, then the actual distance will be** **(IES)**

(a) 301 m (b) 300 m (c) 299 m (d) 298 m

44. **The vertices of an astronomical triangle would include** **(IES)**

(a) zenith, pole and heavenly body (b) azimuth, zenith and pole
(c) azimuth, pole and heavenly body (d) azimuth, zenith and heavenly body

45. **The direction of magnetic meridian is established at each traverse station and direction of the line is determined with reference to the magnetic meridian. This method of traversing is called** **(IES)**

(a) Fast needle method (b) Loose needle method
(c) Bearing method (d) Fixed needle method

46. **If fore bearing of a line is S 49° 52' E (assuming there is no local attraction), then back bearing of the line will be** **(IES)**

(a) S 52° 49' E (b) S 49° 52' E (c) N 49° 08' E (d) N 49° 52' W

47. **The co–ordinates of two end points A and B of a traverse line AB are** **(Civil Services)**

x_A = 1000.0 m y_A = 1000.0 m
x_B = 2000.0 m y_B = 1000.0 m
The bearing of the line AB will be
(a) 0° 0' 00" (b) 60° 0' 00" (c) 90° 0' 00" (d) 180° 0' 00"

48. The downhill end of a 20 m tape is held 80 cm too low, then its horizontal length will be **(Civil Services)**
(a) 19.894 m (b) 19.984 m (c) 20.016 m (d) 20.984 m

49. The following equipments can be used to lay out horizontal angles in field
1. Microptic theodolite 2. Chain and metallic tape
3. Vernier theodolite 4. Prismatic compass
The correct sequence of the decreasing order of their accuracies is
(a) 2, 4, 3, 1 (b) 2, 3, 4, 1 (c) 1, 4, 3, 2 (d) 1, 3, 4, 2

50. Which of the following are the fundamental lines of a theodolite ?
(1) The vertical and horizontal axes
(2) The diagonally opposite screw lines
(3) The line of collimation and axes of the plate levels
(4) The bubble line of the altitude level
Codes :
(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 2 and 3 (d) 1, 3 and 4

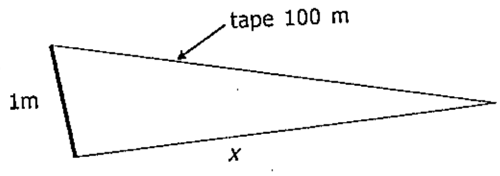
: ANSWERS :

1. (d)	2. (c)	3. (b)	4. (b)	5. (b)
6. (d)	7. (d)	8. (c)	9. (d)	10. (a)
11. (d)	12. (a)	13. (a)	14. (d)	15. (c)
16. (b)	17. (c)	18. (d)	19. (a)	20. (c)
21. (b)	22. (c)	23. (c)	24. (c)	25. (b)
26. (b)	27. (b)	28. (b)	29. (b)	30. (b)
31. (d)	32. (a)	33. (a)	34. (a)	35. (c)
36. (b)	37. (c)	38. (c)	39. (b)	40. (c)
41. (a)	42. (c)	43. (c)	44. (a)	45. (a)
46. (d)	47. (c)	48. (b)	49. (d)	50. (d)

EXPLANATIONS

5. (b) $100^2 = 1^2 + x^2$

∴ $x = 99.9950$ m



10. (a) 1 acre = 2.5 vigha

= 40 Guntha

= 4047 sq.m

21. (b) Since declination is towards west, use – ve sign

∴ True bearing = Magnetic bearing – declination

25° 20' = Magnetic bearing – 5° 40'

∴ Magnetic bearing = S 31° 0' E

24. (c) $h = 0.06735\ D^2$

$= 0.06735 \times (40)^2$

$= 107.75$ m

25. (b) $h = 0.06735\ D^2$

$6.75 = 0.06735\ D^2$

∴ D = 10 km

∴ Distance between two stations = 2 × 10 = 20 km

28. (b) Scale of vertical photograph $= \dfrac{f}{H-h}$

ground is levelled

∴ $\dfrac{8\text{ cm}}{1\text{ km}} = \dfrac{f}{H-h}$

∴ h = 0

$\dfrac{80\text{ mm}}{1\times10^6\text{ mm}} = \dfrac{160}{H-0}$

∴ $H = 2 \times 10^6$ mm

= 2 km = 2000 m

33. (a) Prismoidal rule,

$$V = \frac{h}{3}\,[(A_0 + A_n) + 4\,(A_1 + A_3 + ...) + 2\,(A_2 + A_4 + ...)]$$

$$= \frac{30}{3} \times [(20 + 30) + 4\,(40 + 50) + 2\,(60)]$$

$$= 5300\ m^3$$

34. **(a)** Scale $= \dfrac{f}{H-h}$

$$\frac{0.1}{3000} = \frac{0.21}{H-450}$$

$\therefore$ H = 6750 m

Now for scale at h = 1000 m

$$\text{Scale} = \frac{f}{H-h} = \frac{0.21}{6750-1000} = \frac{1}{27381}$$

35. **(c)** R.F. $= \dfrac{1\text{ cm}}{2500\text{ cm}} = \dfrac{1\text{ cm}}{25\text{ m}}$

36. **(b)** relief displacement,

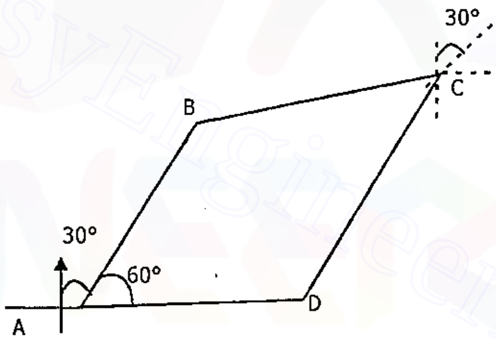
$$d = \frac{rh}{H} = \frac{0.090 \times 500}{5000} = 0.009\text{ m} = 9\text{ mm}$$

37. **(c)** $h = 0.06735\ D^2$

$100 = 0.06735\ D^2$

$\therefore$ D = 38.54 km

40. **(c)**



Bearing of CD = 30° + 180°

= 210°

41. **(d)** $l = l' \times \left(\dfrac{L'}{L}\right)$ $\therefore$ $200 = 200.80 \times \left(\dfrac{L'}{20}\right)$

$\therefore$ L' = 19.92 m

43. **(c)** $l = l' \times \left(\dfrac{L'}{L}\right)$

$$l = 300 \times \left(\frac{29.90}{30}\right)$$

= 299 m

48. **(b)** Horizontal length $= \sqrt{(20)^2 - (0.8)^2}$

= 19.984 m

❖❖❖

17. Fluid Mechanics

MCQ'S

SET-1 : Fluids

1. **An ideal fluid is one which**
   (a) is compressible
   (b) has no viscosity
   (c) is elastic and viscous
   (d) is non–viscous and incompressible
2. **Surface tension is a phenomenon due to**
   (a) cohesion only
   (b) viscous force
   (c) difference in magnitude between forces due to cohesion and adhesion
   (d) adhesion only
3. **Ball pen works on the principle of**
   (a) Viscosity (b) Surface tension (c) Gravitational force (d) Boyle's law
4. **The bulk modulus of elasticity of a fluid is**
   (a) $-\dfrac{\left(\dfrac{dv}{v}\right)}{dp}$ (b) $-\dfrac{dp}{\left(\dfrac{dv}{v}\right)}$ (c) $\mu \cdot \dfrac{dp}{dy}$ (d) $\dfrac{dp}{d\rho}$
5. **The pressure within a soap bubble is**
   (a) the same as the surrounding atmosphere
   (b) less than the external pressure
   (c) greater than the external pressure
   (d) equal to the vapour pressure
6. **A fluid which obeys the relation $\tau = \mu \cdot \dfrac{du}{dy}$ is called the**
   (a) Ideal fluid (b) Newtonian fluid (c) Perfect fluid (d) Pseudo plastic
7. **The viscosity of water with respect to air is about :**
   (a) 50 (b) 55 (c) 60 (d) 65 times
8. **Newton's law of viscosity relates**
   (a) Stress and strain in a fluid
   (b) Shear stress and rate of angular deformation of a fluid
   (c) Pressure, velocity and viscosity of a gas
   (d) Viscosity and rate of angular deformation of a fluid.

9. **The capillary depression in mercury is on account of**
   (a) adhesion being greater than cohesion
   (b) Surface tension being greater than viscosity
   (c) Cohesion being greater than adhesion
   (d) Vapour pressure being small

10. **1 stoke is equal to**
    (a) 1 cm^2/s (b) 1 m^2/s (c) 0.10 cm^2/s (d) 0.10 m^2/s

11. **1 Poise is equal to**
    (a) 1 $N.s/m^2$ (b) 0.10 $N.s/m^2$ (c) 10 $N.s/m^2$ (d) 100 $N.s/m^2$

12. **In case of mechanics of solids, the law similar to Newton's law of viscosity is**
    (a) Hooke's law (b) Archimede's principle
    (c) Newton's first law (d) Newton's second law of motion

13. **The unit of kinematic viscosity of a fluid is**
    (a) m^2/s (b) cm^2/s (c) $N.s/m^2$ (d) Poise

14. **All liquid surfaces tend to stretch. This phenomenon is called**
    (a) Cohesion (b) Adhesion (c) Surface tension (d) Cavitation

15. **Falling drops of water become spherical because of**
    (a) Surface tension (b) Cohesion (c) adhesion (d) Viscosity

16. **For a liquid droplet, the internal pressure in excess of outside pressure is given by**
    (a) $\frac{8\sigma}{d}$ (b) $\frac{4\sigma}{d}$ (c) $\frac{2\sigma}{d}$ (d) $\frac{\sigma}{d}$

17. **At a liquid – air – solid interface, the contact angle θ is less than 90°. This indicates that the liquid is**
    (a) ideal (b) wetting
    (c) Non–wetting (d) does not form a stable bubble.

18. **In the phenomenon of cavitation, the characteristic fluid property involved is**
    (a) Surface tension (b) Viscosity
    (c) Vapour pressure (d) bulk modulus of elasticity

: ANSWERS :

1. (d)	2. (c)	3. (b)	4. (b)	5. (c)
6. (b)	7. (b)	8. (b)	9. (c)	10. (a)
11. (b)	12. (a)	13. (b)	14. (c)	15. (a)
16. (b)	17. (b)	18. (c)		

SET-2 : Hydrostatics

1. One atmospheric pressure equals

(a) 760 mm of mercury head (b) 10.34 m of water column

(c) 1.01325 bar (d) 101.43 kPa

(e) all of the above

2. A block of ice floats on the surface of water contained in a vessel. How the water level will change when the snow melts ?

(a) rises (b) falls

(c) remains the same (d) depends on the temperature

3. Indicate the variation of hydrostatic pressure with depth below the free surface :

(a) It increases as the depth increases.

(b) It decreases with the increase in depth.

(c) There is no change with depth.

(d) After a certain period there is no change in pressure.

4. The hydrostatic law of pressure variation is expressed by :

(a) $p = \frac{z}{w}$ (b) $p = wz$ (c) $p = wz + \text{constant}$ (d) $p = \text{constant}$

5. Local atmospheric pressure is measured by

(a) a manometer (b) a Bourdon gauge

(c) a mercury manometer (d) a vacuum gauge

6. Standard atmospheric pressure in terms of water column is

(a) 9.81 m (b) 10.34 m (c) 8.75 m (d) 12.35 m

7. According to Pascal's law, pressure at any point in a liquid is

(a) same in vertical direction (b) same in horizontal direction

(c) same in all directions (d) different in different directions

8. 1 bar = ... Pa.

(a) 1 Pa (b) 10^3 Pa (c) 1.01325 Pa (d) 10^5 Pa

9. Pressure measured with the help of piezometer tube is

(a) absolute pressure (b) gauge pressure

(c) atmospheric pressure (d) vacuum pressure

10. Math the column A and column B :

A (Structure)	B (hydrostatic force resisted by)
(i) Gravity dam	(a) Strength of cylindrical shell
(ii) Circular water tank	(b) Abutment reactions
(iii) Arch dam	(c) hinge and side reaction
(iv) Lock gates	(d) Weight of concrete

11. Absolute pressure in a flow–system :

(a) is always above local atmospheric pressure.

(b) is a vacuum pressure.

(c) may be above, below or equal to the local atmospheric pressure.

(d) is also called negative pressure.

12. Mercury is generally used in manometers for measuring :

(a) Low pressures accurately

(b) Large pressures only

(c) All pressures except the smaller ones

(d) Very low pressures

13. 0.3 m head of oil (Sp. gr. 0.8) is equal to

(a) 0.3 m head of water (b) 0.24 m head of water

(c) 1.3 m head of water (d) 10.34 m head of water

14. Differential manometer is used to measure

(a) absolute pressure at a point (b) pressure difference between two points

(c) atmospheric pressure (d) all the above

: ANSWERS :

1. (e)	2. (c)	3. (a)	4. (b)	5. (c)
6. (b)	7. (c)	8. (d)	9. (b)	10. (i) – d
(ii) – a	(iii) – b	(iv) – c	11. (c)	12. (c)
13. (b)	14. (b)			

SET-3 : Total Pressure and Centre of Pressure

1. The centre of pressure acts .... the C.G. of the immersed surface.

(a) at (b) above (c) below (d) can't say

2. The distance of C.G. and centre of pressure for a vertically immersed surface is equal to

(a) $\frac{I_g}{\bar{h}}$ (b) $\frac{I_g}{A\bar{h}}$ (c) $\frac{I_g}{A\bar{h}}+\bar{h}$ (d) $\frac{A\bar{h}}{I_g}$

3. The total pressure on an immersed surface inclined at an angle θ with the liquid surface is

(a) $wA\bar{h}$ (b) $\frac{wA\bar{h}}{\sin\theta}$ (c) $\frac{wA\bar{h}}{\cos\theta}$ (d) $\frac{wA\bar{h}}{\tan\theta}$

4. **The total pressure on a vertically immersed surface is**

(a) wA (b) $w\bar{h}$ (c) $wA\bar{h}$ (d) $\frac{wA\bar{h}}{\sin\theta}$

5. **The horizontal component of force on a curved surface is equal to**
   (a) Product of pressure at its centroid and area
   (b) Weight of liquid retained by the curved surface
   (c) Force on a vertical projection of the curved surface
   (d) Weight of liquid vertically above curved surface

6. **The vertical component of pressure force on a submerged curved surface is equal to**
   (a) Product of pressure at its centroid and area
   (b) Weight of liquid vertically above the curved surface
   (c) Weight of liquid retained by the curved surface
   (d) Force on vertical projection of curved surface

7. **The depth of centre of pressure for an immersed surface inclined at an angle θ with the liquid surface lies at a distance .... below its e.G.**

(a) $\frac{I_g . \sin\theta}{A\bar{h}}$ (b) $\frac{I_g . \sin^2\theta}{A\bar{h}}$ (c) $\frac{I_g . \cos\theta}{A\bar{h}}$ (d) $\frac{I_g . \cos^2\theta}{A\bar{h}}$

8. **The depth of centre of pressure for a vertically immersed surface is given by**

(a) $\frac{I_g}{A\bar{h}}$ (b) $\frac{I_g}{A} + \bar{h}$ (c) $\frac{I_g}{A} + A\bar{h}$ (d) $\frac{I_g}{A\bar{h}} + \bar{h}$

: ANSWERS :

1. (c)	2. (b)	3. (c)	4. (c)
5. (c)	6. (b)	7. (b)	8. (d)

SET-4 : Buoyancy and Flotation

1. **The centre of gravity of the volume displaced by a floating body is called**
   (a) Centre of pressure (b) Centre of buoyancy
   (c) Metacentre (d) all of these

2. **When a body floating in a liquid is given a small angular displacement, it starts oscillating about a point. This point is called**
   (a) Centre of pressure (b) Centre of gravity
   (c) Centre of buoyancy (d) metacentre

3. A floating body is in stable equilibrium when

(a) C.G. is below the centre of buoyancy (b) its metacentric height is zero

(c) Its metacentric height is positive (d) its metacentric height is negative

4. If G is the centre of gravity, B is the centre of buoyancy and M is the metacentre of a floating body then for the body to be in unstable equilibrium

(a) GM = 0 (b) BG = 0 (c) M is below G (d) M is above G

5. For stable equilibrium of a floating body

(a) $BG = \frac{I}{V} + MG$ (b) $GM = \frac{I}{V} + BG$ (c) $GM = \frac{I/V}{BG}$ (d) $GM = \frac{I}{V} - BG$

6. For warships, metacentric height of a ship should vary between

(a) 0 – 1 m (b) 1 – 2 m (c) 5 – 10 m (d) More than 10 m

7. The metacentric height of two bodies A and B are 1 m and 1.5 m respectively. Select the correct statement.

(a) Both A and B have equal stability (b) Both A and B are unstable

(c) Body A is more stable than B (d) Body B is more stable than A

8. During flood water entered an office having wooden tables. Indicate the position of tables, if floating

(a) Legs downwards (b) Legs on sides

(c) Legs upwards (d) The tables will not float

9. Match list I and list II.

List I		List II	
A.	G is above M	1.	Stable equilibrium
B.	G and M coincide	2.	Unstable equilibrium
C.	G is below M	3.	Floating body
D.	$F_b \geq W$	4.	Neutral equilibrium

Codes :

	A	B	C	D
(a)	1	3	2	4
(b)	3	1	4	2
(c)	2	3	4	1
(d)	2	4	1	3

: ANSWERS :

1. (b)	2. (d)	3. (c)	4. (c)	5. (d)
6. (b)	7. (d)	8. (c)	9. (d)	

SET-5 : Fluid Kinematics

1. The path traced by a single particle of smoke issuing from a cigarette is a

(a) Streamline (b) Flow line (c) Path line (d) Streakline

2. Laminar flow is also called

(a) Steady flow (b) Uniform flow (c) Unsteady flow (d) Streamline or viscous flow

3. A streamline is a line

(a) Connecting mid points of a flow cross–section

(b) Drawn normal to the velocity vector at any point

(c) Connecting points of equal velocity in a flow

(d) Tangent to which at any point gives the direction of velocity.

4. For a two–dimensional flow field, the equation of streamline is

(a) $\frac{u}{dx} = \frac{dy}{v}$ (b) $\frac{du}{dx} + \frac{dv}{dy} = 0$ (c) $\frac{dy}{u} = \frac{dx}{v}$ (d) $\frac{dx}{u} = \frac{dy}{v}$

5. Steady irrotational flow of an incompressible fluid is called

(a) Streamline flow (b) Potential flow (c) Shear flow (d) Creeping flow

6. During the opening of a valve, the flow is

(a) Laminar (b) Unsteady (c) Uniform (d) Rotational

7. If ψ is the stream function, then velocity components u and v are given by :

(a) $u = \frac{\partial \Psi}{\partial x}, v = \frac{\partial \Psi}{\partial y}$ (b) $u = \frac{\partial \Psi}{\partial y}, v = \frac{-\partial \Psi}{\partial x}$

(c) $u = \frac{-\partial \Psi}{\partial y}, v = \frac{\partial \Psi}{\partial x}$ (d) $u = \frac{-\partial \Psi}{\partial y}, v = \frac{-\partial \Psi}{\partial x}$

8. The continuity equation $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = 0$ is valid for

(a) ideal fluid flow only

(b) incompressible fluids, whether flow is steady or unsteady

(c) steady flow, whether compressible or incompressible flow

(d) incompressible fluids and steady flow only.

9. Flow of water in river is example of

(a) One dimensional flow (b) Laminar flow

(c) Two dimensional flow (d) Three dimensional flow

10. If ϕ is a potential function, then velocity components u and v are given by

(a) $u = \frac{-\partial \phi}{\partial x}, v = \frac{-\partial \phi}{\partial y}$ (b) $u = \frac{\partial \phi}{\partial x}, v = \frac{\partial \phi}{\partial y}$ (c) $u = \frac{-\partial \phi}{\partial x}, v = \frac{\partial \phi}{\partial y}$ (d) $u = \frac{\partial \phi}{\partial x}, v = \frac{-\partial \phi}{\partial y}$

11. Vorticity is given by

(a) 1.5 times rotation (b) Two times rotation

(c) Three times rotation (d) equal to rotation

12. The local acceleration in the direction of x is given by

(a) $u\frac{\partial u}{\partial x}+\frac{\partial u}{\partial t}$ (b) $\frac{\partial u}{\partial t}$ (c) $u\frac{\partial u}{\partial x}$ (d) None of these

13. If velocity in a fluid flow does not change with respect to length of direction of flow, it is called

(a) Uniform flow (b) Steady flow (c) Incompressible flow (d) Rotational flow

14. If density of fluid is constant from point to point in a flow region, it is called

(a) Unsteady flow (b) Irrotational flow (c) Incompressible flow (d) none of the above

15. If the velocity, pressure, density etc. do not change at a point with respect to time, the flow is called

(a) Uniform (b) Steady (c) Non–uniform (d) incompressible

: ANSWERS :

1. (c)	2. (d)	3. (d)	4. (d)	5. (b)
6. (b)	7. (c)	8. (d)	9. (d)	10. (a)
11. (b)	12. (b)	13. (a)	14. (c)	15. (b)

SET-6 : Fluid Dynamics

1. Identify the Bernoulli's equation where each term represents energy per unit mass

(a) $z+\frac{v^2}{2g}+\frac{p}{w}$ = constant (b) $z+\frac{v^2}{2}+\frac{gp}{w}$ = constant

(c) $z+\frac{pv^2}{2}+\frac{g}{w}$ = constant (d) None of these

2. Study of fluid motion with the forces causing the flow is known as

(a) Kinematics of fluid flow (b) Dynamatics of fluid flow

(c) Statics of fluid flow (d) None of above

3. The term $\frac{v^2}{2g}$ is known as

(a) Potential energy (b) Pressure energy

(c) Kinetic energy per unit weight (d) None of the above

4. **The term $\frac{p}{w}$ is known as**
   (a) Kinetic energy per unit weight (b) Pressure energy
   (c) Pressure energy per unit weight (d) Potential energy
5. **The term Z is known as**
   (a) Potential energy (b) Potential energy per unit weight
   (c) Pressure energy (d) Pressure energy per unit weight
6. **The difference of pressure head (h) measured by mercury–oil differential manometer is given by**
   (a) $h = \left(\frac{S_1}{S_2} - 1\right)x$ (b) $h = \left(\frac{S_2}{S_1} - 1\right)x$ (c) $h = (S_1 - S_2)x$ (d) $h = (S_2 - S_1)x$

   where,
   S_1 = Sp. gravity of oil
   S_2 = Sp. gravity of mercury
   x = difference of mercury level
7. **Pitot–tube is used to measure**
   (a) Discharge (b) Average Velocity (c) Velocity at a point (d) Pressure at a point
8. **Venturimeter is used to measure**
   (a) Discharge (b) Average velocity (c) Velocity at a point (d) Pressure at a point
9. **Orifice meter is used to measure**
   (a) Discharge (b) Average velocity (c) Velocity at a point (d) Pressure at a point
10. **The rate of flow through venturimeter varies as**
   (a) H (b) $\sqrt{H}$ (c) $H^{3/2}$ (d) $H^{5/2}$
11. **The kinetic energy correction factor for laminar flow through a circular pipe is approximately equal to**
   (a) 1.0 (b) 1.5 (c) 2.0 (d) 2.25
12. **The Bernoulli's equation deals with the law of conservation of**
   (a) mass (b) work (c) length (d) energy
13. **Which of the following is not the assumption made in Bernoulli's equation ?**
   (a) The fluid is ideal (b) The fluid is compressible
   (c) The flow is irrotational (d) The flow is steady
14. **The working principle of venturimeter is based on**
   (a) Bernoulli's equation (b) Momentum equation
   (c) Continuity equation (d) None of the above

ANSWERS

1. (a)	2. (b)	3. (c)	4. (c)	5. (b)
6. (b)	7. (c)	8. (a)	9. (a)	10. (b)
11. (c)	12. (d)	13. (b)	14. (a)	

SET-7 : Flow through Pipes

1. The loss of head due to friction according to Darcy's formula is

(a) $\frac{f l V^2}{2gd}$ (b) $\frac{4 f l V^2}{2gd}$ (c) $\frac{4 f l V^2}{gd}$ (d) $\frac{4 f l V}{2gd}$

2. The T.E.L. lies over the H.G.L. by an amount equal to

(a) $\frac{V^2}{2g}$ (b) Z (c) $\frac{P}{\rho g}$ (d) $\frac{V}{2g}$

3. The hydraulic mean depth for a circular pipe is

(a) $\frac{d}{2}$ (b) $\frac{d}{3}$ (c) $\frac{d}{4}$ (d) $\frac{d}{6}$

4. The loss of head due to sudden enlargement is given by

(a) $\frac{0.5 V_2^2}{2g}$ (b) $\frac{(V_1 - V_2)^2}{2g}$ (c) $\frac{(V_1 + V_2)^2}{2g}$ (d) $\frac{V^2}{2g}$

5. The loss of head at the exit is

(a) $\frac{0.5 V^2}{2g}$ (b) $\frac{V^2}{2g}$ (c) $\frac{(V_1 - V_2)^2}{2g}$ (d) $\frac{(V_1 + V_2)^2}{2g}$

6. The relation between friction factor and coefficient of friction (f) is given by

(a) $C_f = f$ (b) $C_f = 2f$ (c) $C_f = 4f$ (d) $C_f = 3f$

7. Loss of head due to friction in pipe is given by

(a) Bernoulli's equation (b) Continuity equation

(c) Manning's equation (d) Darcy–Weisbach equation

8. A compound pipe is required to be replaced by a new pipe. Both the pipes are said to be equivalent if both of them have same

(a) length and diameter (b) loss of head (c) discharge (d) both 'b' and 'c'

9. In case of parallel pipes

(a) loss of head for all pipes is same

(b) total discharge is equal to sum of discharge in all pipes

(c) Total loss of head is equal to the sum of loss of heads in all the pipes.

(d) Both 'a' and 'b'

10. For pipes arranged in series

(a) The head loss must be same in all the pipes
(b) The velocity must be same in all pipes
(c) The flow may be different in different pipes
(d) The total flow is same flowing through each pipe

11. Pipes are arranged in parallel to

(a) increase discharge (b) decrease head loss
(c) decrease discharge (d) reduce length of pipe

12. The power transmitted through a pipe is maximum when the head loss due to friction is equal to

(a) $\frac{H}{2}$ (b) $\frac{H}{3}$ (c) H (d) $\frac{H}{4}$

ANSWERS

1. (b)	2. (a)	3. (c)	4. (b)	5. (b)
6. (c)	7. (d)	8. (d)	9. (d)	10. (d)
11. (a)	12. (b)			

SET-8 : Orifice and Mouthpieces

1. The theoretical velocity of the jet at vena–contracta is

(a) $\sqrt{2gH}$ (b) $2\sqrt{gH}$ (c) $2g\sqrt{H}$ (d) 2gH

2. The relation between C_v, C_c and C_d is

(a) $C_d = C_v + C_c$ (b) $C_d = C_v - C_c$ (c) $C_d = C_v \times C_c$ (d) $C_d = C_v/C_c$

3. The coefficient of velocity is determined experimentally by using the relation

(a) $C_v = \sqrt{\frac{y^2}{4xH}}$ (b) $C_v = \sqrt{\frac{y}{4xH}}$ (c) $C_v = \sqrt{\frac{x^2}{4yH}}$ (d) $C_v = \sqrt{\frac{x}{4yH}}$

4. Coefficient of discharge for external cylindrical mouthpiece is

(a) 0.98 (b) 0.90 (c) 0.82 (d) 0.855

5. An orifice is said to be large, if

(a) Size of orifice is large (b) Velocity of flow is large
(c) Available head of water is more than 5 times its height
(d) Available head of water is less than 5 times its height

6. An orifice fitted with some kind of pipe extension is known as

(a) Notch (b) Weir (c) mouthpiece (d) Nozzle

ANSWERS

1. (a)	2. (c)	3. (c)	4. (d)	5. (d)	6. (c)

SET-9 : Notches and Weirs

1. **The discharge over rectangular notch is**
   (a) directly proportional to $H^{3/2}$ (b) Directly proportional to $H^{5/2}$
   (c) Inversely proportional to $H^{3/2}$ (d) Inversely proportional to $H^{5/2}$
2. **The discharge over a triangular notch is**
   (a) directly proportional to $H^{3/2}$ (b) Directly proportional to $H^{5/2}$
   (c) Inversely proportional to $H^{3/2}$ (d) Inversely proportional to $H^{5/2}$
3. **The discharge over a rectangular notch is given by**
   (a) $\frac{3}{2}C_d.L\sqrt{2gH}$ (b) $\frac{2}{3}C_d.L\sqrt{2g}\times H$
   (c) $\frac{2}{3}C_d.L.\sqrt{2g}\times H^{3/2}$ (d) $\frac{2}{3}C_d.L.\sqrt{2g}.H^{5/2}$
4. **The maximum discharge over a broad crested weir is**
   (a) $1.71\ C_d\cdot L\cdot\sqrt{2gH}$ (b) $1.71\ C_d\cdot L\cdot\sqrt{2g}\ H$
   (c) $1.71\ C_d\cdot L\cdot\sqrt{2g}\times H^{3/2}$ (d) $1.71\ C_d\cdot L\cdot H^{3/2}$
5. **The upper surface of a weir over which water flows is known as**
   (a) nappe (b) crest (c) edge (d) weir top
6. **Cipolletti weir is a special type of .... weir.**
   (a) triangular (b) trapezoidal (c) stepped (d) all of above

ANSWERS

1. (a)	2. (b)	3. (c)	4. (d)	5. (b)	6. (b)

SET-10 : Compressible Fluid Flow

1. **The value of gas constant (R) is**
   (a) 0.287 J/kg°k (b) 2.87 J/kg°k (c) 28.7 J/kg°k (d) 287 J/kg°k
2. **When a gas is heated or expanded in such a way that the product of its pressure and volume remains constant, it is called**
   (a) isothermal process (b) adiabatic process
   (c) isobaric process (d) None of these
3. **The velocity of sound wave is given by**
   (a) $C=\sqrt{\frac{k}{RT}}$ (b) $C=\sqrt{\frac{1}{kRT}}$ (c) $C=\sqrt{kRT}$ (d) $C=k\sqrt{RT}$

4. If the mach number of flow is unity, then the flow is

(a) Subsonic (b) Sonic (c) Supersonic (d) hypersonic

5. Mach number is the ratio of inertia force and

(a) Viscous force (b) Gravity force (c) Pressure Force (d) elastic force

6. Mach angle (α) is given by

(a) $\sin^{-1}\left(\frac{1}{M}\right)$ (b) $\sin^{-1}\left(\frac{1}{M^2}\right)$ (c) $\sin^{-1}(M)$ (d) $\tan^{-1}\left(\frac{1}{M}\right)$

7. Velocity of sound wave in isothermal process is

(a) $\sqrt{kRT}$ (b) $\sqrt{RT}$ (c) kRT (d) RT

8. When a projectile moves with supersonic velocity

(a) Pressure wave also travels with projectile.

(b) Pressure wave lag behind the projectile.

(c) Pressure wave travels at speed higher than the speed of projectile.

(d) None of these

9. For supersonic flow, if the area of flow increases then

(a) Velocity decreases (b) Velocity increases

(c) Velocity is constant (d) None of the above

10. The velocity of sound is largest in

(a) air (b) kerosene (c) water (d) steel

11. The effect of compressibility can be neglected when mach number

(a) 1 (b) less than 1 (c) up to 0.5 (d) up to 0.2

12. Across the normal shock the fluid properties change in such a way that the

(1) Velocity of flow is subsonic (2) Pressure increases

(3) Specific volume decreases (4) Temperature decreases

(a) 2, 3 and 4 (b) 1, 2 and 4 (c) 1, 3 and 4 (d) 1, 2 and 3

ANSWERS

1. (d)	2. (a)	3. (c)	4. (b)	5. (d)
6. (a)	7. (b)	8. (b)	9. (b)	10. (d)
11. (d)	12. (d)			

SET-11

1. **When shear stress is applied to a substance it is found to resist it by static deformation. The substance is a** (GATE)
   (a) liquid (b) solid (c) gas (d) uncertain

2. **A fluid is said to be Newtonian when the shear stress is** (GATE)
   (a) directly proportional to the velocity gradient
   (b) inversely proportional to the velocity gradient
   (c) independent of the velocity gradient
   (d) None of these

3. **Shear stress develops on a fluid element, if** (GATE)
   (a) The fluid is at rest
   (b) The fluid container is subject to uniform linear acceleration
   (c) The fluid is in viscid
   (d) The fluid is viscous and the flow is nonuniform

4. **Bodies in flotation to be in stable equilibrium, the necessary and sufficient condition is that the centre of gravity is located below the** (GATE)
   (a) centre of gravity (b) Centroid (c) metacentre (d) epicentre

5. **What can be definitely said about the tube flow in the diagram below ?** (GATE)

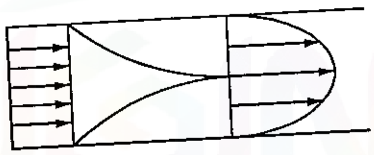


FIG. Q–5

   (a) Flow is turbulent
   (b) Compressible flow
   (c) Flow is laminar
   (d) Incompressible flow

6. **In which of the following arrangements would the vertical force on the cylinder due to water be the maximum ?** (GATE, IES)

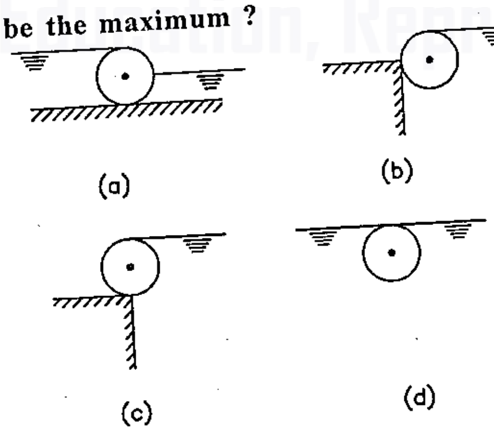


FIG. Q–6

7. **If for a fluid in motion, pressure at a point is same in all directions, then the fluid is** **(GATE)**

   (a) a real fluid (b) a Newtonian fluid
   (c) an ideal fluid (d) a non–Newtonian fluid

8. **A vertical triangular plane area, submerged in water, with one side in the free surface, vertex downward and altitude h, has the pressure centre below the free surface by** **(GATE)**

   (a) $\frac{h}{4}$ (b) $\frac{h}{3}$ (c) $\frac{2h}{3}$ (d) $\frac{h}{2}$

9. **The unit of dynamic viscosity is** **(GATE)**

   (a) m^2/sec (b) $N.sec/m^2$ (c) $Pa.sec/m^2$ (d) $kg.sec^2/m^2$

10. **The discharge velocity at the pipe exit in the given figure is** **(GATE)**

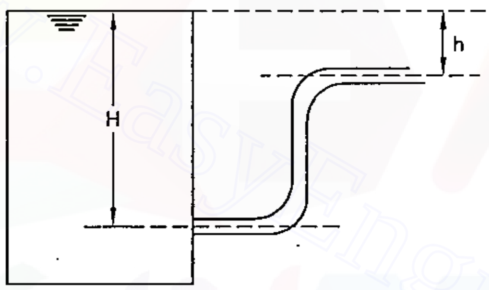


FIG. Q–10

   (a) $\sqrt{2}\,gH$
   (b) $\sqrt{2gh}$
   (c) $\sqrt{2g(H+h)}$
   (d) 0

11. **The centre of pressure of a liquid on a plane surface immersed vertically in a static body of liquid, always lies below the centroid of the surface area, because** **(GATE)**

   (a) in liquids the pressure acting is same in all directions
   (b) there is no shear stress in liquids at rest
   (c) the liquid pressure is constant over depth
   (d) the liquid pressure increases linearly with depth

12. **A force F of 800 N is applied as shown, what maximum weight W can be supported ? Neglect the weight of the pistons.** **(NTPC)**

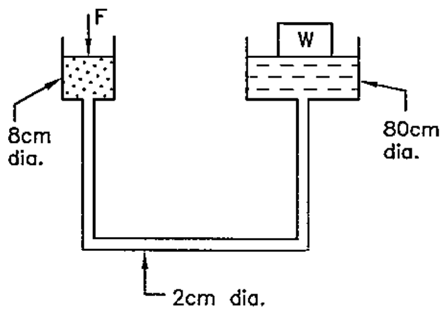


FIG. Q–12

   (a) 800 N
   (b) 8000 N
   (c) 40000 N
   (d) 80,000 N

13. Water is flowing with a flow rate of 0.002 m^3/s. What is its average velocity at an outlet where the area is 4 cm^2 ? (NTPC)

(a) 50 m/s (b) 20 m/s (c) 10 m/s (d) 5 m/s

14. For a fluid, the shear stress was found to be directly proportional to the rate angular deformation. The fluid is classified as (NTPC)

(a) Newtonian (b) Non–Newtonian (c) Dilantant fluid (d) Thixotropic

15. A vertical square gate holds back water as shown in figure given below. The moment about the bottom edge is (NTPC)

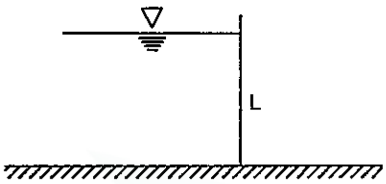


FIG. Q–15

(a) $\frac{\gamma L^3}{2}$ (b) $\frac{\gamma L^3}{3}$

(c) $\frac{\gamma L^4}{3}$ (d) $\frac{\gamma L^4}{6}$

16. Broadly speaking, water is (GATE)

(a) 10 times more compressible than steel

(b) 80 times more compressible than steel

(c) 80 times less compressible than steel

(d) 800 times less compressible than steel

17. A pathline is the (GATE)

(a) Mean direction of a number of particles at the same instant of time

(b) Instantaneous picture of positions of all particles in the flow which passed a given point

(c) Trace made by a single particle over a period of time

(d) Path traced by continuously injected tracer at a point

18. A floating body is in stable equilibrium (Civil Services)

(a) When its metacentric height is zero

(b) When the centre of gravity of the body is below the centre of buoyancy

(c) When its metacentre is above the centre of gravity of body

(d) None of these

19. F **μ = 0.06 poise, ρ = 0.9 gm/cm^3, kinematic viscosity ν in stokes is** (Civil Services)

(a) 0.04 (b) 0.054 (c) 0.067 (d) 0.4

20. A worden plank (sp. gravity 0.5) 1 m × 1 m × 0.5 m floats in water with 1.5 kN load on it with 1 m × 1 m surface horizontal. The depth of plank lying below water surface shall be (Civil Services)

(a) 0.178 m (b) 0.250 m (c) 0.403 m (d) 0.50 m

21. The centre of pressure of a submerged plane area is (BHEL)

(a) at the centroid of the area

(b) always below the centroid of the area

(c) independent of the orientation of the area

(d) The point where the resultant force due to pressure acts on the area

22. A rectangular open container filled with water as shown below and is at rest. If this container is moved horizontally to the right at a constant uniform acceleration, the pressure at A will (IES)

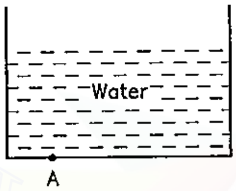


FIG. Q–22

(a) decrease

(b) increase

(c) stay the same

(d) First decrease then stay the same

23. A streamline is a line (BHEL)

(a) which is normal to the velocity vector at every point

(b) which represents lines of constant velocity potential

(c) which is normal to the lines of constant stream function

(d) which is tangential to the velocity vector everywhere at a given instant

24. Match List I and List II. (Civil Services)

List I		List II	
A.	Venturimeter	1.	Flow rate
B.	Current meter	2.	Flow velocity
C.	Piezometer	3.	Flow pressure

Codes :

	A	B	C
(a)	1	2	3
(b)	2	1	3
(c)	3	1	2
(d)	3	2	1

25. The viscosity of (IES)

(a) liquids increases with temperature

(b) gases increases with temperature

(c) fluids decreases with temperature

(d) fluids increases with temperature

26. Viscosity has dimension (IES)

(a) $\frac{FT^2}{L}$ (b) $\frac{F}{LT^2}$ (c) $\frac{M}{LT^2}$ (d) $\frac{M}{LT}$

27. **The dimensions of kinematic viscosity are** (IES)
(a) $ML^{-1}T^{-2}$ (b) $ML^{-1}T^{-1}$ (c) LT^{-1} (d) LT^{-2}

28. **The dimensions of a pressure gradient in a fluid flow are** (GATE)
(a) $ML^{-1}T^{2}$ (b) $ML^{-3}T^{-2}$ (c) $ML^{-2}T^{-2}$ (d) $M^{-1}L^{-3}T^{-2}$

29. **The point in the immersed body through which the resultant pressure of the liquid may be taken to act is known as** (IES)
(a) Centre of gravity (b) Centre of buoyancy
(c) Centre of pressure (d) metacentre

30. **If the weight of a body immersed in a fluid exceeds the buoyant force, then the body will** (IES)
(a) rise until its weight equals the buoyant force
(b) tend to move downward and it may finally sink
(c) float
(d) None of these

31. **Which one of the following pressure units represents the least pressure ?**
(a) Millibar (b) mm of mercury (c) N/mm^2 (d) kgf/cm^2

32. **A vertical gate 6 m × 6 m holds water on one side with the free surface at its top. The moment about the bottom edge of the gate of the water force will be (γ is the specific weight of water)** (IES)
(a) 18 γ (b) 36 γ (c) 72 γ (d) 216 γ

33. **In a fluid flow, the line of constant piezometric head passes through two points which have the same** (IES)
(a) Elevation (b) pressure (c) Velocity (d) Velocity potential

34. **All other conditions and parameters remaining the same, water hammer pressure can be reduced by** (IES)
(a) using pipe of greater diameter (b) using pipe of greater wall thickness
(c) using a more elastic pipe (d) increasing the velocity of pressure wave

35. **The flow of water in wash hand basin when it is being emptied through a central opening is an example of** (IES)
(a) free vortex (b) forced vortex (c) rotational vortex (d) Rankine vortex

36. **At a hydraulic jump, the depths at the two sides are 0.4 m and 1.4 m. The head loss in the jump is nearly** (IES)
(a) 1.0 m (b) 0.9 m (c) 0.7 m (d) 0.45 m

37. **There are four variables, namely** (IES)
E (Volume modulus of elasticity) p (Pressure per unit area)
g (acceleration due to gravity) μ (viscosity of water)

They are associated with Mach, Euler, Froude and Reynolds numbers respectively, in the order

(a) E, p, μ, g (b) p, E, μ, g (c) p, E, g, μ (d) E, p, g, μ

38. The coefficient of velocity for an orifice is given by (using usual notations) (IES)

(a) $\frac{x}{2\sqrt{yH}}$ (b) $\frac{2x}{\sqrt{yH}}$ (c) $\frac{x}{\sqrt{yH}}$ (d) $\sqrt{\frac{x^2}{2yH}}$

39. An object floats in water such that nine tenth of the object is submerged. What is its density ?

(a) 600 kg/m^3 (b) 700 kg/m^3 (c) 800 kg/m^3 (d) 900 kg/m^3

40. A real fluid is any fluid which

(a) has surface tension and is incompressible (b) has zero shear stress
(c) has constant viscosity and density (d) has viscosity

41. The moody diagram is used in fluid mechanics to obtain the

(a) drag coefficient (b) strouhal number
(c) friction factor (d) Manning's constant, n

42. A model study is to be performed to investigate the problem of the pollution of smoke emanating from the stacks on the deck of a passenger ship. A parameter of primary concern in this study is the

(a) Reynolds number (b)Mach number (c) Froude number (d) Weber number

43. A control volume is

(a) a volume of fluid flowing per unit of time
(b) a volume fixed in space
(c) The volume in which a control device is situated
(d) the volume of the fluid controlling device

44. A model of reservoir is emptied in 10 minutes. If the model scale is 1 : 25, the time taken by the prototype to empty itself, would be (IES)

(a) 250 minutes (b) 50 minutes (c) 6250 minutes (d) 2 minutes

45. The ratio of inertia force to pressure force is called

(a) Weber number (b) Froude number (c) Euler number (d) Prandtl number

46. An equipotential line

(a) has no velocity component normal to it (b) has constant dynamic pressure
(c) has no velocity component tangent to it (d) is the same as stream line

47. Existence of velocity potential implies that (GATE)

(a) Fluid is in continuum (b) fluid is irrotational
(c) Fluid is ideal (d) fluid is compressible

48. **In a flow field, the stream line and equipotential lines** (GATE)
(a) are parallel (b) are orthogonal anywhere in the flow field
(c) cut at any angle (d) cut orthogonally except at the stagnation point

49. **For fully developed flow through a pipe, the ratio of the maximum velocity to the average velocity is** (GATE)
(a) 1 (b) 2 (c) $\sqrt{2}$ (d) 4

50. **The path traced by a single particle of smoke issing from a cigarette is a**
(a) Stream line (b) Streak line (c) Pathline (d) Flowline

51. **If the Froude number of flow in an open channel is more than 1, the flow is said to be** (Civil Services)
(a) critical (b) Shooting (c) Streaming (d) transitional

52. **Oscillating hydraulic jump is formed when the Froude's number is** (IES)
(a) 1.0 (b) 1.5 (c) 2.0 (d) 5.0

53. **Aging of pipes implies** (IES)
(a) relative roughness decrease with time (b) pipe becoming smoother with time
(c) increase in absolute roughness (d) decrease in absolute roughness

54. **A centrifugal pump takes too much power due to** (Civil Services)
(a) low speed (b) air in water (c) air leakage (d) heavy liquid

55. **If specific speed of a turbine is 6, then turbine should be** (IES)
(a) Francis (b) Kaplan (c) Pelton wheel (d) Thomson

56. **The specific speed of a pump is defined as the speed of a pump of such size that** (IES)
(a) With unit discharge at unit head (b) it requires unit power for unit head
(c) it delivers unit discharge at unit head (d) it delivers unit discharge at any head

57. **A foot value is provided on** (IES)
(a) Centrifugal pump (b) Kaplan turbines (c) Pelton wheels (d) all of these

58. **If specific speed of a turbine is 800, then terbine should be** (Civil Services)
(a) Francis (b) Kaplan (c) Girard (d) Pelton wheel

59. **The discharge through rectangular weir varies as** (IES)
(a) H (b) $H^{1/2}$ (c) H^2 (d) $H^{3/2}$

60. **The hydraulic gradient line is always** (IES)
(a) below the total energy line (b) parallel to the bottom
(c) above the total energy line (d) none of these

61. **If a centrifugal pump is noisy in operation it may be due to,** (IES)
(a) Faulty priming (b) Suction head too high
(c) air in water (d) Mechanical defect

62. **Low specific speed of turbine implies that it is a** **(Civil Services)**
(a) Propeller turbine (b) Francis turbine (c) Impulse turbine (d) None of these

63. **High specific speed of turbine implies that it is a** **(Civil Services)**
(a) Propeller turbine(b) Francis turbine (c) Impulse turbine (d) None of these

64. **Reaction turbines are used for** **(Civil Services)**
(a) Low head (b) high head
(c) high head and low discharge (d) low head and high discharge

65. **Low specific speed of a pump implied that it is a** **(IES)**
(a) Centrifugal pump (b) Mixed flow pump
(c) axial flow pump (d) none of these

66. **Hydraulic jump is used for** **(IES)**
(a) increasing the flow rate (b) reducing the flow rate
(c) reducing the velocity of flow (d) reducing the energy of flow

67. **For small discharge at high pressure, pump preferred is** **(IES)**
(a) Centrifugal pump (b) axial flow (c) propeller (d) reciprocating

68. **In centrifugal pump, the liquid enters the pump** **(IES)**
(a) at the top (b) at the bottom (c) at the centre (d) from sides

69. **In centrifugal pumps, maximum efficiency is obtained when the blades are** **(IES)**
(a) Straight (b) bent forward (c) bent backward (d) radial

70. **Power required to drive a centrifugal pump is proportional to** **(Civil Services)**
(a) N (b) N^2 (c) N^3 (d) N^4
where, N = speed

71. **The unit of specific speed is** **(IES)**
(a) RPM (b) metres/sec (c) dimensionless (d) None of these

72. **For pumping viscous oil, the pump used is** **(Civil services)**
(a) Centrifugal pump (b) Reciprocating pump
(c) Turbine pump (d) None of these

73. **In Kaplan turbine runner, number of blades is generally** **(IES)**
(a) 2 – 4 (b) 4 – 8 (c) 8 – 16 (d) 16 – 24

74. **Air vessels used in reciprocating pumps are initially filled with** **(IES)**
(a) compressed air (b) water (c) vacuum (d) none of these

75. **Priming is required in** **(Civil Services)**
(a) Centrifugal pumps (b) gear pumps (c) Reciprocating pumps (d) all of these

76. **The hydraulic radius is given by** **(IES)**
(a) Wetted perimeter divided by area
(b) Area divided by square of wetted perimeter

(c) square root of area
(d) area divided by wetted perimeter

77. One horse power is equal to (IES)
(a) 102 watts (b) 75 watts (c) 550 watts (d) 735 watts

78. Air vessel is used in a reciprocating pump to obtain (IES)
(a) reduction of suction head (b) rise in delivery head
(c) continuous supply of water at uniform rate (d) increase in supply of water

79. The magnus effect is defined as
(a) the generation of lift per unit drag force
(b) the circulation induced in an air craft wing
(c) The separation of boundary layer near the trailing edge of a slender body
(d) the generation of lift on a rotating cylinder in a uniform flow

80. Laminar layer may develop during flow over a flat–plate. It exists in (IES)
(a) Laminar zone (b) Transition zone
(c) Turbulent zone (d) Laminar and transition zone

81. Laminar flow occurs between extensive stationary plates. The kinetic energy correction factor is nearly (IES)
(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.3

82. The relative thickness (δ/x) of turbulent boundary layer on a flat plate (IES)
(a) Decreases with distance (x) (b) Increases with distance (x)
(c) Remains constant (d) Depends on relative roughness

83. The increase in metacentric height
(a) increases stability (b) decreases stability
(c) increases comfort for passengers (d) decrease comfort for passengers
The correct answer is
(a) 1 and 3 (b) 1 and 4 (c) 2 and 3 (d) 2 and 4

84. Surface tension of water
(a) increase with decrease in temperature (b) decrease with decrease in temperature
(c) independent of temperature (d) none of these

85. A vertical triangular area with vertex downward and altitude h has its base lying on the free surface of a liquid. The centre of pressure below the free surface is at a distance of
(a) $\frac{h}{4}$ (b) $\frac{h}{3}$ (c) $\frac{h}{2}$ (d) $\frac{2h}{3}$

86. Size of venturimeter is specified by
(a) pipe dia (b) throat dia
(c) angle of diverging section (d) both pipe dia and throat dia

87. **The locus of elevations that water will rise in a series of pitot tubes is called**
    (a) energy grade line (b) hydraulic grade line
    (c) pressure head (d) velocity head
88. **The continuity equation is based on the principle of conservation of**
    (a) mass (b) energy (c) momentum (d) none of these
89. **In steady flow of a fluid, total acceleration of any fluid particle**
    (a) can be zero (b) is never zero
    (d) is always zero (d) is independent of co–ordinates
90. **The non–dimensinal parameter is**
    (a) Froude number (b) Darcy – Weisbach friction factor
    (c) Chezy's coefficient (d) Mach number
91. **The non–dimensional parameter is**
    (a) Specific weight (b) Manning's coefficient n
    (c) angular velocity (d) Specific gravity
92. **In the Bernoulli's equation, used in pipe flow each term represents**
    (a) energy per unit weight (b) energy per unit mass
    (c) energy per unit volume (d) energy per unit flow length
93. **The relation between hydraulic coefficients C_v, C_c and C_d is given by**
    (a) $C_v = C_d \times C_c$ (b) $C_d = C_v \times C_c$
    (c) $C_v = C_d + C_c$ (d) $C_d = C_v + C_c$
94. **For the most economic rectangular channel section having width = b, water depth = d,**
    (a) b = 2 d (b) b = d (c) b = 1.5 d (d) b = 3d
95. **For the most economic trapezoidal channel the relation between hydraulic radius (R) and depth of flow is**
    (a) R = d (b) R = 2d (c) $R = \frac{d}{2}$ (d) R = 3d
96. **At room temperature, the dynamic and kinematic viscosity of water**
    (a) are both greater than that of air
    (b) are both less than that of air
    (c) are respectively greater than and less than that of air
    (d) are respectively less than and greater than that of air

: ANSWERS :

1. (b)	2. (a)	3. (d)	4. (c)	5. (c)
6. (b)	7. (c)	8. (c)	9. (b)	10. (b)
11. (d)	12. (d)	13. (d)	14. (a)	15. (d)
16. (b)	17. (c)	18. (c)	19. (c)	20. (c)

21. (d)	22. (b)	23. (d)	24. (a)	25. (b)
26. (d)	27. (c)	28. (c)	29. (c)	30. (b)
31. (c)	32. (b)	33. (a)	34. (c)	35. (a)
36. (d)	37. (d)	38. (a)	39. (d)	40. (d)
41. (c)	42. (a)	43. (b)	44. (b)	45. (c)
46. (c)	47. (b)	48. (b)	49. (b)	50. (c)
51. (b)	52. (c)	53. (a)	54. (b)	55. (c)
56. (c)	57. (a)	58. (b)	59. (d)	60. (a)
61. (d)	62. (c)	63. (a)	64. (d)	65. (a)
66. (d)	67. (d)	68. (c)	69. (c)	70. (c)
71. (a)	72. (c)	73. (b)	74. (b)	75. (a)
76. (d)	77. (d)	78. (c)	79. (d)	80. (c)
81. (a)	82. (b)	83. (a)	84. (a)	85. (c)
86. (d)	87. (a)	88. (a)	89. (a)	90. (c)
91. (d)	92. (a)	93. (b)	94. (a)	95. (c)
96. (b)				

EXPLANATIONS

12. (d) The pressure at a given height in a static fluid is constant. Hence, the pressure under both pistons is the same.

$$\therefore \quad \frac{F}{A_1} = \frac{W}{A_2}$$

$$\therefore \quad \frac{800}{\frac{\pi}{4} \times 8^2} = \frac{W}{\frac{\pi}{4} \times 80^2} \qquad \therefore \; W = 80{,}000 \text{ N}$$

13. (d) $Q = AV$

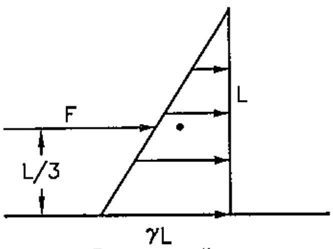
$$\therefore \quad V = \frac{Q}{A} = \frac{0.002}{4 \times 10^{-4}} = 5 \text{ m/s}$$

15. (d) Gate is square

$\therefore$ area of gate = L × L

Total force, $F = (\frac{1}{2} . \gamma L . L) \times$ length of gate

$$F = \frac{1}{2} . \gamma . L^3$$



Pressure dia.

FIG. E–15

∴ Moment at base

$$M = \frac{1}{2}\gamma . L^3 \times \frac{L}{3} = \frac{1}{6}\gamma L^4$$

19. (c) $\nu = \frac{\mu}{\rho} = \frac{0.06 \text{ Poise}}{0.9 \text{ gm/cm}^3} = 0.067$ stokes

OR

$\mu = 0.06$ Poise $= 0.006$ N.s/m^2

$\rho = 0.9$ gm/cm^3 $= 900$ kg/m^3

$$\therefore \quad \nu = \frac{\mu}{\rho} = \frac{0.006}{900} = 6.66 \times 10^{-6} \text{ m}^2/\text{s}$$

$= 6.66 \times 10^{-6} \times 10^4$ stokes

$= 0.067$ stokes

1 stoke $= 1 \times 10^{-4}$ m^2/s

20. (c) Volume of plank $= 1 \times 1 \times 0.5 = 0.5$ m^3

density of plank $= 0.5 \times 1000 = 500$ kg/m^3

$$G = \frac{\gamma_s}{\gamma_w}$$

∴ wt.of plank $= 0.5 \times 500 = 250$ kg

Additional wt $= 1.5$ kN $= \frac{1.5 \times 1000}{9.81}$ kg

$= 153$ kg

∴ Total wt $= 250 + 153 = 403$ kg

∴ Total wt. of water displaced $= 403$ kg

$$\therefore \quad \text{vol. of plank immersed} = \frac{403}{1000} = 0.403 \text{ m}^3$$

$$\therefore \quad \text{depth} = \frac{\text{vol.}}{\text{Area}} = \frac{0.403}{1 \times 1} = 0.403 \text{ m}$$

28. (c) Pressure gradient

= pressure intensity per unit length

$$= \frac{\text{dimension of pressure intensity}}{\text{dimension of length}}$$

$$= \frac{ML^{-1}T^{-2}}{L} = ML^{-2}T^{-2}$$

32. (d) Total force on gate

$F = \frac{1}{2}\cdot(\gamma h)$. h × length of gate

$= \frac{1}{2} \times \gamma \times 6 \times 6 \times 6$

$= 108\ \gamma$

∴ Moment at base $= 108\ \gamma \times \frac{1}{3} \times 6 = 216\ \gamma$

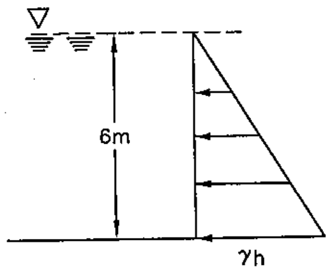


FIG. E–32

36. (d) $h_L = \frac{(y_2 - y_1)^3}{4y_1y_2} = \frac{(1.4-0.4)^3}{4\times 0.4\times 1.4} = 0.446\ \text{m} \simeq 0.45\ \text{m}$

38. (a) $C_v = \sqrt{\frac{x^2}{4yH}} = \frac{x}{2\sqrt{yH}}$

39. (d) density of object $= \text{density of water} \times \frac{9}{10}$

$= 1000 \times \frac{9}{10}$

$= 900\ \text{kg/m}^3$

44. (b) $T_r = \frac{T_p}{T_m}$ but $T_r = \sqrt{L_r} = \sqrt{25}$

$= 5$

$L_r = \frac{L_p}{L_m}$

$= \frac{25}{1}$

$= 25$

∴ $5 = \frac{T_p}{10}$ ∴ $T_p = 50$ minutes

51. (b) $F_r = 1$ critical flow

$F_r < 1$ Subcritical flow (Streaming)

$F_r > 1$ Super critical flow (Shooting)

55. (c) Low specific speed turbine .... Ns = 10 to 35
e.g. Pelton wheel

Medium specific speed .... Ns = 60 to 400
e.g. Francis turbine

High specific speed .... Ns = 300 to 1000
e.g. Kaplan turbine

85. (c) $h^* = \frac{I_g}{A\bar{h}} + \bar{h}$

$= \frac{bh^3/36}{\frac{1}{2}bh \times \frac{h}{3}} + \frac{h}{3} = \frac{h}{6} + \frac{h}{3} = \frac{h}{2}$

18.

Building Materials

MCQ'S

SET-1

1. **Gypsum is a**
   (a) mechanically formed sedimentary rock
   (b) metamorphic rock
   (c) chemically precipitated sedimentary rock
   (d) igneous rock
2. **Granite is not suitable for ordinary building purpose because**
   (a) it can not be polished (b) it is not fire proof material
   (c) it is costly (d) it has less crushing strength
3. **Which of the following trees yields hard wood ?**
   (a) deodar (b) chir (c) shishum (d) pine
4. **In which of the following pairs both trees yield soft wood ?**
   (a) deodar and shishum (b) chir and sal
   (c) sal and teak (d) chir and deodar
5. **Which of the following timbers is suitable for making sports goods ?**
   (a) mulberry (b) sal (c) mahogany (d) deodar
6. **In which of the following directions the tensile strength of timber is maximum ?**
   (a) Parallel to grain (b) 45^0 to grains
   (c) Perpendicular to grains (d) Same in all direction
7. **The moisture content in a well seasoned timber is**
   (a) 4% to 6% (b) 10% to 12% (c) 15% to 20% (d) 100%
8. **The trunk of tree left after cutting all the branches is known as**
   (a) log (b) batten (c) plank (d) baulk
9. **The age of a tree can be known by examining**
   (a) cambium layer (b) annular rings (c) medullary rays (d) heart wood
10. **First class timber has an avg. life of**
    (a) less than one year (b) 1 to 5 years
    (c) 5 to 10 years (d) more than 10 years

11. **A first class brick when immersed in cold water for 24 hrs should not absorb water more then**
(a) 15% (b) 20% (c) 22% (d) 25%

12. **Crushing strength of the first class brick should not be less then**
(a) 3.5 N/mm^2 (b) 7 N/mm^2 (c) 10.5 N/mm^2 (d) 14 N/mm^2

13. **The percentage of alumina in a good brick earth lies between**
(a) 5 to 10% (b) 20 to 30% (c) 50 to 60% (d) 70 to 80%

14. **The nominal size of the modular brick is**
(a) 190 mm × 90 mm × 80 mm (b) 190 mm × 190 mm × 90 mm
(c) 200 mm × 100 mm × 100 mm (d) 200 mm × 200 mm × 100 mm

15. **The process of mixing clay water and other ingredients to make brick is know as**
(a) kneading (b) moulding (c) pugging (d) drying

16. **The frog of the brick in a brick masonry is generally kept on**
(a) bottom face (b) top face (c) shorter side (d) longer side

17. **No. of bricks required for our cubic metre of brick majority is**
(a) 400 (b) 450 (c) 500 (d) 550

18. **Quick lime is**
(a) calcium carbonate (b) calcium oxide
(c) calcium hydroxide (d) none of the above

19. **The main ingredients of port land cement are**
(a) lime & silica (b) lime & alumina
(c) silica & alumina (d) lime & iron

20. **For testing compressive strength of cement the size of cube used is**
(a) 90 mm (b) 70.6 mm (c) 100 mm (d) 150 mm

21. **The slump recommended for mass concrete is about**
(a) 25 mm to 50 mm (b) 50 mm to 100 mm
(c) 100 mm to 125 mm (d) 125 mm to 150 mm

22. **For testing compressive & tensile strength of cement, the cement morter is made by mixing cement & standard sand in proportions of**
(a) 1 : 2 (b) 1 : 3 (c) 1 : 4 (d) 1 : 6

23. **Which of the following cement contains maximum % of dicalcium silicate ?**
(a) ordinary portland cement (b) low heat cement
(c) rapid hardening cement (d) sulphate resisting cement

24. **Which of the following is the parest form of iron ?**
(a) Cast iron (b) Wrought iron (c) mild steel (d) high carbon steel

25. **The amount of water used for one kg of distemper is**
(a) 0.2 litre (b) 0.4 litre (c) 0.6 litre (d) 0.8 litre

26. **The Distemper is used to coat**
(a) external concrete surface (b) interior surface not exposed to weather
(c) wood work (d) compound walls

27. **Cement used in underwater construction work is**
(a) High alumina cement (b) Quick Setting Cement
(c) Water Proof Cement (d) Rapid hardening cement

28. **Calcination is the process of heating the limestone with**
(a) Water (b) Carbon (c) Air (d) Cement

29. **The lime specifically used for white washing is**
(a) Fat lime (b) Poor lime (c) Hydraulic lime (d) Colour lime

30. **Commonly used raw material in the manufacture of cement is**
(a) Sand Stone (b) Slate (c) lime stone (d) Rock

31. **Bulking of sand is caused because of**
(a) Voids (b) Surface moisture (c) Clay (d) None of above

32. **Which lime contains high percentage of calcium oxide ?**
(a) Rich lime (b) White lime (c) Fat lime (d) All of above

33. **Lime morter is generally made with**
(a) Fat lime (b) hydraulic lime (c) Quick lime (d) None of above

34. **Which lime Slack with water and mainly contains calcium oxide ?**
(a) Poor lime (b) hydraulik lime (c) Quick lime (d) Fat lime

35. **Strength to cement is provided by**
(a) Di – Calcium Silicate (b) Tri – Calcium Silicate
(c) Tri – Calcium aluminate (d) Tri – Calcium alumino femite

36. **PCC means**
(a) Plain Cement Concrete (b) Part of Cement
(c) Paper Cement Concrete (d) None of above

37. **To reduce the weight of concrete following which material is used ?**
(a) Kapchi (b) Furnace Slag (c) Rock (d) All the above

38. **Cement concrete is a mixture of**
(a) cement, sand and gravel (b) water, cement and gravel
(c) sand, water and cement (d) None of above

39. **In concrete proportion 1 : 3 : 6, where 3 indicating**
(a) Cement (b) Sand (c) Water (d) Aggregate

40. **Full Form of R. C. C. is**
(a) Rough Cement Concrete (b) Road Cement Concrete
(c) Reinforced Cement Concrete (d) Rapid Cement Concrete

41. **The cement morter mix generally used for masonary work is**
(a) 1 : 3 (b) 1 : 5 (c) 1 : 10 (d) 1 : 6

42. **The strength of cement concrete for a given mix depends on**
(a) Initial Setting time (b) Final Setting time
(c) Water Cement Ratio (d) Curing

43. **Playwood size available in market.**
(a) 1 mm thick (b) 2 mm thick (c) 2–3 mm thick (d) 3–4 mm thick

44. **Which of the following is not a hard wood ?**
(a) Teak (b) Oak (c) Deodor (d) Sal

45. **The main parpose of Seasoning is**
(a) To remove moisture from a timber (b) To make the timber fire resistant
(c) To make the timber water proof (d) None of above

46. **Playwood is identified by**
(a) Volume (b) Thickness (c) Weight (d) Area

47. **Age of Tree may be Judged from**
(a) Sapwood (b) Heart wood (c) Combium layer (d) None of above

48. **Most valuable timber is**
(a) Sal (b) Shisham (c) Chir (d) Teak

49. **Venering is**
(a) Carving out designs on timber planks.
(b) Thin layer of Superior wood glued to inferior wood.
(c) Thick layer of superior wood glued to inferior wood.
(d) Chemically treating timber planks.

50. **Invar is a nickel steel with nickel content between**
(a) 10–20% (b) 20–30% (c) 30–40% (d) 40–50%

51. **Wrough Iron contains carbon up to**
(a) 0.15% (b) 1.5% (c) 1.0% (d) 2%

52. **Cast Steel is manufacture by**
(a) Cruable Process (b) Bessemer Process
(c) Cementation Process (d) Open Heart Process

53. **Ferrous Metal is**
(a) Wrought iron (b) Cast iron (c) Steel (d) All the above

54. **Minimum of 40% of iron is available**
(a) Magnetite (b) Black bard (c) Sidenite (d) Limonte

55. **Cast iron is**
(a) Obtained by purifying pig iron.

(b) May contain 2 to 5 percent of carbon with other impurities.
(c) Manufactured in required shape.
(d) All the above.

56. **Shale is which type of rock ?**
(a) Igneous (b) Sedimentary (c) Plutonic (d) Meta morphic

57. **Marble is which type of rock ?**
(a) Plutonic (b) Sedimentary (c) Igneous (d) Metamorphic

58. **Frog is which portion of brick ?**
(a) Front (b) Back (c) Bottom (d) Top

59. **Basalt can be classified as**
(a) Metamorphic rock (b) Sedimentary rock
(c) Extrusive igneous (d) Intrusive igneous

60. **Slate belong to**
(a) Igneous rock (b) Sedimentary rock (c) Foliated rock (d) Metamorphic rock

61. **The indentation provided in a face of the brick is called**
(a) Strike (b) Frog (c) Pallet (d) None of above

62. **The standard size of brick as per Indian standards is**
(a) 20 × 10 × 10 cm (b) 19 × 9 × 9 cm
(c) 24 × 12 × 6 cm (d) 18 × 9 × 9 cm

63. **The bricks manufactured to withstand high temperature is called**
(a) First class bricks (b) Second class bricks
(c) Refractory bricks (d) None of the above

64. **The red colour obtained by the bricks is due of the presence of**
(a) Lime (b) Iron Oxide (c) Silica (d) Mangenese

65. **When a brick is cut into two haves longitudinally, each part is called**
(a) King closer (b) Voussoir (c) Cornice brick (d) Queen closer

66. **Asphalt is obtained from**
(a) Bitumen Distillation (b) Plastic Distillation
(c) Petroleum Distillation (d) None of above

67. **Bullet Proof glass is made with**
(a) Steel (b) High test plastic
(c) Stainless Steel (d) All the above

68. **Bitumen may be dissolved in**
(a) Water (b) Carbon dioxide (c) Sodium Chloride (d) Carbon disulphide

69. **Plastic asphalt is**
(a) Elastic (b) Water Proof (c) Fire Proof (d) all the above

70. In window glass Silica Content is

(a) 50 to 55% (b) 60 to 65% (c) 70 to 75% (d) None of above

71. Asbestos is

(a) Corrugated Sheet used for roofing (b) Organic Substance
(c) Fire Proofing Material (d) All above

72. Distemper is a type of

(a) Oil Paint (b) Plastic Paint (c) Water Paint (d) Enamel Paint

73. The Paint used for automobiles is

(a) Oil Paint (b) Plastic Paint (c) Water Paint (d) Enamel Paint

74. The Quantity of painting work is measured in

(a) Weight of Paint (b) Number of labours
(c) Area of Painter Surface (d) None of above

75. Duco paints are

(a) Plastic Paints (b) Cellulose Paints
(c) Bituminus Paints (d) Oil Paints

76. Linseed oil is used as

(a) vehicle (b) base (c) thinner (d) Drier

77. Turpentine oil is used as

(a) Drier (b) base (c) thinner (d) vehicle

78. For timber painting commonly used

(a) White lead (b) Zinc White (c) Ved lead (d) Titanium white

79. Iron and Steel woul most commonly base is

(a) white lead (b) red lead (c) zink white (d) titunium white

80. In oil paint important constitute is

(a) thinner (b) vehicle (c) pigment (d) all the above

81. French polish is

(a) Spint varnish (b) Distemper (c) Oil paint (d) bitumenous piant

82. Lacauer is

(a) Distemper (b) Spirit varnish (c) Paint (d) All of above

: ANSWERS :

1. (c)	2. (c)	3. (c)	4. (d)	5. (a)
6. (a)	7. (b)	8. (a)	9. (b)	10. (d)
11. (b)	12. (c)	13. (b)	14. (c)	15. (a)
16. (b)	17. (c)	18. (b)	19. (a)	20. (b)
21. (a)	22. (b)	23. (b)	24. (b)	25. (c)

26. (b)	27. (b)	28. (c)	29. (a)	30. (c)
31. (b)	32. (d)	33. (b)	34. (c)	35. (a)
36. (a)	37. (b)	38. (a)	39. (b)	40. (c)
41. (d)	42. (c)	43. (d)	44. (c)	45. (a)
46. (b)	47. (b)	48. (d)	49. (c)	50. (d)
51. (a)	52. (a)	53. (d)	54. (b)	55. (d)
56. (b)	57. (d)	58. (d)	59. (c)	60. (d)
61. (b)	62. (b)	63. (c)	64. (b)	65. (d)
66. (c)	67. (b)	68. (d)	69. (d)	70. (c)
71. (d)	72. (c)	73. (a)	74. (c)	75. (d)
76. (a)	77. (a)	78. (a)	79. (b)	80. (d)
81. (a)	82. (b)			

SET-2

1. **Granite is an example of**
   (a) Igneous rocks (b) Sedimentary rocks (c) Metamorphic rocks (d) aqueous rocks
2. **Marble is an example of**
   (a) Igneous rocks (b) Sedimentary rocks (c) Metamorphic rocks (d) aqueous rocks
3. **The colour of granite is**
   (a) grey (b) green (c) brown (d) all of these
4. **Bituminous paint consists of bitumen dissolved in**
   (a) Spirit (b) naptha (c) linseed oil (d) either (a) or (b)
5. **The base in a paint is added to**
   (a) Improve the quality of paint (b) Make smooth surface
   (c) hide the surface to be painted (d) all of these
6. **A good quality stone must absorb water less than**
   (a) 2.5 % (b) 5 % (c) 10 % (d) 20 %
7. **In stone masonry the direction of pressure line is**
   (a) Parallel to natural bed (b) Perpendicular to natural bed
   (c) inclined to natural bed at 30° (d) inclined to natural bed at 45°
8. **Good quality building stones should not contain soluble salts more than**
   (a) 0 % (b) 1 % (c) 2 % (d) 3 %
9. **For stones Mhos scale is used to determi**
   (a) toughness (b) hardness (c) flakiness index (d) durability
10. **Stone generally used for railway ballast is**
    (a) Sand stone (b) dolomite (c) marble (d) basalt or trap basalt

11. **The soil good for making bricks is**
    (a) black cotton (b) alluvial (c) Silty (d) Sand and silt
12. **The red colour of brick is due to**
    (a) iron oxide (b) silica (c) magnesia (d) alumina
13. **Pug mill is used for**
    (a) clay preparation (b) clay moulding (c) brick drying (d) brick burning
14. **Hollow bricks are used for**
    (a) Ornamental design (b) thermal insulation
    (c) reduction in cost (d) earthquake resistant buildings
15. **Glazing is used to make earthware**
    (a) hard (b) soft (c) porous (d) impervious
16. **The formula of quick lime is**
    (a) CaO (b) $CaCO_3$ (c) $Ca(OH)_2$ (d) None of these
17. **Lime used for making mortar is**
    (a) Semi hydraulic lime (b) fat lime
    (c) eminently hydraulic lime (d) all of these
18. **Plaster of Paris is obtained from the calcination of**
    (a) bauxite (b) lime stone (c) dolomite (d) gypsum
19. **Fat lime is also called**
    (a) quick lime (b) hydraulic lime (c) slaked lime (d) white lime
20. **Lea and Nurse apparatus determines**
    (a) Soundness due to free lime (b) Soundness due to free lime and magnesia
    (c) specific surface area of OPC (d) Minor oxide contents in OPC
21. **The sports goods are made from**
    (a) Sal (b) deodar (c) chir (d) mulberry
22. **Plywood is obtained from**
    (a) teak wood (b) structural wood (c) bamboo (d) commonly available wood
23. **The commonly used thinner in oil paints is**
    (a) naptha (b) turpentine (c) olive oil (d) both (a) and (b)
24. **In high tensile steel, carbon should be less than**
    (a) 0.1 % (b) 0.15 % (c) 0.7 % (d) 1.5 %
25. **Galvanising means covering iron with a thin coat of**
    (a) tin (b) glaze (c) zinc (d) coaltar
26. **In mild steel carbon content is**
    (a) less than 0.25 % (b) between 0.25 % and 0.75 %
    (c) between 0.75 % and 1.5 % (d) more than 1.5 %

27. Purest form of iron is
(a) mild steel (b) cast iron (c) high carbon steel (d) wrought iron

28. In railway tracks metal used is
(a) cast iron (b) Wrought iron (c) mild steel (d) Stainless steel

29. Basalt and trap are used in
(a) roads (b) dams (c) ornamental works (d) monumental works

30. Fire bricks are used
(a) to reflect heat (b) to increase heat flow
(c) to decrease heat flow (d) to protect building against lighting

31. Annual rings of the tree represent its
(a) life (b) strength (c) density (d) type

32. The paints used on aircraft structure are
(a) Oil paints (b) dry paints (c) emulsion paints (d) cellulose paint

33. Asphalt is good insulator of
(a) heat (b) sound (c) electricity (d) all of the above

34. Acoustical material
(a) absorb sound (b) reflect sound (c) create sound (d) increase sound

35. Asphalt is a
(a) Pure bitumen (b) impure bitumen
(c) Mixture of bitumen and inert material (d) by-product of bitumen

: ANSWERS :

1. (a)	2. (c)	3. (d)	4. (d)	5. (c)
6. (b)	7. (b)	8. (a)	9. (b)	10. (b)
11. (a)	12. (a)	13. (a)	14. (b)	15. (d)
16. (a)	17. (c)	18. (c)	19. (d)	20. (c)
21. (d)	22. (d)	23. (d)	24. (b)	25. (c)
26. (a)	27. (d)	28. (c)	29. (a)	30. (c)
31. (a)	32. (d)	33. (d)	34. (a)	35. (c)

19.

Building Construction

MCQ'S

SET-1 : Shallow Foundations

1. **Which type of foundation is most preferred for foundations on black cotton soils ?**
   (a) Raft foundation (b) Strip footing (c) Under reamed Piles (d) Column footing
2. **Which of the following is not a shallow foundation ?**
   (a) Grillage foundation (b) Well foundation
   (c) Combined footing (d) Mat foundation
3. **Raft foundation is not suitable**
   (a) when the structure loads are heavy.
   (b) when columns and walls are close to each other.
   (c) when there is large variation in the loads on individual columns.
   (d) none of these
4. **When there are chances of differential settlements, the foundation preferred is**
   (a) spread footing (b) wall footing (c) raft foundation (d) grillage foundation
5. **For lowering of water table by about 10 m the following method is generally the most suitable.**
   (a) Well Point method (b) Shallow Well method
   (c) Deep Well method (d) Electro-osmosis method
6. **Vacuum method of well points is generally used for draining**
   (a) coarse sands (b) fine sands and silty sands
   (c) silts (d) clays
7. **Electro-osmosis for a clayey soils generally leads to**
   (a) decrease in shear strength (b) increase in shear strength
   (c) increase in water content (d) increase in plasticity
8. **In a Shallow Well System, the suction lift is usually limited to**
   (a) 5 m (b) 10 m (c) 15 m (d) 20 m

: ANSWERS :

1. (c)	2. (b)	3. (d)	4. (c)	5. (a)	6. (b)	7. (b)	8. (b)

SET-2 : Masonry Construction

1. **The brick laid with its length parallel to the face of the wall, is known as**
   (a) header (b) stretcher (c) closer (d) none of these
2. **The brick laid with its breadth parallel to the face of the wall, is known as**
   (a) header (b) stretcher (c) closer (d) none of these
3. **The 9 cm × 9 cm side of a brick as seen in the wall face, is generally known as**
   (a) stretcher (b) face (c) front (d) header
4. **The 19 cm × 9 cm side of a brick as seen in wall face, is generally known as**
   (a) stretcher (b) face (c) front (d) header
5. **The position of a brick when laid on its side 19 cm × 9 cm with its frog in the vertical plane, is called**
   (a) brick on edge (b) brick on end (c) brick on bed (d) brick held vertically
6. **The portion of a brick cut across the width is called**
   (a) closer (b) half brick (c) bed (d) bat
7. **The portion of a brick cut across the length is called**
   (a) king closer (b) queen closer (c) bat (d) quoin
8. **To obtain good bonding in brick masonry**
   (a) first class bricks are used.
   (b) vertical joints in alternate courses are kept in plumb line.
   (c) bats are used where necessary.
   (d) all the above.
9. **Cavity wall is generally provided for**
   (a) heat insulation (b) sound insulation
   (c) prevention of dampness (d) all the above
10. **To construct a 10 cm thick partition wall, you will prefer**
    (a) English bond (b) Flemish bond (c) Header bond (d) Stretcher bond
11. **The type of bond in which every course contains both headers and stretchers is called**
    (a) English bond (b) Flemish bond (c) Header bond (d) Stretcher bond
12. **The type of bond in which alternate courses are stretcher and header is**
    (a) English bond (b) Flemish bond (c) Header bond (d) Stretcher bond
13. **Exposed portions of a vertical surface at right angles to the door or window frame, are known as :**
    (a) Jambs (b) lintels (c) Reveals (d) Soffits
14. **The vertical sides of door and window openings provided in a wall, are known as**
    (a) Jambs (b) lintels (c) Reveals (d) Soffits

15. The header bond is generally used for

(a) half brick wall (b) single brick-wall (c) $1\frac{1}{2}$ brick wall (d) arches

16. The stretchar bond is generally used for

(a) half brick wall (b) simple brick wall (c) $1\frac{1}{2}$ brick wall (d) arches

17. Herringbone bond is used for

(a) walls having thickness more than 4 bricks
(b) Architectural finish to the face work
(c) ornamental panels in brick flooring
(d) all the above

18. The stone masonry in which stones of same height are laid in layers, is called

(a) random rubble masonry (b) course rubble masonry
(c) uncoursed rubble masonry (d) ashlar masonry

19. The stone masonry of finely dressed stones laid in cement or lime is

(a) random rubble masonry (b) course rubble masonry
(c) uncoursed rubble masonry (d) ashlar masonry

20. The thickness of a reinforced brick partition wall, is generally kept

(a) 5 cm (b) 10 cm (c) 15 cm (d) 20 cm

21. The triangular portion between two adjacent arches and the tangent to their crown is

(a) haunch (b) spandril (c) soffit (d) rise

22. An arch may fail due to

(a) crushing of material (b) sliding of voussoirs
(c) differential settlement of abutments (d) all the above

23. The inclined surface of an abutment to receive the arch is known as :

(a) skewback (b) soffit (c) spandrill (d) haunch

24. The voussoir placed at the crown of arch is called

(a) key (b) soffit (c) springer (d) haunch

25. The under surface of an arch is called

(a) soffit (b) intrados (c) extrados (d) back

26. The angle between skewback of a flat arch and the horizontal, is kept approximately equal to

(a) 0° (b) 30° (c) 60° (d) 90°

27. The depth of an arch is the distance between

(a) ground level and springing line (b) crown and springing line
(c) crown and ground level (d) intrados and extrados

28. The thickness of outer leaf of cavity wall is normally kept

(a) 5 cm (b) 10 cm (c) 15 cm (d) 20 cm

: ANSWERS :

1. (b),	2. (a),	3. (d),	4. (a),	5. (a),
6. (d),	7. (b),	8. (d),	9. (d),	10. (d),
11. (b),	12. (a),	13. (c),	14. (a),	15. (d),
16. (a),	17. (d),	18. (b),	19. (d),	20. (b),
21. (b),	22. (d),	23. (a),	24. (a),	25. (a),
26. (c),	27. (d),	28. (b).		

SET-3

1. The moisture content in a well seasoned timber is (IES)

(a) 4 to 6 % (b) 10 to 12 % (c) 15 to 20 % (d) 100 %

2. The slenderness ratio for masonry walls should not be more than

(a) 10 (b) 20 (c) 30 (d) 40

3. Neoprine is suitable for use in (IES)

(a) bearing of bridges (b) hard duty rubber coatings of floors
(c) joinery work (d) Floors for dance halls

4. Timber can be made more fire resistant by (IES)

(a) Dipping and steeping process (b) Sir Abel's process
(c) Charring (d) hot and cold open tank treatment

5. Distemper is used to coat (IES)

(a) external concrete surfaces (b) interior surfaces not exposed to weather
(c) Wood work (d) Compound walls

6. Putty is made up of (IES)

(a) White lead and turpentine (b) Powdered chalk and raw linseed oil
(c) red lead and linceed oil (d) zinc oxide and boiled linceed oil

7. Limit of proportionality is applicable more in the case of (IES)

(a) concrete (b) wood (c) cast iron (d) mild steel

8. The expansion and shrinkage of plywood are comparatively very low as (IES)

(a) They are held in position by adhesives
(b) They are glued under pressure
(c) Piles are placed at right angles to each other
(d) they are prepared from veneers

9. Seasoning of timber is required to (IES)

(a) Soften the timber (b) harden the timber
(c) Straighten the timber (d) Remove sap from the timber

10. **The important purpose of frog in a brick is to** (IES)
(a) emboss manufacturer's name
(b) reduce weight of brick
(c) form keyed joint between brick and mortar
(d) Improve insulation by providing 'hollows'.

11. **Surkhi is added to lime mortar to** (IES)
(a) Prevent shrinkage (b) decrease setting time
(c) increase bulk (d) impart hydraulicity

12. **Before testing setting time of cement, one should test for**
(a) soundness (b) strength (c) fineness (d) consistency

13. **Match list I and List II and select correct answer from the codes given below lists :**

List I (Component of scaffolding)		List II (Function)	
A.	Putlog	1.	Diagonal member
B.	Ledger	2.	Vertical member
C.	Brace	3.	Horizontal member
D.	Standard	4.	Transverse member

(IES)

Codes :

	A	B	C	D
(a)	4	3	1	2
(b)	4	3	2	1
(c)	3	4	1	2
(d)	3	4	2	1

14. **Polyvinyl chloride (PVC) is a** (IES)
(a) thermosetting material (b) thermoplastic material
(c) elastoplastic material (d) rigid - plastic material

15. **The approximate ratio between strengths of cement concrete at 7 days and 28 days is** (IES)
(a) $\frac{3}{4}$ (b) $\frac{2}{3}$ (c) $\frac{1}{2}$ (d) $\frac{1}{3}$

16. **The approximate ratio of strength of 15 cm × 30 cm concrete cylinder to that of 15 cm cube of the same concrete is** (IES)
(a) 1.25 (b) 1.0 (c) 0.85 (d) 0.50

17. **What is efflorescence ?** (IES)
(a) Formation of white patches on the brick surface due to insoluble salts in the brick clay

(b) Swelling of brick due to presence of carbonaceous matter and gas

(c) Deformation of brick due to exposure to rain

(d) impurities in the brick clay which show after burning

18. According to the relevant I.S. code weight of the timber is to be reckoned at a moisture content of **(IES)**

(a) Zero (b) 4 % (c) 8 % (d) 12 %

19. For good bonding in brick mesonry **(IES)**

(a) all bricks need not be uniform in size

(b) bats must be used in alternate courses should fall in plumb

(d) Cement mortar used must have surkhi as additive

20. The ratio of Young's modulus of high tensile steel to that of mild steel is about **(IES)**

(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0

21. The optimum number of revolutions over which concrete is required to be mixed in a mixer machine is **(IES)**

(a) 10 (b) 20 (c) 50 (d) 100

22. Gauged mortar is obtained by adding which of the following ingredients to cement ? **(IES)**

(a) Sand stone (b) sand and surkhi (c) sand and lime (d) Surkhi alone

23. To make one cubic metre 1 : 2 : 4 by volume concrete, the volume of coarse aggregates required is **(IES)**

(a) 0.95 m^3 (b) 0.85 m^3 (c) 0.75 m^3 (d) 0.65 m^3

Hint : C.A. $= \frac{4}{7} \times 1.52 = 0.856\ m^3$

24. Consider the following strengths of concrete

1. Cube strength
2. Cylinder strength
3. Split - tensile strength
4. Modulus of rupture

The correct sequence in increasing order of these strengths is **(IES)**

(a) 3, 4, 2, 1 (b) 3, 4, 1, 2 (c) 4, 3, 2, 1 (d) 4, 3, 1, 2

25. The role of superplasticizer in a cement paste is to **(IES)**

(a) disperse the particles

(b) disperse the particles and to remove air bubbles

(c) disperse the particles, remove air bubbles and to retard setting

(d) retard setting

26. Maximum differential settlement, in case of foundations on sandy soils is usually limited to

(a) 10 mm (b) 25 mm (c) 40 mm (d) 45 mm

27. Maximum differential settlement, in case of foundations on clayey soils is limited to
(a) 40 mm (b) 60 mm (c) 100 mm (d) 400 mm

28. Piles are usually not made of
(a) steel (b) Stainless steel (c) timber (d) RCC

29. In machine foundations the material used for preventing transmission of vibration is
(a) Cork or rubber (b) lead sheets (c) felt (d) all of these

30. Black cotton soil is unsuitable for foundations because of its
(a) low bearing capacity
(b) uncertain permeability
(c) Cohesive property
(d) Property to undergo a volumetric change due to variation of moisture content

31. Raft foundation is generally used, when the area required for individual footing is more than
(a) 25 % of total area (b) 30 % of total area
() 40 % of total area (d) 50 % of total area

32. Maximum total settlement of raft on sand is usually limited to
(a) 65 mm (b) 100 mm (c) 150 mm (d) 200 mm

33. Maximum total settlement of raft on clayey soils is usually limited to
(a) 65 mm (b) 100 mm (c) 150 mm (d) 200 mm

34. The depth of excavation for foundation is usually checked with a
(a) tape (b) ranging rod (c) levelling staff (d) boning rod

35. Minimum thickness of a wall in stone masonry can not be less than
(a) 10 cm (b) 20 cm (c) 35 cm (d) 50 cm

36. In a single day, maximum height of brick masonry to be raised should not be more than
(a) 0.5 m (b) 1.0 m (c) 1.5 m (d) 2 m

37. While laying bricks in a wall, frog of the brick must be kept
(a) upward (b) downward (c) sideward (d) in any position

38. The external corner in brick masonry is called
(a) Jamb (b) quoin (c) sleeper wall (d) parapet

39. The part of a wall at the side of an opening in the masonry is called
(a) quoin (b) Jamb (c) sleeper wall (d) parapet

40. Expansion joints in masonry walls are provided in wall lengths more than
(a) 10 m (b) 20 m (c) 30 m (d) 40 m

41. The nominal thickness of an expansion joint in brick wall must be more than
(a) 10 mm (b) 20 mm (c) 30 mm (d) 40 mm

42. To protect the top of a parapet wall from the action of rain water, it is provided with a special course called
(a) drip course (b) cornice (c) string course (d) coping

43. A semitight material which forms an excellent impervious layer for damp proofing is called
(a) bitumen (b) bituminous felt (c) mastic asphalt (d) aluminal

44. In residential buildings, the D.P.C. is provided at
(a) ground level (b) Plinth level (c) sill level (d) parapet level

45. D.P.C. may be
(a) Vertical (b) Horizontal (c) both (a) and (b) (d) none of these

46. The maximum size of the aggregate used in a D.P.C. is about
(a) 6 mm (b) 10 mm (c) 16 mm (d) 20 mm

47. Portion of the wall left on the face of the door/window is called
(a) Jamb (b) reveal (c) sill (d) all of these

48. Vertical member used in a door frame is called
(a) Post (b) still (c) rail (d) style

49. The bottom horizontal member of a window frame is called
(a) transom (b) sill (c) rail (d) threshold

50. The vertical member of a frame which is employed to sub-divide a window or door vertically is called
(a) style (b) horn (c) mullion (d) transom

51. The horizontal member of a frame, which is employed to sub-divide a window opening horizontally is called
(a) style (b) horn (c) mullion (d) transom

52. The horizontal projections of top member of door or window frame is called
(a) Head (b) horn (c) post (d) threshold

53. Timber or glass pieces fixed in inclined position in a frame of ventilator are called
(a) styles (b) posts (c) louvers (d) Sash

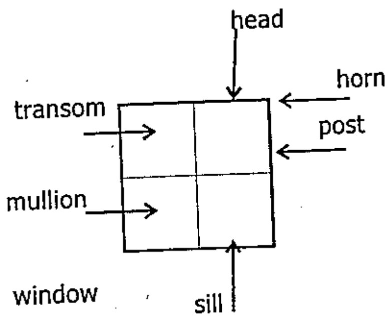
54. The window which projects outward from the walls of a room to provide increased area of opening for admitting more light and ventilation is called

(a) dormer window

(b) corner window

(c) bay window

(d) clearstorey window



55. The window usually provided near the main roof of a room and opens above the adjoining verandah is called

(a) dormer window (b) Corner window (c) bay window (d) clear storey window

56. A window provided in the sloping roof is called

(a) dormer window (b) bay window
(c) Corner window (d) clear storey window

57. A window provided in the sloping pitched roof is called

(a) Casement window (b) sky light
(c) dormer window (d) bay window

58. In air conditioned building, a door has to serve both purposes of opening and closing. The most suitable type of door is

(a) Sliding door (b) swing door (c) revolving door (d) Collapsible door

59. The doors most suitable for the entrance of banks, hotels, hospitals, theatres etc. are

(a) sliding door (b) revolving door
(c) collapsible steel door (d) Rolling steel shutter doors

60. The door commonly used of entrances of godowns, sheds, showrooms, garages, shops is

(a) sliding door (b) revolving door
(c) Rolling steel shutter (d) both (a) and (c)

61. The number of steps in a ordinary flight should not be more than

(a) 12 (b) 10 (c) 15 (d) 20

62. The number of steps in a flight should not be less than

(a) 12 (b) 3 (c) 2 (d) 5

63. The width of landing should not be less than

(a) 1.0 m (b) 1.2 m (c) 0.9 m (d) Stair width

64. The sum of tread and rise should lie between

(a0 30 - 40 cm (b) 40 - 45 cm (c) 50 - 55 cm (D) 55 - 60 cm

65. Half turn stairs change their direction through

(a) 90° (b) 135° (c) 180° (d) 270°

66. Dog-legged stairs are

(a) Straight stairs (b) Quarter turn stairs
(c) half turn stairs (d) three fourth stairs

67. Horizontal distance between two consecutive risers is called

(a) tread (b) going (c) stringer (d) none of these

68. A platform at the end of a series of steps is called

(a) relief (b) landing (c) platform (d) end point

69. **Minimum width of a stair in a residential building is**
(a) 50 cm (b) 75 cm (c) 90 cm (d) 100 cm

70. **In public buildings, the minimum tread width should be**
(a) 15 cm (b) 20 cm (c) 30 cm (d) 40 cm

71. **The location of stair in a public building should be near**
(a) the entrance (b) the centre (c) the lavatory (d) end of the building

72. **In public buildings, maximum riser is limited to**
(a) 10 cm (b) 12 cm (c) 15 cm (d) 20 cm

73. **The angular steps used for changing direction of stairs are called**
(a) angular steps (b) radial steps (c) winders (d) spandril

74. **The height of hand rail above the tread should be generally in between**
(a) 40 to 50 cm (b) 60 to 75 cm (c) 75 to 80 cm (d) 100 cm

75. **Minimum headroom required in a staircase is**
(a) 3.5 m (b) 3 m (c) 2.1 m (d) 1.5 m

76. **The first voussoir at the springing level on either side of the arch is called**
(a) springer (b) spandril crown (c) haunch (d) rise

77. **The voussoir placed at the crown of an arch is called**
(a) springer (b) spandril (c) launch (d) key

78. **The temporary structure to support an arch during construction is called**
(a) Scaffolding (d) shoring (c) Jacking (d) Centering

79. **The bearing of lintel should not be less than**
(a) 10 cm (b) 15 cm (c) 20 cm (d) 30 cm

80. **A rolling steel shutter is often used for**
(a) cinema halls (b) shops (c) drawing rooms (d) beauty parlours

81. **The development of one or more local swellings on the finished plastered surface is called**
(a) Foaming (b) boiling (c) blistering (d) swelling

82. **Screws for wood work is specified by**
(a) length (b) diameter (c) weight (d) gauge

83. **In king post truss, the number of vertical posts is**
(a) one (b) two (c) three or more (d) none

84. **The projecting part of the tread beyond the face of riser is called**
(a) pitch (b) nosing (c) baluster (d) stringer

85. In stairs 'Soffit' is

(a) A vertical portion of a step providing support to the tread

(b) A straight step having a parallel width of tread

(c) The under surface of a stair

(d) the angle which the line of nosing of the stair makes with the horizontal

: ANSWERS :

1. (b)	2. (c)	3. (a)	4. (b)	5. (b)
6. (b)	7. (d)	8. (c)	9. (d)	10. (c)
11. (d)	12. (d)	13. (a)	14. (b)	15. (b)
16. (c)	17. (a)	18. (d)	19. (c)	20. (b)
21. (b)	22. (c)	23. (b)	24. (a)	25. (c)
26. (b)	27. (a)	28. (b)	29. (d)	30. (d)
31. (d)	32. (a)	33. (b)	34. (d)	35. (c)
36. (c)	37. (a)	38. (b)	39. (b)	40. (d)
41. (b)	42. (d)	43. (c)	44. (b)	45. (c)
46. (b)	47. (b)	48. (a)	49. (b)	50. (c)
51. (d)	52. (b)	53. (c)	54. (c)	55. (d)
56. (a)	57. (b)	58. (b)	59. (b)	60. (d)
61. (a)	62. (b)	63. (d)	64. (b)	65. (c)
66. (c)	67. (b)	68. (b)	69. (c)	70. (c)
71. (a)	72. (c)	73. (c)	74. (c)	75. (c)
76. (a)	77. (d)	78. (d)	79. (b)	80. (b)
81. (c)	82. (a)	83. (a)	84. (b)	85. (c)

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20.

Construction Management and Equipments

MCQ'S

1. **On a bar chart the various activities of a project are shown by**
   (a) Vertical lines (b) horizontal lines (c) shaded area (d) dot marks
2. **Bar charts are consider suitable for**
   (a) major projects (b) large projects (c) minor projects (d) all of these
3. **CPM network is**
   (a) activity oriented (b) event oriented (c) slack oriented (d) work oriented
4. **PERT is**
   (a) activity oriented (b) event oriented (c) slack oriented (d) work oriented
5. **A dummy activity**
   (a) had no tail event but had only a head event
   (b) had only tail event but no head event
   (c) had no sequence and can be fitted anywhere
   (d) neither require any resource nor any time
6. **A bar chart is drawn for**
   (a) time versus activity (b) activity versus resources
   (c) resources versus progress (d) progress versus time
7. **A 'dummy activity' in a network**
   (a) is represented by a dotted line
   (b) is an artificial activity
   (c) does not consume any time or resources
   (d) all of these
8. **A critical activity has**
   (a) maximum float (b) minimum float (c) zero float (d) average float
9. **Which of the following is a dummy activity ?**
   (a) Excavation of foundations (b) Laying the foundation concrete
   (c) Awaiting the arrival of concrete (d) Curing the foundation concrete

10. Critical path

(a) is the shortest path (b) has null path

(c) has the maximum slack (d) has the minimum slack

11. The activity which is crashed first has

(a) highest cost slope (b) least cost slope

(c) crashing has no relation with cost slope (d) none of these

12. The reduction in project time normally results in **(IES)**

(a) decreasing the direct cost and increasing the indirect cost

(b) increasing the direct cost and decreasing the indirect cost

(c) increasing the direct cost and indirect cost both

(d) decreasing the direct cost and indirect cost both

13. Site order book is used for recording **(IES)**

(a) instructions of executive engineer (b) construction measurements

(c) requisition of plants and equipment (d) indents for materials to be ordered**14.**

A system of organisation introduced by F.W. Taylor is called **(IES)**

(a) effective organisation (b) functional organisation

(c) line and staff organisation (d) line organisation

15. Match list I and list II and select the correct answer using the codes given below the lists : **(IES)**

List I (Activity type)	**List II (Property of activity)**
A. Critical activity to be crashed first	1. It has float
B. Critical activity	2. It has least cost slope
C. Dummy activity	3. It maintains logic of network
D. Subcritical activity	4. It has no float

Codes :

	A	B	C	D
(a)	1	2	4	3
(b)	3	1	2	4
(c)	2	4	3	1
(d)	4	3	1	2

16. Mobilization advance up to 10 % of the cost of work is given to a contractor **(IES)**

(a) on commencement of work at site for payment of loan taken by him

(b) for the purchase of construction materials

(c) for the payment of advances to labour and other staff

(d) For all activities required to start the work at site on finalization of the contract document

17. Security deposit deducted at 5 % from contractor's bill is **(IES)**

(a) refunded when the contractor has completed the work

(b) refunded even before the completion of the work provided good progress has been established

(c) retained till the expected life of the structure of say 100 years and spent for maintenance

(d) refunded when the defect liability period of six months or one monsoon which ever is later is over

18. In resource levelling **(IES)**

(a) total duration of project is reduced

(b) total duration of project is increased

(c) uniform demand of resources is achieved

(d) cost of project is controlled

19. Consider the following activities in a building construction : **(IES)**

(1) Concreting of roof slabs (2) Brick-jelly lime concrete terracing

(3) erection of frame work for slab (4) Construction of parapet wall in terrace

The correct sequence of these activities is

(a) 1, 3, 2, 4 (b) 3, 1, 4, 2 (c) 3, 1, 2, 4 (d) 1, 3, 4, 2

20. Consider the following operations : **(IES)**

1. Drilling 2. Blasting 3. Mucking 4. Placing steel

5. Placing concrete

The correct sequence of these operations in tunnel construction is

(a) 1, 2, 4, 3, 5 (b) 1, 3, 2, 4, 5 (c) 1, 2, 3, 4, 5 (d) 1, 3, 4, 2, 5

21. Match list I and list II and select the correct answer using the codes given below the lists : **(IES)**

List I (Item)			List II (characteristic)
A.	Activity	1.	Resourceless
B.	Event	2.	Resource consuming element
C.	Dummy	3.	Spare time
D.	Float	4.	Instantaneous stage

Codes :

	A	B	C	D
(a)	1	3	4	2
(b)	2	1	4	3
(c)	2	4	1	3
(d)	3	4	1	2

22. Grader is used mainly for **(IES)**

(a) trimming and finishing (b) shaping and trimming
(c) finishing and shaping (d) finishing, shaping and trimming

23. Which one of the following is not an excavating and moving type of equipment ? **(IES)**

(a) Buldozer (b) clam shell (c) scraper (d) Dump truck

24. The most suitable type of equipment for compaction of cohesive soils is (IES)

(a) smooth wheel rollers (b) vibratory rollers
(c) Sheep foot rollers (d) Tampers

25. The basic action involved in sheep foot rolling is

(a) kneading (b) pressing (c) tamping (d) vibrating

26. For excavating utility trenches with precise control of depth, the excavation equipment used is **(IES)**

(a) Hoe (b) Shovel (c) Dragline (d) none of these

27. Cost of owning an equipment would include **(IES)**

(a) cost of depreciation, maintenance, repair and fuel
(b) cost of investment, wages of the crew and fuel
(c) cost of fuel, lubricating oil, investment and depreciation
(d) cost of investment, major repairs and depreciation

28. Match list I (nature of work) with list II (machine required) and select the correct answer using the codes given below the list : **(IES)**

List I		List II	
A.	Excavation and moving	1.	Derrick
B.	Pure excavation	2.	Dump truck
C.	Pure transportation	3.	Power shovel
D.	Pure hoisting	4.	Drag line

Codes :

	A	B	C	D
(a)	1	3	2	4
(b)	3	4	2	1
(c)	4	3	2	1
(d)	4	3	1	2

29. The difference between the total float and free float is called

(a) duration (b) interfering float (c) Independent float (d) free float

30. The occurance of the completion of an activity, is called

(a) head event (b) tail event (c) dual role event (d) none of these

31. In CPM, cost slope is determined by

(a) $\frac{\text{Crash cost}}{\text{Normal cost}}$ (b) $\frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

(c) $\frac{\text{Normal cost}}{\text{Crash cost}}$ (d) $\frac{\text{Normal time} - \text{Crash time}}{\text{Crash cost} - \text{Normal cost}}$

32. In PERT, expected time is given by Float = Available time - Required time

(a) $\frac{t_o + t_p + t_m}{3}$ (b) $\frac{t_o + 2t_p + t_m}{4}$ (c) $\frac{t_o + 4t_m + t_p}{6}$ (d) $\frac{t_o + 4t_p + t_m}{6}$

33. Which of the following pairs are correctly matched ?

1. Sub-critical activity-positive float
2. Critical activity - zero float
3. Supercritical activity - negative float

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2 and 3

34. CPM requires

(a) Single time estimate (b) double time estimate

(c) triple time estimate (d) none of these

35. PERT stands for

(a) Programme estimation and reporting technique

(b) Process estimation and review technique
(c) Programme evaluation and review technique
(d) Planning estimation and resulting technique

36. The start or completion of task is called
(a) an activity (b) an event (c) a duration (d) none of these

37. An activity requires
(a) Time (b) resources (c) time and resources (d) energy

38. An activity is
(a) concrete cured (b) walls plastered
(c) excavation for foundation (d) all of these

39. Free float is the
(a) Portion of independent float (b) portion of positive total float
(c) portion of interfering float (d) all of these

40. CPM network is updated
(a) at regular intervals (b) at fixed time (c) at any time
(d) whenever there is difference in planned and actual performance

41. Direct cost of a project is due to
(a) delay in project (b) loss or gain of project
(c) establishment charges (d) man power and material cost

42. For excavating solid rocks, the most suitable equipment is
(a) dragline (b) power shovel (c) clamshell (d) hoe

43. The size of power shovel is indicated by the size of
(a) boom (b) hoist line (c) dipper (d) cab

44. The equipment most suitable for removing earth from ditch and canal is
(a) drag line (b) power shovel (c) Hoe (d) Scraper

45. The effectiveness of explosion during tunnelling increases by the process of
(a) priming (b) Stemming (c) firing (d) squibbing

46. A drill most suitable for drilling down, horizontal or up holes is
(a) Jackhammer (b) Drifter (c) Shot drill (d) blast hole drill

47. An event is
(a) a definite job (b) a definite time interval
(c) the terminals of an activity (d) a definite position of an activity

48. **Latest finish time in CPM technique is indicated by**
(a) rectangle (b) circle (c) triangle (d) line

49. **Crashing is**
(a) reduction in duration (b) reduction in resource
(c) reduction in cost (d) reduction in project size

50. **PERT technique of network analysis is mainly useful for**
(a) small projects (b) large and complex projects
(c) research and development projects (d) deterministic activities

51. **Which of the following does not represent an activity ?**
(a) Site cleaned (b) foundation is being dug
(c) concrete is being poured (d) masonry is being laid

52. **The direct cost of a project with respect to normal time is**
(a) minimum (b) maximum (c) zero (d) infinite

53. **For a given activity, the optimistic time, pessimistic time and the most probable time estimates are 5, 17, 8 days respectively. The expected time is**
(a) 8 days (b) 9 days (c) 10 days (d) 15 days

Hint : $t_e = \dfrac{t_o + 4t_m + t_p}{6} = \dfrac{5 + 4 \times 8 + 17}{6} = 9$ days

54. **Slack time refers to**
(a) an activity (b) an event
(c) both event and activity (d) none of the above

55. **Critical path**
(a) is always longest (b) is always shortest
(c) may be longest (d) may be shortest

56. **The time by which a particular activity may be delayed without affecting the preceeding and succeding activities is known as**
(a) total float (b) free float (c) interfering float (d) independent float

57. **The time corresponding to minimum total project cost is**
(a) crash time (b) normal time
(c) optimistic time (d) between normal time and crash time

58. **The estimated time required to complete an activity is termed as**
(a) event (b) duration (c) active time (d) float

59. **Total float for any activity is defined as the difference between**
(a) its latest finish time and earliest start time for its successor activity
(b) its latest start time and earliest start time

(c) its latest start time and earliest finish time
(d) its earliest finish time and earliest start time for its successor activity

60. A canal is trimmed on its sides and bottom by
(a) drag line (b) trimmer (c) trencher (d) angle dozer

61. Which of the following is not a hauling equipment ?
(a) tractor (b) bulldozer (c) dragline (d) scraper

62. A concrete mixer is specified by
(a) The volume of the mixing drum
(b) horse power of prime mover
(c) volume of mixed concrete discharged after mixing of each batch
(d) mixer drum speed

: ANSWERS :

1. (b)	2. (c)	3. (a)	4. (b)	5. (d)
6. (a)	7. (d)	8. (c)	9. (c)	10. (d)
11. (b)	12. (b)	13. (a)	14. (b)	15. (c)
16. (c)	17. (d)	18. (c)	19. (c)	20. (c)
21. (c)	22. (d)	23. (d)	24. (c)	25. (a)
26. (a)	27. (d)	28. (b)	29. (b)	30. (a)
31. (b)	32. (c)	33. (d)	34. (a)	35. (c)
36. (b)	37. (c)	38. (c)	39. (b)	40. (d)
41. (d)	42. (d)	43. (c)	44. (a)	45. (b)
46. (b)	47. (d)	48. (c)	49. (a)	50. (c)
51. (a)	52. (a)	53. (b)	54. (b)	55. (a)
56. (d)	57. (d)	58. (b)	59. (b)	60. (b)
61. (d)	62. (c)			

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21.

Earthquake Engineering

SHORT ANSWER QUESTIONS

1. According to IS : 1893 (Part 1)- 2002, India is divided into ________ seismic zones.

Ans : 4 zones - zone II, III, IV and V.

2. List important Indian cities located in zone V.

Ans :

Bhuj	Tezpur
Imphal	Mandi
Guwahati	Srinagar
Kohima	Darbhanga

3. The ground motion during a Richter magnitude 8 earthquake is ________ times larger than the ground motion during a Richter magnitude 6 earthquake.

Ans : Increase in magnitude by 1.0 implies 10 times higher waveform amplitude.

∴ ground motion during 8 earthquake is 10 × 10 = 100 times larger than 7 magnitude earthquake.

4. How many seismograph stations are needed to locate the epicenter of an earthquake ?

Ans : Three

5. A soft storey is one in which the lateral stiffness is less than ________ percent of that in the storey above or less than ________ percent of the average lateral stiffness of the three storeys above.

Ans : 70% and 80%

6. A weak storey is one in which the storey lateral strength is less than ________ percent of that in the storey above.

Ans : 80%

7. According to IS : 1893 (Part-I) - 2002, the ratio (I/R) shall not be greater than ________

Ans : 1.0

8. After the 2001 Bhuj (Gujarat) earthquake, the four-storey Bhuj hospital building was built with base isolation using ________.

Ans: Lead Rubber Bearings

9. For the earthquake of magnitude 8.0, the maximum intensity on MMI scale would be about ________

Ans : As per Gutenbery and Richter

$$M_L = \left(\frac{2}{3}\right) I_o + 1 \qquad I_o = \text{intensity of earthquake}$$

$$8 = \left(\frac{2}{3}\right) I_o + 1 \qquad M_L = \text{magnitude}$$

$\therefore \quad I_o = 10.5$

10. According to MSK (64) scale of intensity the total number of intensity classes (or grades) is ________.

Ans : 12 classes

11. When does the natural building period coincide with the earthquake period ?

Ans : When frequency of earthquake force becomes equal to one of the natural frequency of building, i.e. at resonance.

12. According to IS : 13920 : 1993, for all buildings which are more than 3 storeys in height, the minimum grade of concrete shall preferably be ________.

Ans. M 20 (f_{ck} = 20 MPa)

13. As per IS : 13920 - 1993, the thickness of any part of the shear wall shall preferably, not be less than ________.

Ans : 150 mm

14. Which is thickness layer in the cross section of Earth ?

Ans : Mantle 2900 km thick.

Crust	= 5 to 40 km
Mantle	= 2900 km
outer core	= 2200 km
Inner core	= 1290 km
Total	= 6400 km

15. Which are the fastest and slowest seismic waves ?

Ans : Fastest - P waves

Slowest - surfaces waves

16. The distance between focus and epicentre is known as ________.

Ans : focal depth

17. Which is the most difficult structural element to retrofit ?

Ans : Beam

18. **Energy released in a M 7.0 earthquake is about ________ times that released in M 6.0 earthquake, and is about ________ times that released in a M 5.0 earthquake.**

Ans : 31 times

1000 times

19. **For good earthquake resistance, the columns of a building should be made ________ than beams.**

Ans : stronger

20. **RCC slab acts as ________ diaphragm.**

Ans : Rigid

21. **Intensity of vibrations ________ with increase in epicentral distance.**

Ans : decreases

22. **________ is the body wave in which material particles vibrate at right angle to the direction of propagation.**

Ans : S-waves

23. **Delhi lies in zone ________ as per IS : 1893-2002 (I).**

Ans : IV

24. **The sciencc dealing with study of earthquake is known as ________.**

Ans : seismology

25. **The record of an earthquake is called ________**

Ans : Seismogram

26. **The instrument used to record earthquake motion is called ________**

Ans : Seismograph

27. **The point on the fault where slip starts is known as ________**

Ans : Focus or hypocentre

28. **The amount of energy released during earthquake is measured by ________**

Ans : Magnitude

29. **Isoseismals are contours joining places of equal ________.**

Ans : Intensity of earthquake

30. **Magnitude of earthquake is expressed as ________ while intensity is expressed as ________**

(i) Richter scale

(ii) MMI or MSK scale

31. **S-waves can travel through ________ only.**

Ans : Solids

32. **The point on the surface of the earth lying vertically above the focus is called ________.**

Ans : Epicentre

33. Earthquake that occur away from the plate boundary are called ________

Ans : Intraplate earthquake

e.g. 1993 Latur earthquake

1967 Koyna earthquake

34. ________ waves can pass through solid, liquid and gas.

Ans : P-waves

35. ________ waves are most destructive in nature.

Ans : Surface waves

36. Earthquake size is defined in terms of its ________ and ________.

Ans : Magnitude, Intensity

37. The magnitude of an earthquake is generally measured on ________ scale.

Ans : Richter

38. The earthquake with magnitude greater than 8.0 are known as ________

Ans : Great

39. Hard rock foundations can vibrate more by ________ waves and soft soils can vibrate more by ________ waves.

Ans : (i) P and S

(ii) Surface

40. What is PGA ?

Ans : The largest horizontal acceleration of a ground is known as PGA. PGA value of 0.6 g means, movement of ground can cause a maximum horizontal force on a rigid structure equal to 60% of its weight.

41. Inertia force is equal to ________

Ans : Inertia force = mass × acceleration

42. The loads which vary with time are called as ________.

Ans : dynamic loads

43. A mass in space has ________ number of degree of freedom.

Ans : Six

44. The effect of damping is to ________

Ans : decrease the amplitude of vibration

45. The value of damping for buildings may be taken as ________ percent of the critical for dynamic analysis.

Ans : 2 to 5

46. Restoring force is equal to ________

Ans : stiffness × displacement

47. The equation of dynamic equilibrium is written as

Ans : $m\ddot{x} + c\dot{x} + kx$

48. **Earthquake load is an example of ________**

Ans : Non-periodic dynamic load

49. **If the building is flexible then fundamental natural period of building will be ________**

Ans : longer

50. **If the building has more mass, the fundamental natural period will be ________**

Ans : Longer

51. **The force $m\ddot{x}$ is called as ________**

Ans : Inertia force

52. **The force $c\dot{x}$ is called ________**

Ans : damping force

53. **For rigid buildings fundamental period is less than ________ seconds and for flexible buildings fundamental period is greater than ________ seconds.**

Ans : (i) 0.3 (ii) 1.0

54. **Overhead watertank is the simplest example of ________.**

Ans : Single degree freedom system (SDF)

55. **In general, taller buildings are ________ flexible and have ________ fundamental natural period.**

Ans : (i) more (ii) longer

56. **In a building 'diaphragm' term is used for ________..**

Ans : Roof

57. **As per IS : 4326 - 1993 the crushing strength of masonry unit should not be less than ________**

Ans : 3.5 MPa

58. **Minimum recommended cement : sand mortar for earthquake resistant masonry construction is ________**

Ans : 1 : 6

59. **The thickness of load bearing walls shall not be less than ________.**

Ans : 190 mm

60. **The masonry load bearing walls can be built up to a maximum of ________ storeys.**

Ans : 4

61. **Open ground storey building is called as ________**

Ans : soft storey

62. **A discontinuous columns are called as ________**

Ans : Floating columns

63. **A short column attracts ________ inertia force.**

Ans : More

64. **Re-entrant corners of a building are subjected to ________ during earthquake shaking.**

Ans : Stress concentration

65. **Soft storey is an example of ________ irregulatiry.**

Ans : vertical

66. **Short columns are also called as ________ columns.**

Ans : captive

67. **The top storeys of a building are subjected to ________.**

Ans : Larger forces

68. **When earthquake forces are considered in design, the permissible stresses in material are increased by ________ percent.**

Ans : 33%

69. **What is Whythes ?**

The thick stone walls have two vertical layers of large stones and the space between them is filed with mortar and small stones. The two layers of stones are called as whythes.

TRUE/FALSE

- **State whether following statments are true or False and justify your answer in short :**

1. Liquefaction is only possible in cohesive soil.

   False :

   For liquefaction to occur soil must be loose, granular, saturated, earthquake fore and undrained condition.

2. As per IS 1893-2002, Gujarat is divided in Zone-III, IV and V only.

   True

3. Ductile detailing is compulsory for RCC building located in Gujarat.

   False

   Ductile detailing is necessary for buildings located in zone IV and V.

4. Design philosophy for gravity loads & design philosophy for lateral loads due to earthquake are same.

   False

   Gravity loads are static loads while earthquake load is dynamic load.

5. Performance of shear walls which are located near geometric centre of building is better than the identical shear wall located on periphery.

   False

Shear walls are more effective when located along the periphery of the building. Such a layout increases resistance of the building to twisting.

6. Non-structural wall will fail before structural wall.
True
7. IS : 13920-1993 has given special detailing for beam-column joint.
True
8. Concrete structures offer less damping as compared to steel structures.
False

Structure	damping ratio (ξ)
Steel frame	2 to 5%
RCC frame	5 to 7%
RCC frame with shear wall	10%
Timber wall	15%

9. Code specifies higher value of R for building having better performance.
True : Reference IS : 1893 -2002, Table-7.
10. Any structure is designed as earthquake proof structure.
False
Practically no building can be made earthquake proof. The engineering intention is to make buildings earthquake resistant.
11. Numbers of intra-plate earthquakes in world are more than number of inter-plate earthquakes.
False
Number of interplate earthquakes are more (about 99%) which occur along the boundaries of the tectonic plates.
12. Kochi is having maximum earthquake risk.
False
Kochi is situated on west coast in Kerala in zone III.
13. Peak Ground Acceleration (PGA) and zero period acceleration (ZPA) are same.
True
Effective PGA shall be taken as ZPA.
(Reference IS : 1893 - 2002, cl.3.11)
14. A building is located on the boundary of zone IV & V. It will be designed as if it is in zone IV.
False
It will be designed for more severe zone.
15. Two identical buildings to be constructed in zone IV & V. Building in zone V should be designed for lower lateral load than building in zone IV.
False

Building in zone V should be designed for higher lateral load.

16. R.C. frame building is more ductile as compared to steel frame building.

false

Steel frame building is more ductile as compared to R.C. frame building.

17. Taller buildings have smaller fundamental natural period.

False

Taller buildings are more flexible having longer fundamental natural period.

18. Engineers design buildings as earthquake resistant and not earthquake proof.

True

19. The intensity and magnitude of earthquake decreases as the epicentral distance increases.

False

Intensity decreases but magnitude remains same with increase in epicentral distance.

20. Surface waves are most destructive in nature.

True

21. S-Waves are also called shear waves.

True

22. Intensity value of earthquake is based on the experience by the people and performance of structures during earthquake.

True

23. Energy released in an earthquake of magnitude 6 is double compared to that released in magnitude 3 earthquake.

False

Energy released in EQ of magnitude 6 is (31 × 31 × 31) times more than that released in magnitude 3 EQ.

24. Intensity scale X is the highest intensity scale.

False

Highest intensity in MSK and MMI scale is XII.

25. Generally shallow focus earthquakes are more destructive compared to deep focus earthquakes of same magnitude.

True

26. Natural frequency of vibrating system will remain unchanged if damping level is increased.

False

If damping level is increased, multiplying factor for $\frac{S_a}{g}$ decreases (Table 3 of IS : 1893), i.e., $\frac{S_a}{g}$ decreases.

As $\frac{S_a}{g}$ decreases, period (T) increases (Fig. 2, IS : 1893). $f = \frac{1}{T}$ therefore, as T increases, f will decrease.

27. During liquefaction, underground lighter objects are raising up.
False
Objects will sink into the ground.

28. Over damped system comes to rest, faster than critically damped system.
False
Critically damped system comes to rest, faster than overdamped system.

29. Moment resisting capacity of a column should be more than that of beam framing on it.
True

30. Ductility of RCC column increases by providing sufficient confining reinforcement.
True

31. Love waves are most damaging seismic waves.
True
They have only horizontal component of velocity and they create shearing or breaking ruptures.

32. Damping can be neglected in the dynamic analysis of buildings.
False
It should be considered in dynamic analysis.

33. Stiffer columns means greater restoring force.
True

34. Liquefaction of soil generally occur in dry sand.
False
Liquefaction of soil generally occur in loose, saturated sand under dynamic load.

35. Openings in walls should be placed near the corners to prevent failure.
False
Openings in walls should be placed near centre.

36. Roofs made of timber or joists with brick tile coverings are called rigid diaphragms.
False
Flexible diaphragms.

37. It is advisable to have one long room rather than separate small rooms.
False

38. The length of masonry wall should not be greater than 15 m.
True

39. R.C. frame buildings should be designed on the concept of strong column and weak beam.

    True

40. Infill walls increases the flexibility of the building.

    false

    Infill walls decreases the flexibility of the building.

41. Lower grade steel is more ductile than higher grade steel.

    True

42. As per ductile detailing, the bar in a lateral tie should have 135° hook with extension not less than 75 mm.

    True

43. The longitudinal bars in a beam should not be overlapped at the ends.

    False

    Should not be overlapped at the middle of beam.

44. The lateral ties in a column should be provided over the entire lap length at a spacing not more than 150 mm.

    True

45. As per IS : 1893 - 2002 earthquake is not likely to occur simultaneously with wind.

    True

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22.

Water Supply and Sanitrary Engineering

MCQ'S

(A) WATER SUPPLY ENGINEERING

1. The average domestic water consumption per capita per day for an Indian city as per IS: 1172 is
(a) 135 lpcd (b) 240 lpcd (c) 270 lpcd (d) 150 lpcd

2. The multiplying factor, as applied to obtain the maximum daily water demand, in relation to the average i.e. per capita daily demand is
(a) 1.5 (b) 1.8 (c) 2.0 2.7

3. The multiplying factor, as applied to obtain the peak hourly demand, in relation to the maximum daily demand is
(a) 1.5 (b) 1.8 (c) 2.0 (d) 2.7

4. The multiplying factor, as applied to obtain the peak hourly demand, in relation to the average daily demand is
(a) 1.5 (b) 1.8 (c) 2.0 (d) 2.7

5. The total water consumption per capita per day, including domestic, commercial, and industrial demands for an average Indian city, as per IS: 1172 is
(a) 135 lpcd (b) 240 lpcd (c) 270 lpcd (d) 150 lpcd

6. Water losses in water supply system are assumed as
(a) 5% (b) 7.5% (c) 15% (d) 25%

7. $Q = 3182 \sqrt{P}$ is the formula for fire demand furnished by
(a) Kuichling (b) Freeman
(c) National Board of fire protection (d) Buston

8. The total water requirement of a city is generally assessed on the basis of :
(a) Maximum hourly demand
(b) Maximum daily demand + fire demand
(c) average daily demand + fire demand
(d) greater of (a) and (b)

9. The most satisfactory formula for an estimate of fire demand Q for a city of population P in thousands for Indian conditions is

(a) $1136\left[\frac{P}{10}+10\right]$ .... Freeman's formula

(b) $3182\sqrt{P}$ ... Kuichling's formula

(c) $4640\sqrt{P}\,[1 - 0.01\sqrt{P}\,]$ ... National board of fire

10. The average rainfall of a country is a figure which is average over a period of

(a) 10 years (b) 15 years (c) 50 years (d) 35 years

: ANSWERS :

1. (a)	2. (b)	3. (a)	4. (d)	5. (c)
6. (c)	7. (a)	8. (d)	9. (b)	10. (d)

11. The evaporation losses from the surface of a reservoir can be reduced by sprinkling

(a) D.D.T. (b) acetyl alcohol

(c) Potassium permangamate (d) none of these

12. Pipes for branches to bathrooms and lavatories in domestic water supply are usually

(a) 10 mm (b) 12 mm (c) 15 mm (d) 25 mm

13. The most widely used type of a tube well in India is

(a) a dug well (b) a cavity well

(c) a stainer well (d) a ranney well

14. The suitable method for forecasting population for a young and a rapidly growing city is

(a) arithmetic mean method (b) geometric mean method

(c) comparative graphical method (d) None of these

15. The maximum quantity of water that can be supplied from a reservoir with full guarantee during critical periods is called

(a) reservoir yield (b) design yield (c) secondary yield (d) firm yield

16. Select the correct relationship between porosity (N), specific yield (y) and specific retention (R).

(a) R = N + Y (b) N = Y + R (c) R > N + Y (d) Y = N + R

17. The presence of algae in water indicates that the water is

(a) hard (b) soft (c) acidic (d) pure

18. Turbidity of water is due to

(a) algae (b) fungi

(c) organic salts (d) finely divided particles of clay, silt, etc.

19. The maximum permissible turbidity for drinking water is

(a) 1 to 4 ppm (b) 5 to 10 PPM (c) 15 to 20 PPM (d) 25 to 30 PPM

20. For public water supply the maximum limit permissible of nitrates is

(a) 200 PPM (b) 100 PPM (c) 50 PPM (d) zero

: ANSWERS :

11. (b)	12. (b)	13. (c)	14. (b)	15. (d)
16. (b)	17. (c)	18. (d)	19. (b)	20. (d)

21. For maximum acidity the pH value of water should be

(a) 0 (b) 1 (c) 7 (d) 14

22. For maximum alkalinity in water, the pH value should be

(a) 0 (b) 1 (c) 7 (d) 14

23. The pH value of drinking water should be

(a) 3 to 5 (b) 7 to 8.5 (c) 10 to 12 (d) 12 to 15

24. The most common cause of acidity in water is

(a) Oxygen (b) Hydrogen (c) Carbon dioxide (d) nitrogen

25. A water having pH = 9, will have hydroxyl ion concentration equal to

(a) 10^9 (b) 10^{-9} (c) 10^{-5} (d) 10^5

26. The most appropriate hardness in drinking water is of the order of

(a) 50 PPM (b) 100 PPM (c) 200 PPM (d) 300 PPM

27. Waters are considered 'hard', if their hardness is of the order of

(a) 50 PPM (b) 100 PPM (c) 200 PPM (d) 300 PPM

28. Waters are considered 'soft' if their hardness does not exceed

(a) 75 PPM (b) 100 PPM (c) 150 PPM (d) 300 PPM

29. Hard water is tastier than soft water due to the presence of

(a) Sodium (b) Calcium (c) Carbonates (d) bicarbonates

30. When fluoride concentration in water exceeds 1.5 mg/*l*, the disease that may be caused is

(a) methaemoglobinemia (b) fluorosis

(c) dental caries in children (d) poliomyelitis

: ANSWERS :

21. (a)	22. (d)	23. (b)	24. (c)	25. (c)
26. (b)	27. (d)	28. (a)	29. (d)	30. (b)

31. Dental carries in children may be caused due to water deficient in

(a) calcium (b) iron (c) fluorides (d) none of these

32. Higher quantities of copper, more than 2.5 mg/l or so, can cause diesease pertaining to

(a) kidney (b) lungs (c) lever (d) teeth

33. Blue baby disease may be caused in infants due to drinking water containing higher concentration of

(a) nitrites (b) nitrates (c) lead (d) arsenic

34. The metal which is the most hazardons to human beings, among the following is

(a) Iron (b) Barium (c) Silver (d) Arsenic

35. The only metal among the following which is not toxic to human beings is

(a) Sodium (b) Mercury (c) Lead (d) cadmium

36. The maximum allowable concentration of iron in water is

(a) 1.0 PPM (b) 0.05 PPM (c) 0.3 PPM (d) 0.03 PPM

37. The maximum safe permissible limit of chlorides in domestic water supply is

(a) 0.5 mg/*l* (b) 2.5 mg/*l* (c) 250 mg/*l* (d) 100 mg/*l*

38. The maximum safe permissible limit of sulphates in domestic water supplies is

(a) 100 mg/*l* (b) 200 mg/*l* (c) 500 mg/*l* (d) 1000 mg/*l*

39. The valve which allows the flow only in one direction is

(a) reflux valve (b) Sluice valve (c) gate valve (d) air-relief valve

40. 'Wholesome water is the one, which doesn't contain

(a) Pathogenic bacteria

(b) Suspended matter quantities harmful to man

(c) dissolved matter quantities harmful to man

(d) all of the above

: ANSWERS :

31. (c)	32. (b)	33. (c)	34. (c)	35. (a)
36. (c)	37. (c)	38. (b)	39. (a)	40. (d)

41. The treatments which are generally given to treat raw water supplies, follow the sequence.

(a) Screening, sedimentation, disinfection, filtration

(b) Screening, sedimentation filtration, disinfection

(c) Screening, sedimentation, disinfection, aeration

(d) Screening, sedimentation, coagulation, filtration, disinfection

54. A check valve is also known as

(a) relief valve (b) reflux valve (c) blow off valve (d) none of these

55. A sluice valve is also known as

(a) air-inlet valve (b) scour valve (c) gate valve (d) none of these

56. Scour valves are provided

(a) at the screet corners to control flow

(b) at the dead ends to drain out the waste water

(c) at every summit of the rising main

(d) at the foot of the rising main to prevent back running of water.

57. The formula which is most appropriate for the design of pressure pipes is :

(a) Darcy-weisbach formula (b) Manning's formula

(c) Chezy's formula (d) Dupuit's formula

58. 'Shrouding' is essentially provided in

(a) strainer type tube wells (b) cavity type tube wells

(c) slotted pipe tube wells (d) all of the above

59. The settling velocity of inorganic particles in a sedimentation tank of a water treatment plant is governed by

(a) Darcy's law (b) Stoke's law (c) Dupuit's law (d) none of these

60. Sedimentation can remove inorganic particles having specific gravity upto

(a) 2.65 (b) 1.65 (c) 1.20 (d) 1.03

: ANSWERS :

51. (d)	52. (d)	53. (b)	54. (b)	55. (c)
56. (b)	57. (a)	58. (c)	59. (b)	60. (c)

61. If the temperatuare of sedimentation tank is increased, the sedimentation speed will

(a) get hastened (b) get slowed down (c) not be affected at all

62. Surface loading or overflow rate of sedimentation tank, passing a discharge = Q, and having length L_1 depth = H, width = B is given by

(a) $\frac{Q}{B.H.}$ (b) $\frac{Q}{B.L.}$ (c) Q.B.H. (d) $\frac{Q}{B.H.L.}$

63. The horizontal flow velocity in a sedimentation tank passing a discharge = Q, having length = L, width = B and depth = H is given by

(a) $\frac{Q}{B.H.}$ (b) $\frac{Q}{B.L.}$ (c) B.H. (d) none of the above

42. A harmful organism, which may be present in feacal matter may be

(a) bacteria - coil (b) escherichia-coli
(c) Vibrio cholerae (d) none of these

43. The bacteria which survive in the presence as well as absence of oxygen, are called

(a) anaerobic (b) facultative (c) B-coli (d) E-coli

44. Breweries and distilleries preferably require

(a) hard waters (b) soft waters (c) potable waters (d) none of these

45. The waters to be used for boilers should be

(a) Hard (b) soft (c) Potable (d) none of these

46. The B-coli test is conducted to serve as a

(a) very good indicator of pathogenic bacteria
(b) very good indicator of acidity
(c) very good indicator of alkalinity
(d) means of detecting turbidity

47. The suspended solids present in water may give colour to water, which is known as

(a) apparent colour (b) true colour (c) colour (d) none of these

48. The colour of water contributed by dissolved solids is

(a) apparent colour (b) true colour (c) colour (d) b and c both

49. The true colour of water is measured on

(a) Platinum cobalt scale (b) Silica scale
(c) nickel scale (d) all of the above

50. EDTA solution is used to determine, by titrating it against water is

(a) turbidity of water (b) hardness of water
(c) DO in water (d) residual chlorine in water.

: ANSWERS :

41. (b)	42. (c)	43. (b)	44. (a)	45. (b)
46. (a)	47. (a)	48. (d)	49. (a)	50. (b)

51. Based on the cobalt scale, the maximum permissible colour for domestic supplies is

(a) 100 (b) 50 (c) 25 (d) 20

52. Drinking water will be safe if its B.O.D. is

(a) 25 (b) 10 (c) 5 (d) 0

53. The valve which is used to control the flow of water in the water distribution system is

(a) air valve (b) Sluice valve (c) Scour valve (d) reflux valve

54. A check valve is also known as

(a) relief valve (b) reflux valve (c) blow off valve (d) none of these

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: ANSWERS :

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(a) $\frac{Q}{B.H.}$ (b) $\frac{Q}{B.L.}$ (c) Q.B.H. (d) $\frac{Q}{B.H.L.}$

63. The horizontal flow velocity in a sedimentation tank passing a discharge = Q, having length = L, width = B and depth = H is given by

(a) $\frac{Q}{B.H.}$ (b) $\frac{Q}{B.L.}$ (c) B.H. (d) none of the above

64. **Detention time for a sedimentation tank (continuous flow type) is given for a discharge = Q, Length = L, Width = B and depth = H is given by**

(a) $\frac{LBH}{Q}$ (b) $\frac{Q}{LBH}$ (c) $\frac{Q}{B.L.}$ (d) none of the above

65. **Surface loading or overflow velocity of a plain sedimentation tank may vary in the range**

(a) 100-500 l/hr/m^2 (b) 500-750 l/hr/m^2
(c) 1000-1250 l/hr/m^2 (d) none of these

66. **The velocity of flow of water in a plain sedimentation tank may normally be taken as**

(a) 15-30 cm/sec (b) 15-30 cm/min (c) 15-30 cm/hr (d) none of these

67. **The most widely used coagulant for water treatment is**

(a) lime and soda (b) Chlorinated copperas
(c) ferrous sulphate (d) alum

68. **A clariflocculator is a**

(a) plain sedimentation unit (b) aeration unit
(c) coagulation-sedimentation unit (d) none of the above

69. **The detention time for a water sedimentation tank may vary between**

(a) 1-2 hr (b) 2-4 hr (c) 4-8 hr (d) 16-24 hr

70. **Particles of around 1 micron (10^{-6} m) size are best removed by**

(a) filtration (b) plain sedimentation
(c) Chemical precipitation (d) chemical coagulation

: ANSWERS :

61. (a)	62. (b)	63. (a)	64. (a)	65. (b)
66. (b)	67. (d)	68. (c)	69. (c)	70. (d)

71. **The aeration of water is done to remove**

(a) colour (b) Turbidity (c) odour (d) bacteria

72. **Disinfection of water is done by**

(a) filtration (b) Passing chlorine (c) Alum (d) Heating

73. **In water distribution scheme the commonly used pipe is**

(a) C.I. Pipes (b) G.I.Pipes (c) Hume pipes (D) PVC Pipes

74. **Rapid gravity filters remove bacteria to as much as**

(a) 80-90% (b) 90-95% (c) 98-99% (d) none of these

75. Slow sand filters remove bacteria as much as

(a) 80-90 % (b) 90-95% (c) 98-99% (d) none of these

76. Cleaning of rapid sand filters is done by

(a) Scraping and removal of sand (b) back washing
(c) any of the above (d) none of these

77. Activated carbon is used in water treatement for removing

(a) colour (b) tastes and odours (c) turbidity (d) corrosiveness

78. The water tap of hour house is known as

(a) Sluice tap (b) Stop cock (c) bib cock (d) ferrule

79. Which of the following compound is used in algae control

(a) Ferric sulphate (b) Calcium chloride (c) Copper sulphate (d) Ferric chloride

80. The suitable method for disinfection of swimming pool water is

(a) ultr-violet rays treatment (b) lime treatment
(c) chlorination (d) use of $kmno_4$

: ANSWERS :

71. (c)	72. (b)	73. (a)	74. (a)	75. (c)
76. (b)	77. (b)	78. (c)	79. (c)	80. (a)

81. Match list I and list II and select the correct answer using the codes given below in the list :

List I	**List II**
Sources of water supply	**Water quality parameters**
A. Ground water	1. Low D.O. and colour
B. Lake water at the bottom	2. Carbondioxide and hardness
C. Canal water	3. Low organic content and high D.O.
D. River water in floods	4. Silt and bacteria
	5. High turbidity and D.O.

Codes :

	A	B	C	D
(a)	2	1	3	5
(b)	3	4	2	1
(c)	3	2	4	1
(d)	1	2	3	5

82. Dechlorination of water is achieved by adding

(a) Sodium thiosulphate (b) Sodium sulphate
(c) Sodium hexametaphosphate (d) Sodium bisulphate

83. **The efficiency of sedimentation does not depend upon**
(a) detention time (b) depth of tank
(c) length of tank (d) horizontal velocity of flow

84. **Which of the following treatment reduce salinity of water.**
1. Flocculation and sedimentation 2. Filtration
3. Reverse osmosis 4. Electrodialysis
Select the correct answer using the codes given below :
(a) 1 and 2 (b) 3 and 4 (c) 2 and 3 (d) 1 and 4

85. **If present in water, chlorination of water does not reduce the**
(a) ammonia content (b) organic matter content
(c) B.O.D. (d) dissolved oxygen content

86. **Match list I with list II and select the correct answer using coed given below the lists :**

List I	List II
A. cast iron pipes	1. Simplex joint
B. Asbestos cement pipes	2. Spigot and socket joint
C. Plain ended pipes subject to frequent vibrations	3. Screwed joint
D. G.I.pipe	4. Victaulic joint

Codes :	A	B	C	D
(a)	1	3	2	4
(b)	2	1	4	3
(c)	3	4	2	1
(d)	4	2	1	3

87. **The water supply to a house begins with the connection of the service pipe with the municipal water mains. The connection comprises.**
1. stop cock 2. Goose neck 3. ferrule 4. Water meter
The correct sequence of these connections is :
(a) 1, 2, 3, 4 (b) 3, 1, 2, 4 (c) 3, 2, 1, 4 (d) 1, 2, 4, 3

88. **Type II settling in water treatment is defined**
(a) Settling of discrete particles in dilute suspensions
(b) Settling of flocculent particles in dilute suspension
(c) Settling of flocculent particles in concentrated suspensions
(d) Settling of particles in the form of a sludge blanket

89. **The chlorine demand of a water sample was found to be 0.2 mg/*l*. The amount of bleaching powder containing 30% available chlorine to be added to treat one litre of such a water sample is**
(a) 0.67 mg (b) 0.06 mg (c) 1.33 mg (d) 0.14 mg

Chlorine demand to treat 1 litre of water = 0.2 mg x mg of bleaching powder containing 30% chlorine, will supply $x \times 0.3$ mg of chlorine, To balance

$0.2 = 0.3 \times x$

$\therefore \quad x = 0.67$ mg

90. Which of the following pairs are correctly matched ?

1. lime soda process ...... softening
2. Nalgonda technique....... fluoride removal
3. Aeration.......... coagulation
4. Ozonation........... disinfection

Codes :

(a) 1, 2 and 3 (b) 1, 3 and 4 (c) 1, 2 and 4 (d) 2, 3 and 4

: ANSWERS :

81. (a)	82. (a)	83. (b)	84. (b)	85. (d)
86. (b)	87. (c)	88. (b)	89. (a)	90. (c)

91. The ideal residual pressure at the farthest consumer's tap in a properly designed water distribution system is in the range of

(a) 0.06 to 0.20 N/mm^2 (b) 0.21 to 0.25 N/mm^2

(c) 0.26 to 0.30 N/mm^2 (d) 0.31 to 0.35 N/mm^2

92. Consider the following statements in respects of slow sand filters

1. Qualitywise they are more efficient than rapid sand filters
2. They need periodic back washing
3. Their flow rate is much smaller than that of pressure filters of these statements :

(a) 1, 2 and 3 are correct (b) 1 and 2 are correct

(c) 1 and 3 are correct (d) 2 and 3 are correct

93. Match list I and list II and select the correct answer using the codes given below the lists.

List I Type of water Source	List II Treatment to be given
A. Surface water (river or canal)	1. Aeration, coagulation, sedimentation, disinfection
B. Water from infiltration gallery	2. Disinfection
C. Lake/pond water	3. $C_u SO_4$ treatment, coagulation, sedimentation, filtration, disinfection
D. Tube well water	4. Coagulation. flocculation, sedimentation. Filtration, disinfection

Codes :	A	B	C	D
(a)	4	1	3	2
(b)	1	4	3	2
(c)	1	4	2	3
(d)	4	1	2	3

94. Two reservoirs at different levels are connected by two parallel pipes of diameter 2d and d. The ratio of the flows in the two pipes (larger : smaller) is

(a) $\sqrt{2} : 1$ (b) 2 : 1 (c) 4 : 1 (d) $4\sqrt{2} : 1$

95. The yield of a well depends upon

(a) Permeability of soil (b) area of equifer opening into the wells
(c) actual flow velocity (d) all of the above

96. The cleaning of slow sand filter is done by

(a) reversing the direction of flow of water
(b) Passing air through the filter
(c) Passing a solution of alum and lime through the filter
(d) Scraping off the top layers of sand and admitting water.

97. Which one of the following would contain water with the maximum amount of turbidity ?

(a) Lakes (b) Oceans (c) Rivers (d) Wells

98. Which one of the following pair is not correctly matched ?

(a) Check valve....... to check water flow in all direction
(b) Sluice valve .... To control flow of water through pipe lines
(c) Air valve .... to release the accumulated air
(d) Scour valve....... To remove silt in a pipe line.

99. Match list I with List II and select the correct answer using the codes given below the lists :

List I Name of impurity in water	List II Removed by
A. Fluorides	1. Activated carbon
B. Manganese	2. Activated alumina
C. Taste and odour	3. Manganese zeolite

Codes :	A	B	C
(a)	1	2	3
(b)	2	3	1
(c)	2	1	3
(d)	3	2	1

100. Uniformity coefficient of filter media is given by

(a) D_{50}/D_5 (b) D_{50}/D_{10} (c) D_{60}/D_5 (d) D_{60}/D_{10}

: ANSWERS :

91. (d)	92. (c)	93. (a)	94. (d)	95. (a)
96. (d)	97. (c)	98. (a)	99. (b)	100 (d)

101. After which of the following water treatement units, the turbidity is maximum ?

(a) chlorination (b) primary sedimentation

(c) Flocculation basin (d) Secondary sedimentation

102. Which one of the following chemicals is employed for dechlorination of water ?

(a) Sodium sulphite (b) Sodium bicarbonate

(c) Calcium carbonate (d) Hydrogen peroxide

103. In which treatment unit is 'schmutz decke' formed ?

(a) Sedimentation tank (b) Rapid sand filter

(c) Coagulation tank (d) Slow sand filter

104. Chlorides from water are removed by

(a) Lime soda process (b) Reverse osmosis

(c) Cation exchange process (d) Chemical coagulation

105. Which one of the following statements is not correct ?

(a) Solution of pipe network by Hardy cross method is a trial and error solution.

(b) At a junction of pipes, total inflow is equal to the total outflow.

(c) Loss of head due to flow in a clockwise direction should be equal to loss of head in flow in a counter clockwise direction.

(d) Hardy cross method can be extended to open channel flow also

106. Match list I and list II and select the correct answer using the code given below the lists :

List I Treatment process	List II Removed matter
A. Plain sedimentation	1. dissolved gases
B. Chemical precipitation	2. Dissolved solids
C. Slow sand filter	3. Suspended solids with specific gravity more than 1.0
D. Aeration	4. Floating solids
	5. Bacterial cells

Codes :	A	B	C	D
(a)	5	1	4	2
(b)	3	2	5	1
(c)	5	2	4	1
(d)	3	1	5	2

107. Match list I (Equation/law) with list II (related application) and select the correct answer using the code given below the lists :

List I	List II
A. Chick's law	1. Discrete particle settling
B. Darcy - weisbach equation	2. Head loss in pipe
C. Stoke's law	3. Head loss in filter
D. Carmen -kozeny equation	4. Rate of bacterial kill

Code :	A	B	C	D
(a)	4	2	1	3
(b)	3	1	2	4
(c)	4	1	2	3
(d)	3	2	1	4

108. Match list I (type of impurity) with list II (effect) and select the correct answer using the code given below the lists :

List I	List II
A. Carbonates and bicarbonates of Ca and Mg	1. Permanent hardness
B. Carbonates and bicarbonates of sodium	2. Temporary hardness
C. Sulphates and chlorides of Ca and Mg	3. Alkalinity and softness
D. Oxides of iron and managnese	4. Colour and taste

Codes :	A	B	C	D
(a)	1	3	2	4
(b)	2	4	1	3
(c)	1	4	2	3
(d)	2	3	1	4

109. Match list I (type of pipe) with List II (purpose) and select the correct answer using the codes given below the lists

List I	List II
Type of pipe	Purpose
A. Steel pipe	1. House plumbling
B. Cast iron pipe	2. Hot water carrying
C. G.I. pipe	3. Distribution main
D. PVC pipe	4. Pumping main

Codes :	A	B	C	D
(a)	4	1	2	3
(b)	4	3	2	1
(c)	2	1	4	3
(d)	2	3	4	1

110. Consider the following statements

The basic difference between water pipes and sewer pipes is

1. in the material used for the pipes
2. in the pressure of the liquid flow
3. in the suspended solids they carry

Which of the statements given above is/are correct ?

(a) 1 and 3 (b) 1 only (c) 2 and 3 (d) 1, 2 and 3

: ANSWERS :

101. (c)	102. (a)	103. (d)	104. (b)	105 (d)
106. (b)	107. (a)	108. (d)	109. (b)	110. (d)

111. Which one of the following organism is responsible for enteric fever ?

(a) ECHO (b) Salmonella typhi

(c) Entamoeba histolytica (d) Echinococcus

112. On which of the following factors, does the population growth in a town normally depends ?

(1) Birth and death rates (2) Migrations

(3) Probabilistic growth (4) logistic growth

Select the correct answer using the codes given below :

(a) 1 and 4 (b) 1 and 2 (c) 1, 2 and 3 (d) 2 and 4

113. Match List I (Tests) and List II (Features) and select the correct answer using the codes given below the lists :

List I (Tests)		List II (Features)
A. Pumping test	1.	The gradual rise of water level in well is observed as time progresses.
B. Recuperation test	2.	Rate of pumping is adjusted to constant level of water in well
C. Pressure test	3.	Vigorous mixing of the chemical followed by slow mixing
D. Jar test	4.	Pipeline is filled up with water, allowed to stand for sometime and then atleast double the maximum pressure is applied.

Codes :

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	1	2	4	3
(d)	2	1	3	4

114. Which of the following are removed by rapid sand filter from water ?

1. Dissolved solids
2. suspended solids
3. Bacteria
4. Hel minths

Select the correct answer using the codes given below

Codes :

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 2, 3 and 4

115. Which of the following treatment processes are necessary for removing suspended solids from water ?

1. Coagulation
2. Flocculation
3. Sedimentation
4. Disinfection

Select the correct answer using the codes given below :

(a) 1 and 2 (b) 1, 2 and 3 (c) 2 and 3 (d) 1 and 4

116. The population figures in a growing town are as follows :

Year	Population
1970	40,000
1980	46,000
1990	53,000
2000	8,000

The predicted population in 2010 by Arithmetic Regression method is

(a) 62,000 (b) 63,000 (c) 64,000 (d) 65,000

Hint : $\bar{x} = \frac{6000 + 7000 + 5000}{2} = 6000$

$\therefore \quad P_{2010} = P_o + n.\bar{x}$

$= 58,000 + 1 \times 6000 = 64,000$

117. The amount of bleaching powder containing 20% available chlorine needed to chlorinate a rural water supply covering a population of 10,000 at 50 lpcd at the rate of 2 ppm is

(a) 1 kg (b) 5 kg (c) 0.2 kg (d) 20 kg

Hint : Refer question no.89

Chlorine needed to treat 1 lit of water = 2 mg (ppm)

x mg of bleaching powder containing 20% chlorine will supply $x \times 0.2$ mg of chlorine

Total quantity of water = 10,000 × 50

$= 5 \times 10^5$ litres

To balance,

$0.2 \times x = 2$

$\therefore \quad x = 10$ mg....... for 1 litre of water

$\therefore$ For 5×10^5 litre of water,

Chlorine required $= 10 \times 5 \times 10^5$

$= 5 \times 10^6$ mg

$= 5$ kg

118. Consider the following statments :

While deciding to locate an intake structure for a city situated on a river bank, intake for water supply should be located

1. in deep waters
2. Sufficiently away from shore lines
3. upstream of the populated city
4. near navigational channel

which of these are correct ?

(a) 1, 2 and 4 (b) 1, 2 and 3 (c) 2, 3 and 4 (d) 1, 3 and 4

119. Match list I (water quality) with List II (method of determination) and select the correct answer using the codes given below the lists :

List I (water quality)	**List II (Method of determination)**
A. Hardness	1. Winkler method
B. Chlorine	2. EDTA method
C. DO	3. Orthotolidine test
D. chloride	4. Mohr method

Codes :	A	B	C	D
(a)	2	3	1	4
(b)	2	4	1	3
(c)	1	3	2	4
(d)	1	4	2	3

120. The purpose of providing balancing reservoir in a water supply distribution system is to

(a) equalize pressure in the distribution system

(b) Store adequate quantity of water to meet requirements in case of breakdown of flow

(c) Store adequate fire fighting reserve

(d) take care of fluctuations in the rate of consumption

: ANSWERS :

111. (b)	112. (b)	113. (b)	114. (d)	115. (d)
116. (c)	117. (b)	118. (b)	119. (a)	120. (d)

121. Which of the following are the common problems associated with the operation of rapid sand filter ?

1. Air binding
2. cracking of sand beds
3. Bumping of filter beds
4. mud balls

Codes :

(a) 1 and 2 (b) 2 and 3 (c) 2, 3 and 4 (d) 1,2,3 and 4

122. Match list I (unit in water treatment plant) with list II (impurities removed) and select the correct answer using the codes given below the lists :

List I		List II	
A.	Aerator	1.	Excess CO_2 and H_2S
B.	Rapid sand filter	2.	Settleable and colloidal matter
C.	Slow sand filter	3.	Suspended matter
D.	Sedimentation tank (after coagulation and flocculation)	4.	Suspended colloidal and bacteriological matter

Codes :	A	B	C	D
(a)	1	3	2	4
(b)	3	1	2	4
(c)	3	1	4	2
(d)	1	3	4	2

123. COnsider the following impurities

1. CO_2 and H_2S
2. Finely divided suspended matter
3. Disease causing bacteria
4. Excess alkalinity

The correct sequence of the removal of these impurities in a water treatment plant is :

(a) 1, 2, 3, 4 (b) 1, 4, 3, 2 (c) 1,4,2,3 (d) 4, 1, 3, 2

124. The usual size of residential ferrule bore varies from :

(a) 1 mm to 5 mm (b) 10 mm to 50 mm
(c) 100 mm to 500 mm (d) 1000 mm to 5000 mm

125. Reciprocating pumps are suitable for

(a) low discharge and high heads (b) high discharge and low heads
(c) low discharge and low heads (d) high discharge and high heads

126. Which one of the following filters will produce water of higher bacteriological quality ?

(a) Slow sand filter (b) Rapid sand filter
(c) Pressure filter (d) Dual media filter

127. Commonly used hand pump is the

(a) Centrifugal pump (b) reciprocating pump
(c) rotary pump (d) axial flow pump

128. Match list I (parameters) with list II (permissible concentration in drinking water) and select the correct answer using the codes given below the list :

	List I		List II
A.	Hardness	1.	0.1 mg/*l*
B.	Nitrate concentration	2.	0.5 mg/*l*
C.	Iron concentration	3.	200 mg/*l*
D.	Fluoride concentration	4.	45 mg/*l*

Codes :	A	B	C	D
(a)	3	4	2	1
(b)	3	4	1	2
(c)	4	3	2	1
(d)	4	3	1	2

129. The various treatment processes in a water treatment plant are listed below :

1. Filteration 2. Chlorination 3. Sedimentation
4. Coagulation 5. Flocculation

The correct sequence of these processes in water treatment is

(a) 1,2,3,4,5 (b) 4, 5,3,1,2 (c) 2,3,1,5,4 (d) 1,2,5,3,4

130. Which one of the following is the purpose of providing a surge tank in a pipeline carrying water ?

(a) To store water

(b) to increase the pressure throughout the pipeline

(c) To stop overflowing water

(d) To protect the pipe line against water hammer

: ANSWERS :

121. (d)	122. (d)	123. (c)	124. (b)	125. (a)
126. (d)	127. (b)	128. (b)	129. (b)	130. (d)

❖❖❖

(B) SANITARY ENGINEERING

1. **The sewerage system originates from**
   (a) outfall sewer (b) main sewer (c) house sewer (d) none of these
2. **The sewer which transports the sewage to the point of treatment, is called**
   (a) house sewer (b) main sewer (c) outfall sewer (d) none of these
3. A sewer which receives the discharge from a number of independent houses is called :
   (a) house sewer (b) intercepting sewer (c) lateral sewer (d) none of these
4. **The waste water coming from kitchens and bathrooms is popularly know as**
   (a) domestic sewage discharge (b) sludge discharge
   (c) drainage discharge (d) none of these
5. **The type of sewage system which carries storm water and sewage is called a ______ system.**
   (a) storm water (b) domestic (c) separate (d) combined
6. **Branch and main sewers are widely made of :**
   (a) R.C.C. (b) P.C.C. (c) glazed stone wave (d) cast iron
7. **Pick up the correct statement from the following :**
   with self cleansing velocity in sewers
   (a) the silting occurs at the bottom
   (b) the scouring occurs at the bottom
   (c) the silting and scouring both occurs at the bottom
   (d) neither silting nor scouring occur at the bottom
8. **Sewer pipes of diameter less than 0.4 m are designed at maximum flow, to be running at :**
   (a) full depth (b) $\frac{1}{2}$ full depth (c) $\frac{2}{3}$ full depth (d) $\frac{3}{4}$ full depth
9. **The water carriage system of collection of waste products is preferred to dry conservancy system, because :**
   (a) it is cheaper in initial cost
   (b) it does not require treatment before disposal
   (c) it is more hygienic in nature (d) it is easier to maintain
10. **For the design of sewers in India, the percentage of sewage discharge is assumed as**
    (a) 25-30% of water supplied from water works
    (b) 75-80% of water supplied from water works
    (c) 100 % of water supplied from water works
    (d) none of these

: ANSWERS :

1. (c)	2. (c)	3. (c)	4. (b)	5. (d)
6. (a)	7. (d)	8. (b)	9. (c)	10. (b)

11. The sewer pipes have to be designed and checked for :
(a) only maximum flow (b) only minimum flow
(c) both maximum and minimum flow (d) none of them

12. Sewage treatment works are normally designed for a period of
(a) 5-10 years (b) 15-20 years (c) 30-40 years (d) 40-50 years

13. A.C. pipes are generally joined by using
(a) bell and spigot joint (b) simplex joint
(c) lock joint (d) none of these

14. Testing of sewer may involve
(a) water test (b) mirror test (c) ball test (d) all these tests

15. Sewers are generally laid starting from
(a) all take point (b) outfall point
(c) mid point (d) any point long the alignment

16. The minimm and maximum diameters of sewers generally adopted in the designs, may be :
(a) 15 cm and 100 cm (b) 15 cm and 300 cm
(c) 25 cm and 450 cm (d) 60 cm and 300 cm

17. $\frac{1}{4}$ to $\frac{1}{3}$ space is left vacant in the design of sewers pipes at maximum discharge due to :
(a) possible low estimates of maximum and average flow
(b) large scale possible infiltration of storm water
(c) unexpected increase in population
(d) all the above factors

18. For a circular sewer of diameter D and running half full, the hydraulic mean depth is
(a) $\frac{D}{2}$ (b) $\frac{D}{3}$ (c) $\frac{D}{4}$ (d) $\frac{D}{5}$

19. A pipe that receives discharge from soil fittings like urinals, water closets, etc. is called
(a) Soil pipe (b) waste pipe (c) vent pipe (d) antisiphonage pipe

20. **The lowest level of the surface of a sewer is known as**
(a) basement (b) invert (c) bedding (d) bed level

: ANSWERS :

11. (c)	12. (b)	13. (b)	14. (d)	15. (b)
16. (b)	17. (d)	18. (c)	19. (a)	20. (b)

21. **Decayed fuits, grass, leaves, vegetable waste etc. belong to refuse called**
(a) sewage (b) garbage (c) sullage (d) soil waste

22. **Waste waters from bathrooms, kitchens, washing places, wash basins etc. is known as**
(a) Garbage (b) Rubbish (c) sullage (d) sewage

23. **Laying of sewers is usually done with the help of**
(a) a theodolite (b) a compass
(c) a plane table (d) sight rails and boning rods

24. **The sewer pipes of dia 0.4 to 0.9 m are designed at maximum flow, running at :**
(a) full depth (b) $\frac{1}{2}$ full depth (c) $\frac{2}{3}$ full depth (d) $\frac{3}{4}$ full depth

25. **The most suitable section of a sewer in a separate sewerage system is**
(a) rectangular (b) circular (c) new egg shaped (d) parabolic

26. **The approximate % of water in sewage is**
(a) 90 % (b) 99 % (c) 99.9 % (d) 100 %

27. **Manholes are generally located**
(a) at all changes of direction of sewer (b) at all changes of gradient of sewer
(c) at all junctions of different sewers (d) all of the above

28. **A manhole is generally classified as a deep manhole, if its depth is more than**
(a) 0.9 m (b) 1.2 m (c) 1.5 m (d) 2.0 m

29. **Manhole covers are made circular**
(a) for architectural reason
(b) to prevent falling of the cover into the manhole
(c) for strengthen the cover (d) to make the entry convenient

30. **An egg-shaped sewer, when compared to a circular sewer, is**
(a) economical (b) more stable
(c) provide better self cleansing velocity at low discharges
(d) easier to construct

: ANSWERS :

21. (b)	22. (c)	23. (d)	24. (c)	25. (b)
26. (c)	27. (d)	28. (c)	29. (d)	30. (c)

31. The flow velocity in a sewer does not depend on

(a) its grade (b) its length
(c) its hydraulic mean depth (d) its roughness

32. In a circular sewer of dia D, if the depth of flow is $\frac{D}{4}$, the wetted perimeter will be

(a) $\frac{\pi D}{4}$ (b) $\frac{\pi D}{2}$ (c) $\frac{\pi D}{3}$ (d) none of these

Mint : $\frac{d}{D} = \frac{1}{2}[1 - \cos\frac{\theta}{2}]$ $\frac{d}{D} = \frac{D}{4 \times D} = 0.25$

$$0.25 = \frac{1}{2}[1 - \cos\frac{\theta}{2}]$$

$\therefore$ $\theta = 120°$

Now $P = \pi D \times \frac{\theta}{360} = \pi D \times \frac{120}{360} = \frac{\pi D}{3}$

33. The most prominent force acting on the underground sewer pipes, would be

(a) compressive force (b) tensile force (c) bending force (d) all of these

34. House connections and lateral sewers are widely made of

(a) R.C.C. (b) P.C.C. (c) glazed stoneware (d) cost iron

35. S.W. pipes are generally not used for sewer mains because they are :

(a) weak in tension (b) weak in compression
(c) hydraulically less efficient (d) less reistant to organic corrosion

36. The maximum spacing of manholes on sewers having diameter more than 1.5 m is

(a) 75 m (b) 150 m (c) 200 m (d) 300 m

37. The gas, which is generally found present in sewers in

(a) H_2S (b) CO_2 (c) CH_4 (d) all of these

38. A drop manhole may be provided along a sewer line

(a) when the sewer drops from a height of more than 0.6 m or so.
(b) when a branch sewer outfalls into it from a height of more than 0.6 m or so.
(c) to provide inspection chambers in the sewer lines
(d) for none of these

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39. Ventilating columns are placed along a sewer line at intervals of about
(a) 30-50 m (b) 75-100 m (c) 150-300 m (d) 500-750 m

40. The specific gravity of sewage is
(a) zero (b) equal to 1 (c) slightly less than 1
(d) slightly greater than 1

: ANSWERS :

31. (b)	32. (c)	33. (a)	34. (c)	35. (a)
36. (d)	37. (d)	38. (b)	39. (c)	40. (d)

41. When a sewer line dropped below the hydraulic gradient line to pass it through an obstruction the arrangement is know as
(a) inverted siphon (b) depressed weir (c) sag pipe (d) all of these

42. (Ventilation columns in sewers are provided to
(a) help in escaping of foul gases
(b) help in preventing spread of foul gases
(c) to provide support to the sewers
(d) none of these

43. Gases which are generally evolved during aerobic decomposition of sewage are :
(a) $CO_2 + NH_3 + H_2S$ (b) $CO_2 + NH_3 + H_2S + CH_4$
(c) $CO_2 + NH_3 + SO_2$ (d) $CO_2 + NH_3 + SO_2 + CH_4$

44. Gases which are generally evolved during anaerobic decompositon of sewage, are :
(a) $CO_2 + NH_3 + H_2S$ (b) $CO_2 + NH_3 + H_2S + CH_4$
(c) $CO_2 + NH_3 + SO_2$ (d) $CO_2 + NH_3 + SO_2 + CH_4$

45. 1000 kg of sewage is estimated to contain approximately, total solids, equal to
(a) 0.5 - 1 kg (b) 2 - 5 kg (c) 5 - 10 kg (d) 10- 20 kg

46. Imhoff cone is used to measure, in sewage
(a) total solids (b) total organic solids
(c) total inorganic solids (d) settleable solids

47. Minimum D.O. prescribed for a river/stream to avoid fish kills is
(a) 2 ppm (b) 4 ppm (c) 8 ppm (d) 10 ppm

48. BOD_5 represents 5 days biochemical oxygen demand at a temperature of
(a) 0°C (b) 20°C (c) 30°C (d) none of these

49. The pH of fresh sewage is usually
(a) less than 7 (b) more than 7 (c) equal to 7 (d) equal to zero

50. The average BOD_5 of domestic sewage is
(a) 80 kg/day/person (b) 8 kg/day/person
(c) 0.8 kg/day/person (d) 0.08 kg/day/person

: ANSWERS :

41. (d)	42. (a)	43. (a)	44. (b)	45. (a)
46. (d)	47. (b)	48. (b)	49. (b)	50. (d)

51. Standard 5 day BOD at 20°C, when compared to ultimate BOD, is about::
(a) 58% (b) 68% (c) 98% (d) none of these
52. D.O. in streams is
(a) maximum at noon (b) minimum at noon
(c) maximum at mid night (d) same throughout the day
53. As compared to fresh river water, sea water contains :
(a) 10% more oxygen (b) 20% more O_2
(c) 10% less O_2 (d) 20% less O_2
54. The most common method of W.W. disposal is
(a) evaporation (b) dilution in surface water
(c) rapid infiltration (d) application in irrigation
55. Most of the bacteria in sewage are
(a) anaerobic (b) pathogenic (c) saprophytic (d) parasitic
56. The natural process, under which the flowing river water gets cleaned, is knowns as :
(a) oxidation (b) self purification (c) photosynthesis (d) none of these
57. During preliminary treatment of sewage :
(a) oils and greases are removed by skimming tanks
(b) floating materials are removed by screening
(c) grit and sand are removed by grit chambers
(d) all of the above are correct
58. The detention period adopted for sewage sedimentation tanks is of the order of
(a) 1-2 hr (b) 4-8 hr (c) 2-4 hr (d) 24-36 hrs
59. The detention period adopted for oxidation ponds is of the order of
(a) 24-36 hrs (b) 2-4 days (c) 1-2 weeks (d) 2-6 weeks
60. The detention period in a septic tank is of the order of
(a) 2-6 hrs (b) 4-8 hrs (c) 12-36 hrs (d) 2-4 days

: ANSWERS :

51. (b)	52. (a)	53. (d)	54. (b)	55. (c)
56. (b)	57. (d)	58. (a)	59. (d)	60. (c)

61. The gas which may cause explosion is sewer is

(a) methane (b) carbon-monoxide (c) carnbon-di-oxide (d) ammonia

62. In sewers the velocity of flow usually should not be

(a) more than 25 m/sec (b) less than 8 m/sec

(c) less than self cleaning velocity (d) more than self cleaning velocity

63. Hydraulic mean radius is :

(a) average of radii in a sewer line of varying cross-sections

(b) heads difference between two points in circular pipe lines

(c) cross-sectional area of sewer divided by wetted perimeter

(d) mean radius of sewer line

64. Self-cleaning velocity of sewage flowing in pipe lines is usually

(a) 0.25 m/sec (b) 0.40 m/sec (c) 0.8 m/sec (d) 1.0 m/sec

(e) 1.5 m/sec (f) 2.0 m/sec

65. In case of combined sewer, the dry weather flow is

(a) storm water flowing in it (b) domestic sewage flowing in it

(c) industrial sewage flowing in it

(d) both industrial and domestic sewage without storm water

66. For satisfactory working of a sludge digestion unit, the pH range of digested sludge shluld be maintained in the range of

(a) 3 to 5 (b) 6.5 to 8 (c) 8.5 to 10 (d) any of these

67. The gas coming out from a sludge disgestion tank is

(a) methane only (b) CO_2 only

(c) 70% CH_4 and 30% CO_2 (d) 30% CH_4 and 70% CO_4

68. Leachate is a coloured liquid, that comes out of

(a) septic tanks (b) sanitary land fills

(c) compost plants (d) aerated lagoons

69. A nahani trap is provided

(a) at the head of each house drain

(b) at the outfall end of each house drain

(c) at the junction of two house drains

(d) none of these

70. A pipe which is installed in house drainage to preserve the water seal of traps, is called.
(a) vent pipe (b) waste pipe (c) soli pipe (d) antisiphonage pipe

: ANSWERS :

61. (a)	62. (c)	63. (c)	64. (b)	65. (d)
66. (b)	67. (c)	68. (b)	69. (a)	70. (d)

71. The spacing of bars in coarse screens is generally more than
(a) 6 mm or so (b) 10 mm or so (c) 25 mm or so (d) 50 mm or so

72. Activated sludge treatment plants are normally preferred for
(a) towns and smaller cities (b) medium sized cities
(c) large sized cities (d) all of them

73. Trickling filter plants are preferred for sewage treatment for
(a) towns and smaller cities (b) medium sized cities
(c) large sized cities (d) (a) and (b) both

74. The working conditions in imchoff tanks are
(a) aerobic only (b) anerobic only
(c) aerobic in lower compartment and anaerobic in upper compartment
(d) anaerobic in lower compartment and aerobic in upper compartment

75. The secondary treatment of sewage is caused by :
(a) bacteria (b) algae (c) coagulants (d) none of these

76. The gas, which is evolved in a sludge digestion tank, is mainly composed of
(a) Nitrogen (b) Ammonia (c) H_2S (d) CH_4

77. Dissolved organic solids in W.W. treatment may be removed by :
(a) coagulation (b) hypochlorination (c) reverse osmosis (d) none of them

78. In a shallow waste stabilisation pond, the sewage is treated by :
(a) aerobic bacteria only (b) algae only
(c) dual action of aerobic bacteria and algae (d) sedimentation

79. The max^m efficiency of BOD_5 removal is achieved in.
(a) oxidation ditch (b) oxidation pond
(c) aerated lagoon (d) trickling filter

80. Compostion and lagooning are the methods of
(a) filtration (b) sedimentation
(c) sludge digestion (d) sewage disposal

: ANSWERS :

71. (d) 76. (d)	72. (c) 77. (c)	73. (d) 78. (c)	74. (d) 79. (a)	75. (a) 80. (d)

81. The quantity of liquid waste flowing in sewer line during the period of rainfall is called

(a) industrial waste (b) storm sewage (c) sanitary sewage (d) all of these

82. The most suitable cross-section of a sewer to carry the combined flow is

(a) circular (b) egg-shaped (c) square (d) rectangular
(e) horse-shoe

83. The design of sewer too D.W.F.is done on the basis of

(a) average demand (b) twice the average demand
(c) thrice the average demand (d) from time the average demand

84. The sewer line collecting the sewage from two or more main sewers is know as :

(a) out all sewer (b) main sewer
(c) an intercepting sewer (d) trunk sewer

85. The minimum diameter of manhole opening is :

(a) 30 cm (b) 40 cm (c) 50 cm (d) 60 cm (e) 70 cm

86. Oxidation ponds treat the sewage by :

(a) sedimentation (b) action of algae (c) aerobic bacteria
(d) Oxidation (e) both (b) and (c)

87. The trickling filter works on :

(a) bilogical action (b) filtration process (c) both (a) and (b) (d) none of these

88. Traps are provided in the sanitary system

(a) to trap the rats, snakes entering the sewers
(b) preventing the foul gases from sewers entering the residence/toilets
(c) to dissolve the foul gases in sewage
(d) to increase the quick disposal of sewage

89. Lead caulked joints are provided with

(a) G.I. pipes (b) P.V.C. pipes (c) S.W. pipes (d) C.I.pipes

90. Usually minimum diameter of sewer pipes are kept as

(a) 200 mm (b) 150 mm (c) 100 mm (d) 75 mm
(e) 50 mm

: ANSWERS :

81. (b) 86. (e)	82. (b) 87. (c)	83. (a) 88. (b)	84. (d) 89. (d)	85. (c) 90. (b)

91. In house drainage the minimum gradient kept is :

(a) 1 in 40 (b) 1 in 100 (c) 1 in 200 (d) 1 in 400

92. Oil and grease from the sewage is removed by :

(a) skimming tanks (b) screening
(c) sedimentation tanks (d) detritus tanks

93. Self cleaning velocity in large size sewers is :

(a) 0.30 m/sec. (b) 0.50 m/sec. (c) 0.60 m/sec. (d) 0.70 m/sec.

94. The gradient of sewers depend upon :

(a) sewer diameter (b) discharge of sewer
(c) velocity of flow (d) all of these

95. Tick the correct statement from the following :

(a) in larger size sewer, no deposit will take place
(b) in smaller size sewer the velocity of sewage will be less
(c) in larger size sewer the velocity will be more
(d) in larger size sewer deposit will take place

96. For disposal of sewage by separate system, the cross-section of sewer most suitable is

(a) rectangular (b) circular (c) egg-shaped (d) horse shoe shaped

97. The tests conducted for checking the drainage pipes is :

(a) smoke test (b) water test
(c) straightness test (d) pressure test (e) all the above

98. The region most affected by acid rains, is

(a) India and China (b) Africa
(c) Europe and North East America (d) South America

99. A rainfall is generally classified as acidic, if its pH is less than equal to

(a) 5.4 (b) 6.5 (c) 7 (d) 7.5

100. An ordinary rain, will generally be

(a) slightly acidic (b) slightly alkaline (c) neither acidic nor alkaline

: ANSWERS :

91. (d)	92. (a)	93. (c)	94. (d)	95. (d)
96. (c)	97. (e)	98. (c)	99. (a)	100. (a)

101. Match list I with list II and select the correct answer using the codes given below the lists :

List I (Treatment units)		List II (Detention time)	
A.	Grit chamber	1.	Six hours
B.	Primary sedimentation	2.	Two minutes
C.	Activated sludge	3.	Two hours
D.	Sludge digestion	4.	Twenty days

Codes :	A	B	C	D
(a)	3	1	4	2
(b)	2	3	1	4
(c)	2	1	3	4
(d)	1	2	3	4

102. Which one of the following statements is true of tricking filter sludge ?

(a) It has a comparatively low sludge volume index

(b) It is more difficlt to dewater than activated sludge

(c) It has a comparatively low concentration of sludge solids

(d) It is bulky

103. Match List I with list II and select the correct answer using the codes given below the lists :

List I (Pipe material)		List II (Property of material)	
A.	Concrete sewer	1.	Cannot withstand high external load.
B.	Stone ware sewer	2.	Corrosion resistance in most natural soils
C.	Cost iron sewer	3.	Resitant to corrosion from most acids
D.	Steel sewer	4.	Unsuitable where soil contains excessive sulphates

Codes :	A	B	C	D
(A)	1	2	3	4
(B)	4	3	2	1
(C)	4	1	2	3
(D)	2	1	3	4

104. BOD is preferred to COD as an index of sewage concentration, because

(a) BOD represents both carbonaceous and nitrogenous organic matter, while COD may indicate carbonaceous matter only.

(b) BOD test is easier to perform and gives more reliable results

(c) BOD relates specifically to putrescible organic matter which is the most objectionable sewage constituent.

(d) COD relates to the impurities which can only be removed by chemical treatment which is expensive.

105. Under Indian conditions, the average per capits contribution of BOD is

(a) 10 to 20 gm/d (b) 20 to 35 gm/d (c) 35 to 50 gm/d (d) 50 to 70 gm/d

106. Match list I with list II and select the correct answer using the codes given below the lists

	List I		**List II**
A.	Waste pipe	1.	Carries waste water
B.	Soil pipe	2.	Carries liquid wastes that do not include human excreta
C.	Vent pipe	3.	Preserves the water seal of traps through access to atmospheric air
D.	Antisiphonage pipe	4.	Carries liquid wastes including human excreta
		5.	Provides flow of air to or from drainage system in order to prevent vacuum pressures and excessive pressure and provides excape for foul gases.

Codes :	A	B	C	D
(a)	2	4	5	3
(b)	3	5	1	2
(c)	4	5	1	2
(d)	1	4	5	3

107. Match List I with List II and select the correct answer using the codes given below the list :

	List I (Cause)		**List II (Effect)**
A.	Carbon monoxide	1.	Acid rain
B.	Carbon dioxide	2.	Explosion
C.	Methane	3.	Asphyxiation
D.	Sulphur dioxide	4.	Green house effect

Codes :	A	B	C	D
(a)	2	3	1	4
(b)	3	4	2	1
(c)	1	3	4	2
(d)	4	2	1	3

108. Sewage sickness ralates to :

(a) tioxicity of sewage interferring with response to treatment.

(b) destruction of aquatics flora and fauna due to gross pollution of receiving bodies of water by sewage.

(c) reduction in the waste purifying capacity of the soil.

(d) clogging of pores in soil due to excessive application of sewage to land, obstructing aeration and leading to spetic conditions.

109. Under natural conditions of flow, an unpolluted river would contain

(a) more dissolved oxygen in summer than in winter

(b) less dissolved oxygen in summer than in winter

(c) more or less the same amount of dissolved oxygen in winter and summer.

(d) the least amount of dissolved oxygen during the floods

110. Consider the data presented in the following table :

Temperature in °C	BOD reaction rate constant (K)
20	0.01
30	0.02
10	0.005

In the data presented above, the value of K

(a) should have remained constant

(b) should have decreased with increase in temperature

(c) should have remained the same at 20°C and 30°C

(d) has followed the correct trend

: ANSWERS :

101. (b)	102. (a)	103. (b)	104. (c)	105. (d)
106. (a)	107. (b)	108. (d)	109. (b)	110. (d)

111. For the combined sewerage system egg shaped sewers are preferred because :

(a) their construction is economical

(b) they are structurally more stable

(c) their maintenance is easier

(d) they offer good flow velocity during the dry weather flow condition.

112. Match List I with List II and select the correct answer using the codes given below the lists :

List I (Terms/Description)		List II (Treatment operation/process)	
A.	Sludge volume index	1.	Settling in primary sedimentation tank
B.	Thickening of sludge	2.	Settling in secondary sedinmentation tank
C.	Scum removal	3.	Filtration in trickling filter
D.	Recycling of efflent	4.	Activated sludge process

Codes :	A	B	C	D
(a)	2	4	1	3
(b)	4	2	3	1
(c)	2	4	3	1
(d)	4	2	1	3

An aeration basin with a volume of 400 m^3 contains mixed liquor with suspended solid concentration of 1000 mg/*l*. The amount of mixed liquor suspended solids in the tank is

(a) 500 kg (b) 250 kg (c) 600 kg (d) 400 kg

113. The following reactions take place during anaerobic digestion of organics.

1. Methane production
2. Alkaline fermentation
3. Acid fermentation
4. Acid regression

The correct sequence of these reactions is

(a) 3, 4, 2, 1 (b) 4, 3, 2, 1 (c) 3, 4, 1, 2 (d) 4, 3, 1, 2

114. Traps are used in household drainage systems to :

(a) prevent entry of foul gases in the houses
(b) restrict the flow of water
(c) provide a partial vacuum
(d) trap the soild wastes

115. Modern coal-based thermal power stations pollute the atmosphere by adding :

(a) NO_x and SO_2
(b) NO_x, SO_2 and SPM
(c) NO_x, SO_2, SPM and CO
(d) NO_x, SPM and CO.

116. Consider the following statements :

Excessive growth of water weeds in a water body is attributed to the :

1. increases in the benthic organisms including bacteria
2. inbalance in aquatic ecosystem
3. execssive inflow of nutrients

Of these statments :

(a) 1, 2 ande 3 are correct
(b) 1 and 2 are correct
(c) 1 and 3 are correct
(d) 2 and 3 are correct

117. Various unit operations exist in a sewage treatment plant These would include :

1. screening
2. grit removal
3. Secondary sedimentation
4. aeration
5. primary sedimentation

The correct sequence of these operation is

(a) 1, 2, 3, 4, 5 (b) 1, 2, 5, 4, 3 (c) 2, 1, 4, 5, 3 (d) 2, 1, 4, 3, 5

118. In transition of sewers from smaller diameter sewers to larger diameters sewers, the continuity of sewers is maintained at the

(a) bottom of the concrete bed of sewers (b) inverts of the sewers

(c) crowns of the sewers (d) hydraulic gradients of the sewers

119. The slope of a 1.0 m diameter concrete sewer laid at a slope of 1 in 1000 develops a velocity of 1 m/s, when flowing full. When it is flowing half full, the velocity of flow through the sewers will be

(a) 0.5 m/s (b) 1.0 m/s (c) $\sqrt{2}$ m/s (d) 2.0 m/s

120. Match, List I with List II and select the corrent answer using the codes given below the lists :

	List I (Process)		**List II (Biological agent)**
A.	Oxidation ditch	1.	Facultative bacteria
B.	Waste stabilization pond	2.	Anaerobic bacteria
C.	Imhoff tank	3.	Aerobic bacteria (suspended culture)
D.	Rotating Biological Contractor (RBC)	4.	Aerobic bacteria (attached culture)

Codes :	A	B	C	D
(a)	4	1	2	3
(b)	3	1	2	4
(c)	1	2	3	4
(d)	3	4	1	2

: ANSWERS :

111. (d)	112. (d)	113. (a)	114. (a)	115. (b)
116. (d)	117. (b)	118. (c)	119. (b)	120. (b)

121. One litre of sewage, when allowed to settle for 30 minutes gives a sludge of 27 cm_3. If the dry weight of sludge is 3.0 gm, then its sludge volume index will be :

(a) 9 (b) 24 (c) 30 (d) 81

List-I (Contaminant)		List-II (Environmental significance)
A. Suspended solids	1.	May cause entrophication
B. Nutrients	2.	Toxic, may interfere with effluent reuse
C. Heavy metals	3.	May interfere with effluent reuse
D. Dissolved inorganic solids	4.	Cause sludge deposits

Codes :	A	B	C	D
(a)	4	1	2	3
(b)	2	3	4	1
(c)	4	3	2	1
(d)	2	1	4	3

175. Match List-I with List-II and select the correct answer using the codes given below the lists :

List -I (Physical properties of filtering material for trickling filters)		List-II (Limiting value)
A. Crushing strength, N/mm^2	1.	12.0
B. Hardness	2.	100.0
C. Percent wear	3.	4.0
D. Specific gravity	4.	2.6

Codes :	A	B	C	D
(a)	3	1	2	4
(b)	2	4	3	1
(c)	3	4	2	1
(d)	2	1	3	4

176. What is eutrophication of lakes primarily due to ?

(a) Multiplication of bacteria (b) Excessive inflow of nutrients

(c) Increase in benthic organisms (d) Thermal and density currents

177. The daily cover of MSW landfills consists of which one of the following ?

(a) Compacted soil (b) Geomembrane (c) Geotextile (d) Geocomposite

178. Match List-I with List-II and select the correct answer using the codes given below the lists :

	List-I (Air pollutant)		List-II (Impact on Human Health)
A.	Particulates	1.	Impairs transport of O_2 in bloodstream
B.	Carbon monoxide	2.	Irritation of mucous membrances of respiratory tract
C.	Sulphur oxides	3.	Causes coughing, shortness of breath, headache, etc.
D.	Photochemical oxidants	4.	Causes respiratory illness

Code :	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

179. A machine in a steel plate fabricating industry is foumd to be producting a sound level of 50 dB. In the expansion plans, one more such machine needs to be added. What will be the combined noise level ?

(a) 80-100 dB (b) 101-150 dB (c) 51-70 dB (d) 40-50 dB

180. Which one of the following is the correct statement ?

A heterotroph is an organism that obtains

(a) its cell carbon from an inorganic source

(b) its energy from the oxidation of simple inorganic compounds

(c) its cell carbon as well as its energy from organic matter

(d) its energy from a natural ecosystem.

: ANSWERS :

171. (b)	172. (c)	173. (a)	174. (a)	175. (d)
176. (b)	177. (b)	178. (c)	179. (c)	180. (c)

181. In which type of lakes, does a perfect ecological equilibrium among the producers, decomposers, and consumer groups of organisms exist ?

(a) Senescent lakes (b) Mesotrophic lakes

(c) Oligotrophic lakes (d) Eutrophic lakes

182. Which one of the following types of settling phenomenon can be analysed by the classic sedimentation laws of Newton and Stokes ?

(a) Discrete setting (b) Flocculent settling

c) Hindered settling (d) Compression settling

183. Match List I (Treatment Process) with List II (Related Terms) and select the correct answer using the code given below the lists :

List I		List II	
A.	Lagoons	1.	Attached growth system
B.	Trickling filter	2.	Algae-bacteria symbiotic relationship
C.	Oxidation ponds	3.	Extended aeration
D.	Activated sludge process	4.	Low cost treatment method

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	3	4	1

184. Which is the major pollutant present in photochemical smog ?

(a) PAN (b) SO_2 (c) HC (d) NO_2

185. Consider the following statement ?

In solid wast management :

1. Density separation of solid wastes can be accoplished by air classifiers.
2. Iron recovery from solid wastes can be done by magnetic separators.
3. Aluminium separation from solid wastes can be aecomplished by eddy current separators.

Which of the statements given above are correct ?

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2 and 3

186. Which of the following statement in not correct ?

(a) Settling and sludge digestion occurs in septic tanks in one compartment

(b) Settling and sludge digestion occurs in imhoff tank in different compartments

(c) Septic tank is a low-rate anaerobic unit whereas an inhoff tank is a high rate anaerobic unit

(d) The rate of sludge accumulation in septic tank is approximately 40-70 litres/capita/year

187. Consider the following statements in regard to aerobic and anaerobic treatment processes :

1. Biomass production in the aerobic treatment process is more as compared to the anaerobic treatment process.
2. Start-up period is more in the aerobic treatment process as compared to the anaerobic treatment process.
3. Energy consumption and production is more in the aerobic treatment process as compared to the anaerobic treatment process.

Which of the statements given above is/are correct ?

(a) 1 and 2 (b) 2 and 3 (c) Only 2 (d) only 1

188. What is 5 days 20°C BOD equal to ?

(a) 3 days 27°C BOD (b) 4 days 30°C BOD

(c) 6 days 32°C BOD (d) 7 days 35°C BOD

189. When the recirculation ratio in a high rate trickling filter is unity, then what is the value of the recirculation factor ?

(a) 1 (b) > 1 (c) < 1 (d) Zero

190. Presence of nitrogen in a waste water sample is due to the decomposition of :

(a) Carbohydrates (b) Proteins (c) Fats (d) Vitamins

: ANSWERS :

181. (c)	182. (a)	183. (b)	184. (a)	185. (a)
186. (c)	187. (d)	188. (b)	189. (b)	190. (b)

191. In which one of the following tests is the organic matter in the waste water used as food by micro-organisms ?

(a) BOD (b) Most probable number

(c) COD (d) chlorine demand

192. The function of algae in an oxidation pond is to :

(a) provide a mat over the surface of the oxidation pond so as to prevent evaporation of water

(b) provide oxygen for bacteria to degrade organic matter

(c) provide a greenish appearance to the pond

(d) prevent the odour nuisance.

193. Consider the following pairs of treatment units and impurities removed :

1. Grit chamber — Sand and silt
2. Detritus tank — Organic matter
3. Primary sedimentation tank — Suspended impurities
4. Aeration tank of activated sludge process plant — Oil and grease

Which of these pairs are correctly matched ?

(a) 1 and 2 (b) 1,2,3 and 4 (c) 2, 3 and 4 (d) 1 and 3

194. The ultimate BOD value of a waste :

(a) increase with temperature (b) decreases with temperature

(c) remains the same at all temperature

(d) doubles with every 10°C rise in temperature

195. For the design of a storm sewer in a drainage area, if the time of concentration is 20 min, then the duration of rainfall will be taken as :
(a) 10 min. (b) 20 min. (c) 30 min. (d) 40 min.

196. From ecological considerations, the minimum level of dissolved oxygen (D.O.) necessary in the rivers and streams is :
(a) 1 mg/*l* (b) 2 mg/*l* (c) 4 mg/*l* (d) 8 mg/*l*

197. Which one of the followiing pollutants or pairs of pollutants is formed due to photochemical reactions ?
(a) CO alone (b) O_3 and PAN (c) PAN and NH_3 (d) NH_3 and CO.

198. Organisms that mineralise organic matter in an ecosystem are called :
(a) producers (b) consumers (c) decomposers (d) carnivorous

199. Aerobic method of composting practised in India is called :
(a) Bangalore method (b) Nagpur method
(c) Delhi method (d) Indore method

200. When sewage enters a flowing river, the rapid depletion of dissolved oxygen is due to :
(a) change in temperature of river water
(b) the suspended particles in river and waste
(c) respiratory activity of aquatic plants
(d) microbial activity

: ANSWERS :

191. (a)	192. (b)	193. (d)	194. (c)	195. (b)
196. (c)	197. (b)	198. (c)	199. (d)	200. (b)

201. Match List 1 (unit) with List II (purpose) and select the correct answer using the codes given below the lists :

List I (Unit)		List II (Purpose)	
A.	Leaping weir	1.	To prevent grit, sand, debris etc. from entering the storm sewer.
B.	Gutter inlet	2.	To carry the sewer below a stream or railways line
C.	Inverted syphon	3.	To drain rain water from roads to the storm sewer.
D.	Catch basin	4.	To separate storm water and the sanitary sewage.

Codes :	A	B	C	D
(a)	4	3	1	2
(b)	4	3	2	1
(c)	3	4	2	1
(d)	3	4	1	2

202. Match List I (Treatment Units) with List II (Types of processes) and select the correct answer using the codes given below the list :

List I (Treatment units)		List II (Types of processes)	
A.	Trickling filter	1.	Symbiotic
B.	Activated sludge processes	2.	Extended aeretion
C.	Oxidation ditch	3.	Suspended growth
D.	Oxidation pond	4.	Attached growth

Codes :	A	B	C	D
(a)	3	4	2	1
(b)	4	3	1	2
(c)	3	4	1	2
(d)	4	3	2	1

203. If the moisture content of a sludge is reduced from 98% to 96%, the volume of sludge will decrease by

(a) 2% (b) 20% (c) 25% (d) 50%

Hint : $V_2 = V_1 \dfrac{(100-98)}{(100-96)} = \dfrac{V_1}{2} = 0.5\ V_1$

204. In a high rate Trickling filter, the problem of ponding can be solved by :

(a) flooding and raking (b) chlorination and supply of air

(c) raking and chlorination (d) flooding and supply of air

205. Consider the following statements :

The process of activated sludge can be explained as :

1. a physical action whereby the finer suspended particles of sewage form a sublayer for a bacterial film at the surface.
2. a chemical action whereby the finer suspended particles and colloidal solids are combined into masses of large bulk.
3. a biochemical action whereby the sludge flocs so formed act as vehicle for acrobic bacteria oxidising the organic matter.

Which of these statements are correct ?

(a) 1, 2 and 3 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

206. Sewage may be disposed of without treatment into a water body if the available dilution is

(a) less than 150 (b) more than 150 (c) more than 300 (d) more than 500

207. In a sanitary plumbing of buildings, a two pipe system signifies :

(a) separate soil-pipe and waste pipe without vent pipes

(b) A soil cum waste pipe and a ventillating pipe

(c) Separate soil and waste pipe and a common ventillating pipe

(d) Separate soil pipe and waste pipe, each with its own vent pipe.

208. The least expensive and most suitable excreta disposal unit for rural areas would be the :

(a) soak pit (b) pit privy (c) leaching casspool (d) septic tank

209. Which one of the following terms correctly describes 'Biomagnification' ?

(a) Reproduction of micro-organisms

(b) Observation of micro-organisms under a microscope

(c) Ability of micro-organisms to form zooleal film

(d) Concentration of toxic materials in the food chain.

210. Which one of the following comprehensive classifications is used for different types of solid waste ?

(a) Residential, commercial and treatment plant wastes

(b) Food, demolition and construction wastes

(c) Municipal, industrial and hazardous wastes

(d) Rubbish, special wastes and wastes from open areas

: ANSWERS :

201. (b)	202. (d)	203. (d)	204. (c)	205. (a)
206. (d)	207. (d)	208. (b)	209. (d)	210. (c)

211. 'Air binding' may occur in

(a) Sewers (b) Artesian well (c) Aerator (d) Filter

212. The description of solid waste collected is as follows :

Night soil - 35 t
Rubbish - 40 t
Debris - 25 t
Garbage - 40 t

The organic solids in the above composition is

(a) 35 t (b) 60 t (c) 100 t (d) 75 t

213. In an activated sludge process, the sludge volume index can be controlled by

(a) Aeration (b) Adding chlorine

(c) Reducing recycling (d) Increasing the depth of aeration tank

214. A primary sedimentation tank is not required for

(a) Activated sludge system (b) Extended aeration system

(c) Trickling filtration system

(d) Tapered activated sludge process using pure oxygen for aeration.

215. The term 'Refuse' generally does not include

(a) Putrescible solid waste (b) Excreta

(c) Non-putrescible solid waste (d) Ashes

216. Bangalore method and Indore method of disposing solid wastes are

(a) Identical

(b) Different as Bangalore method is an anaerobic method

(c) Different as Bangalore method does not contain human excreta

(d) Different as Indore method is an incineration method

217. Which one of the following statements explains the term pyrolysis ?

(1) Solid waste is heated in closed containers in oxygen free atmosphere

(2) They must be provided at the head of all sewers.

(3) They must be provided at every junction of two or more sewers.

(4) They must be provided at every 100 m along straight runs of sewers.

Which of the statements given above are correct ?

(a) 1, 2, 3 and 4 (b) 1, 3 and 4 (c) 1, 2 and 3 (d) 2 and 4

218. Which of the following pairs is correctly matched ?

(a) $\frac{BOD}{COD} = 0$; Waste-water is toxic

(b) $\frac{BOD}{COD} = \leq 0.20$: Acclimatization of seed is necessary

(c) $\frac{BOD}{COD} = \geq 0.6$: Waste-water is non-biodegradable

(d) BOD = COD = 0 : Waste -water is devoid of organic matter

219. In aerobic conditions the microbial decomposition of organics results in the formation of which one of the following ?

(a) Stable and objectionable end products

(b) Unstable and objectionable end products

(c) Unstable and acceptable end products

(d) Stable and unobjectionable end products

220. Consider the following statements :

The basic difference between water pipes and sewer pipes is :

1. in the material used for pipes
2. in the pressure of the liquid flow
3. in the suspended solids they carry

Which one of the statements given above is/are correct ?

(a) 1 and 3 (b) 1 only (c) 2 and 3 (d) 1, 2 and 3

: ANSWERS :

211. (d)	212. (d)	213. (c)	214. (b)	215. (b)
216. (b)	217. (a)	218. (d)	219. (d)	220. (d)

❖❖❖

23.

Building Planning

MCQ'S

1. **Proper placing of building and its component rooms with respect to the natural weathering elements such as sun, wind, and rain and environmental factors like topography is called**
   (a) Planning (b) Design (c) Orientation (d) Grouping
2. **A room which receives light and air from a specific direction is known as**
   (a) aspect (b) prospect (c) elegance (d) circulation
3. **The aspect preferred for living room is**
   (a) North east (b) South east (c) South west (d) North west
4. **In India, wind direction in summer and monsoon is**
   (a) North east (b) South east (c) South west (d) North west
5. **Better aspect for verandah is**
   (a) west, sw (b) NW (c) NE (d) SE
6. **Which IS code is referred for building planning regulation and services ?**
   (a) IS : 456–2000 (b) IS : 1893– 2002
   (c) IS : 800–2007 (d) SP –7 (2005) – NBC
7. **As per NBC – 2005, Hospitals are**
   (a) Business buildings (b) Assembly buildings
   (c) Institutional buildings (d) Mercantile buildings
8. **For good orientation, the the direction of longer outer walls should be**
   (a) East–west direction (b) North–south direction
   (c) NE–SW direction (d) NW–SE direction
9. **For better privacy in a room**
   (a) Door should be placed near the corner (b) Single shutter door should be provided
   (c) Provision of ground glass for windows (d) all of the above
10. **For residential buildings window openings area should be minimum**
    (a) 5% of floor area (b) 10% of floor area
    (c) 20% of floor area (d) 25% of floor area

11. For Drawing room and bedroom minimum no. of air changes per hour required for good ventilation are
(a) 1 (b) 3 (c) 6 (d) 10

12. For roads wider than 12 m, setback recommended is
(a) 1.0 m (b) 1.5 m (c) 2.0 m (d) 3.0 m

13. The angle of light plane commonly adopted is
(a) 30° (b) 45° (c) 63.50° (d) 55°

14. FSI is
(a) Plot area/total area of all floors (b) total area of all floors/plot area
(c) Plot area/area of one floor (d) area of one floor/plot area

15. In Ahmedabad city on a BRTS road if permissible FSI is 4, total area of all floors that can be constructed in a plot of 1000 m^2 is
(a) 250 m^2 (b) 1000 m^2 (c) 4000 m^2 (d) 2000 m^2

16. The usual percentage of consolidated open plot (C.O.P.) area is
(a) 10% (b) 20% (c) 30% (d) 40%

17. Area of Mezzanine floor is restricted to
(a) $\frac{1}{2}$ of the area of that floor (b) $\frac{1}{3}$ of the area of that floor
(c) $\frac{1}{4}$ of the area of that floor (d) $\frac{1}{5}$ of the area of that flow

18. Maximum permissible covered area for a residential plot of size 501 to 1000 m^2 is
(a) 66.67 % (b) 50 % (c) 40 % (d) 33.33 %

19. In industrial plot, the covered area shall not exceed
(a) 60% (b) 50% (c) 40% (d) 25%

20. Plinth height generally provided for buildings is
(a) 0.30 m (b) 0.45 m (c) 0.75 m (d) 1.0 m

21. Minimum width of habitable room is
(a) 1.8 m (b) 2.1 m (c) 2.5 m (d) 3.0 m

22. Minimum width required for bath room is
(a) 1.0 m (b) 1.2 m (c) 1.5 m (d) 2.0 m

23. Minimum floor area required for bath & WC is
(a) 1.2 m^2 (b) 1.5 m^2 (c) 1.8 m^2 (d) 2.5 m^2

24. Minimum headroom required on staircase landing is
(a) 1.5 m (b) 1.8 m (c) 2.1 m (d) 2.5 m

25. Open parking space required in public building for cars is
    (a) 15 m^2/car (b) 20 m^2/car (c) 25 m^2/car (d) 30 m^2/car
26. Open parking space required in public building for scooter/motocycle is
    (a) 1.5 m^2/vehicle (b) 2.0 m^2/vehicle (c) 2.5 m^2/vehicle (d) 3.0 m^2/vehicle
27. Minimum width of w.c. required in residential buildings is
    (a) 0.9 m (b) 1.0 m (c) 1.2 (d) 1.5 m
28. For primary school, the class room is designed at the rate of
    (a) 0.5 m^2/pupil (b) 0.9 m^2/pupil (c) 1.2 m^2/pupil (d) 1.5 m^2/pupil
29. The height of classroom should not be less than
    (a) 2.5 m (b) 3.0 m (c) 3.2 m (d) 3.6 m
30. In the classroom minimum window area required is
    (a) 10% of floorarea (b) 15% of floor area
    (c) 20 % of floor area (d) 25% of floor area
31. As per NBC –2005, in a school, no. of w.c. required for boys are
    (a) 1 per 20 (b) 1 per 25 (c) 1 per 30 (d) 1 per 40
32. In a school, no. of drinking water foundations required are
    (a) 1 per 30 (b) 1 per 40 (c) 1 per 50 (d) 1 per 60
33. In hospital ward minimum ventilation area required is
    (a) 10% of floor area (b) 20% of floor area
    (c) 25% of floor area (d) 30% of floor area
34. Minimum allowable thickness of load bearing walls up to 3 storey height is
    (a) 15 cm (b) 20 cm (c) 25 cm (d) 30 cm
35. As per NBC–2005, the width of main street on which the building abuts shall not be less than
    (a) 7.5 m (b) 10 m (c) 12 m (d) 15 m
36. As per NBC – 2005 the minimum width of staircase in residential buildings is
    (a) 1.0 m (b) 1.2 m (c) 1.5 m (d) 1.8 m
37. As per NBC – 2005, the minimum width of staircase in public building is
    (a) 1.0 m (b) 1.2 m (c) 1.5 m (d) 1.8 m
38. A drawing sheet designated as Ao has size
    (a) 841 × 1189 mm (b) 594 × 841 mm (c) 420 × 594 mm (d) 297 × 420 mm

39. Who is known as the divine architect who spread the knowledge of shilpa–shastras

(a) Vishveshvaria (b) Kautilya (c) Vishva karma (d) Chanakya

40. Slum area are commonly known as

(a) Bustees in kolkata (b) Jhuggi in new Delhi

(c) Cheries in chennai (d) all of the above

41. Match correctly

	Smart city		Country
1.	King Abdullah	A.	Korea
2.	Lavasa	B.	Saudi Arabia
3.	Songdo	C.	India
4.	Nepolis	D.	Cyprus

(a) 1–B, 2–C, 3–D, 4–A (b) 1–B, 2–C, 3–A, 4–D

(c) 1–C, 2–B, 3–D, 4–A (d) 1–C, 2–B, 3–A, 4–D

42. The type of planning system of Gandhinagar city is

(a) Concentric and radial street system

(b) rectangular grid iron system

(c) Rectangular combined with radial street system

(d) Organic street system

43. Indian city with rectangular grid iron pattern is

(a) chandigarh (b) Gandhinagar (c) Jaipur (d) all of the above

: ANSWERS :

1. (c)	2. (a)	3. (b)	4. (c)	5. (a)
6. (d)	7. (c)	8. (b)	9. (d)	10. (b)
11. (b)	12. (c)	13. (c)	14. (b)	15. (c)
16. (c)	17. (b)	18. (c)	19. (a)	20. (b)
21. (b)	22. (b)	23. (c)	24. (c)	25. (b)
26. (d)	27. (a)	28. (b)	29. (d)	30. (c)
31. (d)	32. (c)	33. (b)	34. (b)	35. (c)
36. (a)	37. (c)	38. (a)	39. (c)	40. (d)
41. (b)	42. (b)	43. (d)		

SYLLABUS

GATE –SYLLABUS

SECTION–1 : ENGINEERING MATHEMATICS

Linear Algebra : Matrix algebra: systems of linear equations; Eigen values and Eigen vectors.

Calculus : Functions of single variable; Limit, continuity and differentiability; Mean value theorems, local maxima and minima, Taylor and Maclaurin series; Evaluation of definite and indefinite integrals, application of definite integral to obtain area and volume; Partial derivatives; Total derivative; Gradient, Divergence and Curt, Vector identities, Directional derivatives, Line, Surface and Volume integrals, stokes, Gauss and Green's theorems.

Ordinary Differential Equation (ODE) : First order (linear and non–linear) equations; higher order linear equations with constant coefficients; Euler–Cauchy equations; Laplace transform and its application in solving linear ODEs; initial and boundary value problems.

Partial Differential Equation (PDE) : Fourier series; separation of variables; solutions of one–dimensional diffusion equation; first and second order one–dimensional wave equation and two–dimensional Laplace equation.

Probability and statistics : Definitions of probability and sampling theorems; Conditional probability; Discrete Random variables; Poisson and Binomial distributions; Continuous random variables; normal and exponential distributions; Descriptive statistics – Mean, median, mode and standard deviation; Hypothesis testing.

Numerical MEthods : Accuracy and precision ; error analysis, Numerical solutions of linear and non–linear algebraic equations; Least square approximation, NEwton's and Lagrange polynomials, numerical differentiation, integration by trapezoidal and simpson's rule, single and multi–step methods for first order differential equations.

SECTION–2 : STRUCTURAL ENGINEERING

Engineering Mechanics : System of forces, free–body diagrams, equilibrium equations; internal forces in structures; friction and its applications, kinematics of point mass and rigid body; Centre of mass; Euler's equations of motion; impulse–momentum; Energy methods; Principles of virtual work.

Solid Mechanics : Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresse, shear centre; Uniform torsion, buckling of column, combined and direct bending stresses.

Structural Analysis : Statically determinate and indeterminate structures by force/energy/ methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines: stiffness and flexibility methods of structural analysis.

Construction Materials and Management : Construction materials: structural steel – composition, material properties and behaviour; Concrete – constituents, mix design, short–term and long–term properties; Brick and mortar; Timber; Bitumen. Construction Management: Types of construction projects; Tendering and construction contracts; Rate analysis and standard specifications; Cost estimation; Project planning and network analysis– PERT and CPM.

Concrete Structures : Working stress, limit state and ultimate load design concepts; Design of beams, slabs, columns, Bond and development length; Prestressed concrete; Analysis of beam sections at transfer and service loads.

Steel structures : Working stress and limit state design concepts; Design of tension and compression members, beams and beam–columns, column bases; Connections – simple and eccentric, beam–column connections, plate girders and trusses; Plastic analysis of beams and frames.

SECTION 3 : GEOTECHNICAL ENGINEERING :

Soil Mechanics : Original of soils, soil structure and fabric; Three-phase system and phase relationships index properties, Unified and Indian standard soil classification system; Permeability-one dimensional flow, Darcy's law; Seepage through soils - two-dimensional flow, flow nets, uplift pressure, piping; Principle of effective stress, capillarity, seepage force and quicksand condition; Compaction in laboratory and field conditions; One-dimensional consolidation, time rate of consolidation; Mohr's circle, stress paths, effective and total shear strength parameters, characteristics of clays and sand.

Foundation Engineering : Sub-surface investigations - scope, drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; stability of slopes - finite and infinite slopes, method of slices and Bishop's method; stress distribution in soils - Boussinesq's and Westergaard's theories, pressure bulbs; shallow foundations - Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in ands and clays; Deep foundations - types of piles, dynamic and static formulae, load capacity of plles in sands and clays, pile load test, negative skin friction.

SECTION 4 : WATER RESOURCES ENGINEERING

Fluid Mechanics : Properties of fluids, fluid statics; Continuity, momentum energy and corresponding equations; Potential flow, applications of momentum and energy equations; Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth.

Hydraulics : Forces on immersed bodies: Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; kinematics of flow, velocity triangles; Basics of hydraulic machines, specific speed of pumps and turbines; Channel Hydraulics - Energy- depth relationships, specific energy, critical flow, slope profile, hydraulic jump, uniform flow and gradually varied flow.

Hydrology : Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, flood estimation and routing reservoir cpacity, reservoir and channel routing, surface run-off models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's law.

Irrigation : Duty, delta estimation of evapo-transpiration; Crop water requirements; Design of lined and unlined canals head works, gravity dams and spillways; Design of weirs on permeable foundation Types of irrigation systems, irrigation methods; Water logging and drainage, Canal regulatory works, cross-drainage structures, outlets and escapes.

Water and Waste Water : Qualoty standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water, Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and fertiary treatment of wastewater effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment, Unit operations and unit processes of domestic wastewater, sludge disposal.

Air pollution : Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.

Municipal Solid Wastes : Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/recycle, energy recovery, treatment and disposal).

Noise pollution : Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

SECTION 6 : TRANSPORTATION ENGINEERING

Transportation Infrastructure : Highway alignment and engineering surveys; Geometric design of highways - cross - sectional elements, sight distances, horizontal and vertical alignments; Geometric design of railway track; Airport runway length, taxiway and exit taxiway design.

Highway Pavements : Highway materials - desirable properties and quality control tests; Design of bituminous paving mixes, Design factors for flexible and rigid pavements; Design of flexible pavement using IRC : 37-2012; Design of rigid pavements using IRG : 58-2011; Distresses in concrete pavements.

Traffic Engineering : Traffic studies on flow, speed, travel time - delay and O-D study, PCU, peak hour factor parking study, accident study and analysis, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Control devices, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads.

SECTION 7 : GEOMATICS ENGINEERING :

Principles of surveying; Errors and their adjustment; Maps - scale, coordinate system; Distance and angle measurement - Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves.

Photogrammetry - scale, flying height; Remote sensing - basics, platform and sensors, visual image interpretation; Basics of Geographical information system (GIS) and Geographical Positioning system (GPS).

❖❖❖

GATE -2014, PAPER-1

Q.No. 1-5 carry one Mark Each

1. A student is required to demonstrate a high level of **comprehension** of the subject, especially in the social sciences.

   The word closest in meaning to **comprehension** is

   (A) understanding (B) meaning (C) concentration (D) stability

Answer: (A)

2. Choose the most appropriate word from the options given below to complete the following sentence.

   One of his biggest ______ was his ability to forgive.

   (A) vice (B) virtues (C) choices (D) strength

Answer: (B)

3. Rajan was not happy that Sajan decided to do the project on his own. On observing his unhappiness, Sajan explained to Rajan that he preferred to work independently. Which one of the statements below is logically valid and can be inferred from the above sentences?

   (A) Rajan has decided to work only in a group.

   (B) Rajan and Sajan were formed into a group against their wishes.

   (C) Sajan had decided to give in to Rajan's request to work with him.

   (D) Rajan had believed that Sajan and he would be working together.

Answer: (D)

4. If y = 5x2 + 3, then the tangent at x = 0, y = 3

   (A) passes through x = 0, y = 0 (B) has a slope of +1

   (C) is parallel to the x-axis (D) has a slope of -1

Answer: (C)

Exp: $y = 5x^2 + 3, \frac{dy}{dx} = 10x$

Slope of tan gent $= \left(\frac{dy}{dx}\right)_{x=0,\,y=3} = 10 \times 0 = 0$

Slope = 0 $\Rightarrow$ tangent is parallel to x-axis.

5. A foundry has a fixed daily cost of Rs 50,000 whenever it operates and a variable cost of Rs 800Q, where Q is the daily production in tonnes. What is the cost of production in Rs per tonne for a daily production of 100 tonnes?

Answer: 1300 to 1300

Exp: Fixed cost = Rs. 50,000

Variable cost = Rs. 800Q

Q = daily production in tones

For 100 tonnes of production daily, total cost of production = 50,000 + 800 × 100 = 130,000

So, cost of production per tonne of daily production

$$= \frac{130,000}{100} = \text{Rs.}1300.$$

Q.No. 6-10 carry one Mark Each

6. Find the odd one in the following group: ALRVX, EPVZB, ITZDF, OYEIK

(A) ALRVX (B) EPVZB (C) ITZDF (D) OYEIK

Answer: (D)

Exp: ALRVX → only one vowel

EPVZB → only one vowel

ITZDF → only one vowel

OYEIK → three vowels

7. Anuj, Bhola, Chandan, Dilip, Eswar and Faisal live on different floors in a six-storeyed building (the ground floor is numbered 1, the floor above it 2, and so on). Anuj lives on an even-numbered floor. Bhola does not live on an odd numbered floor. Chandan does not live on any of the floors below Faisal's floor. Dilip does not live on floor number 2. Eswar does not live on a floor immediately above or immediately below Bhola. Faisal lives three floors above Dilip. Which of the following floor-person combinations is correct?

	Anuj	Bhola	Chandan	Dilip	Eswar	Faisal
(A)	6	2	5	1	3	4
(B)	2	6	5	1	3	4
(C)	4	2	6	3	1	5
(D)	2	4	6	1	3	5

Answer: (B)

Exp: (a) Anuj: Even numbered floor (2,4,6)

(b) Bhola: Even numbered floor (2,4,6)

(c) Chandan lives on the floor above that of Faisal.

(d) Dilip: not on 2nd floor.

(e) Eswar: does not live immediately above or immediately below Bhola

From the options its clear, that only option (B) satisfies condition (e).

So, correct Ans is (B).

8. The smallest angle of a triangle is equal to two thirds of the smallest angle of a quadrilateral. The ratio between the angles of the quadrilateral is 3:4:5:6. The largest angle of the triangle is twice its smallest angle. What is the sum, in degrees, of the second largest angle of the triangle and the largest angle of the quadrilateral?

Answer: 180 to 180

Exp: Let the angles of quadrilateral are 3x, 4x, 5x, 6x

So, $3x + 4x + 5x + 6x = 360$

$x = 20$

Smallest angle of quadrilateral $= 3 \times 20 = 60°$

Smallest angle of triangle $= \frac{2}{3} \times 60° = 40°$

Largest angle of triangle $= 2 \times 40° = 60°$

Three angles of triangle are 40°, 60°, 80°

Largest angle of quadrilateral is 120°

Sum (2nd largest angle of triangle + largest angle of quadrilateral)

$= 60° + 120° = 180°$.

9. One percent of the people of country X are taller than 6 ft. Two percent of the people of country Y are taller than 6 ft. There are thrice as many people in country X as in country Y. Taking both countries together, what is the percentage of people taller than 6 ft?

(A) 3.0 (B) 2.5 (C) 1.5 (D) 1.25

Answer: (D)

Exp: Let number of people in country y = 100

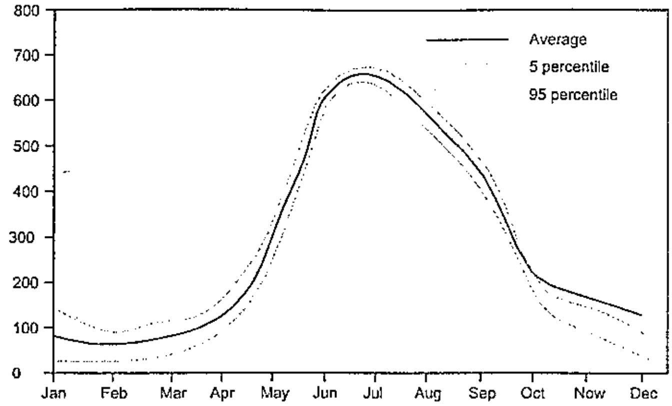
So, number of people in country x = 300

Total number of people taller than 6ft in both the countries

$$= 300 \times \frac{1}{100} + 100 \times \frac{2}{100} = 5$$

% of people taller than 6ft in both the countries $= \frac{5}{400} \times 100 = 1.25\%$

10. The monthly rainfall chart based on 50 years of rainfall in Agra is shown in the following figure. Which of the following are true? (k percentile is the value such that k percent of the data fall below that value)



(i) On average, it rains more in July than in December

(ii) Every year, the amount of rainfall in August is more than that in January

(iii) July rainfall can be estimated with better confidence than February rainfall

(iv) In August, there is at least 500 mm of rainfall

(A) (i) and (ii) (B) (i) and (iii) (C) (ii) and (iii) (D) (iii) and (iv)

Answer: (B)

Exp: In the question the monthly average rainfall chart for 50 years has been given. Let us check the options.

(i) On average, it rains more in July than in December correct.

(ii) Every year, the amount of rainfall in August is more than that in January. may not be correct because average rainfall is given in the question.

(iii) July rainfall can be estimated with better confidence than February rainfall.

From chart it is clear the gap between 5 percentile and 95 percentile from average is higher in February than that in July correct.

(iv) In August at least 500 mm rainfall

May not be correct, because its 50 year average.

So correct option (B) (i) and (iii).

Q.No. 1-25 carry one Mark Each

1. $\lim_{x \to \infty} \left(\frac{x + \sin x}{x} \right)$ equals to

(A) $-\infty$ (B) 0 (C) 1 (D) ∞

Answer: (C)

Exp. $\lim_{x \to \infty} \left(\frac{x + \sin x}{x} \right) = \lim_{x \to \infty} \left(1 + \frac{\sin x}{x} \right)$

2. Given the matrices $J = \begin{bmatrix} 3 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 6 \end{bmatrix}$ and $K = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$, the product $K^T JK$ is ________

Answer: 23 to 23

Exp. $K^T JK = [1 \; 2 \; -1] \begin{bmatrix} 3 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 6 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$

$= [6 \quad 8 \quad -1] \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix} = 23$

3. The probability density function of evaporation on any day during a year in a watershed is given by

$$f(E) = \begin{cases} \frac{1}{5} & 0 \le E \le 5 \text{ mm / day} \\ 0 & \text{otherwise} \end{cases}$$

The probability that E lies in between 2 and 4 mm/day in a day in the watershed is (in decimal) ________

Answer: 0.4 to 0.4

Exp.

4. The sum of Eigen values of the matrix, [M] is

(A) 915 (B) 1355 (C) 1640 (D) 2180

Answer: (A)

Exp. Sum of the eigen values = Trace of the matrix

= 215 + 150 + 550

= 915

5. With reference to the conventional Cartesian (x, y) coordinate system, the vertices of a triangle have the following coordinates: $(x_1, y_1) = (1, 0)$; $(x_2, y_2) = (2, 2)$; and $(x3, y_3) = (4, 3)$. The area of the triangle is equal to

(A) $\frac{3}{2}$ (B) $\frac{3}{4}$ (C) $\frac{4}{5}$ (D) $\frac{5}{2}$

Answer: (A)

Exp. Area of triangle $= \frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \\ 1 & 1 & 1 \end{vmatrix} = \frac{1}{2}\begin{vmatrix} 1 & 2 & 4 \\ 0 & 2 & 3 \\ 1 & 1 & 1 \end{vmatrix}$

$$= \frac{1}{2}\left| 1(2-3) - 2(0-3) + 4(0-2) \right|$$

$$= \frac{1}{2}|1-3| = \frac{3}{2}$$

6. Match the information given in Group – I with those in Group II.

Group - I	Group - II
(p) Factor to decrease ultimate strength to design strength	(1) Upper bound on ultimate load
(q) Factor to increase working load to ultimate load for design	(2) Lower bound on ultimate load
(r) Statical method of ultimate load analysis	(3) Material partial safety factor
(s) Kinematical mechanism method of ultimate load analysis	(4) Load factor

(A) P – 1; Q – 2; R – 3; S – 4 (B) P – 2; Q – 1; R – 4; S - 3

(C) P – 3; Q – 4; R – 2; S – 1 (D) P – 4; Q – 3; R – 2; S – 1

Answer: (C)

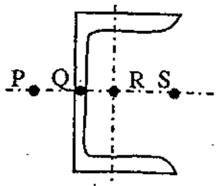
Exp. Static method Upper bound method of ultimate load analysis

Kinematic method → Lower bound on ultimate load

$F_a = F \times \gamma_f$ IS : 456 - 2000

$f_d = \frac{f}{\gamma_m}$ P.68

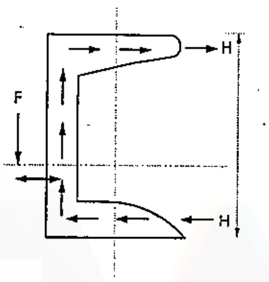
7. The possible location of shear centre of the channel section, shown below, is



(A) P (B) Q (C) R (D) S

Answer: (A)

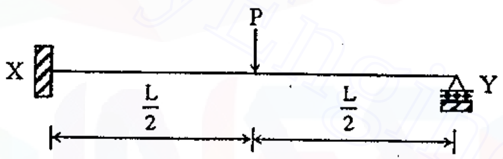
Exp. F.e = H × h



$$\Rightarrow F = \frac{H \times h}{e}$$

Only possible location is P

8. The ultimate collapse load (*P*) in terms of plastic moment Mp by kinematic approach for a propped cantilever of length L with P acting at its mid-span as shown in the figure, would be



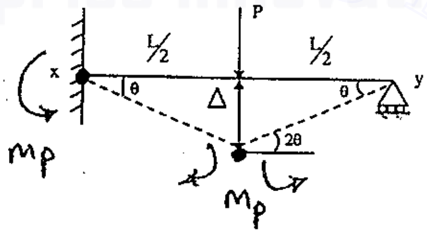
(A) $P = \frac{2M_P}{L}$ (B) $P = \frac{4M_P}{L}$ (C) $P = \frac{6M_P}{L}$ (D) $P = \frac{8M_P}{L}$

Answer: (C)

Exp. D_s =1 D_s = 4 – 3 = 1

So, no. of plastic hinges = D_s + 1 = 2

External work done = P . Δ = P . $\left(\frac{L}{2}.\theta\right)$



Internal work done $M_P .\theta + M_P .2\theta = 3M_P .\theta$

By principal of virtual work

$$= P.\frac{L}{2}.\theta = 3M_p.\theta \Rightarrow P = \frac{6M_P}{L}$$

9. While designing, for a steel column of Fe250 grade, a base plate resting on a concrete pedestal of M20 grade, the bearing strength of concrete (in N/mm2) in limit state method of design as per IS:456-2000 is ___________

Answer: 9 to 9

Exp. Permissible bearing strength ck

$= 0.45\ f_{ck}$

$= 0.45 \times 20 = 9N / mm^3$

IS : 456 – 2000
P. 66

10. A steel section is subjected to a combination of shear and bending actions. The applied shear force is V and the shear capacity of the section is Vs. For such a section, high shear force (as per IS:800-2007) is defined as

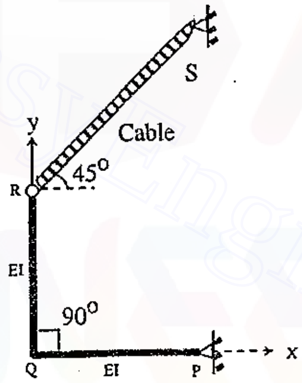
(A) V > 0.6VS (B) S V > 0.7V (C) S V > 0.8V (D) S V > 0.9V

Answer: (A)

Exp. As per clause 9.2.1 (IS: 800-2007) for combined shear and bending: Factored value of applied shear force is greater than or equal to shear strength for high shear.

i.e., V>0.6V

11. The degree of static indeterminacy of a rigid jointed frame PQR supported as shown in the figure is



(A) Zero (B) One (C) Two (D) Unstable

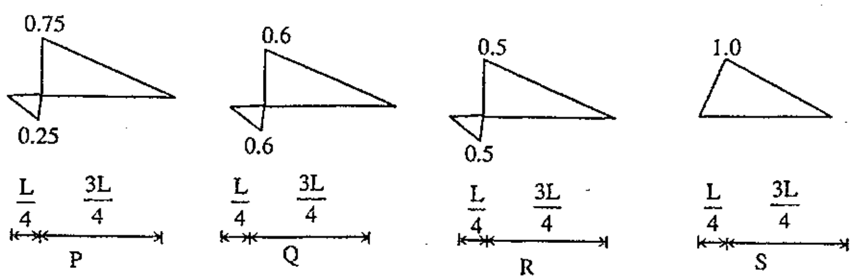
Answer: (A)

Exp. $D_s = Ds_e + D_{si}$ $D_{se} = R - r$ rr = no. of members connected to pin-1

$= (r_e - 3) + 3c - r_r$ $D^{si} = 3c - rr$ R = 4, r = 3 = 2 - 1

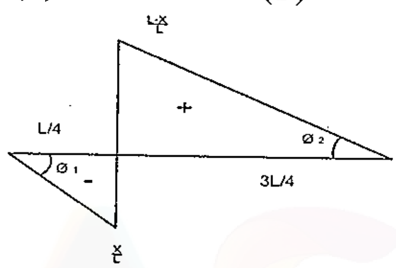
$= (4 - 3) + 3 \times 0 - 1 = 0$ = 1

12. In a beam of length L, four possible influence line diagrams for shear force at a section located at a distance of $\frac{L}{4}$ of from the left end support (marked as P, Q, R and S) are shown below. The correct influence line diagram is



(A) P (B) Q (C) R (D)

Answer: (A)



Exp. $\frac{X}{L} = \frac{1}{4L} = 0.25$

$\frac{L-X}{L} = \frac{3L}{4L} = 0.75$

13. The degree of disturbance of the sample collected by the sampler is expressed by a term called the "area ratio". If the outer diameter and inner diameter of the sampler are D_o and D_i respectively, the area ratio is given by

(A) $\frac{D_0^2 - D_i^2}{D_i^2}$ (B) $\frac{D_i^2 - D_0^2}{D_i^2}$ (C) $\frac{D_0^2 - D_i^2}{D_0^2}$ (D) $\frac{D_i^2 - D_0^2}{D_0^2}$

Answer: (A)

14. For a saturated cohesive soil, a triaxial test yields the angle of internal friction φ as zero. The conducted test is

(A) Consolidated Drained (CD) test
(B) Consolidated Undrained (CU) test
(C) Unconfined Compression (UC) test
(D) Unconsolidated Undrained (UU) test

Answer: (D)

Exp. Unconsolidated undrained test is used for completely saturated cohesive soil. In this test, no drainage is permitted during the first state as well as in the second stage.

15. The action of negative skin friction on the pile is to

(A) increase the ultimate load on the pile
(B) reduce the allowable load on the pile
(C) maintain the working load on the pile
(D) reduce the settlement of the pile

Answer: (B)

16. A long slope is formed in a soil with shear strength parameters: c' = 0 and ϕ' = 34°. A firm stratum lies below the slope and it is assumed that the water table may occasionally rise to the surface, with seepage taking place parallel to the slope. Use γ_m = 18kN/m^3 and γ_w =10kN/m^3. The maximum slope angle (in degrees) to ensure a factor of safety of 1.5, assuming a potential failure surface parallel to the slope, would be

(A) 45.3 (B) 44.7 (C) 12.3 (D) 11.3

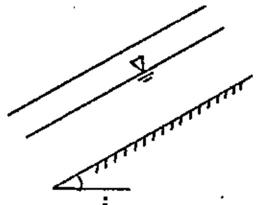
Answer: (D)

Exp. c'= 0, ϕ' = 34°

γ_{sat} = 18k N/m^3

γ_{sat} = 10kN/m^3

F.O.S = 1.5



$\gamma'_{sub} = \gamma_{sat} - \gamma_w$

When water table rises to surface = 3 18 – 10 = 8kN/m^3

$$\text{F.O.S.} = \frac{\gamma'_{sub}}{\gamma_{sat}} \frac{\tan\phi}{\tan i}$$

$$\Rightarrow 1.5 = \frac{8}{18} \times \frac{\tan 34°}{\tan i}$$

$$\Rightarrow \tan i = 0.199 \Rightarrow i = 11.30°$$

17. An incompressible homogeneous fluid is flowing steadily in a variable diameter pipe having the large and small diameters as 15 cm and 5 cm, respectively. If the velocity at a section at the 15 cm diameter portion of the pipe is 2.5 m/s, the velocity of the fluid (in m/s) at a section falling in 5 cm portion of the pipe is ___________

Answer: 22 to 23

Exp. By continuity equation between two sections

$A_1 V_1 = A_2 V_2$

$$\Rightarrow \frac{\pi}{4} \times (d_1)^2 . V_1 = \frac{\pi}{4} (d_2)^2 . V_2$$

$$\Rightarrow (15)^2 \times 2.5 = (5)^2 \times V_2$$

$$\Rightarrow V_2 = \frac{225 \times 2.5}{25} = 22.5 \text{ m/s}$$

18. A conventional flow duration curve is a plot between

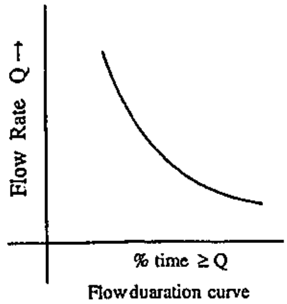
(A) Flow and percentage time flow is exceeded

(B) Duration of flooding and ground level elevation

(C) Duration of water supply in a city and proportion of area receiving supply exceeding this duration

(D) Flow rate and duration of time taken to empty a reservoir at that flow rate

Answer: (A)

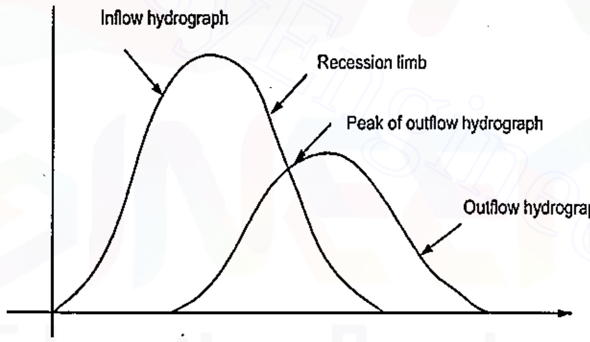


Flowduaration curve

19. In reservoirs with an uncontrolled spillway, the peak of the plotted outflow hydrograph
    (A) lies outside the plotted inflow hydrograph
    (B) lies on the recession limb of the plotted inflow hydrograph
    (C) lies on the peak of the inflow hydrograph
    (D) is higher than the peak of the plotted inflow hydrograph

Answer: (B)

Exp.



20. The dimension for kinematic viscosity is

(A) $\frac{L}{MT}$ (B) $\frac{L}{T^2}$ (C) $\frac{L^2}{T}$ (D) $\frac{ML}{T}$

Answer: (C)

Exp. Kinematic viscosity (V) → cm^2/s : $\frac{L^2}{T}$

21. Some of the nontoxic metals normally found in natural water are
    (A) arsenic, lead and mercury (B) calcium, sodium and silver
    (C) cadmium, chromium and copper (D) iron, manganese and magnesium

Answer: (D)

22. The amount of CO2 generated (in kg) while completely oxidizing one kg of CH4 to the end products is ________

Answer: 2.7 to 2.8

Exp. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

16 g 44g

When completely oxidized, 16g CH4 liberates = 44g CO_2

So, 1 kg.CH_4 will liberate $= \frac{44}{16} \times 1 = 2.75$kg

23. The minimum value of 15 minute peak hour factor on a section of a road is

(A) 0.10 (B) 0.20 (C) 0.25 (D) 0.33

Answer: (C)

Exp. 15 minute peak hour factor is used to design traffic intersections

$$PHF = \frac{\left(V/4\right)}{V_{15}}$$

Where V= peak hour volume (veh/hr)

V_{15} = Maximum 15 minute volume within the peak hour.

Minimum value is 0.25

24. The following statements are related to temperature stresses developed in concrete pavement slabs with free edges (without any restraint):

(P) The temperature stresses will be zero during both day and night times if the pavement slab is considered weightless

(Q) The temperature stresses will be compressive at the bottom of the slab during night time if the self-weight of the pavement slab is considered

(R) The temperature stresses will be compressive at the bottom of the slab during day time if the self-weight of the pavement slab is considered

The TRUE statement(s) is(are)

(A) P only (B) Q only (C) P and Q only (D) P and R only

Answer: (C)

Exp. Temperature stress = 0 if pavement is weightless

Temperature stress = Tensile at bottom of slab in day time

= Compressive at bottom of slab in night time

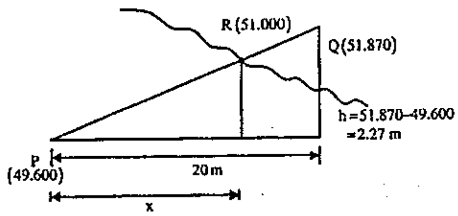
25. The Reduced Levels (RLs) of the points P and Q are +49.600 m and + 51.870 m respectively. Distance PQ is 20 m. The distance (in m from P) at which the +51.000 m contour cuts the line PQ is

(A) 15.00 (B) 12.33 (C) 3.52 (D) 2.27

Answer: (B)

Exp. $\frac{h}{20} = \frac{51 - 49.6}{x}$

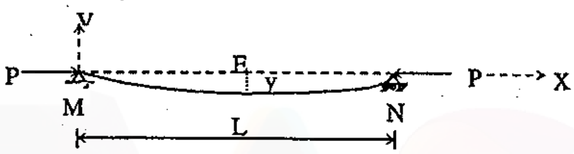
$\Rightarrow x = \frac{1.4 \times 20}{2.27} = 12.33 \text{ m}$



Q.No. 26-55 carry Two Marks

26. If the following equation establishes equilibrium in slightly bent position, the mid-span deflection of a member shown in the figure is

$$\frac{D^2 y}{dx^2} + \frac{P}{EI} y = 0$$



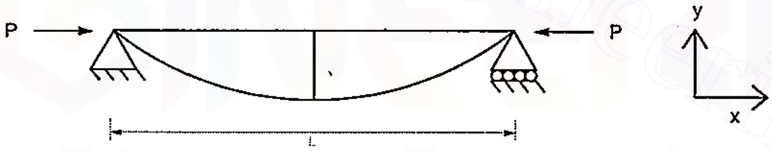
If α is amplitude constant for y, then

(A) $y = \frac{1}{P}\left(1 - \alpha \cos \frac{2\pi x}{L}\right)$ (B) $y = \frac{1}{P}\left(1 - \alpha \sin \frac{2\pi x}{L}\right)$

(C) $y = \alpha \sin \frac{n\pi x}{L}$ (D) $y = \alpha \cos \frac{n\pi x}{L}$

Answer: (C)

Exp.



$$\frac{d^2 y}{dex^2} = \frac{-P}{EI} . y = -k^2 . y$$

Solution of this differential equation is

y = a sin kx + b cos kx

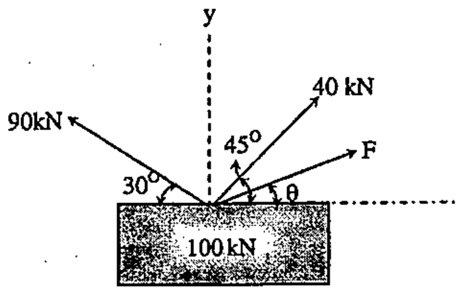
at x = 0, y = 0 ⇒ b = 0

at x = L, y = 0 ⇒0 = a sinKL

$$\Rightarrow KL = n\pi \Rightarrow K = \frac{n\pi}{L}$$

$$\therefore\ y = a \sin \frac{n\pi}{L} x$$

27. A box of weight 100 kN shown in the figure is to be lifted without swinging. If all forces are coplanar, the magnitude and direction (θ) of the force (F) with respect to x-axis should be



(A) F = 56.389 kN and θ = 28.28°

(B) F = -56.389 kN and θ = - 28.28°

(C) F = 9.055 kN and θ = 1.414°

(D) F = -9.055 kN and θ = -1.414°

Answer: (A)

Exp. For no swinging, $\Sigma F_H = 0$

$\Rightarrow$ 90 cos 30° Fcos θ + 40 cos 45°

$\Rightarrow$ F cos θ = 49.658 .... (i)

Also, $\Sigma F_v = 0$

$\Rightarrow$ 100 = 90sin30° 40sin 45° Fsin θ

$\Rightarrow$ F sin θ = 26.715 ....(ii)

solving(i) and (ii)

F = 56.389 kN, θ = 28.28°

28. A particle moves along a curve whose parametric equations are: $x = t^3 + 2t$, $y = -3e^{-2t}$ and $z = 2\sin(5t)$, where x, y and z show variations of the distance covered by the particle (in cm) with time t (in s). The magnitude of the acceleration of the particle (in cm/s^2) at t = 0 is ________

Answer: 12 to 12

Exp. $x = t^3 + 2t$, $y = -3e^{-2t}$, $z = 2\sin(5t)$

$$a_x = \frac{\partial^2 x}{\partial t^2} = 6t$$

$$a_y = \frac{\partial^2 y}{\partial t^2} = -12.e^{-2t}$$

$$a_z = \frac{\partial^2 z}{\partial t^2} = -50\sin 5t$$

$$a = a_x\,\hat{i} + a_y\,\hat{j} + a_z\,\hat{k} = (6t)\,\hat{i} - (12e^{-2t})\,\hat{j} - (50\sin 5t)\,\hat{k}$$

$$a\,(t = 0) = -12\,\hat{j}$$

so, $|a|_{t=0} = 12\ cm/s^2$

29. A traffic office imposes on an average 5 number of penalties daily on traffic violators. Assume that the number of penalties on different days is independent and follows a Poisson distribution. The probability that there will be less than 4 penalties in a day is ______

Answer: 0.26 to 0.27

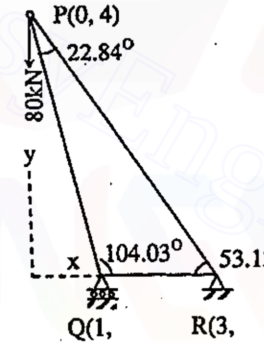
Exp. $P(x)=\frac{e^{-\lambda}\lambda^{x}}{x!}, \lambda=5$

$$P(x<4)=P(x=0)+P(x=1)+P(x=2)+P(x=3)$$

$$=\frac{e^{-5}5^{0}}{\lfloor 0}+\frac{e^{-5}5^{1}}{\lfloor 1}+\frac{e^{-5}5^{2}}{\lfloor 2}+\frac{e^{-5}5^{3}}{\lfloor 3}$$

$$=e^{-5}\left[1+5+\frac{25}{2}+\frac{125}{6}\right]=0.265$$

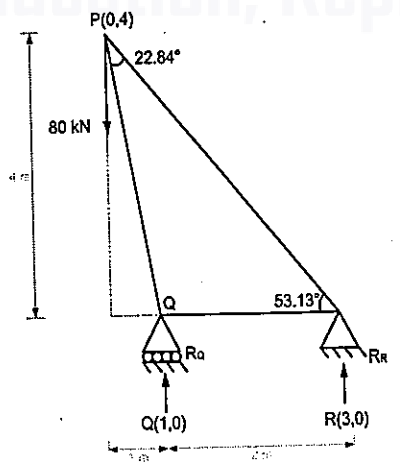
30. Mathematical idealization of a crane has three bars with their vertices arranged as shown in the figure with a load of 80 kN hanging vertically. The coordinates of the vertices are given in parentheses. The force in the member QR, FQR will be



(A) 30 kN Compressive
(B) 30 kN Tensile
(C) 50 kN Compressive
(D) 50 kN Tensile

Answer: A

Exp.



$\Sigma F_v = 0 \Rightarrow R_Q + R_R = 80$ ....(i)

Taking moment about Q=0

$\Rightarrow 80 \times 1 + R_R \times 2 = 0$

$\Rightarrow$ RR = – 40kN ↓

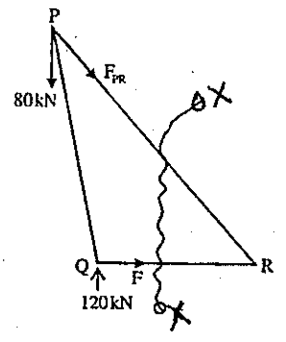
From (i), we get $R_Q = 120$kN↑

Consider section x-x

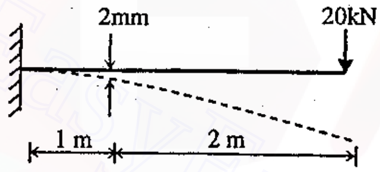
Taking moment about P = 0, LHS in equilibrium

$F_{QR} \times 4 + 120 \times 1 = 0$

$\Rightarrow F_{QR} = -30$kN (–) means compressive

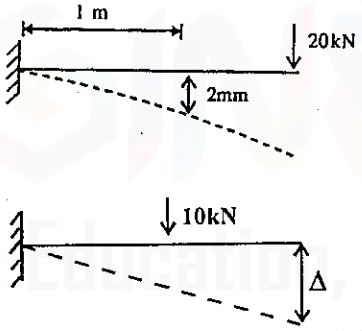


31. For the cantilever beam of span 3 m (shown below), a concentrated load of 20 kN applied at the free end causes a vertical displacement of 2 mm at a section located at a distance of 1 m from the fixed end. If a concentrated vertically downward load of 10 kN is applied at the section located at a distance of 1 m from the fixed end (with no other load on the beam), the maximum vertical displacement in the same beam (in mm) is



Answer: 1 to 1

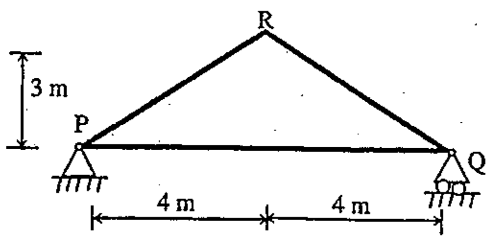
Exp.



By Bettis theorem,

$20 \times \Delta = 10 \times 2 \quad \Delta = 1$mm.

32. For the truss shown below, the member PQ is short by 3 mm. The magnitude of vertical displacement of joint R (in mm) is __________



Answer: 1.0 to 2.5

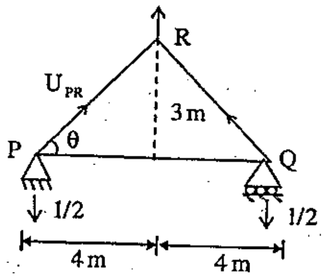
Exp. Since deflection at R is required. So, let us apply a virtual unit load at point R in upwards direction.

At point P $\Sigma F_v = 0 \Rightarrow U_{PR} \sin\theta = \frac{1}{2}$

$\Sigma FH = 0 \Rightarrow U_{PR} \cos\theta + U_{PQ} = 0$

$\Rightarrow U_{PQ} = -U_{PR} \cos\theta$

$= \frac{1}{2} \times \frac{1}{\tan\theta} = \frac{1}{2} \times \frac{4}{3} = -2/3$



$\tan\theta = \frac{3}{4}$

$\delta_R = U_{PQ} \times \lambda_{PQ}$

$= \frac{-2}{3} \times (-3)$ ($\because$ PQ is 3 mm short] = 2mm

So, deflection at R = 2mm (upwards)

33. A rectangular beam of width (*b*) 230 mm and effective depth (*d*) 450mm is reinforced with four bars of 12 mm diameter. The grade of concrete is M20 and grade of steel is Fe500. Given that for M20 grade of concrete the ultimate shear strength, 2 ∞ 0.36N/ mm τ = for steel percentage, p = 0.25, and 2 ∞ 0.48N/mm τ = for *p* = 0.50. For a factored shear force of 45kN, the diameter (in mm) of Fe500 steel two legged stirrups to be used at spacing of 375 mm, should be

(A) 8 (B) 10 (C) 12 (D) 16

Answer: (A)

Exp. $\tau_v = \frac{V_U}{bd} = \frac{45 \times 1000}{230 \times 450} = 0.434\ N/mm^2$

% tensile reinforcement (p) = $\frac{4 \times \frac{\pi}{4} \times (12)^2}{230 \times 450} \times 100 = 0.437\%$

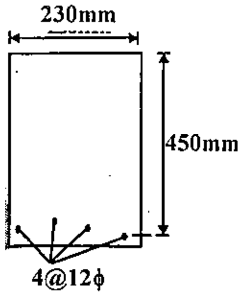
$\tau_c = 0.36 + \frac{0.12}{0.25} \times (0.437 - 0.25) = 0.45\ N/mm^2$

$\tau_v < \tau_c$

So, minimum shear reinforcement is required

Minimum shear reinforcement

So, adopt 8mm



$\frac{A_{sv}}{b \times S_v} = \frac{0.4}{0.87 f_y}$

$$\Rightarrow A_{sv} = \frac{0.4 \times b \times S_v}{0.87 \times f_y}$$

$$\Rightarrow 2 \times \frac{\pi}{4} \times \phi^2 = \frac{0.4 \times 230 \times 375}{0.87 \times 500} \Rightarrow \phi = 7.10 \text{ mm}$$

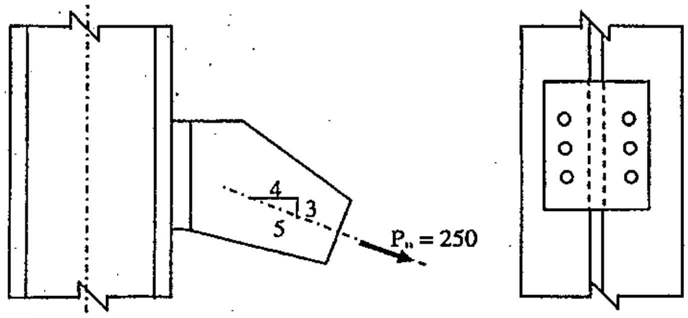
34. The tension and shear force (both in kN) in each bolt of the joint, as shown below, respectively are

(A) 30.33 and 20.00

(B) 30.33 and 25.00

(C) 33.33 and 20.00

(D) 33.33 and 25.00

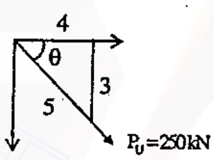


Answer: (D)

Exp. $\sin\theta = \frac{3}{5}, \cos\theta = \frac{4}{5}$

$P_U \cos\theta = \frac{4}{5}.P_U$

$P_U \sin\theta = \frac{3}{5}.P_U$



$$\text{Tension in each bolt} = \frac{P_U \cos\theta}{6} = \frac{4P_U}{5 \times 6} = \frac{4}{30} \times 250 = 33.33 \text{ kN}$$

$$\text{Shear in each bolt} = \frac{P_U \sin\theta}{6} = \frac{3}{5} \times \frac{P_U}{6} = \frac{3}{5 \times 6} \times 250 = 25 \text{ kN}$$

35. For a beam of cross-section, width = 230 mm and effective depth = 500 mm, the number of rebars of 12 mm diameter required to satisfy minimum tension reinforcement requirement specified by IS:456-2000 (assuming grade of steel reinforcement as Fe500) is __________

Answer: 2 to 2

Exp. $\frac{(A_{st})_{min}}{bd} = \frac{0.85}{f_y}$

$$\Rightarrow (A_{st})_{min} = \frac{0.85}{500} \times 230 \times 500 = 195.5 \text{ mm}^2$$

$$n \times \frac{\pi}{4} d^2 = 195.5 \Rightarrow n = 1.73$$

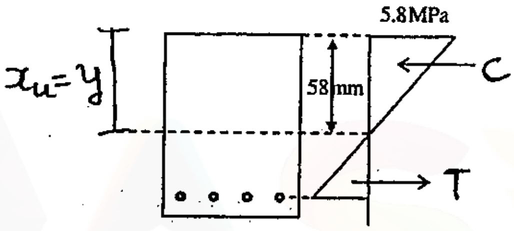
So, take n = 2

36. In a reinforced concrete section, the stress at the extreme fibre in compression is 5.80 MPa. The depth of neutral axis in the section is 58 mm and the grade of concrete is M25. Assuming linear elastic behavior of the concrete, the effective curvature of the section (in per mm) is

(A) 2.0×10^{-6} (B) 3.0×10^{-6} (C) 4.0×10^{-6} (D) 5.0×10^{-6}

Answer: (C)

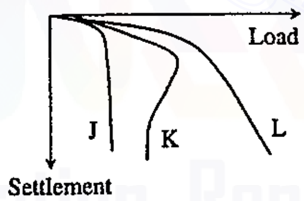
Exp. $E = 5000\sqrt{f_{ck}} = 5000 \times \sqrt{25} = 25000 \text{ N/mm}^2$



$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

curvature, $\frac{1}{r} = \frac{f}{yE} = \frac{5.8}{58 \times 25000} = 4 \times 10^{-6}$ per mm

37. Group I contains representative load-settlement curves for different modes of bearing capacity failures of sandy soil. Group II enlists the various failure characteristics. Match the load-settlement curves with the corresponding failure characteristics.



Group I	Group II
(p) Curve J	(1) No apparent heaving of soil around the footing
(q) Curve K	(2) Rankine's passive zone develops imperfectly
(r) Curve L	(3) Well defined slip surface extends to ground surface

(A) P - 1, Q - 3, R - 2 (B) P - 3, Q - 2, R - 1

(C) P - 3, Q - 1, R - 2 (D) P - 1, Q - 2, R – 3

Answer: (A)

Exp. K → General shear failure

L → Local shear failure

J → Punching shear failure

General shear failure (Q) :	Well define failure pattern(3)
Local shear failure (L) :	Rankine passive zone developes(2)
Punching shear failure:	No heaving of soil around footing

38. A given cohesionless soil has e_{max} = 0.85 and e_{max} = 0.50. In the field, the soil is compacted to a mass density of 1800 kg/m3 at a water content of 8%. Take the mass density of water as 1000kg/m^3 and G, as 2.7.The relative density (in %) of the soil is

(A) 56.43 (B) 60.25 (C) 62.87 (D) 65.7

Answer: (D)

Exp. $e_{max} = 0.85$, $e_{min} = 0.5$ $\rho_{field} = 1800$ kg/m^3

$w = 8$ %, $\rho_w = 1000$ kg/m^3, $G_s = 27$

$$\rho_b = \frac{G(1+w)}{1+e}\rho_w$$

$$\rho_d = \frac{G.\rho_w}{1+e},\ \rho_d = \frac{\rho_b}{1+\omega}$$

$$\therefore\ \rho_b = \frac{G(1+\omega)\rho_w}{1+e}$$

$$\Rightarrow 1 + e = G(1 + w)\frac{\rho_w}{\rho_b} = \frac{2.7(1+.08)}{1800}\times 1000$$

$$\Rightarrow e = 0.62$$

$$\text{Relative Density} = \frac{e_{max} - e}{e_{maqx} - e_{min}}\times 100 = \frac{0.85 - 0.62}{0.85 - 0.5}\times 100 = 65.1\ \%$$

39. The following data are given for the laboratory sample.

$\sigma_o' = 175$kPa; $e_0 = 1.1$; $\sigma_0' + \Delta\sigma_0 = 300$kPa; $e = 0.9$

If thickness of the clay specimen is 25mm, the value of coefficient of volume compressibility is ________ × 10^{-4} m^2/kN

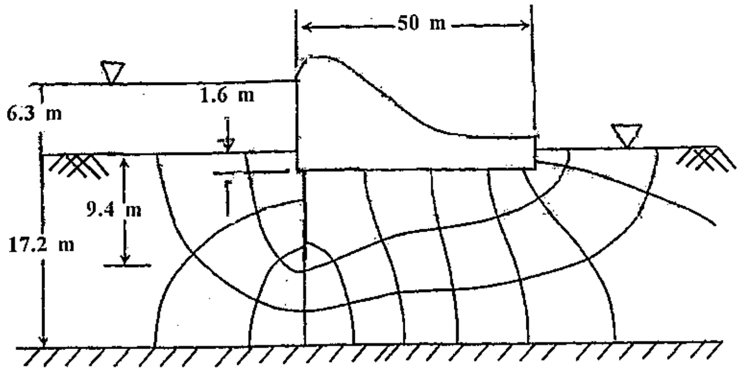
Answer: 7.6 to 8.0

Exp. Volume compressibility, $m_v = \frac{a_v}{1+e_0}$, $a_v = \frac{\Delta_e}{\Delta\sigma'}$

$$\therefore\ m_v = \frac{\Delta_e}{(1+e_0)\Delta\sigma'}$$

$$m_v = \frac{0.2}{1+1.1}\times\frac{1}{125} = 7.62\times 10^{-4}\ m^2/kN$$

40. The flow net constructed for the dam is shown in the figure below. Taking the coefficient of permeability as 3.8 × 10^{-6} m/s, the quantity of flow (in cm^3/s) under the dam per meter of dam is ____________



Answer: 7.10 to 7.85

Exp. $Q = K.H.\frac{N_f}{N_d}$

N_f = No. of flow channels = 3

N_d = No. of equipotential drops = 10

K = 3.8×10^{-4} s /m

H = 6.3m

$Q = 3.8 \times 10^{-6} \times 6.3 \times \frac{3}{10} = 7.182 \times 10^{-6}$ m³/s/m 7.182cm³ /s/m

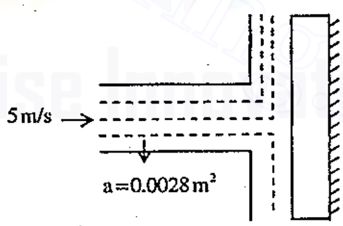
41. A horizontal jet of water with its cross-sectional area of 0.0028 m2 hits a fixed vertical plate with a velocity of 5 m/s. After impact the jet splits symmetrically in a plane parallel to the plane of the plate. The force of impact (in N) of the jet on the plate is

(A) 90 (B) 80 (C) 70 (D) 60

Answer: (C)

Exp. Force on plate, $F = \rho.a.v^2$

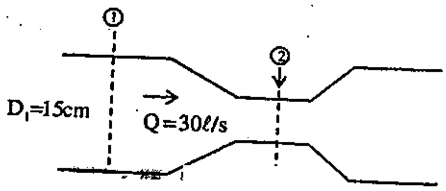
$1000 \times 0 \times 0028 \times 5^2 = 70N$



42. A venturimeter, having a diameter of 7.5 cm at the throat and 15 cm at the enlarged end, is installed in a horizontal pipeline of 15 cm diameter. The pipe carries an incompressible fluid at a steady rate of 30 litres per second. The difference of pressure head measured in terms of the moving fluid in between the enlarged and the throat of the venturimeter is observed to be 2.45 m. Taking the acceleration due to gravity as 9.81 m/s², the coefficient of discharge of the venturimeter (correct up to two places of decimal) is ____________

Answer: 0.93 to 0.96

Exp. $Q = \frac{cd.a_1 a_2}{\sqrt{a_1^2 - a_2^2}}.2gh$



$$a_1 = \frac{\pi}{4}\times(.15)^2 = 0.0176\,m^2$$

$$a_2 = \frac{\pi}{4}\times(.75)^2 = 0.044\,m^2$$

$$\Rightarrow 30\times10^{-3} = C_d.\frac{0.0176\times0.0044}{\sqrt{(0.0176)^2-(0.0044)^2}}\times\sqrt{2\times9.81\times2.45}$$

$$\Rightarrow C_d = 0.95$$

43. A rectangular channel having a bed slope of 0.0001, width 3.0 m and Manning's coefficient 'n' 0.015, carries a discharge of 1.0 m^3/s. Given that the normal depth of flow ranges between 0.76 m and 0.8 m. The minimum width of a throat (in m) that is possible at a given section, while ensuring that the prevailing normal depth is not exceeded along the reach upstream of the contraction, is approximately equal to (assume negligible losses)

(A) 0.64 (B) 0.84 (C) 1.04 (D) 1.24

Answer: (B)

Exp. 3 n = 0.015, Q = $1m^3$ /s, B = 3.0m

Normal depth of flow ranges between 0.76m to 0.8 m

If prevailing normal depth of flow is not exceeded, there must not be choking of the section or it should be at boundary condition of choking.

So, width of section should be such that there should be critical flow corresponding to the prevailing specific energy.

$$\text{i.e. } \frac{3}{2}\left(\frac{q^2}{g}\right)^{1/3} = E_c = E_{initial}$$

$$q = \frac{Q}{B_{min}}, \text{So } \frac{3}{2}\left[\frac{\left(\frac{Q}{B_{min}}\right)^2}{g}\right]^{1/3} = E_{initial}$$

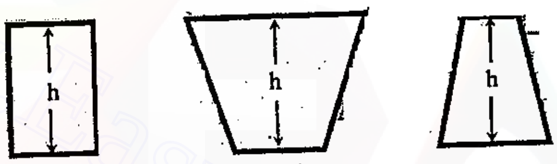
$$E_{initial} = y + \frac{q^2}{2gy^2}$$

$$\Rightarrow 1 = \frac{1}{0.015}.(3y).\left(\frac{3y}{3+2y}\right).(0.0001)^{1/2} \Rightarrow y = 0.78\,m$$

$$\text{So, } E_{initial} = 0.78 + \frac{\left(\frac{1}{3}\right)^2}{2 \times 9.81 \times (0.78)^2} = 0.789 \text{ m}$$

$$\text{So, } \frac{3}{2}\left(\frac{Q}{g.(B_{min})^2}\right)^{1/3} = 0.789 \Rightarrow B_{min} = 0.84 \text{ m}$$

44. Three rigid buckets, shown as in the figures (1), (2) and (3), are of identical heights and base areas. Further, assume that each of these buckets have negligible mass and are full of water. The weights of water in these buckets are denoted as W_1, W_2, and W3 respectively. Also, let the force of water on the base of the bucket be denoted as F_1, F_2, and F_3 respectively. The option giving an accurate description of the system physics is



ALL THREE BUCKETS HAVE THE SAME BASE AREA
(1) (2) (3)

(A) $W_2 = W_1 = W_3$ and $F_2 > F_1 > F_3$

(B) $W_2 > W_1 > W_3$ and $F_2 > F_1 > F_3$

(C) $W_2 = W_1 = W_3$ and $F_1 = F_2 = F_3$

(D) $W_2 > W_1 > W_3$ and $F_1 = F_2 = F_3$

Answer: (D)

Exp.

Force on base of Bucket, w base $F = \gamma_w.h.A_{base}$

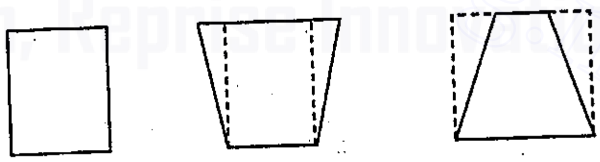
$\because$ Base area of all buckets is same.

So, $F_1 = F_2 = F_3$

Weight of water, $W = \gamma_w \cdot V$

Since $V_2 > V_1 > V_3$

so, $W_2 > W_1 > W_3$



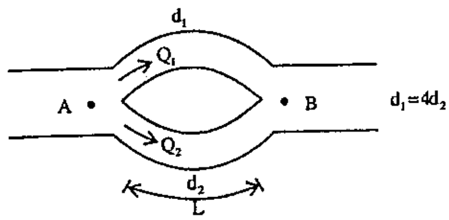
45. An incompressible fluid is flowing at a steady rate in a horizontal pipe. From a section, the pipe divides into two horizontal parallel pipes of diameters d_1 and d_2 (where $d_1 = 4d_2$) that run for a distance of L each and then again join back to a pipe of the original size. For both the parallel pipes, assume the head loss due to friction only and the Darcy-Weisbach friction factor to be the same. The velocity ratio between the bigger and the smaller branched pipes is ________

Answer: 2 to 2

Darcy's formula, $h_f = \frac{fLV^2}{2gD}$ f = Darcy's friction factor

Exp. Since pipes are in parallel,

so, head loss will be same



$$\frac{fL}{d_2}\cdot\frac{V_1^2}{2g}=\frac{fL}{d_2}\cdot\frac{V_2^2}{2g}$$

$$\Rightarrow\frac{V_1^2}{d_1}=\frac{V_2^2}{d_2}\Rightarrow\frac{V_1^2}{V_2^2}=\frac{d_1}{d_2}=4$$

$$\Rightarrow\frac{V_1}{V_2}=2$$

46. 16 MLD of water is flowing through a 2.5 km long pipe of diameter 45 cm. The chlorine at the rate of 32 kg/d is applied at the entry of this pipe so that disinfected water is obtained at the exit. There is a proposal to increase the flow through this pipe to 22 MLD from 16 MLD. Assume the dilution coefficient, n = 1. The minimum amount of chlorine (in kg per day) to be applied to achieve the same degree of disinfection for the enhanced flow is

(A) 60.50 (B) 44.00 (C) 38.00 (D) 23.27

Answer: (A)

Exp. For disinfection, we have n tc =K

Where t = time required to kill all organisms

c = concentration of disinfectant

n = dilution coefficient

k = constant

So, $t_1 c_1^n = t_2 c_2^n$

here, n = 1

$t_1 c_1 = t_2 c_2$

$t_1=\frac{L}{V_1}$; L = Length of pipe, V_1 = velocity of flow

$=\frac{L}{Q_1/A}=\frac{L.A}{Q_1}$; Q_1 = discharge per day

$C_1=\frac{W_1}{Q_1}$, W_1 = weight of disinfectant per day

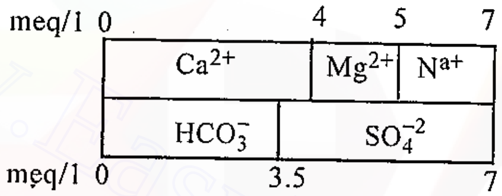
$$\text{so, }\frac{LA}{Q_1}\cdot\frac{W_1}{Q_1}=\frac{LA}{Q_2}\cdot\frac{W_2}{Q_2}$$

$$W_2=\left(\frac{Q_2}{Q_1}\right)^2\cdot W_1=\left(\frac{22}{16}\right)^2\times 32=60.5\text{ kg/d}$$

47. The potable water is prepared from turbid surface water by adopting the following treatment sequence.
    (A) Turbid surface water → Coagulation → Flocculation → Sedimentation → Filtration → Disinfection → Storage & Supply
    (B) Turbid surface water → Disinfection → Flocculation → Sedimentation → Filtration → Coagulation → Storage & Supply
    (C) Turbid surface water → Filtration → Sedimentation → Disinfection → Flocculation → Coagulation → Storage & Supply
    (D) Turbid surface water → Sedimentation → Flocculation → Coagulation → Disinfection → Filtration . Storage & Supply

Answer: (A)

48. For a sample of water with the ionic composition shown in the figure below, the carbonate and non-carbonate hardness concentrations (in mg/l as $CaCO^3$), respectively are:



(A) 200 and 50 (B) 175 and 75 (C) 75 and 175 (D) 50 and 200

Answer: (B)

Exp. Carbonate hardness CH = 3.5 × 50 mg/*l* as $CaCO_3$ = 175mg/*l*

Non Carbonate hardness, NCH = Total Hardness – Carbonate hardness

= 5.0 × 50 – 175

= 75 mg/*l* as $CaCO_3$

49. A straight 100 m long raw water gravity main is to carry water from an intake structure to the jack well of a water treatment plant. The required flow through this water main is 0.21 m^3/s. Allowable velocity through the main is 0.75 m/s. Assume f = 0.01, g = 9.81 m/s^2. The minimum gradient (in cm/100 m length) to be given to this gravity main so that the required amount of water flows without any difficulty is ___

Answer: 4.7 to 4.9

Exp. $Q = 0.21\ m^3/s$

$V_a = 0.75\ m/s,\ f = 0.01,\ g = 9.81\ m/s^2$

$$A = \frac{Q}{V} \Rightarrow \frac{\pi}{4}.d^2 = \frac{0.21}{0.75}$$

$\Rightarrow d = 0.60$ m

$$h_f = \frac{f \times L}{d} \times \frac{V^2}{2g} = \frac{0.01 \times 100 \times (0.75)^2}{0.60 \times 2 \times 9.81} = 0.047\ m = 4.7\ cm$$

$$\text{Minimum gradient} = \frac{h_f}{L} = \frac{4.7\text{ cm}}{100\text{ m}}$$

50. A traffic survey conducted on a road yields an average daily traffic count of 5000 vehicles. The axle load distribution on the same road is given in the following table:

Axle load (tonnes)	Frequency of traffic (%)
18	10
14	20
10	35
8	15
6	20

The design period of the road is 15 years, the yearly traffic growth rate is 7.5% and the load safety factor (LSF) is 1.3. If the vehicle damage factor (VDF) is calculated from the above data, the design traffic (in million standard axle load, MSA) is

Answer: 307 to 310

Exp. Vehicle damage factor

$$VDF = \frac{V_1 \times \left(\frac{W_1}{W_s}\right)^4 + V_2 \cdot \left(\frac{W_2}{W_s}\right)^4 + \ldots\ldots\ldots V_s\left(\frac{W_s}{W_s}\right)^4}{V_1 + V_2 + V_3 + V_4 + V_5}$$

$$= \frac{10\times\left(\frac{18}{8.2}\right)^4 + 20\times\left(\frac{14}{8.2}\right) + 35\times\left(\frac{10}{8.2}\right)^4 + 15\times\left(\frac{8}{8.2}\right)^4 + 20\times\left(\frac{16}{8.2}\right)^4}{10+20+35+15+20} = 4.99$$

$$N = \frac{365\times A\left[(1+r)^n - 1\right]}{r}\times VDF$$

$$= \frac{365\times 5000\times\left[(1.075)^n - 1\right]}{0.075}\times 4.99 = 237.785\text{ MSA}$$

So, Design traffic = 237.785 · 1.3= 309.21MSA

51. The perception-reaction time for a vehicle travelling at 90 km/h, given the coefficient of longitudinal friction of 0.35 and the stopping sight distance of 170 m (assume $g = 9.81\text{ m/s}^2$), is ________ seconds.

Answer: 3.1 to 3.2

Exp. V = 90 km/h $\therefore$ $v = \frac{90\text{ m}\times 1000}{3600} = 25\text{ m/s}$

$$SSD = v.t + \frac{v^2}{2gf}$$

$$170 = 25t + \frac{25^2}{2 \times 9.81 \times 0.35}$$

$\therefore$ t = 3.16 see

52. The speed-density (u-k) relationship on a single lane road with unidirectional flow is u = 70 – 0.7k, where u is in km/hr and k is in veh/km. The capacity of the road (in veh/hr) is ________

Answer: 1750 to 1750

Exp. U = 70 – 0.7 K

$$\text{capacity} = \frac{U_I \times K_j}{4} \quad U_f = \text{free velocity}, \; K_j = \text{jam density}$$

At K_j, U = 0

So $k_j = \frac{70}{7} = 100$ veh/km

At K = 0, U = U_f = 70 km/hr

$$\text{So, capacity} = \frac{70 \times 100}{4} = 1750 \text{ veh/hr}$$

53. An isolated three-phase traffic signal is designed by Webster's method. The critical flow ratios for three phases are 0.20, 0.30, and 0.25 respectively, and lost time per phase is 4 seconds. The optimum cycle length (in seconds) is ________

Answer: 90 to 95

Exp. Total time lost in a cycle, L = 4 × 3 = 12sec

$$C = \frac{1.5L + 5}{1 - y} = \frac{1.5 \times 12 + 5}{1 - (0.2 + 0.3 + 0.25)} = 92s$$

54. A levelling is carried out to establish the Reduced Levels (RL) of point R with respect to the Bench Mark (BM) at P. The staff readings taken are given below.

Staff Station	BS	IS	FS	RL
P	1.655 m			100.000 m
Q	-0.950 m		-1.500 m	
R			0.750 m	?

If RL of P is +100.000 m, them RL (in m) of R is

१८

(A) 103.355 (B) 103.155 (C) 101..455 (D) 100.355

Answer: (C)

Exp.

RL of P = 100.0 m

HI at P = 100 + 1.655 = 101.655 m

RL of Q = 101.655 – (–1.5) = 103.155 m

HI at Q = 103.155 + (–0.95) = 102.205 m

RL of R = 102.205 – 0.75 = 101.455 m

55. Group I lists tool/instrument while Group II lists the method of surveying. Match the tool/instrument with the corresponding method of surveying.

Group I	Group II
(p) Alidade	(1) Chain surveying
(q) Arrow	(2) Levelling
(r) Bubble tube	(3) Plain table surveying
(s) Stadia hair	(4) Theodolite surveying

(A) P – 3; Q – 2; R – 1; S – 4
(B) P – 2; Q – 4; R – 3; S – 1
(C) P – 1; Q – 2; R – 4; S – 3
(D) P – 3; Q – 1; R – 2; S – 4

Answer: (D)

Exp. Alidade → used in plane table surveying
Arrow → chain surveying
Bubble tube → leveling
Stadia hair → Theodolite surveying

❖❖❖

GATE -2014, PAPER-2

Q. No. 1-5 carry one Mark Each

1. Choose the most appropriate word from the options given below to complete the following sentence.

   A person suffering from Alzheimer's disease __________ short-term memory loss.

   (A) experienced (B) unexperienced (C) is experiencing (D) experiences

Answer: (D)

2. Choose the most appropriate word from the options given below to complete the following sentence. __________ is the key to their happiness; they are satisfied with what they have.

   (A) Contentment (B) Ambition (C) Perseverance (D) Hunger

Answer: (A)

3. Which of the following options is the closest in meaning to the sentence below?

   "As a woman, I have no country."

   (A) Women have no country

   (B) Women are not citizens of any country.

   (C) Women's solidarity knows no national boundaries

   (D) Women of all countries have equal legal rights.

Answer: (C)

4. In any given year, the probability of an earthquake greater than Magnitude 6 occurring in the Garhwal Himalayas is 0.04. The average time between successive occurrences of such earthquakes is ______ years.

Answer: 25 to 25

Exp:

$P = 0.04 = \frac{4}{100}$

For 1 earth quake

$\frac{100}{4}$ P = 1 earth quake

25 years

] Reverse probability

5. The population of a new city is 5 million and is growing at 20% annually. How many years would it take to double at this growth rate?

(A) 3-4 years (B) 4-5 years (C) 5-6 years (D) 6-7 years

Answer: (A)

Exp: $\frac{20}{140} \times 8$

After 1 year

P = 6

2 years = 7.2

After 3 = $\frac{20}{100} \times 1.2$

= 8.65

After 4 years = $\frac{20}{100} \times 8.65$

Time will be in between 3–4 years.

Q. No. 6-10 carry one Mark Each

6. In a group of four children, Som is younger to Riaz. Shiv is elder to Ansu. Ansu is youngest in the group. Which of the following statements is/are required to find the eldest child in the group?

Statements :

1. Shiv is younger to Riaz.
2. Shiv is elder to Som.

(A) Statement 1by itself determines the eldest child.

(B) Statement 2 by itself determines the eldest child.

(C) Statement 1 and 2 are both required to determine the eldest child.

(D) Statement 1 and 2 are not sufficient to determine the eldest child.

Answer: (A)

7. Moving into a world of big data will require us to change our thinking about the merits of exactitude. To apply the conventional mindset of measurement to the digital, connected world of the twenty-first century is to miss a crucial point. As mentioned earlier, the obsession with exactness is an artefact of the information-deprived analog era. When data was sparse, every data point was critical, and thus great care was taken to avoid letting any point bias the analysis. *From "BIG DATA" Viktor Mayer-Schonberger and Kenneth Cukier*

The **main** point of the paragraph is:

(A) The twenty-first century is a digital world

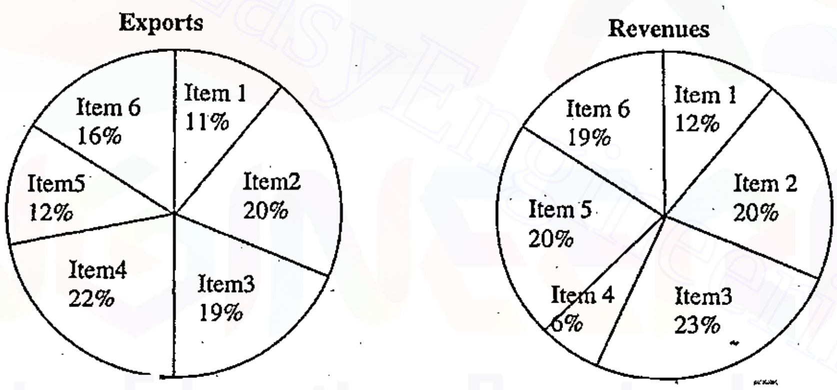
(B) Big data is obsessed with exactness

(C) Exactitude is not critical in dealing with big data

(D) Sparse data leads to a bias in the analysis

Answer: (C)

8. The total exports and revenues from the exports of a country are given in the two pie charts below. The pie chart for exports shows the quantity of each item as a percentage of the total quantity of exports. The pie chart for the revenues shows the percentage of the total revenue generated through export of each item. The total quantity of exports of all the items is 5 lakh tonnes and the total revenues are 250 crore rupees. What is the ratio of the revenue generated through export of Item 1 per kilogram to the revenue generated through export of Item 4 per kilogram?



(A) 1:2 (B) 2:1 (C) 1:4 (D) 4:1

Answer: (D)

Exp: revenue generated through export of item 1 Kg

$$\Rightarrow \frac{\text{Item}}{\text{quantity}} = \frac{11}{100}\times 5 = \frac{11}{20}\text{(lakhs tows)}$$

$$\left.\begin{matrix}\text{revenue gen}\\ \text{Item1}\end{matrix}\right\} \frac{12}{100}\times 6\times 250\times (C) = \frac{30cr}{11}\times 20 \qquad ...(1)$$

$$\text{Revenue gen Item } 4 = \frac{6}{100}\times 250\,(C)$$

$= \frac{15\text{ cr}}{22} \times 20\text{ Lt.}$ ...(2)

1 : 2

$\frac{30}{11} \times \frac{20 \times 22}{15 \times 20} = 4:1$

9. X is 1 km northeast of Y. Y is 1 km southeast of Z. W is 1 km west of Z. P is 1 km south of W. Q is 1 km east of P. What is the distance between X and Q in km?

(A) 1 (B) 2 (C) 3 (D) 2

Answer: (C)

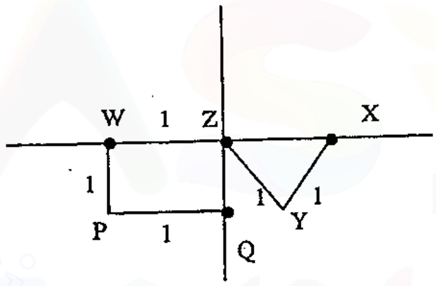
Exp: From the fig: zx = $\sqrt{2}$. [Pythagoras theorem] zQ = 1 Given

⇒ Considering ZQX, which is right angle, is

⇒ $Qx^2 = ZQ^2 + Zx^2$

$= \sqrt{1+2}$

$= \sqrt{3}$



10. 10% of the population in a town is HIV+. A new diagnostic kit for HIV detection is available; this kit correctly identifies HIV+ individuals 95% of the time, and HIV" individuals 89% of the time. A particular patient is tested using this kit and is found to be positive. The probability that the individual is actually positive is ______

Answer: 0.48 to 0.49

Exp: Let total population = 100

HIV + patients = 10

For the patient to be +Ve, should be either +Ve and test is showing +Ve or the patient should

be – Ve but rest is showing +Ve

$$\Rightarrow \frac{0.1 \times 0.95}{0.1 \times 0.95 + 0.9 \times 0.11}$$

Q. No. 1-25 carry one Mark Each

1. A fair (unbiased) coin was tossed four times in succession and resulted in the following outcomes: (i) Head, (ii) Head, (iii) Head, (iv) Head. The probability of obtaining a 'Tail' when the coin is tossed again is

(A) 0 (B) $\frac{1}{2}$ (C) $\frac{4}{5}$ (D) $\frac{1}{5}$

Answer: (B)

Exp. $P(T) = \frac{1}{2}$

2. The determinant of matrix $\begin{bmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 3 & 0 & 1 & 2 \end{bmatrix}$ is ....

Answer: 88 to 88

Exp.

$$\begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 0 \\ 2 & 3 & 0 & 1 \\ 3 & 0 & 1 & 2 \end{vmatrix} = -1\begin{vmatrix} 1 & 2 & 3 \\ 3 & 0 & 1 \\ 0 & 1 & 2 \end{vmatrix} - 3\begin{vmatrix} 0 & 1 & 3 \\ 2 & 3 & 1 \\ 3 & 0 & 2 \end{vmatrix}$$

= [1(0 -1) - 2 (6 - 0) + 3 (3 - 0)]

= - 3 [0 - 1 (4 - 3) + 3 (0 - 9)] = 88

3. $z = \frac{2-3i}{-5+i}$ can be expressed as

(A) - 0.5 - 0.5i (B) - 0.5 + 0.5i (C) 0.5 - 0.5i (D) 0.5 + 0.5i

Exp. $z = \frac{2-3i}{-5+i}$

$$z = \frac{2-3i}{-5+i} \times \frac{-5-i}{-5-i}$$

$$= \frac{-10-2i+15i+3i^2}{5^2-i^2} = \frac{-10+13i-3}{25+1}$$

$$= \frac{13i-13}{26} = 13\frac{(i-1)}{26} = \frac{i-1}{2} = \frac{i}{2} - \frac{i}{2} = 0.5i = 0.5.$$

4. The integrating factor for the differential equation $\frac{dp}{dt} + k_2 P = k_1 L_0 e^{-k_1 t}$ is

(A) $e^{-k_1 t}$ (B) $e^{-k_2 t}$ (C) $e^{k_1 t}$ (D) $e^{k_2 t}$

Answer: (D)

Exp. $\frac{dp}{dt} + k_2 P = k_1 L_0 e^{k_2 t}$

The standard form of Linear differential equations is

$\frac{dy}{dx} + py = Q;\ I.F = e^{\int pdx}$

$\Rightarrow \frac{dp}{dt} + k_2 P = \left(K_1 L_0 e^{-k_1 t}\right)$

Integrating factor, I.F. = $e^{\int k_2 dt} = e^{k_2 t}$

5. If {x} is a continuous, real valued random variable defined over the interval $(-\infty, +\infty)$ and its occurrence is defined by the density function given as: $f(x) = \frac{1}{\sqrt{2\pi * b}} e^{\frac{1}{2}\left(\frac{x-a}{b}\right)^2}$ where 'a' and 'b' are the statistical attributes of the random variable {x}. The value of the integral $\int_{-\infty}^{a} \frac{1}{\sqrt{2\pi * b}} e^{\frac{1}{2}\left(\frac{x-a}{b}\right)^2} dx$ is

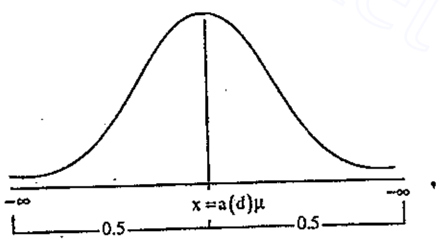
(A) 1 (B) 0.5 (C) π (D) $\frac{\pi}{2}$

Answer: (B)

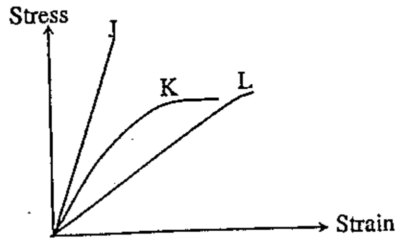
Exp. We have $\int_{-\infty}^{\infty} f(x)\,dx = 1$

$\Rightarrow \int_{-\infty}^{a} f(x)\,dx + \int_{a}^{-\infty} f(x)\,dx = 1$

$\Rightarrow \int_{-\infty}^{a} f(x)\,dx = 0.5$



6. Group I contains representative stress-strain curves as shown in the figure, while Group II gives the list of materials. Match the stress-strain curves with the corresponding materials.

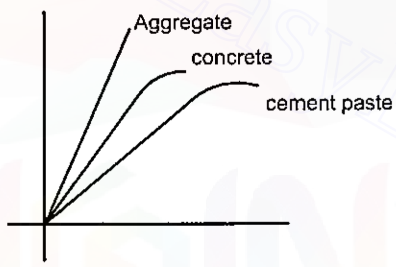


Group I		Group II	
(p)	Curve J	(1)	Cement paste
(q)	Curve K	(2)	Coarse aggregate
(r)	Curve L	(3)	Concrete

(A) P - 1; Q - 3; R - 2
(B) P - 2; Q - 3; R - 1
(C) P - 3; Q - 1; R - 2
(D) P - 3; Q - 2; R – 1

Answer: (B)

Exp.



So, P = 2,
Q = 3,
R = 1

7. The first moment of area about the axis of bending for a beam cross-section is
(A) moment of inertia
(B) section modulus
(C) shape factor
(D) polar moment of inertia

Answer: (B)

Exp. ∵ Section modulus, $z = \frac{I}{r} = \frac{A.r^2}{r}$ = A.r, i.e. Moment of Area

8. Polar moment of inertia (I_p), in cm4, of a rectangular section having width, b = 2 cm and depth, d = 6 cm is ________________

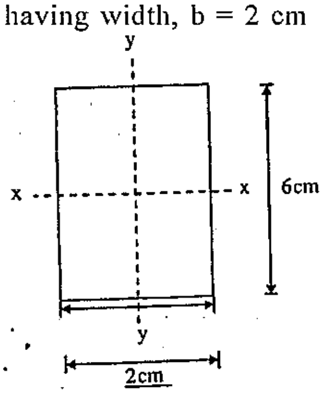
Answer: 40.00 to 40.00

Exp. $I_p = I_{xx} + I_{yy}$

$$= \frac{2 \times (6)^3}{12} + \frac{6(2)^3}{12}$$

$= 40\ cm^4$

M.I. about axis perpendicular to the plane is called polar M.I.



9. The target mean strength f_{cm} for concrete mix design obtained from the characteristic strength f_{ck} and standard deviation s, as defined in IS:456-2000, is

(A) $f_{ck} + 1.35\sigma$ (B) $f_{ck} + 1.45\sigma$ (C) $f_{ck} + 1.55\sigma$ (D) $f_{ck} + 1.65\sigma$

Answer: (D)

Exp. $f_m = f_{ck} + 1.65\sigma$ As per IS: 456.2000

10. The flexural tensile strength of M25 grade of concrete, in N/mm^2, as per IS:456-2000 is __________

Answer: 3.5 to 3.5

Exp. Flexural tensile strength, $f_{cr} = 0.7\sqrt{f_{ck}}$ N/mm^2 | IS : 456 - 2000 P.16

$= 0.7 \times \sqrt{25}$

$= 3.5 \text{N} / \text{mm}^2$

11. The modulus of elasticity, $_{ck}$ E = 5000 f where f_{ck} is the characteristic compressive strength of concrete, specified in IS:456-2000 is based on

(A) tangent modulus
(B) initial tangent modulus
(C) secant modulus
(D) chord modulus

Answer: (B)

12. The static indeterminacy of the two-span continuous beam with an internal hinge, shown below, is __________

Answer: 0 to 0

Exp. $D_{se} = R - r$

$= 4 - 4 = 0$

one extra condition is provided by internal hinge.

13. As per Indian Standard Soil Classification System (IS: 1498 - 1970), an expression for A-line is

(A) $I_p = 0.73\ (w_L - 20)$
(B) $I_p = 0.70\ (w_L - 20)$
(C) $I_p = 0.73\ (w_L - 10)$
(D) $I_p = 0.70\ (w_L - 10)$

Answer: (A)

Exp. $I_p = 0.73\ (W_L - 20)$

14. The clay mineral primarily governing the swelling behavior of Black Cotton soil is

(A) Halloysite (B) I llite (C) Kaolinite (D) Montmorillonite

Answer: (D)

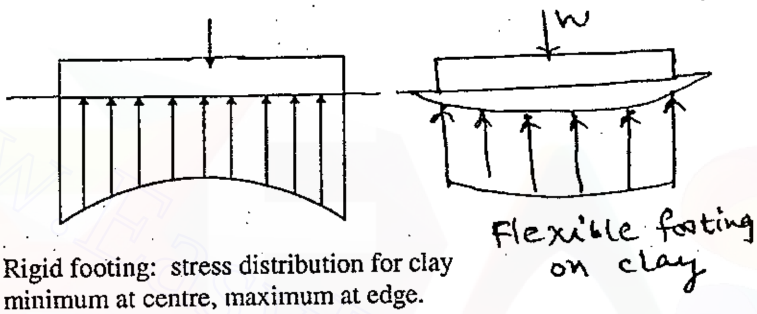
15. The contact pressure for a rigid footing resting on clay at the centre and the edges are respectively

(A) maximum and zero (B) maximum and minimum

(C) zero and maximum (D) minimum and maximum

Answer: (D)

Exp.



Rigid footing: stress distribution for clay minimum at centre, maximum at edge.

$G_s = 2.71$, $n = 40\% = 0.40$,

$W = 20\%$, $S = ?$

16. A certain soil has the following properties: Gs = 2.71, n = 40% and w = 20%. The degree of saturation of the soil (rounded off to the nearest percent) is ________

Answer: 81.0 to 81.5

Exp. $G_s = 2.71$, $n = 40\% = 0.40$,

$w = 20\%$, S ?

$$e = \frac{n}{1-n} = \frac{0.4}{0.6} = 0.67$$

$$S = \frac{wG}{e} = \frac{0.20 \times 2.71}{0.67} = 0.808 = 81\%$$

17. A plane flow has velocity components $u = \frac{x}{T_1}, v = -\frac{y}{T_2}$ and w = 0 and x, y and z directions respectively, where T_1 ($\neq 0$) and T_2 ($\neq 0$) are constants having the dimensions of time. The given flow is incompressible if

(A) $T_1 = -T_2$ (B) $T_1 = -\frac{T_2}{2}$ (C) $T_1 = \frac{T_2}{2}$ (D) $T_1 = T_2$

Answer: (D)

Exp. $U = \frac{x}{T_1}$, $V = \frac{-y}{T_2}$, $w = 0$

For incompressible flow

$$\frac{2v}{2x} + \frac{2v}{2y} + \frac{2w}{2z} = 0$$

$$\Rightarrow \frac{1}{T_1} - \frac{1}{T_2} = 0 \quad \Rightarrow T_1 = T_2$$

18. Group I lists a few devices while Group II provides information about their uses. Match the devices with their corresponding use.

Group I	Group II
(p) Anemometer	(1) Capillary potential of soil water
(q) Hygrometer	(2) Fluid velocity at a specific point in the flow stream
(r) Pitot Tube	(3) Water vapour content of air
(s) Tensiometer	(4) Wind speed

(A) P - 1; Q -2; R - 3; S - 4 (B) P - 2; Q - 1; R - 4; S- 3
(C) P - 4; Q - 2; R - 1; S - 3 (D) P - 4; Q - 3; R - 2; S – 1

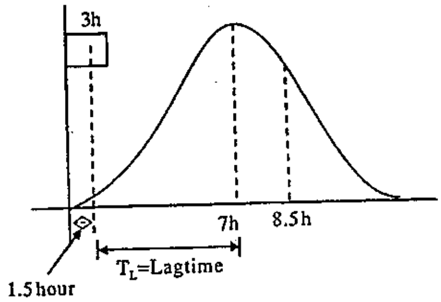
Answer: (D)

Exp. Aneometer → wind speed
Hygrometer → water vapour content of air
Pilot tube → flow velocity at a specific point in the flow stream
Tensionmeter → Capillary potential of soil water

19. An isolated 3-h rainfall event on a small catchment produces a hydrograph peak and point of inflection on the falling limb of the hydrograph at 7 hours and 8.5 hours respectively, after the start of the rainfall. Assuming, no losses and no base flow contribution, the time of concentration (in hours) for this catchment is approximately
(A) 8.5 (B) 7.0 (C) 6.5 (D) 5.5

Answer: (D)

Exp.



For small catchment, time of concentration is equal to lag time of peak flow.
T_c =7 – 1.5 = 5.5h

20. The Muskingum model of routing a flood through a stream reach is expressed as $O_2 = K_0 I_2 + K_1 I_1 + K_2 O_1$, where K_0, K_1 and K_2 are the routing coefficients for the concerned reach, I_1 and I_2 are the inflows to reach, and O_1 and O_2 are the are the outflows from the reach corresponding to time steps 1 and 2 respectively. The sum of K_0, K_1 and K_2 of the model is

(A) -1 (B) -0.5 (C) 0.5 (D) 1

Answer: (D)

Exp. $K_0 + K_1 + K_2 = 1$

1.5 hour

21. The dominating microorganisms in an activated sludge process reactor are

(A) aerobic heterotrophs (B) anaerobic heterotrophs

(C) autotrophs (D) phototrophs

Answer: (A)

22. The two air pollution control devices that are usually used to remove very fine particles from the flue gas are

(A) Cyclone and Venturi Scrubber (B) Cyclone and Packed Scrubber

(C) Electrostatic Precipitator and Fabric Filter (D) Settling Chamber and Tray Scrubber

Answer: (C)

23. The average spacing between vehicles in a traffic stream is 50 m, then the density (in veh/km) of the stream is__________

Answer: 20.0 to 20.0

Exp. Density, $K = \frac{1000}{s} = \frac{1000}{50} = 20 \text{ veh/km}$

24. A road is being designed for a speed of 110 km/hr on a horizontal curve with a super elevation of 8%. If the coefficient of side friction is 0.10, the minimum radius of the curve (in m) required for safe vehicular movement is

(A) 115.0 (B) 152.3 (C) 264.3 (D) 528.5

Answer: (D)

Exp. Ruling gradient $= \frac{V^2}{127(e+f)}$

$$= \frac{110 \times 110}{127(0.08 + 0.10)} = 529.30 \text{ m}$$

25. The survey carried out to delineate natural features, such as hills, rivers, forests and manmade features, such as towns, villages, buildings, roads, transmission lines and canals is classified as

(A) engineering survey (B) geological survey

(C) land survey (D) topographic survey

Answer: (D)

Exp. Topographic survey is carried out to delineate natural features.

Q. No. 26-55 carry Two Marks

26. The expression $\lim_{\alpha \to 0} \frac{x^{\alpha} - 1}{\alpha}$ is equal to

(A) log x (B) 0 (C) x log x (D) ∞

Answer: (A)

Exp. By L' Hospital rule,

$$L = \frac{\frac{d}{da}\left(x^{\alpha-1}\right)}{\frac{d}{d\alpha}(\alpha)}$$

$$= \lim_{\alpha \to 0} \frac{x^{\alpha} . \log x}{1} = \log x$$

27. An observer counts 240 veh/h at a specific highway location. Assume that the vehicle arrival at the location is Poisson distributed, the probability of having one vehicle arriving over a 30- second time interval is__________

Answer: 0.25 to 0.28

Exp. Average no. of vehicles per hour,

$\lambda = 240$ / hour

$= \frac{240}{60}$ / min

= 4 / min 2 / 30sec

$P(x = 1) = \frac{e^{-2} . 2^{1}}{1!}$ 0.27

28. The rank of matrix $\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 8 \\ 14 & -14 & 0 & -10 \end{bmatrix}$ is ______

Answer: 2.0 to 2.0

Exp. $\begin{bmatrix} 6 & 0 & 4 & 4 \\ -2 & 14 & 8 & 8 \\ 14 & -14 & 0 & -10 \end{bmatrix}$ $R2 \rightarrow 3R_2 + R_1$; $R_3 \rightarrow 6R_3 - 14R_1$

$$\sim \begin{bmatrix} 6 & 0 & 4 & 4 \\ 0 & 42 & 28 & 58 \\ 0 & -84 & -56 & 0 \end{bmatrix} R_3 \rightarrow R_3 + 2R_2$$

$$\sim \begin{bmatrix} 6 & 0 & 4 & 4 \\ 0 & 42 & 28 & 58 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

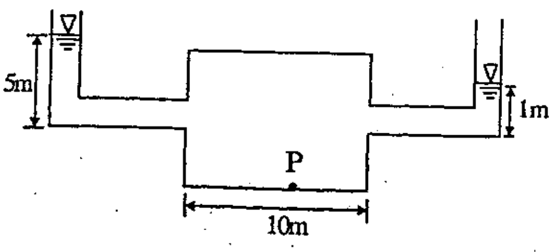
$\rightarrow$ Rank = No. of non-zero rows = 2

29. Water is flowing at a steady rate through a homogeneous and saturated horizontal soil strip of 10 m length. The strip is being subjected to a constant water head (*H*) of 5 m at the beginning and 1 m at the end. If the governing equation of flow in the soil strip is $\frac{d^2H}{dx^2} = 0$ = (where *x* is the distance along the soil strip), the value of *H* (in m) at the middle of the strip is ______

Answer: 3.0 to 3.0

Exp. $\frac{d^2H}{dx^2} = 0$

$\Rightarrow \frac{dH}{dX} = K \Rightarrow H = Kx + C$



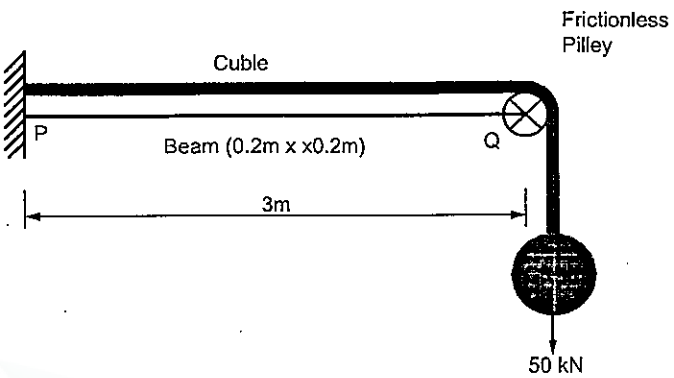
at x = 0, H = 5 $\Rightarrow$ C = 5

at x = 10, H = 1 $\Rightarrow$ K = – 0.4

so, H = – 0.4x + 5

At x = 5, H = –.4 × 5 + 5 = 3m

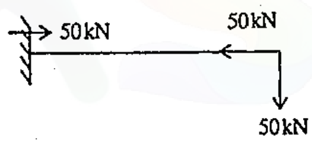
30. The values of axial stress (σ) in kN/m^2, bending moment (M) in kNm, and shear force (V) in kN acting at point P for the arrangement shown in the figure are respectively



(A) 1000, 75 and 25
(B) 1250, 150 and 50
(C) 1500, 225 and 75
(D) 1750, 300 and 100

Answer: (B)

Exp. Loading after removing of cable

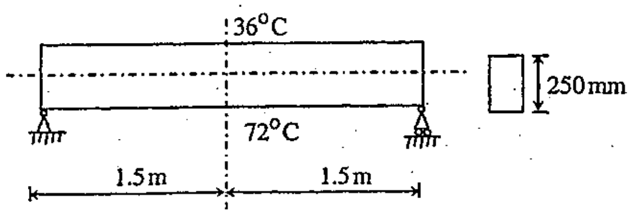


$$\text{Axial stress} = \frac{50}{0.2 \times 0.2} = 1250 \text{ kN/m}^2$$

B.M. = 50 ×3 = 150 kNm

S.F = 50kN

31. The beam of an overall depth 250 mm (shown below) is used in a building subjected to two different thermal environments. The temperatures at the top and bottom surfaces of the beam are 36°C and 72°C respectively. Considering coefficient of thermal expansion (α) as 1.50×10^{-5} per °C, the vertical deflection of the beam (in mm) at its mid-span due to temperature gradient is ________

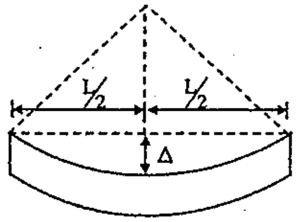


Answer: 2.38 to 2.45

Exp. From properties of circle,

$$(2R - \Delta)\ .\ \Delta = \frac{L}{2} \times \frac{L}{2}$$

$\because$ Δ is very small, neglect Δ^2



$$2R.\Delta = \frac{L^2}{4}$$

$$\Rightarrow \Delta = \frac{L^2}{8R} \qquad \text{But } R = \frac{h}{\alpha T}$$

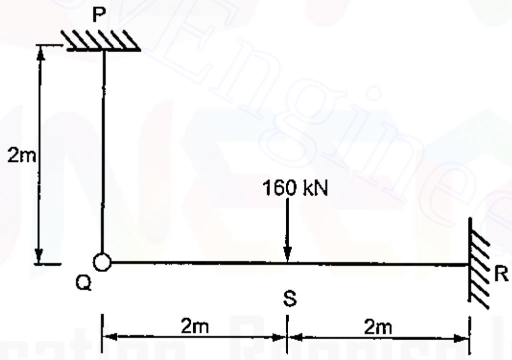
$$= \frac{L_2}{8.h}.\alpha T$$

Here, L = 3m, $\alpha = 1.50 \times 10^{-5}$ / °C,

T = 72° – 36° = 36° C

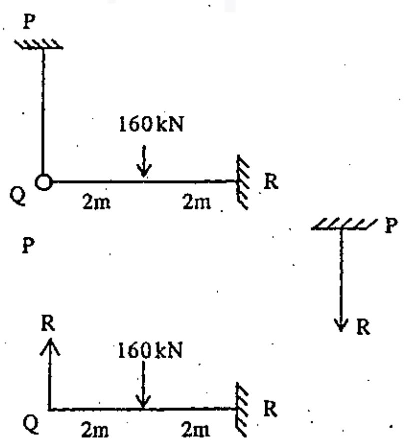
$$\Delta = \frac{(3)^2 \times 1.5 \times 10^{-5} \times 36}{8 \times 0.250} = 0.00243\text{m } 2.43\text{mm}$$

32. The axial load (in kN) in the member PQ for the arrangement/assembly shown in the figure given below is ____________



Answer: 50.0 to 50.0

Exp.



Taking PQ to be rigid; so, $\Delta_Q = 0$

$$\Rightarrow = \frac{R(4)^3}{3EI} = \frac{160(2)^3}{3EI} + \frac{160(2)^2}{2EI} \times 2$$

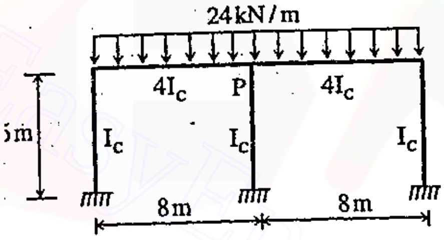
def. at φ due to R = def. at φ due to 160 kN

$\Rightarrow$ 64R = 160 × 8 + 160 × 4 × 3

$\Rightarrow$ R = 50kN

So, Tension in PQ = 50 kN

33 Considering the symmetry of a rigid frame as shown below, the magnitude of the bending moment (in kNm) at P (preferably using the moment distribution method) is

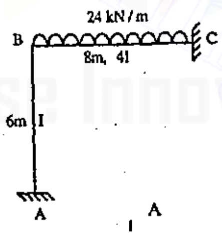


(A) 170 (B) 172 (C) 176(D) 178

Answer: (C)

Exp. Axis of symmetry is passing through a column; hence it can be treated as

Member	Stiffness	D.F
BA	$\frac{4EI}{6}$	$\frac{1}{4}$
BC	$\frac{4E(4I)}{8}$	$\frac{3}{4}$

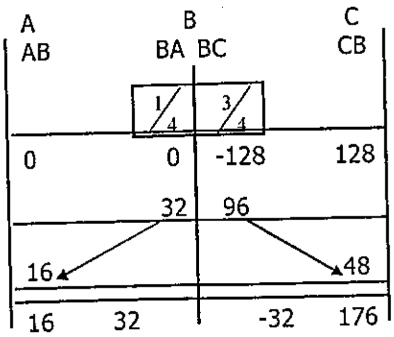


FE11:

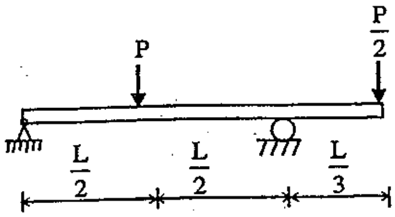
$$M_{BC} = \frac{-WL^2}{12} = \frac{-24 \times 8 \times 8}{12} = -128\text{kNM}$$

M_{CB} = + 128 kNM

B.M. at C = 176 kN.m



34. A prismatic beam (as shown below) has plastic moment capacity of *Mp*, then the collapse load *P* of the beam is



(A) $\frac{2M_p}{L}$ (B) $\frac{4M_p}{L}$ (C) $\frac{6M_p}{L}$ (D) $\frac{8M_p}{L}$

Answer: (C)

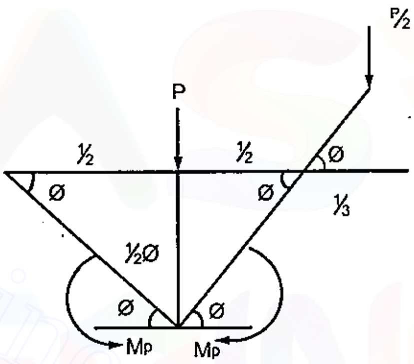
Exp. Degree of static indeterminacy $D_s = 0$

Number of plastic hinges = $D_s + 1 = 1$

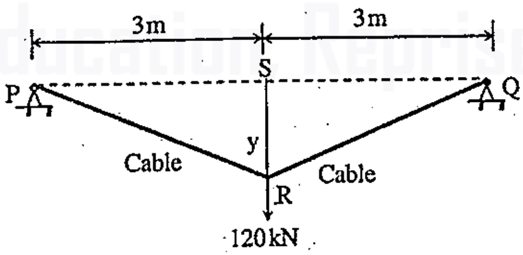
From principal of virtual work

$$Mp.\theta + Mp.\theta = P = \left(\frac{L}{2}\theta\right) - \frac{P}{2}.\left(\frac{L}{3}.\theta\right) = 0$$

$$\Rightarrow P = \frac{6M_P}{L}$$



35. The tension (in kN) in a 10 m long cable, shown in the figure, neglecting its self-weight is



(A) 120 (B) 75 (C) 60 (D) 45

Answer: (B)

Exp. Taking moment about Q = 0

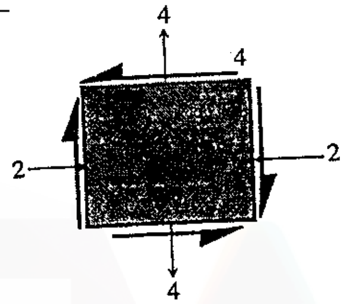
$R \times 6 - 120 \times 3 = 0 \Rightarrow R_A = 60kN$

Taking moment about R = 0

$$R \times 3 - H \times 4 = 0 \Rightarrow H = \frac{3}{4} \times 60 = 45kN$$

$$T = \sqrt{R^2 + H^2} = \sqrt{(60)^2 + (45)^2} = 75kN$$

36. For the state of stresses (in MPa) shown in the figure below, the maximum shear stress (in MPa) is ____________



Answer: 5.0 to 5.0

Exp. $\sigma_x = -2,\ \sigma_y = 4,\ \tau = 4$

Max shear stress, $t_{max} = \dfrac{\sigma_1 - \sigma_2}{2}$

Where, $\sigma_1 = \dfrac{\sigma_x - \sigma_y}{2} + \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$

$$= \frac{-2+4}{2} + \sqrt{\left(\frac{-2-4}{2}\right)^2} + (4)^2 = 1 + 5 = 6\ \text{MPa}$$

$$\sigma_1 = \frac{\sigma_x - \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2} + \tau_2 = 1 - 5 = -4\ \text{MPa}$$

So, $\tau_{max} = \dfrac{6-(-4)}{2}$ 5 MPa

37. An infinitely long slope is made up of a c- φ soil having the properties: cohesion (c) = 20 kPa, and dry unit weight (γ_d) = 16kN/m^3. The angle of inclination and critical height of the slope are 40° and 5 m, respectively. To maintain the limiting equilibrium, the angle of internal friction of the soil (in degrees) is ____________

Answer: 21.0 to 23.0

Exp. Given, C = 20KPa, $\gamma d = 16\ kN/m^3$

$\beta = 40°$, H = 5m, ϕ = ?

$$H = \frac{C}{\gamma_d (\tan\beta - \tan\phi)\cos^2\beta}$$

$$\Rightarrow 5 = \frac{20}{16\left(\tan 40° - \tan \phi\right).\cos^2 40°}$$

$$\Rightarrow \phi = 22.44°$$

38. Group I enlists in-situ field tests carried out for soil exploration, while Group II provides a list of parameters for sub-soil strength characterization. Match the type of tests with the characterization parameters

Group I	Group II
(P) Pressuremeter Test (PMT)	(1) Menard's modulus (E_m)
(Q) Static Cone Penetration Test (SCPT)	(2) Number of blows (N)
(R) Standard Penetration Test (SPT)	(3) Skin resistance (f_c)
(S) Vane Shear Test (VST)	(4) Undrained cohesion (c_x)

(A) P - 1; Q - 3; R - 2; S - 4 (B) P - 1; Q - 2; R - 3; S - 4

(C) P - 2; Q - 3; R - 4; S - 1 (D) P - 4; Q - 1; R - 2; S – 3

Answer: (A)

39. A single vertical friction pile of diameter 500 mm and length 20 m is subjected to a vertical compressive load. The pile is embedded in a homogeneous sandy stratum where: angle of internal friction (*f*d) = 30°, dry unit weight (*f*d) = 20 kN/m^3 and angle of wall friction (*f*Ñ) = 2*f*Ñ/3. Considering the coefficient of lateral earth pressure (K) = 2.7 and the bearing capacity factor (Nq) = 25, the ultimate bearing capacity of the pile (in kN) is ____________

Answer: 6150 to 6190

Exp. For friction pile

$Q_U = f_s \cdot A_s$

Where, $f_s = \frac{1}{2}\sigma_v . K . \tan\delta$

$\sigma_v = \gamma_d \times L \quad = 20 \times 20 = 400 kN / m^2$

K = 2.7

$\tan \delta = \tan\left(\frac{2}{3}\phi\right) = \tan\left(\frac{2}{3}\times 30\right) = 30\ 0.364$

So, $f_s = \frac{1}{2} \times 400 \times 2.7 \times 0.364 = 196.56\ kN / m^2$

So, $Q_u = (196.56) \times \pi D.L = 196.56 \times \pi \times 0.5 \times 20 = 6175 kN$

40. A circular raft foundation of 20 m diameter and 1.6m thick is provided for a tank that applies a bearing pressure of 110 kPa on sandy soil with Young's modulus, E,' = 30 MPa and Poisson's ration, υ_s = 0.3. The raft is made of concrete E_c = 30 GPa and υ_c = 0.15. Considering the raft as rigid, the elastic settlement (in mm) is
(A) 50.96 (B) 53.36 (C) 63.72 (D) 66.71

Answer: (B)

Exp. Elastic settlement of rigid footing

$$S = 0.8\left[\frac{qB\left(1-\mu^2\right)}{E}\right]$$

Given, $q = 110 kN/m^2$, B = 20m, $\mu = 0.30$

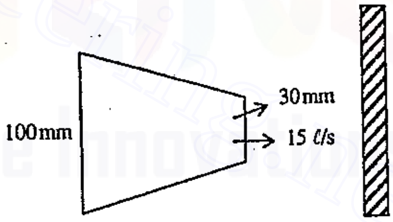
$E_s = 30GPa = 30 \times 10^3\ kN/m^2$

$$S = 0.8\left[\frac{110\times 20\times(1-0.09)}{30\times 10^3}\right] = 53.38\ mm$$

41. A horizontal nozzle of 30 mm diameter discharges a steady jet of water into the atmosphere at a rate of 15 litres per second. The diameter of inlet to the nozzle is 100 mm. The jet impinges normal to a flat stationary plate held close to the nozzle end. Neglecting air friction and considering the density of water as 1000 kg/m³, the force exerted by the jet (in N) on the plate is ______

Answer: 318 to 319

Exp. Velocity of jet, $v = \frac{Q}{A} = \frac{15\times 10^{-3}\ m^3/s}{\frac{\pi}{4}\times(0.03)^2} = 21.22 m/s$



Force on plate, $F = \rho a.v^2$

$= 1000 \times \frac{\pi}{4} \times (0.03)^2 \times (21.22)^2$

$= 318.29N$

42. A venturimeter having a throat diameter of 0.1 m is used to estimate the flow rate of a horizontal pipe having a diameter of 0.2 m. For an observed pressure difference of 2 m of water head and coefficient of discharge equal to unity, assuming that the energy losses are negligible, the flow rate (in m³/s) through the pipe is approximately equal to
(A) 0.500 (B) 0.150 (C) 0.050 (D) 0.015

Answer: (C)

Exp. $$Q = C_d \cdot \frac{a_1 \times a_2}{\sqrt{a_1^2 - a_2^2}} \cdot \sqrt{2gh}$$

$$a_1 = \frac{\pi}{4}\times(0.2)^2 = 0.0314\,m^2$$

$$a_2 = \frac{\pi}{4}\times(0.1)^2 = 0.0078\,m^2$$

$$\text{so, } Q = \frac{1\times 0.0314\times 0.0078}{\sqrt{(0.314)^2-(0.0078)^2}}\times\sqrt{2\times 9.81\times 2} = 0.050\,m^3/s$$

43. A rectangular channel of 2.5 m width is carrying a discharge of 4 m3/s. Considering that acceleration due to gravity as 9.81 m/s^2, the velocity of flow (in m/s) corresponding to the critical depth (at which the specific energy is minimum) is _______

Answer: 2.45 to 2.55

Exp. B =2.5m, Q = 4m^3 / s , g = 9.81/ s^2

$$\text{Critical depth, } y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$\text{So, } y_c = \left[\frac{(1.6)^2}{9.81}\right]^{1/3} = 0.64m$$

Now, $Q = A.v_c$

$$\Rightarrow v_c = \frac{Q}{B.y_c} = \frac{4}{2.5\times 0.64} = 2.5m/s$$

44. Irrigation water is to be provided to a crop in a field to bring the moisture content of the soil from the existing 18% to the field capacity of the soil at 28%. The effective root zone of the crop is 70 cm. If the densities of the soil and water are 1.3 g/cm^3 and 1.0 g/cm^3 respectively, the depth of irrigation water (in mm) required for irrigating the crop is ________

Answer: 91 to 91

Exp. Depth of irrigation water

$$d = \frac{\gamma_d}{\gamma_w} d\,(F.C - W.P)$$

$$= \frac{1.3}{1}\times 70\times(0.28-0.18)$$

$$= 9.1cm \Rightarrow 91mm$$

45. With reference to a standard Cartesian (x, y) plane, the parabolic velocity distribution profile of fully developed laminar flow in x-direction between two parallel, stationary and identical plates that are separated by distance, h, is given by the expression

$$u = -\frac{h^2}{8\mu}\frac{dp}{dx}\left[1-4\left(\frac{y}{h}\right)^2\right]$$

In this equation, the y = 0 axis lies equidistant between the plates at a distance h/2 from the two plates, p is the pressure variable and μ is the dynamic viscosity term. The maximum and average velocities are, respectively

(A) $u_{max} = -\frac{h^2}{8\mu}\frac{dp}{dx}$ and $u_{average} = \frac{2}{3}u_{max}$ (B) $u_{max} = \frac{h^2}{8\mu}\frac{dp}{dx}$ and $u_{average} = \frac{2}{3}u_{max}$

(C) $u_{max} = -\frac{h^2}{8\mu}\frac{dp}{dx}$ and $u_{average} = \frac{3}{8}u_{max}$ (D) $u_{max} = \frac{h^2}{8\mu}\frac{dp}{dx}$ and $u_{average} = \frac{3}{8}u_{max}$

Answer: (A)

Exp. $U = \frac{h^2}{8\mu}\left(\frac{dp}{dx}\right)\left[1 - 4\left(\frac{y}{h}\right)^2\right]$

Maximum velocity is at y = 0

$$U_{max} = \frac{-h^2}{8\mu}\left(\frac{dp}{dx}\right)$$

$$U_{avg} = \frac{Q}{A} = \frac{\int U.dA}{A} = \frac{\int U_{max}\left(1 - \frac{4y^2}{h^2}\right).dA}{A}$$

$$= \frac{2\int_0^{h/2} U_{max}\left(1 - \frac{4y^2}{h^2}\right).dy \times 1}{h \times 1} = \frac{2U_{max}}{h}\left[y - \frac{4y^3}{3h^2}\right]_0^{h/2}$$

$$= \frac{2U_{max}}{h}\left[\frac{h}{2} - \frac{4h^3}{24h^2}\right] = \frac{2}{3}U_{max}$$

46. A suspension of sand like particles in water with particles of diameter 0.10 mm and below is flowing into a settling tank at 0.10 m^3/s. Assume g = 9.81 m/s^2, specific gravity of particles = 2.65, and kinematic viscosity of water =1.0105×10-2 cm^2/s. The minimum surface area (in m^2) required for this settling tank to remove particles of size 0.06 mm and above with 100% efficiency is ____________

Answer: 31.0 to 32.0

Exp. Particle size = 0.06m < 0.1 mm

So, Stoke's law is valid

$\frac{Q}{A}$ = overflow rate ≤ settling velocity of 0.06mm particle

$$\Rightarrow \frac{Q}{A} \le V_s \Rightarrow A = \frac{Q}{V_s}$$

$$V_s = \frac{1}{18}\cdot\frac{d^2g}{V}(G_s - 1) = \frac{1}{18}\times\frac{(0.06\times10^{-3})^2\times9.81}{1.0105\times10^{-6}}\times(2.65-1) = 3.20\times10^{-3}\text{ m/s}$$

$$\Rightarrow A \geq \frac{0.1}{3.20\times10^{-3}} = 31.21\text{ m}^2$$

47. A surface water treatment plant operates round the clock with a flow rate of 35 m^3/min. The water temperature is 15ƒÑ and jar testing indicated an alum dosage of 25 mg/l with flocculation at a Gt value of 4×10^4 producing optimal results. The alum quantity required for 30 days (in kg) of operation of the plant is ________ .

Answer: 37800 to 37800

Exp. G i v= $35m^3$ / min = 35 × 10^3 × 60 × 24 *l* / day

Alum dosage = 25 mg/l

Alum quantity required for 30 days

= 35 × 10^3 × 60 × 24 × 25 × 10^{-6} × 30 = 37800kg.

48. An effluent at a flow rate of 2670 m^3/d from a sewage treatment plant is to be disinfected. The laboratory data of disinfection studies with a chlorine dosage of 15 mg/l yield the model $N_t = N_0e^{-0.145t}$ where N_t = number of micro-organisms surviving at time t (in min.) and N_O = number of micro-organisms present initially (at t = 0). The volume of disinfection unit (in m^3) required to achieve a 98% kill of micro-organisms is ____________

Answer: 49.0 to 51.0

Exp. Q = 2760 m^3 / day, chlorine dose 15mg / *l*

$N_b = N_0 .e^{-0.145t}$

If 98% micro organisms are killed, 2% are surviving.

So, N_t = 0.02

N_0 = number of microorganisms present at t = 0

ie., 100% = 1

So, 0.02 $e^{-0.145t}$ $\Rightarrow$ t = 26.98min utes

$$V = Q \times t_d = \left(2670\frac{m^3}{d}\right)\times\left(\frac{26.98}{60\times24}\right) = 50.02m^3$$

49. A waste water stream (flow = 2 m^3/s, ultimate BOD = 90 mg/l) is joining a small river (flow = 12 m^3/s, ultimate BOD = 5 mg/l). Both water streams get mixed up instantaneously. Crosssectional area of the river is 50 m^2. Assuming the de-oxygenation rate constant, k' = 0.25/day, the BOD (in mg/l) of the river water, 10 km downstream of the mixing point is

(A) 1.68 (B) 12.63 (C) 15.46 (D) 1.37

Answer: (C)

Exp. $Q_s = 2m^3 / s$, BOD ultimate, $L_s = 90mg / l$

$Q_s = 12m^3 / s$, $L_R = 5mg / l$

$$(BOD)_{mix} = \frac{90 \times 2 + 12 \times 5}{2+12} = 17.14mg / l$$

Velocity of River flow, $V_R = \frac{Q}{A} = \frac{12+2}{50} = 0.28\, m/s$

Time taken to travel 10km $= = \frac{1000}{0.28} = 35714.28s = 0.41d$

$L_t = L_0 \times e^{-kt} = 17.14 \times e^{-0.25 \times 0.41} = 15.46\ mg / l$

50. In a Marshall sample, the bulk specific gravity of mix and aggregates are 2.324 and 2.546 respectively. The sample includes 5% of bitumen (by total weight of mix) of specific gravity 1.10. The theoretical maximum specific gravity of mix is 2.441. The void filled with bitumen (VFB) in the Marshall sample (in %) is ______

Answer: 62 to 66

Exp. $VFB = \frac{V_h}{V_{MA}} \times 100$

Where, V_b = voids filled with bitumen = $\frac{G_m}{G_4} \times W_4 = \frac{2.324}{1.10} \times 5 = 10.564$

$V_{MA} = V_v + V_b$

Vv = Volume of voids = $\frac{G_t - G_m}{G_t} \times 100 = \frac{2.441 - 2.324}{2.441} \times 100$ 4.79%

$V_{MA} = 10.56 + 4.79 = 15.35$

So, $V_{FB} = \frac{10.564}{15.35} \times 100 = 68.82\%$

51. A student riding a bicycle on a 5 km one-way street takes 40 minutes to reach home. The student stopped for 15 minutes during this ride. 60 vehicles overtook the student (assume the number of vehicles overtaken by the student is zero) during the ride and 45 vehicles while the student stopped. The speed of vehicle stream on that road (in km/hr) is

(A) 7.5 (B) 12 (C) 40 (D) 60

Answer: (D)

52. On a section of a highway the speed-density relationship is linear and is given by $v = \left[80 - \frac{2}{3}k\right]$; where v is in km/h and k is in veh/km. The capacity (in veh/h) of this section of the highway would be

(A) 1200 (B) 2400 (C) 4800 (D) 9600

Answer: (B)

Exp. $V = 80 - \frac{2}{3}k$

Capacity $= \frac{V_f \times k_j}{4}$, where V_f = free mean velocity

K_j is when, V = 0 K_j = Jam density

$K_j = 80 \times \frac{3}{2} = 120 \text{veh / km}$

V_f is at K = 0, V_f = 80 km/h

So, Capacity $= \frac{80 \times 120}{4} = 2400$ veh / h

53. A pre-timed four phase signal has critical lane flow rate for the first three phases as 200, 187 and 210 veh/hr with saturation flow rate of 1800 veh/hr/lane for all phases. The lost time is given as 4 seconds for each phase. If the cycle length is 60 seconds, the effective green time (in seconds) of the fourth phase is ____________

Answer: 14.0 to 18.0

Exp. Total time lost,t = 4 × = 16s; $C = \frac{1.5L + 5}{1 - y}$

$Y = y_1 + y_2 + y_3 + y_4$

$= \frac{q_1}{s_1} + \frac{q_2}{s_2} + \frac{q_3}{s_3} + \frac{q_4}{s_4}$

$= \frac{200}{1800} + \frac{187}{1800} + \frac{210}{1800} + y_4 = 0.332 + y_4$

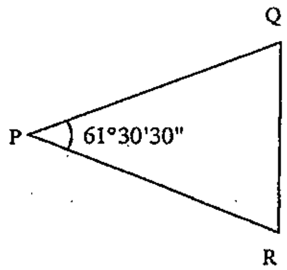
$60 = \frac{1.5 \times + 5}{1 - (0.332 + y_4)} \Rightarrow .668 - y_4 = \frac{29}{60} \Rightarrow y_4 = 0.185$

Effective green time for 4th phase

$= \frac{(Co - L) \times y_4}{y_1 + y_2 + y_3 + y_4} = \frac{(60 - 16) \times 0.185}{0.332 + 0.185} = 15.74s$

54. A tacheometer was placed at point P to estimate the horizontal distances PQ and PR. The corresponding stadia intercepts with the telescope kept horizontal, are 0.320 m and 0.210 m, respectively. The ∠QPR is measured to be 61° 30' 30". If the stadia multiplication constant = 100 and stadia addition constant = 0.10 m, the horizontal distance (in m) between the points Q and R is ______________

Answer: 28.0 to 29.0



Exp. Tacheometric equation,

$D = kS + C$

$D_{PQ} = 100 \times 0.32 + 0.10 = 32.1\text{m}$

$D_{PR} = 100 \times 0.210 + 0.10 = 21.1\text{m}$

From Cosine rule in triangle PQR

$QR^2 = (PQ)^2 + (PR)^2 - 2\,(PQ)\,(PR)\cos 61°\,30'30''$

$= (32.1)^2 + (21.1)^2 - 2 \times 32.1 \times 21.1 \cos 61°\,30'30''\ 28.8\text{m}$

55. The chainage of the intersection point of two straights is 1585.60 m and the angle of intersection is 140o. If the radius of a circular curve is 600.00 m, the tangent distance (in m) and length of the curve (in m), respectively are

(A) 418.88 and 1466.08
(B) 218.38 and 1648.49
(C) 218.38 and 418.88
(D) 418.88 and 218.38

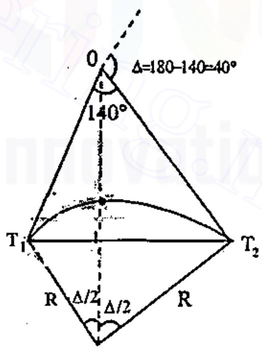
Answer: (C)

Exp. Length of curve, $L = \frac{\pi}{180} \times \Delta \times R$

$= \frac{\pi}{180} \times 40 \times 600 = 418.88\text{m}$

Tangent distance, $T = R\tan(\Delta/2)$

$= 600\tan\left(\frac{40}{2}\right) = 218.38\text{m}$



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Gate -2015, Paper-1

GATE 2015 –CE ON 8TH FEBRUARY, 2015 – (FORENOON SESSION)

GENERAL APTITUDE QUESTIONS

Q. No. 1-5 carry one Mark Each

1. Select the pair that best expresses a relationship similar to that expressed in the pair: Children: Pediatrician

(A) Adult: Orthopaedist (B) Females: Gynaecologist

(C) Kidney: Nephrologist (D) Skin: Dermatologist

Answer: (B)

Exp: Community of people: Doctor

2. Extreme focus on syllabus and studying for test has become such a dominant concern of Indian students that this has closed their minds to anything ________ to the requirements of the exam

(A) related (B) extraneous (C) outside (D) useful

Answer: (B)

Exp: extraneous -irrelevant or unrelated to the subject being dealt with.

3. If ROAD is written as URDG, then SWAN should be written as:

(A) VXDQ (B) VZDQ (C) VZDP (D) UXDQ

Answer: (B)

Exp: R + 3 = U, O + 3 = R, A + 3 = D, D + 3 = G;

S + 3 = V, W + 3 = Z, A + 3 = D, N + 3 = Q

4. The Tamil version of __________ John Abraham-starrer Madras Café _____ cleared by the censor board with no cuts last week, but the film's distributors _______ no takers among the exhibitors for a release in Tamil Nadu ________ this Friday.

(A) Mr., was, found, on (B) a, was found, at

(C) the, was, found, on (D) a, being, find, at

Answer: (C)

Exp: John-Abraham starrer Madras Café talks about the movie not the person, so Mr. is ruled out. 'Find no takers' is not the correct phrase. At this Friday is incorrect. So, option C is correct.

5. A function f(x) is linear and has a value of 29 at x = -2 and 39 at x = 3. Find its value at x = 5.

(A) 59 (B) 45 (C) 43 (D) 35

Answer: (C)

Exp: f (x) = 2x + 33

Q. No. 6-10 carry Two Mark Each

6. The head of a newly formed government desires to appoint five of the six selected members P,Q,R,S,T and U to portfolios of Home, Power, Defense, Telecom and Finance. U does not want any portfolio if S gets one of the five. R wants either Home or Finance or no portfolio. Q says that if S gets either Power or Telecom, then she must get the other one. T insists on a portfolio if P gets one.

Which is the valid distribution of portfolio?

(A) P-Home, Q-Power, R-Defense, S-Telecom, T-Finance

(B) R-Home, S-Power, P-Defense, Q-Telecom, T-Finance

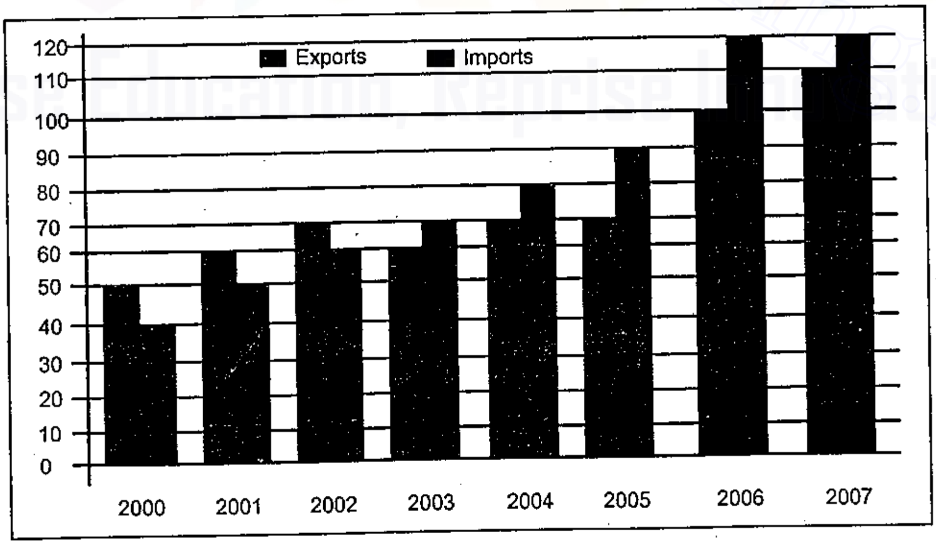
(C) P-Home, Q-Power, T-Defense, S-Telecom, U-Finance

(D) Q-Home, U-Power, T-Defense, R-Telecom, P-Finance

Answer: (B)

Exp: Since U does not want any portfolio, (C) and (D) are ruled out. R wants Home, or Finance or No portfolio, (A) is not valid. Hence option (B) is correct

7. The exports and imports (in crores of Rs.) of a country from the year 2000 to 2007 are given in the following bar chart. In which year is the combined percentage increase in imports and exports the highest?



Answer: 2006

Exp: Increase in exports in 2006 = $\frac{100-70}{70} = 42.8\%$

Increase in imports in 2006 = $\frac{120-90}{90} = 33.3\%$

which is more than any other year

8. Most experts feel that in spite of possessing all the technical skills required to be a batsman of the highest order., he is unlikely to be so due to lack of requisite temperament. He was guilty of throwing away his wicket several times after working hard to lay a strong foundation. His critics pointed out that until he addressed to this problem, success at the highest level will continue to elude him.

Which of the statement (s) below is/are logically valid and can be inferred from the above passage?

(i) He was already a successful batsman at the highest level

(ii) He has to improve his temperament in order to become a great batsman

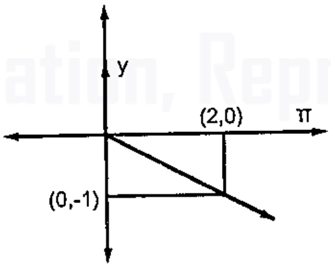
(iii) He failed to make many of his good starts count

(iv) Improving his technical skills will guarantee success

(A) (iii) and (iv) (B) (ii) and (iii) (C) (i), (ii) and (iii) (D) (ii) only

Answer: (B)

9. Choose the most appropriate equation for the function drawn as a thick line, in the plot below.



(A) x = y-|y| (B) x = -(y-|y|) (C) x = y+|y| (D) x = -(y+|y|)

Answer: (B)

10. Alexander turned his attention towards India, since he had conquered Persia.

Which one of the statements below is logically valid and can be inferred from the above sentence?

(A) Alexander would not have turned his attention towards India had he not conquered Persia.

(B) Alexander was not ready to rest on his laurels, and wanted to march to India

(C) Alexander was completely in control of his army and could command it to move towards India.

(D) Since Alexander's kingdom extended to Indian borders after the conquest of Persia, he was keen to move further.

Answer: (A)

Section Name : Civil Engineering

Q.No. 1-25 cary one Mark Each

1. Consider the following statements for air-entrained concrete:

   (i) Air-entrainment reduces the water demand for a given level of workability

   (ii) Use of air-entrained concrete is required in environments where cyclic freezing and thawing is expected.

   Which of the following is TRUE?

   (A) Both (i) and (ii) are True (B) Both (i) and (ii) are False

   (C) (i) is True and (ii) is False (D) (i) is False and (ii) is True

Answer: (A)

2. Which of the following statements is TRUE for the relation between discharge velocity and seepage velocity?

   (A) Seepage velocity is always smaller than discharge velocity

   (B) Seepage velocity can never be smaller than discharge velocity

   (C) Seepage velocity is equal to the discharge velocity

   (D) No relation between seepage velocity and discharge velocity can be established

Answer: (B)

Exp: discharge velocity = $V = \frac{q}{A}$ | A = total area

Seepage velocity = $V_s = \frac{q}{A_v}$ | A_v = void area

since $A_v < A$ $\therefore V_s > V$. | q = discharge per unit time

So, seepage velocity (Vs) can never by smaller than discharge velocity

3. The integral $\int_{x_1}^{x_2} x^2\, dx$ with $x_2 > x_1 > 0$ is evaluated analytically as well as numerically using a single application of the trapezoidal rule. If I is the exact value of the integral obtained analytically and J is the approximate value obtained using the trapezoidal rule, which of the following statements is correct about their relationship?

(A) J > I (B) J < I (C) J = I

(D) Insufficient data to determine the relationship

Answer: (A)

Exp. We know that the approximated value of $\int_a^b f(x)\,dx$ obtained by trapezoidal rule is always greater than the analytical value.

$\therefore J > I$ where J = approximate value

I = analytical value

4. A circular pipe has a diameter of 1m, bed slope of 1 in 1000, and Manning's roughness coefficient equal to 0.01. It may be treated as an open channel flow when it is flowing just full, i.e., the water level just touches the crest. The discharge in this condition is denoted by Q_{full}. Similarly, the discharge when the pipe is flowing half-full, i.e., with a flow depth of 0.5m, is denoted by Q_{half}. The ratio Q_{full}/Q_{half} is:

(A) 1 (B) $\sqrt{2}$ (C) 2 (D) 4

Answer: (C)

For pipe running full, $R = \frac{A}{p} = \frac{\pi}{4}D^2 = \frac{D}{4}$

For pipe running half, $R = A/P = \frac{\pi}{8}D^2/(\pi D/2) = D/4$

Exp: $Q = \frac{1}{n}.AR^{\frac{2}{3}}S^{\frac{1}{2}} \Rightarrow Q_{full} = \frac{1}{n}.\frac{\pi}{4}.D^2.\left(\frac{D^2}{4}\right)^{\frac{2}{3}} S^{\frac{1}{2}}$ ..... Manning's formula

$$Q_{half} = \frac{1}{n}.\frac{\pi D^2}{8}.\left(\frac{D}{4}\right)^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$\frac{Q_{full}}{Q_{half}} = 2$$

5. Which of the following statements is NOT correct?

(A) Loose sand exhibits contractive behavior upon shearing

(B) Dense sand when sheared under undrained condition, may lead to generation of negative pore pressure

(C) Black cotton soil exhibits expansive behavior

(D) Liquefaction is the phenomenon where cohesionless soil near the downstream side of dams or sheet-piles loses its shear strength due to high upward hydraulic gradient

Answer: (D)

Exp: Liquefaction is due to cyclic loads, not due to high hydraulic gradient

Liquefaction is the phenomenon in which loose, saturated, granular soil, under dynamic load loses all its shear strength and behaves like liquid.

The statement (D) indicates boiling of sand (quick sand).

6. A fine-grained soil has 60% (by weight) silt content. The soil behaves as semi-solid when water content is between 15% and 28%. The soil behaves fluid-like when the water content is more than 40%. The 'Activity' of the soil is

(A) 3.33 (B) 0.42 (C) 0.30 (D) 0.20

Answer: (C)

Exp: $I_P = W_L - W_P = 40\ p\ 28 = 12\%$

$$\text{Activity} = \frac{I_P}{F} = \frac{12}{100-60} = 0.3$$

F = clay fraction

= 100 - Silt content

= 100 - 60

7. For steady incompressible flow through a closed-conduit of uniform cross-section, the direction of flow will always be:

(A) from higher to lower elevation (B) from higher to lower pressure

(C) from higher to lower velocity (D) from higher to lower piezometric head

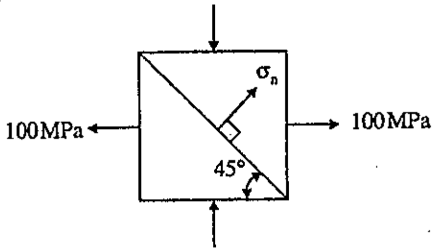
Answer: (B)

8. Two triangular wedges are glued together as shown in the following figure. The stress acting normal to the interface, n is __________ MPa.

Answer: 0

Exp: $\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta$ σ_x = 100 MPa (T)

$= \frac{100 - 100}{2} + \frac{100 - (-100)}{2}\cos(-90°) = 0$ σ_y = – 100 MPa (C) θ = 45° (anticlockwise)



9. In a closed loop traverse of 1 km total length, the closing errors in departure and latitude are 0.3 m and 0.4 m, respectively. The relative precision of this traverse will be;

(A) 1:5000 (B) 1:4000 (C) 1:3000 (D) 1:2000

Answer: (D)

Exp: $e = \sqrt{\ell^2 + d^2} = \sqrt{(0.3)^5 + (0.4)^2} = 0.5 \text{ m}$

Relative precision = $\frac{0.5}{1000}$ = 1:2000

10. Solid waste generated from an industry contains only two components, X and Y as shown in the table below

Component	Composition %weight kg m^3	Density
X	c_1	ρ_1
Y	c_2	ρ_2

Assuming $(c_1 + c_2) = 100$, the composite density of the solid waste (ρ) is given by:

(A) $\frac{100}{\left(\frac{c_1}{\rho_1} + \frac{c_2}{\rho_2}\right)}$ (B) $100\left(\frac{\rho_1}{c_1} + \frac{\rho_2}{c_2}\right)$ (C) $100\,(c_1\rho 1 + c_2\rho_2)$ (D) N77° 50'E

Answer: (A)

Exp: Let density of sludge is ρ

$$\frac{c_1 + c_2}{\rho} = \frac{c_1}{\rho_1} + \frac{c_2}{\rho_2}$$

$$\Rightarrow \rho = \frac{100}{\frac{c_1}{\rho_1} + \frac{c_2}{\rho_2}}$$

11. The two columns below show some parameters and their possible values.

Parameter	Value
P-Gross Command Area	I-100 hectares/cumec
Q-Permanent Wilting Point	II-6 °C
R-Duty of canal water	III-1000 hectares
S-Delta of wheat	IV-1000 cm
	V-40 cm
	VI-0.12

Which of the following options matches the parameters and the values correctly?

(A) P-I, Q-II, R-III, S-IV
(B) P-III, Q-VI, R-I, S-V
(C) P-I, Q-V, R-VI, S-II
(D) P-III, Q-II, R-V, S-IV

Answer: (B)

Exp:

P-Gross Command Area=1000 ha
Q-Permanent Wilting Point=0.12
R-Duty of canal water=100 ha/cumec
S-Delta of wheat=40 cm

12. In an unconsolidated undrained triaxial test, it is observed that an increase in cell pressure from 150 kPa to 250 kPa leads to a pore pressure increase of 80 kPa. It is further observed that, an increase of 50 kPa in deviatoric stress results in an increase of 25 kPa in the pore pressure. The value of Skempton's pore pressure parameter B is;

(A) 0.5
(B) 0.625
(C) 0.8
(D) 1.0

Answer: (C)

Exp: $B = \frac{\Delta U}{\Delta \sigma_3} = \frac{80}{100} = 0.8$

13. Which of the following statements is TRUE for degree of disturbance of collected soil sample?
   (A) Thinner the sampler wall, lower the degree of disturbance of collected soil sample
   (B) Thicker the sampler wall, lower the degree of disturbance of collected soil sample
   (C) Thickness of the sampler wall and the degree of disturbance of collected soil sample are unrelated
   (D) The degree of disturbance of collected soil sample is proportional to the inner diameter of sampling tube

Answer: (A)

Exp: As thickness of sampler increases, disturbance increases

14. Which of the following statements is FALSE?
   (A) Plumb line is along the direction of gravity
   (B) Mean Sea Level (MSL) is used as a reference surface for establishing the horizontal control
   (C) Mean Sea Level (MSL) is a simplification of the Geoid
   (D) Geoid is an equi-potential surface of gravity

Answer: (B)

Exp: Mean Sea Level (MSL) is used as a reference surface for establishing the vertical control and not horizontal control

15. For what value of p the following set of equations will have no solution?

$2x + 3y = 5$

$3x + py = 10$

Answer: 4.5

Exp: Given $2x + 3y = 5$

$3x + py = 10$

$$\Rightarrow \begin{bmatrix} 2 & 3 \\ 3 & p \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 5 \\ 10 \end{bmatrix}$$

$AX = B$

$$\text{Augmented matrix } [A / B] = \begin{bmatrix} 2 & 3 & 5 \\ 3 & P & 10 \end{bmatrix}$$

$R_2 \rightarrow 2R_2 - 3R_1 \begin{bmatrix} 2 & 3 & 5 \\ 0 & 2p-9 & 5 \end{bmatrix}$

system will have no solution if $\rho(A / B) \neq \rho(A)$

$\Rightarrow 2p - 9 = 0$

$\Rightarrow p = \frac{9}{2} = 4.5$

16. In a two-dimensional steady flow field, in a certain region of the x-y plane, the velocity component in the x-direction is given by $v_x = x^2$ and the density varies as $\rho = \frac{1}{x}$. Which of the following is a valid expression for the velocity component in the y-direction, v_y?

(A) $v_y = -x / y$ (B) $v_y = x / y$ (C) $v_y = -xy$ (D) $v_y = xy$

Answer: (C)

Exp: Continuity equation

$$\frac{\partial}{\partial x}(\rho Y) + \frac{\partial}{\partial y}(\rho V) = 0$$

$$\Rightarrow \frac{\partial}{\partial x}(x) + \frac{\partial}{\partial y}\left(\frac{1}{x}.V\right) = 0$$

$$\Rightarrow 1 + \frac{\partial}{\partial y}\left(\frac{V}{x}\right) = 0 \Rightarrow \frac{\partial}{\partial y}\left(\frac{V}{x}\right) = -1$$

$$\Rightarrow V = -xy$$

17. Workability of concrete can be measured using slump, compaction factor and Vebe time. Consider the following statements for workability of concrete:

(i) As the slump increases, the Vebe time increases

(ii) As the slum increases, the compaction factor increases

Which of the following is TRUE?

(A) Both (i) and (ii) are True (B) Both (i) and (ii) are False

(C) (i) is True and (ii) is False (D) (i) is False and (ii) is True

Answer: (D)

Exp: As the slump increases, the Vebe time decreases

18. Consider the following probability mass function (p.m.f) of a random variable X:

$$p(x,q)=\begin{cases} q & \text{if} \quad X=0 \\ 1-q & \text{if} \quad X=1 \\ 0 & \text{otherwise} \end{cases}$$

If q = 0.4, the variance of X is ________ .

Answer: 0.24

Exp: $p(x, q) = q$ if $X = 0$

$= 1 - q$ if $X = 1$

0 otherwise

given $q = 0.4$

$\Rightarrow p(x, q) = 0.4$ if $X = 0$

$= 0.6$ if $X = 1$

$= 0$ otherwise

$\Rightarrow$

X	0	1
$p(X=x)$	0.4	0.6

Required value=V (X) $=E(X)^2 - \{E(X)\}^2$

$E(X) = \Sigma x_i p_i = 0 \times 0.4 + 1 \times 0.6 = 0.6$

$E(X)^2 = \Sigma x_i^2 p_i = 0^2 \times 0.4 + 1^2 \times 0.6 = 0.6$

$V(X) = 0.6 - (0.6)^2$

$= 0.6 - 0.36$

$= 0.24$

19. Which of the following statements CANNOT be used to describe free flow speed (u_f) of a traffic stream?

(A) u_f is the speed when flow is negligible

(B) u_f is the speed when density is negligible

(C) u_f is affected by geometry and surface conditions of the road

(D) u_f is the speed at which flow is maximum and density is optimum

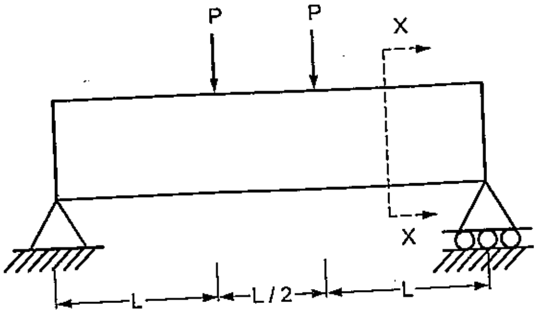
Answer: (D)

Exp: Free flow speed → speed when flow is negligible

→ speed when density is negligible

→ affected by Geometry, deriver's perception, roadway condition etc.

20. Consider the singly reinforced beam shown in the figure below:



At cross-section XX, which of the following statement is TRUE at the limit state?

(A) The variation of stress is linear and that of strain is non-linear

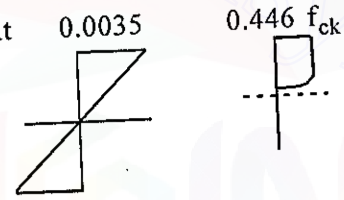
(B) The variation of strain is linear and that of stress is no-linear

(C) The variation of both stress and strain is linear

(D) The variation of both stress and strain is non-linear

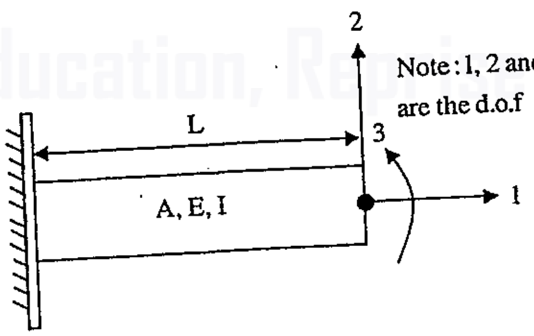
Answer: (B)

Exp: At



Strain variation Stress variation

21. For the beam shown below, the stiffness coefficient K_{22} can be written as



(A) $\frac{6EI}{L^2}$ (B) $\frac{12EI}{L^3}$ (C) $\frac{3EI}{L}$ (D) $\frac{EI}{6L^2}$

Answer: (B)

$$\frac{sw + cover}{sw} = \frac{sw}{sw} + \frac{cover}{sw} = 1.5$$

$$\Rightarrow \frac{cover}{sw} = 0.5$$

$\Rightarrow$ cover $0.5 \times 1.46 \times 10^7 = 0.73 \times 10^7$ m^3

Total volume $= (1.46 + 0.73 \times 10^7) = 21.9 \times 10^6$ m^3

$= 21.9$ million m^3

55. The bearings of two inaccessible stations, S_1 (Easting 500 m, Northing 500 m) and S_2 (Easting 600 m, Northing 450 m) from a station S_3 were observed as 225° and 153° 26' respectively. The independent Easting (in m) of station S_3 is:

(A) 450.000 (B) 570.710 (C) 550.000 (D) 650.000

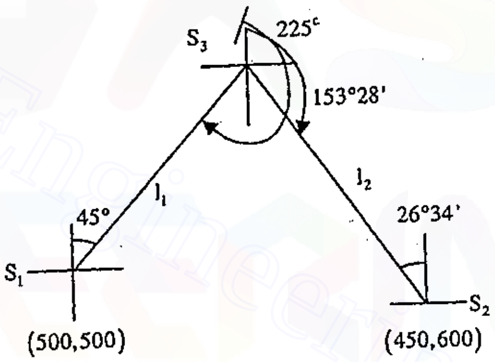
Answer: (C)

Exp: Let $s_1s_3 = l_1$, $s_2s_3 = l_2$

Northing of $S_3 = 500 + l_1 \cos 45°$

$= 450 + l_2 \cos 26° 34'$

$\Rightarrow l_1 \cos 45° - l_2 \cos 26° 34' = -50$



Easting of S_3

$500 + l_1 \sin 45° = 600 - l_2 \sin 26° 34'$

$l_1 \sin 45° + l_2 \sin 26° 34' = 100$

$\Rightarrow l_1 = 70.71$, $l_2 = 111.80$

Easting of S_3 $= 500 + 70.71 \times \sin 45$

$= 549.99\text{m} = 550\text{m}$

❖❖❖

53. In a wastewater treatment plant, primary sedimentation tank (PST) designed at an overflow rate of 32.5 m3/day/m^2 is 32.5 m long, 80 m wide and liquid depth of 2.25 m. If the length of the weir is 75 m, the weir loading rate (in m^3/day/m) is ________.

Answer: 112.67

Exp: $Q = 32.5m^3 / d / m^2$

L 32.5m

B = 8m

D = 2.25m

$$V_0 = \frac{Q}{BL}$$

$$Q = V_0 BL$$

$$= 32.5 \times 32.5 \times 8$$

$$= 8450m^3 / d$$

Weir length =75m.

$$q = \frac{8450}{75} = 112.67 \; m^3 / d / m$$

54. A landfill is to be designed to serve a population of 200000 for a period of 25 years. The solid waste (SW) generation is 2 kg/person/day. The density of the un-compacted SW is 100 kg/m3 and a compaction ratio of 4 is suggested. The ratio of compacted fill (i.e. SW + cover) to compacted SW is 1.5. The landfill volume (in million m3) required is ________.

Answer: 21.9

Exp: Total solid waste generated = $2kg \times 2 \times 10^5$

= 400000 kg/day

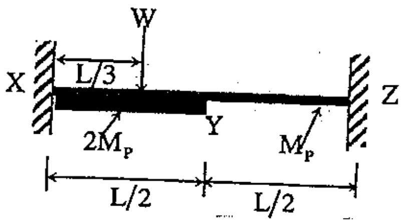
For 25 years = $400000 \times 365 \times 25$

= 3.65×10^9 kg

$$\text{Compaction ratio} = 0.4 = \frac{\text{volume after compaction}}{\text{volume before compaction}}$$

$$V = \frac{3.65 \times 10^9}{100} = 3.65 \times 10^7 \; m^3$$

$$V' = 0.4 \times 3.65 \times 10^7 = 1.46 \times 10^7 \; m^3$$

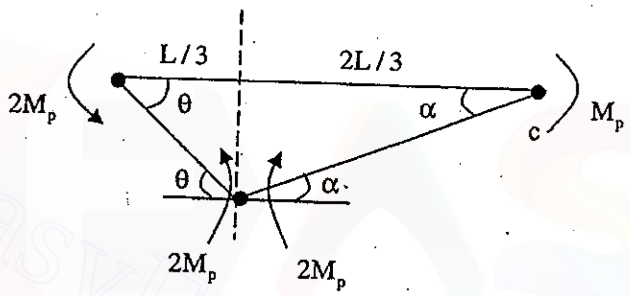


(A) 16.5 M_p/L (B) 15.5 M_p/L (C) 15.0 M_p/L (D) 16.0 M_p/L

Answer: (C)

Exp: Plastic hinges formed =3

(1)



$\alpha = \frac{\theta}{2}$

$\theta = 2\alpha$

$\theta = \frac{\Delta}{L/3}$

$\Delta = \frac{L}{3}\theta$

$\Delta = \frac{\alpha 2L}{3}$.

$\theta = 2\alpha$

$2M_p\theta + 2M_p\,\theta + 2M_p\,\alpha + M_p\alpha = W\Delta$

$2M_p\theta + 2M_p\theta + M_p\theta + M_p\,\frac{\theta}{2} = W \times \frac{L}{3}\theta$

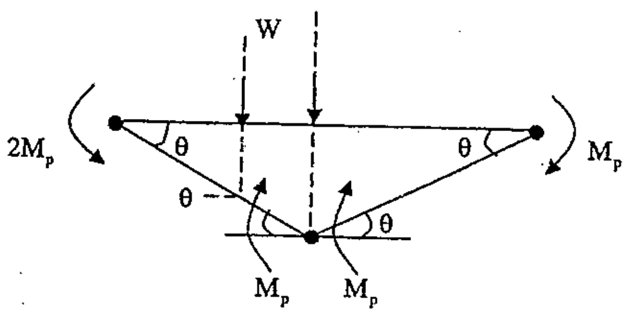
$5.5M_p = \frac{WL}{3} \Rightarrow W = \frac{16.5}{L}M_p$

(2)

$2M_p\theta + M_p\,\theta + M_p\,\Delta + M_p\theta = W \times \Delta$

$5M_p\theta = \frac{WL}{3}\theta$

$15\frac{M_p}{L} = W$



Lowest is collapse load $15\frac{M_p}{L}$

Exp: $$G_t = \frac{w_1 + w_2 + w_3 + w_4}{\frac{w_1}{G_1} + \frac{w_2}{G_2} + ...}$$

$$= \frac{100}{\frac{55}{2.6} + \frac{35.8}{2.7} + \frac{3.7}{2.65} + \frac{5.5}{1.01}} = 2.424$$

Eff 'G' of aggregates G (fine+coarse)

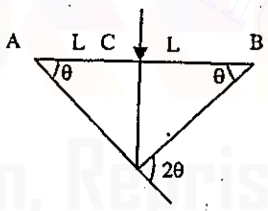
$$G = \frac{(55 \times 2.6) + (35.8 \times 2.7)}{55 + 35.8} = 2.64$$

51. In a system two connected rigid bars AC and BC are of identical length, L with pin supports at A and B. The bars are interconnected at C by a frictionless hinge. The rotation of the hinge is restrained by a rotational spring of stiffness, k. The system initially assumes a straight line configuration, ACB. Assuming both the bars as weightless, the rotation at supports, A and B, due to a transverse load, P applied at C is

(A) $\frac{PL}{4k}$ (B) $\frac{PL}{2k}$ (C) $\frac{P}{4k}$ (D) $\frac{Pk}{4L}$

Answer: (A)

Exp: External work done



$$= \frac{1}{2} \times \rho \times L.\theta ....(i)$$

Strain energy stored in spring

$$= \frac{1}{2} \times k \times (2\theta) \times (2\theta)$$

$= 2k.\theta^2$ ..... (ii)

(i) = (ii)

$$\Rightarrow \frac{1}{2} PL\theta = 2k.\theta^2$$

$$\Rightarrow \theta = \frac{PL}{4k}$$

52. A fixed end beam is subjected to a load, W at 1/3rd span from the left support as shown in the figure. The collapse load of the beam is

Total no. of filters = $\frac{720}{60}$ = 12 filters.

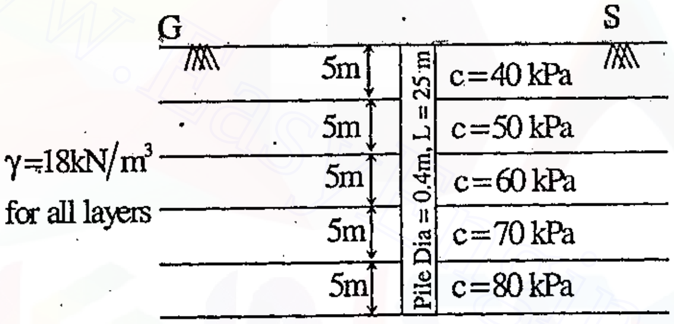
2 out of services, total filters =10.

S.A of filters 2 = 60 × 10 = 600 m^2 .

The loading rate = $\frac{86400}{600}$ = 144 m^3 / day/ m^2 .

49. A pile of diameter 0.4 m is fully embedded in a clay stratum having 5 layers, each 5 m thick as shown in the figure below. Assume a constant unit weight of soil as 18 kN/m3 for all the layers.

Using λ-method (λ = 0.15 for 25 m embedment length) and neglecting the end bearing component, the ultimate pile capacity (in kN) is ________.



Answer: 1060.29

Exp: Ultimate Bearing capacity, Q_u

$= \lambda\ (\sigma_{v.avg} + 2c_u)A_s$

$= 0.15\ [18 \times 12.5 + 2C_u] \times [\pi \times 0.4 \times 25]$

w = 0

$\Rightarrow q_u = 1060.29$ kN

50. In Marshall method of mix design, the coarse aggregate, fine aggregate, fines and bitumen having respective values of specific gravity 2.60, 2.70, 2.65 and 1.01, are mixed in the relative proportions (% by weight) of 55.0, 35.8, 3.7 and 5.5 respectively. The theoretical specific gravity of the mix and the effective specific gravity of the aggregates in the mix respectively are

(A) 2.42 and 2.63 (B) 2.42 and 2.78 (C) 2.42 and 2.93 (D) 2.64 and 2.78

Answer: (A)

46. A field channel has cultivable commanded area of 2000 hectares. The intensities of irrigation for gram and wheat are 30% and 50% respectively. Gram has a kor period of 18 days, kor depth of 12 cm, while wheat has a kor period of 18 days and a kor depth of 15 cm. The discharge (in m3/s) required in the field channel to supply water to the commanded area during the kor period is _____.

Answer: 1.427

Exp: Rafi crops Gran and wheat

$$Q_1 = \frac{A_1}{D_1} = \frac{200 \times 0.3}{8.64 \times \frac{18}{0.12}} = 0.463\ m^3/s \quad ; \text{ Duty} = 8.64\frac{B}{\Delta}$$

$$Q_2 = \frac{A^2}{D_2} = \frac{2000 \times 0.5}{8.64 \times \frac{18}{0.15}} = 0.964\ m^3/s$$

$\therefore Q_1 + Q_2$ is required $= 0.964 + 0.463 = 1.427\ m^3 / s$

47. The relation between speed u (in km/h) and density k (number of vehicles/km) for a traffic stream on a road is u = 70 – 0.7k. The capacity on this road is _________ vph (vehicles/hour).

Answer: 175

Exp: $u = 70 - 7k$

Capacity $u \times k$, $q = uk$

$q = (70 - 0.7k)\ k$

$\frac{dq}{dk} = 70 - 0.7 \times 2k = 0 \Rightarrow k = 50\ V / km.$

$q = (70 - 0.7 \times 50) \times 50 = 175\ V / hr.$

48. A water treatment plant of capacity, 1 m^3/s has filter boxes of dimensions 6 m × 10 m. Loading rate to the filters is 120 $m^3/day/m^2$. When two of the filters are out of service for back washing, the loading rate (in $m^3/day/m^2$) is _______

Answer: 144

Exp: Total water filters $= 24 \times 3600 \times 1 = 86400\ m^3 / day.$

$$S.A. = \frac{86400}{120} = 720\ m^2$$

Area of one filter 2 $= 6 \times 10 = 60\ m^2$.

$$y_p = \frac{1}{D^2}(-12x^2 + 24x - 20)$$

$$= -12\frac{x^4}{12} + 24.\frac{x^3}{6} - 20.\frac{x^2}{2!}$$

$$= -x^4 + 4x^3 - 10x^2$$

$$y = c_1 + c_2x + 10x^2 + 4x^3 - x^4$$

$y(0) = 5 \quad \Rightarrow c1 = 5$

$y(2) = 21 \quad \Rightarrow 21 = 5 + 2c_2 + 40 + 32 - 16$

$21 = 2c_2 + 61$

$c_2 = -20$

$$y = 5 - 20x + 10x^2 + 4x^3 - x^4$$

$y(1) = 5 - 20 + 10 + 4 - 1$

$= -2$

45. For step-size $\Delta x = 0.4$, the value of following int egral usin g Simpson 's 1 3 rule is ________.

$$\int_0^{0.8} (0.2 + 25x + 200x^2 + 675x^3 + 900x^4 + 400x^5)\,dx$$

Answer: -3.8293

Exp: Given $h = \Delta x = 0.4$

$f(x) = 0.2 + 25x\ 200x^2\ 675x^3$

$- 900x^4 + 400x^5$

$$x_0 = 0\ x_n\ 0.8 \Rightarrow n = \frac{0.8 - 0}{0.4} = 0$$

x	0	0.4	0.8
y = f (x)	0.2	24.456	– 126.744

By Simpson's $\frac{1}{3}$ Rule

$$\int_0^{0.8} f(x)\,dx = \frac{0.4}{3}\left[(0.2 - 126.744) + 4(24.456)\right] = -3.8293$$

Ratio for p = 2

⇒ Characteristic equation $\lambda^2-4\lambda+3 = 0$ (by substituting p=2)

⇒ $\lambda=1,3$

If we take $p=\frac{14}{3}$ then $A=\begin{bmatrix} 2 & 1 \\ 1 & \frac{14}{3} \end{bmatrix}$

$$\Rightarrow \lambda^2-\left(2+\frac{14}{3}\right)\lambda+\left(\frac{28}{3}-1\right)=0$$

$$\Rightarrow \lambda^2-\frac{20}{3}\lambda+\frac{25}{3}=0$$

$$\Rightarrow 3\lambda^2-20\lambda+25=0$$

$$\lambda=5,\frac{5}{3}$$

Eigen values $5,\frac{5}{3}$ are in ratio 3:1

$\therefore\ p=\frac{14}{3}$

44. Consider the following second order linear differential equation

$$\frac{d^2y}{dx^2}=-12x^2+24x-20$$

The boundary conditions are at x = 0, y = 5 and at x = 2, y = 21

The value of at x = 1 is ________.

Answer: -2

Exp: Given

$$\frac{d^2y}{dx^2}=-12x^2+24x-20$$

y (0) = 5   y (2) = 21

y (1) = ?

Auxillary equation $m^2 = 0$

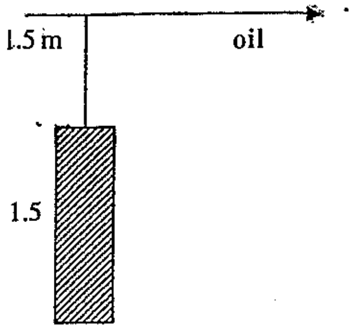
$$m = 0, 0$$

$$y_c=(c_1+c_2x)\,e^{0x}=c_1+c_2x$$

Exp: Force on gate $=\frac{1}{2}\times 1.5\times 2\times G\gamma_{\omega}\left(1.5+\frac{2}{3}\times 1.5\right)$

$= 0.8 \times 9810 \times 2.5 \times 1.5$

$= 29.43$ kN

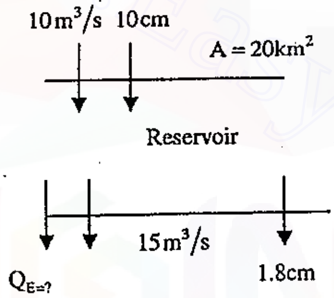


42. The average surface area of a reservoir in the month of June is 20 km^2. In the same month, the average rate of inflow is 10 m3/s, outflow rate is 15 m^3/s, monthly rainfall is 10 cm, monthly seepage loss is 1.8 cm and the storage change is 16 million m^3. The evaporation (in cm) in that month is

(A) 46.8 (B) 136.0 (C) 13.6 (D) 23.4

Answer: (B)

Exp:



$\because$ changeinstorage inflow-outflow

$\Delta S = Q_1 + Q_R - Q_0 - Q_S - Q_E$

$\Rightarrow 16 \times 10^6 = (10 \times 86400 \times 30) + (0.1 \times 20 \times 10^6)$

$- (15 \times 86400 \times 30) - (1.8 \times 10^{-2} \times 20 \times 10)$

$\Rightarrow Q_E = \frac{27320000}{20\times 10^6} = 1.366\text{m } 136.6\text{cm}$

43. The two Eigen values of the matrix have a ratio of 3 : 1 for p = 2. What is another value of p for which the Eigen values have the same ratio of 3 : 1?

(A) –2 (B) 1 (C) 7/3 (D) 14/3

Answer: (D)

Exp: Let $A=\begin{bmatrix}2 & 1\\ 1 & p\end{bmatrix}$

Given that two eigen values of A are in 3:1

Tanβ sinφ 0.5 $\phi = \sin^{-1} \cos 7\ 30°$

C cos30 = $10\sqrt{3}$ C = 20

40. The velocity components of a two dimensional plane motion of a fluid are

$$u = \frac{y^3}{3} + 2x - x^2 y \text{ and } v = xy^2 - 2y - \frac{x^3}{3}$$

The correct statement is:

(A) Fluid is incompressible and flow is irrotational

(B) Fluid is incompressible and flow is rotational

(C) Fluid is compressible and flow is irrotational

(D) Fluid is compressible and flow is rotational

Answer: (A)

Exp: For incompressible flow. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ ...(i)

For irrotational flow. $\frac{1}{2}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0$ ..(ii)

(1) $\frac{\partial}{\partial x}\left(\frac{y^3}{3} + 2x - x^2 y\right) + \frac{\partial}{\partial y}\left(xy^2 - 2y - \frac{x^3}{3}\right) = 0$

$2 - 2xy + 2xy - 2 = 0$

(2) $\frac{\partial}{\partial x}\left(xy^2 - 2y - \frac{x^3}{3}\right) - \frac{\partial}{\partial y}\left(\frac{y^3}{3} + 2x - x^2 y\right)$

$y^2 - x^2 - y^2 + x^2 = 0$

41. A triangular gate with a base width of 2 m and a height of 1.5 m lies in a vertical plane. The top vertex of the gate is 1.5 m below the surface of a tank which contains oil of specific gravity 0.8. Considering the density of water and acceleration due to gravity to be 1000 kg/m3 and 9.81 m/s^2, respectively, the hydrostatic force (in kN) exerted by the oil on the gate is __________.

Answer: 29.43

Exp: $$\Delta H = \frac{C_c}{1+e_0} H_0 \log_{10}\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right).$$

$\Delta_\sigma = \sigma_0$

$$= \frac{0.6}{1+1.3} \times 4 \log_{10}\left(\frac{\sigma_0 + \sigma_0}{\sigma_0}\right)$$

$= 0.314$ m

$\Delta_H = 314$mm

37. According to the concept of Limit State Design as per IS456: 2000, the probability of failure of a structure is __________.

Answer: 0.097

38. Two pegs A and B were fixed on opposite banks of a 50 m wide river. The level was set up at A and the staff readings on Pegs A and B were observed as 1.350 m and 1.550 m, respectively. Thereafter the instrument was shifted and set up at B. The staff readings on Pegs B and A were observed as 0.750 m and 0.550 m, respectively. If the R.L. of Peg A is 100.200 m, the R.L. (in m) of Peg B is _____

Answer: 100

Exp: Reciprocal leveling

$$\Delta_h = \frac{(b_1 - a_1) + (b_2 - a_2)}{2} = \frac{(1.55 - 1.35) + (10.75 - 0.55)}{2}$$

$\Delta h = 0.20$

RL of B = RL of A – 0.20 = 100m

From the reading we can see A is at higher level than B.

39. Stress path equation for tri-axial test upon application of deviatoric stress is, $q = 10\sqrt{3} + 0.5p$. The respective values of cohesion, c (in kPa) and angle of internal friction, are:

(A) 20 and 20° (B) 20 and 30° (C) 30 and 30° (D) 30 and 20°

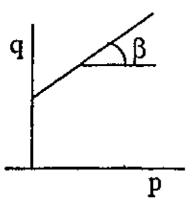
Answer: (B)

Exp: Stress path equations

$$\frac{\sigma_1 - \sigma_3}{2} = C\cos\phi + \frac{\sigma_1 + \sigma_3}{2}\sin\phi$$

$p = 10\sqrt{3} + 0.5$ p

$C\cos\phi = 10\sqrt{3}$



34. A 588 cm3 volume of moist sand weighs 1010 gm. Its dry weight is 918 gm and specific gravity of solids, G is 2.67. Assuming density of water as 1 gm/cm3, the void ratio is ________.

Answer: 0.71

Exp: $e = ?$

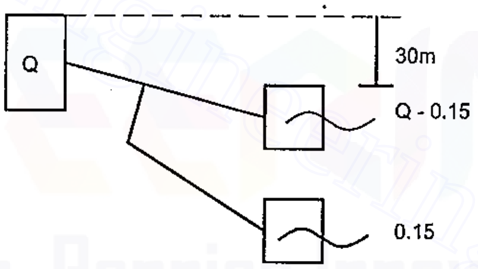
$$\gamma_{moist\ sand} = \frac{1010}{588} = 1.717\ g/cc \qquad \gamma_d = \frac{G\gamma_\omega}{1+e}$$

$$\gamma_d = \frac{918}{588} = 1.561\ g/cc \qquad 1.561 = \frac{2.67\times 1}{1+e}$$

$$e = 0.71$$

35. A pipe of 0.7 m diameter has a length of 6 km and connects two reservoirs A and B. The water level in reservoir A is at an elevation 30 m above the water level in reservoir B. Halfway along the pipe line, there is a branch through which water can be supplied to a third reservoir C. The friction factor of the pipe is 0.024. The quantity of water discharged into reservoir C is 0.15 m^3/s. Considering the acceleration due to gravity as 9.81 m/s^2 and neglecting minor losses, the discharge (in m^3/s) into the reservoir B is ________.

Answer: 0.5716



Exp: $h_f = \dfrac{flQ^2}{12.1d^5}$

$h_{f_1} + h_{f_2} = 30m \rightarrow$ in parallel

$$\frac{0.024\times 3000\times Q^2}{12.1\times 0.7^5} + \frac{0.024\times 3000\,(Q-0.15)^2}{12.1\times 0.7^5} = 30$$

$Q = 0.7216\ m^3/s$

$Q_B = Q - 0.15 = 0.5716\ m^3/s$

36. A 4 m thick layer of normally consolidated clay has an average void ratio of 1.30. Its compression index is 0.6 and coefficient of consolidation is 1 m^2/yr. If the increase in vertical pressure due to foundation load on the clay layer is equal to the existing effective overburden pressure, the change in the thickness of the clay layer is ______ mm.

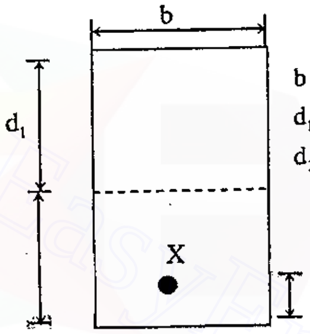
Answer: 314

$$=\frac{1}{4}\left[4.\frac{8}{3}-\frac{32}{5}\right]$$

$$=\frac{32}{4}\left[\frac{1}{3}-\frac{1}{5}\right]$$

$$=8\left[\frac{2}{15}\right]=\frac{16}{15}=1.0667$$

33. In a pre-stressed concrete beam section shown in the figure, the net loss is 10% and the final prestressing force applied at X is 750 kN. The initial fiber stresses (in N/mm^2) at the top and bottom of the beam were:



(A) 4.166 and 20.833

(B) –4.166 and –20.833

(C) 4.166 and –20.833

(D) –4.166 and 20.833

Answer: (D)

Exp: Loss = 10%

Final force = 750 kN

Initial force = $\frac{750}{0.9}=833.33\,\text{kN}$

e = 200 - 100

= 100 mm

$Z = \frac{bd^2}{6}$

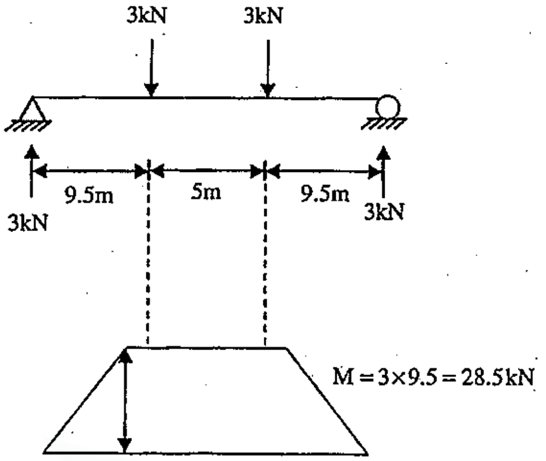
Top & Bottom stress = $\frac{P}{A}\pm m/z$

$$=\frac{833.33}{250\times400}\times10^3\pm\frac{833.33\times10^3\times100\times6}{250\times400^2}$$

= 8.33 ± 12.5

Top = – 4.166 (T)

Bottom = 20.833 (C)



$$\sigma = \frac{M}{I}.y = \frac{M}{Z} = \frac{28.5\times10^6}{16.2\times10^3} = 1759.2 \text{ GPa}$$

32. For probability density function of a random variable, x is

$f(x) = \frac{x}{4}(4-x^2)$ for $0 \le x \le 2$

$= 0$ otherwise

The mean μ_z of the random varialbe is _____

Answer: 1.0667

Exp: $f(x) = \frac{x}{4}(4-x^2) \quad 0 \le x \le 2$

mean $= \mu_z = E(x)$

$$= \int_0^2 xf(x)\,dx$$

$$= \int_0^2 x\left(\frac{x}{4}\right)(4-x^2)dx$$

$$= \frac{1}{4}\int_0^0 (4x^2 - x^2)dx$$

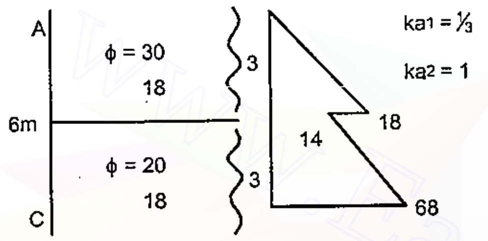
$$= \frac{1}{4}\left[\frac{4x^3}{3} - \frac{x^5}{5}\right]_0^2$$

30. A 6 m high retaining wall having a smooth vertical back face retains a layered horizontal backfill. Top 3 m thick layer of the backfill is sand having an angle of internal friction, $\varphi = 30°$ while the bottom layer is 3 m thick clay with cohesion, c = 20 kPa. Assume unit weight for both sand and clay as 18 kN/m^3. The totalactive earth pressure per unit length of the wall (in kN/m) is:

(A) 150 (B) 216 (C) 156 (D) 196

Answer: (A)

Exp:



above B $= k_{a1}\ 18H = \frac{1}{3} \times 18 \times 3 = 18$ kN/m^2

below B $= ka_2\ 18H - 2c\sqrt{ka_2}$

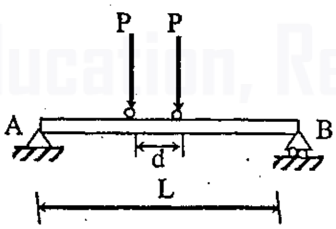
$= 1 \times 18 \times 3 - 2 \times 20\sqrt{1} = 14$ kN /m^2

$Pc = Ka_2 .\gamma z - 2c\sqrt{ka_2} = 18 \times 6 - 2 \times 20$

$= 68$ kN/m^2

$$P_a = \frac{1}{2} \times 18 \times 3 \frac{1}{2}(14+68) \times 3 = 150 kN/m^2$$

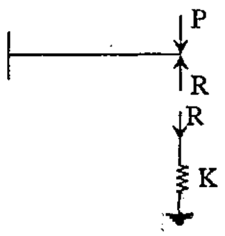
31. A simply supported beam AB of span, L = 24 m is subjected to two wheel loads acting at a distance, d = 5 m apart as shown in the figure below. Each wheel transmits a load, P = 3 kN and may occupy any position along the beam. If the beam is an I-section having section modulus, S = 16.2 cm3, the maximum bending stress (in GPa) due to the wheel loads is __________



Answer: 1759.2

Exp: Maximum bending stress occurs at the point of maximum bending moment. Maximum B.M. will occur under one of the point load such that resultant of the load system and point load under consideration is equidistant from the centre.

Exp:



$k = F/\delta$

$k = R/\delta$

$\delta = R/K$

δ for cantilever

$$\delta = \frac{(P-R)L^3}{3EI} = R/K$$

$$\frac{(50-R)\,200^3}{3\times 200\times 10^3 \times \frac{5\times 10^3}{12}} = R/2$$

R = 3N

28. Match the information related to test on aggregates given in Group-I with that in Group-II.

	Group-I		Group-II
P.	Resistance to impact	1.	Hardness
Q.	Resistance to wear	2.	Strength
R.	Resistance to weathering action	3.	Toughness
S.	Resistance to crushing	4.	Soundness

(A) P-1, Q-3, R-4, S-2 (B) P-3, Q-1, R-4, S-2

(C) P-4, Q-1, R-3, S-2 (D) P-3, Q-4, R-2, S-1

Answer: (B)

Exp: Resistance to impact → Toughness

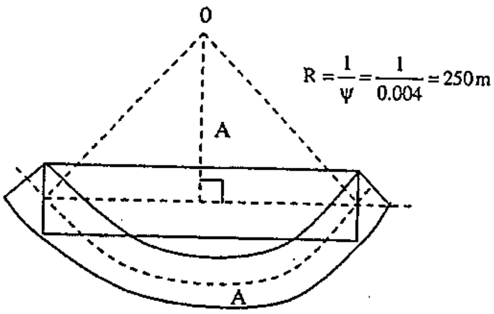
Resistance to wear → Hardness

Resistance to weathering → Soundness

Resistance to crushing → Strength

29. A simply supported reinforced concrete beam of length 10 m sags while undergoing shrinkage. Assuming a uniform curvature of 0.004 m-1 along the span, the maximum deflection (in m) of the beam at mid-span is _______.

Answer: 0.0005



Exp: $OA = \sqrt{(250)^2 - \left(\frac{1}{2}\right)^2} = 249.9995m$

ΔAA' = 0.0005m

(iv) Average number of vehicles (by vehicle type) that would store in all lanes per cycle during the peak hour.

As per the IRC recommendations, the correct choice for design length of storage lanes is

(A) Maximum of (ii and iii)
(B) Maximum of (i and iii)
(C) Average of (i and iii)
(D) Only (iv)

Answer: (A)

Q. No. 26-55 carry Two Marks Each

26. Ultimate BOD of a river water sample is 20 mg/L. BOD rate constant (natural log) is 0.15 day^{-1}. The respective values of BOD (in %) exerted and remaining after 7 days are:

(A) 45 and 55 (B) 55 and 45 (C) 65 and 35 (D) 75 and 25

Answer: (C)

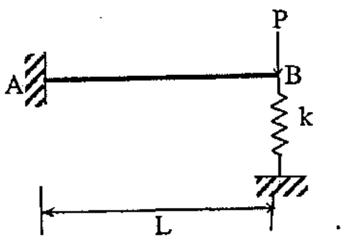
Exp: $y_u = 20$mg L

After 7 days = $y_u\ e^{-kt} = 20 \times e^{0.15 \times 7} = 7$

$\%$ is $= \frac{7}{20} = 35\%$

exerted 100 35 65%

27. A steel strip of length, L = 200 mm is fixed at end A and rests at B on a vertical spring of stiffness, k = 2 N/mm. The steel strip is 5 mm wide and 10 mm thick. A vertical load, P = 50 N is applied at B, as shown in the figure. Considering E = 200 GPa, the force (in N) developed in the spring is ________.



Answer: 3

21. While minimizing the function f(x), necessary and sufficient conditions for a point, x_0 to be a minima are:

(A) $f'(x_0) > 0$ and $f''(x_0) = 0$ (B) $f'(x_0) < 0$ and $f''(x_0) = 0$

(C) $f'(x_0) = 0$ and $f''(x_0) < 0$ (D) $f'(x_0) = 0$ and $f''(x_0) > 0$

Answer: (D)

22. The combined correction due to curvature and refraction (in m) for distance of 1 km on the surface of Earth is

(A) 0.0673 (B) 0.673 (C) 7.63 (D) 0.763

Answer: (A)

Exp: $C = 0.0673d^2 = 0.0673 \times 1$

23. Surcharge loading required to placed on the horizontal backfill of a smooth retaining vertical wall so as to completely eliminate tensile crack is:

(A) 2 c (B) $2\,ck_a$ (C) $2c\sqrt{k_a}$ (D) $2c/\sqrt{k_a}$

Answer: (D)

Exp: Surcharge load to be placed as = $\dfrac{2c}{\sqrt{k_a}}$

24. A nozzle is so shaped that the average flow velocity changes linearly from 1.5 m/s at the beginning to 15 m/s at its end in a distance of 0.375 m. The magnitude of the convective acceleration (in m/s2) at the end of the nozzle is ________.

Answer: 54

Exp: Convective acceleration $= u\dfrac{du}{dx} + v\dfrac{du}{dy} + w\dfrac{du}{dz}$

$$= 1.5\frac{(15-1.5)}{0.375} = 54\ \text{m/s}^2$$

25. The following statements are made related to the lengths of turning lanes at signalised intersections

(i) 1.5 times the average number of vehicles (by vehicle type) that would store in turning lane per cycle during the peak hour.

(ii) 2 times the average number of vehicles (by vehicle type) that would store in turning lane per cycle during the peak hour.

(iii) Average number of vehicles (by vehicle type) that would store in the adjacent through lane per cycle during the peak hour.

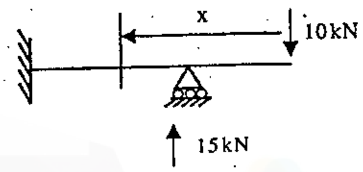
so, $\Delta_{BC} = \frac{10 \times (.75)^3}{3E_1} + \frac{10 \times (.75)^2}{2E_1} \times 0.25$

$= \frac{2.11}{E_1} \downarrow$

Deflection at C due toRedundant R_C

$\Delta_{cc} = R_C \times \frac{(.75)^3}{3E_1} = \frac{0.141R_c}{E_1} \uparrow$

$\because \Delta_C = 0$



$\Rightarrow \frac{2.11}{E_1} - \frac{.141R_C}{E_1} = 0$

$\Rightarrow R_C = 15$ kN

$M_x = 10 \times x - 15 \times (x - .25) = 0$

$\Rightarrow 10x - 15x - 3.75 = 0$

$\Rightarrow x = 0.75$m

So, distance of point of contraflexure from end A

= 1-0.75 = 0.25m

19. If the water content of a fully saturated soil mass is 100% the void ratio of the sample is .

(A) Less than specific gravity of soil (B) equal to specific gravity of soil

(C) greater than specific gravity of soil (D) independent of specific gravity of soil

Answer: (B)

Exp: $e = \frac{wG}{S_r}$

$S = 100\% = 1 \qquad \therefore e = \frac{1 \times G}{1} = G$

w = 100%

20. The relationship between porosity (), specific yield (S_y) and specific retention (S_r) of an unconfined aquifer is

(A) $S_y + S_r =$ (B) $S_y + \ = S_r$ (C) $S_r + \ = S_y$ (D) $S_y + S_r + \ = 1$

Answer: (A)

17. A superspeedway in New Delhi has among the highest super-elevation rates of any track on the Indian Grand Prix circuit. The track requires drivers to negotiate turns with a radius of 335 m and 33° banking. Given this information, the coefficient of side friction required in order to allow a vehicle to travel at 320 km/h along the curve is

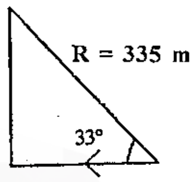
(A) 1.761 (B) 0.176 (C) 0.253 (D) 2.530

Answer: 0.685

Exp: $V = 320\text{kmph}$

$= 320 \times \frac{5}{18}$

$= \frac{800}{9} \text{m/s}$



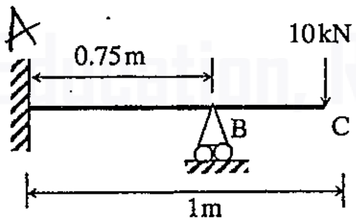
$$\frac{V^2}{gR} = \frac{\tan\theta + f}{1 - f\tan\theta}$$

$$\Rightarrow \frac{(800/g)^2}{9.81 \times 335} = \frac{\tan 33° + f}{1 - f \times \tan 33°}$$

$$\Rightarrow 2.40 = \frac{0.64g + f}{1 - f \times 0.649}$$

$\Rightarrow f = 0.685$

18. A horizontal beam ABC is loaded as shown in the figure below. The distance of the point of contraflexure from end A (in m) is ________.



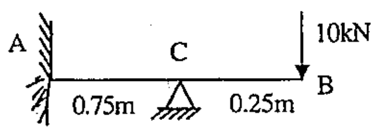
Answer: 0.25

Exp: Let us take R_C as redundant

Deflection at B due to load at C

Deflection at C due to load at B (ΔBC)

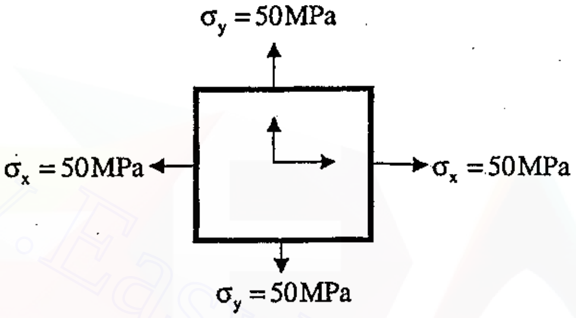
[By Marshall reciprocal theorem]



15. Prying forces are
    (A) shearing forces on the bolts because of the joints
    (B) tensile forces due to the flexibility of connected parts
    (C) bending forces on the bolts because of the joints
    (D) forces due the friction between connected parts

Answer: (B)

16. For the plane stress situation shown in the figure, the maximum shear stress and the plane on which it acts are



    (A) –50 MPa, on a plane 45° clockwise w.r.t. x-axis
    (B) –50 MPa, on a plane 45° anti-clockwise w.r.t. x-axis
    (C) 50 MPa, at all orientations
    (D) Zero, at all orientations

Answer: (D)

Exp: $\sigma_1 = 50 \text{ N/mm}^2$ $\tau = 0$

$\sigma_2 = 50 \text{ N.mm}^2$

$$\sigma_{n_1} = \left(\frac{\sigma_1+\sigma_2}{2}\right) + \sqrt{\left(\frac{\sigma_1+\sigma_2}{2}\right) + \tau^2}$$

$$= \left(\frac{50+50}{2}\right) + \sqrt{0+0} = 50 \text{ N/mm}^2$$

$$\sigma_{n_1} = \left(\frac{50+50}{2}\right) - 0 = 50 \text{ N/mm}^2$$

$$\tau_{max} = \frac{\sigma_{n_1} - \sigma_{n_2}}{2} = \frac{50-50}{2} = 0$$

12. Net ultimate bearing capacity of a footing embedded in a clay stratum
    (A) increases with depth of footing only
    (B) increases with size of footing only
    (C) increases with depth and size of footing
    (D) is independent of depth and size of footing

Answer: (D)

Exp: Because $q_u = CN_c + 8DN_q + 0.5\ \gamma BN_r$

It is clay $\therefore\ \phi = 0 \Rightarrow N_r = 0,\ N_q = 1$

$q_u = CN_c + \gamma D$

$q_{nu} = CN_c + \gamma D - \gamma D = CN_c$

13. A groundwater sample was found to contain 500 mg/L total dissolved solids (TDS). TDS (in %) present in the sample is _______.

Answer: 0.05

Exp: TDS 500mg / lit $\quad$ 1 lit = 500 mg = 500×10^{-3} gm

$\% \text{ TDS} = \frac{500}{1000} \times 10^{-3} \times 100$ $\quad$ 1 lit = 1000 gm

14. In Newton-Raphson iterative method, the initial guess value (x_{ini}) is considered as zero while finding the roots of the equation: $f(x) = -2 + 6x - 4x^2 + 0.5x^3$. The correction, x_{ini}, to be added to xini in the first iteration is _________.

Answer: 0.3333

Exp: $f(x) = -2 + 6x - 4x^2 + (0.5)\ x^3$

$x_0 = 0$

$f'(x) = 6 - 8x + 1.5x^2$

$f(0) = -2 \qquad f'(0) = 6$

By Newton-Raphson method

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = 0 - \frac{(-2)}{6}$$

$$= \frac{2}{6}$$

$$= 0.3333$$

$\Delta x = x_1 - x_0 = 0.3333 - 0 = 0.3333$

8. A steel member 'M' has reversal of stress due to live loads, whereas another member 'N' has reversal of stress due to wind load. As per IS 800:2007, the maximum slenderness ratio permitted is

(A) less for member 'M' than that of member 'N'

(B) more for member 'M' than for member 'N'

(C) same for both the members

(D) not specified in the Code

Answer: (A)

Exp: M – due to live load

N – due to wind load

As per IS800. M – λ – 180, M – λ – 350 M < N

(A) e^{-2} (B) e (C) 1 (D) e^2

Answer: (D)

Exp: $\lim_{x \to \infty}\left(1+\frac{1}{x}\right)^{2x}$

$$= \left(\lim_{x \to \infty}\left(x+\frac{1}{x}\right)^{x}\right)^{2}$$

$= e^2$

10. In a leveling work, sum of the Back Sight (B.S.) and Fore Sight (F.S.) have been found to be 3.085 m and 5.645 m respectively. If the Reduced Level (R.L.) of the starting station is 100.000 m, the R.L. (in m) of the last station is _______.

Answer: 97.440

Exp: ΣBS = 3.085 ΣF.s = 5.645m

Fall = ΣFs – ΣBS = 5.645 – 3.085 = 2.560

R.L of last station = R.L first – fall

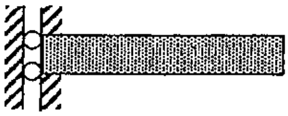
= – 100 – 2.560 = 97.440m

11. In friction circle method of slope stability analysis, if r defines the radius of the slip circle, the radius of friction circle is

(A) r sin ϕ (B) r (C) r cos ϕ (D) r tan ϕ

Answer: (A)

5. A guided support as shown in the figure below is represented by three springs (horizontal, vertical and rotational) with stiffness k_x, k_y and k respectively. The limiting values of k_x, k_y and k are



(A) $\infty, 0, \infty$ (B) ∞, ∞, ∞ (C) $0, \infty, \infty$ (D) $\infty, \infty, 0$

Answer: (A)

Exp: As rotation and horizontal deflection in zero as per given figure. Therefore its stiffness is

'∞' as deflection = 0. stiffness = $\frac{\text{Force}}{\text{deflection}}$

and stiffness is zero in y direction

6. Let $A = [\alpha_{ij}]$, $1 \le i, j \le n$ with $n \ge 3$ and $aij = i.j$. The rank of A is

(A) 0 (B) 1 (C) n – 1 (D) n

Answer: (B)

Exp: Given $A = [a_{ij}]$ $1 \le i, j \le n, n \ge 3$

and $a_{ij} = i.j$

$$\Rightarrow A = \begin{Bmatrix} 1 & 2 & 3 & --- \\ 2 & 4 & 6 & --- \\ 3 & 6 & 9 & --- \\ - & - & - & --- \end{Bmatrix}$$

If we apply R_2-$2R_1$, R_3-$3R_1$........

Every row will be zero row, except first row in echelon form

$\therefore \rho(A) = 1$

7. A hydraulic jump takes place in a frictionless rectangular channel. The pre-jump depth is y_p. The alternate and sequent depths corresponding to y_p are y_a and y_s respectively. The correct relationship among y_p, y_a and y_s is

(A) $y_a < y_s < y_p$ (B) $y_p < y_s < y_a$ (C) $y_p < y_s = y_a$ (D) $y_a = y_s = y_p$

Answer: (B)

$V \alpha \sqrt{y}$

$V \alpha \sqrt{L_r} \qquad \because y \alpha L_r$

3. Given i = $\sqrt{-1}$, the value of the definite int egral, I = $\int_0^{\pi/2} \frac{\cos x + \sin x}{\cos x - i \sin x} dx$ is :

(A) 1 (B) -1 (C) i (D) –i

Answer: (B)

Exp: $I = \int_0^{\pi/2} \frac{\cos x + \sin x}{\cos x - i \sin x} dx$

$= \int_0^{\pi/2} \frac{e^{ix}}{e^{-ix}} dx = \int_0^{\pi/2} e^{2ix} dx$

$= \left(\frac{e^{2ix}}{2}\right)^{\pi/2}$

$= \frac{1}{2}\left[e^{\frac{2i\pi}{2}} - e^0\right]$

$= \frac{1}{2}\left[e^{\pi i} - e^0\right]$

$= \frac{1}{2}[\cos \pi + i \sin \pi - 1]$

$= \frac{1}{2}[-1 + 0 - 1] = -1$

4. SO_2 and CO adversely affect

(A) oxygen carrying capacity of blood and functioning of lungs respectively

(B) functioning of the respiratory system and brain respectively

(C) functioning of the respiratory system and oxygen carrying capacity of blood respectively

(D) functioning of air passages and chest respectively.

Answer: (C)

Exp: Carbon monoxide effects the bloods carrying capacity

Let capacity of tank B is x

$$\frac{70}{100}\times = 14000$$

$\Rightarrow$ x = 20000 gallons

Solution in tank A = $\frac{80}{100}$ × 14000 = 11200 gallons

Solution in tank B = $\frac{40}{100}$ × 20000 = 8000 gallons

Total solution = 11200 + 8000 = 19200 gallons

SECTION NAME: CIVIL ENGINEERING

Q. No. 1-25 carry one Mark Each

1. A column of size 450 mm × 600 mm has unsupported length of 3.0 m and is braced against side sway in both directions. According to IS 456:2000, the minimum eccentricities (in mm) with respect to major and minor principle axes are

(A) 20.0 and 20.0 (B) 26.0 and 21.0 (C) 26.0 and 20.0 (D) 21.0 and 15.0

Answer: (B)

Exp: $e_{min} = \frac{L}{500} + \frac{D}{30}$ (or) 20mm which ever is minimum.

$$e_{xx} = \frac{3000}{500} + \frac{600}{30} = 26\text{ mm}$$

$$e_{yy} = \frac{300}{500} + \frac{450}{30} = 21\text{ mm}$$

2. The relationship between the length scale ratio (L_r) and the velocity scale ratio (V_r) in hydraulic models, in which Froude dynamic similarity is maintained, is

(A) $V_r = L_r$ (B) $L_r = \sqrt{V_r}$ (C) $V_r = L_r^{1.5}$ (D) $V_r = \sqrt{L_r}$

Answer: (D)

Exp: Found number = $\frac{V}{\sqrt{gy}}$

9. Read the following table giving sales data of five types of batteries for years 2006 to 2012

Year	Type I	Type II	Type III	Type IV	Type V
2006	75	144	114	102	108
2007	90	126	102	84	126
2008	96	114	75	105	135
2009	105	90	150	90	75
2010	90	75	135	75	90
2011	105	60	165	45	120
2012	115	85	160	100	145

Out of the following, which type of battery achieved highest growth between the years 2006 and 2012?

(A) Type V (B) Type III (C) Type II (D) Type I

Answer: (D)

Exp: Type-I achieved a growth of 53% in the period which is higher than any other type of battery

10. The given question is followed by two statements: select the most appropriate option that solves the question Capacity of a solution tank A is 70% of the capacity of tank B. How many gallons of solution are in tank A and tank B?

Statements:

I. Tank A is 80% full and tank B is 40% full

II. Tank A if full contains 14,000 gallons of solution

(A) Statement I alone is sufficient

(B) Statement II alone is sufficient

(C) Either statement I or II alone is sufficient

(D) Both the statements I and II together are sufficient

Answer: (D)

Exp: Statement I can be used to solve the question if capacity of both tanks is already known

Statement-II can be used if it is known what quantity of each tank is full/empty.

Therefore, by using both statements

5. Mr. Vivek walks 6 meters North-East, then turns and walks 6 meters South- East, both at 60 degrees to East. He further moves 2 meters South and 4 meters West. What is the straight distance in meters between the point he started from and the point he finally reached?

(A) 2 2 (B) 2 (C) 2 (D) 1 / 2

Answer: (A)

Q. No. 6-10 carry Two Marks Each

6. How many four digit numbers can be formed with the 10 digits 0, 1, 2, ... 9 if no number can start with 0 and if repetitions are not allowed?

Answer: 4536

Exp: In thousands place, 9 digits except 0 can be placed

In hundreds place, 9 digits can be placed (including 0, excluding the one used in thousands place)

In tens place, 8 digits can be placed (excluding the ones used in thousands and hundreds place)

In ones place, 7 digits can be placed (excluding the one used in thousands, hundreds and tens place)

Total number of combinations = $9 \cdot 9 \cdot 8 \cdot 7 = 4536$

7. The word similar in meaning to 'dreary' is

(A) cheerful (B) dreamy (C) hard (D) dismal

Answer: (D)

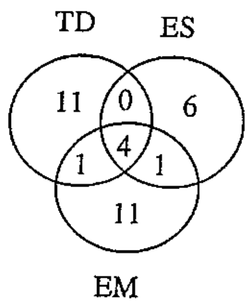
Exp: dreary- depressingly dull and bleak or repetitive.

8. There are 16 teachers who can teach Thermodynamics (TD), 11 who can teach Electrical Sciences (ES), and 5 who can teach both TD and Engineering Mechanics (EM). There are a total of 40 teachers, 6 cannot teach any of the three subjects, i.e. EM, ES or TD. 6 can teach only ES. 4 can teach all three subjects, i.e. EM, ES and TD. 4 can teach ES and TD. How many can teach both ES and EM but not TD?

(A) 1 (B) 2 (C) 3 (D) 4

Answer: (A)

Exp:



GATE -2015, PAPER-2

GATE 2015 –CE on 8th February, 2015 – (Afternoon Session)

General Aptitude Questions

Q. No. 1-5 carry one Mark Each

1. Choose the most appropriate word from the options given below to complete the following sentence The official answered _________ that the complaints of the citizen would be looked into.

   (A) respectably (B) respectfully (C) reputably (D) respectively

Answer: (B)

2. Choose the statement where underlined word is used correctly

   (A) The minister insured the victims that everything would be all right.

   (B) He ensured that the company will not have to bear any loss.

   (C) The actor got himself ensured against any accident.

   (D) The teacher insured students of good results

Answer: (B)

Exp: insured-the person, group, or organization whose life or property is covered by an insurance policy.

ensured- to secure or guarantee

3. Four cards are randomly selected from a pack of 52 cards. If the first two cards are kings, what is the probability that the third card is a king?

   (A) 4/52 (B) 2/50 (C) 1/52 × (1/52) (D) 1/52 × (1/52) × (1/50)

Answer: (B)

Exp: There are 4 kings in a pack of 52 cards.

If 2 cards are selected and both are kings, remaining cards will be 50 out of which 2 will be kings.

4. Which word is not a synonym for the word vernacular?

   (A) regional (B) indigeneous (C) indigent (D) colloquial

Answer: (C)

Exp: vernacular- expressed or written in the native language of a place

indigent -deficient in what is requisite

$$\int dv = \int (\alpha - \beta v_0) e^{-\beta T}.dt$$

$$= \frac{(\alpha - \beta V_0) e^{-\beta t}}{-\beta}$$

$t = 0$, $V = V_0$

$$\Rightarrow V_0 = \frac{(\alpha - \beta V_0)}{-\beta} + C$$

$$C = V_0 = \frac{\alpha - \beta V_0}{-\beta} \Rightarrow C = \frac{\alpha}{\beta}$$

$$\Rightarrow V = \frac{\alpha - (\alpha\beta V_0) \times e^{-\beta t}}{\beta}$$

$$x = \frac{\alpha t_0}{\beta} + \frac{\alpha - \beta V_0}{\beta^2}\left(e^{-\beta t_0} - 1\right)$$

$$\left.\frac{dv}{dt}\right|_{t=3} = (\alpha - \beta V_0)\, e^{-3\beta} = 1.3$$

$$\Rightarrow \alpha - \beta V_0 = \frac{1.3}{e^{-3\beta}}$$

$$x = \frac{\alpha t_0}{\beta} + \frac{1.3}{\beta^2 \left(e^{-\beta t}\right)}\left(e^{-\beta t_0} - 1\right)$$

$$= \frac{2 \times 35}{0.05} + \frac{1.3\left(e^{-35 \times 0.05} - 1\right)}{(0.05)^2 \left(e^{-3 \times 0.05}\right)}$$

$= 1400 - 499.17 = 900.83$ m

55. On a circular curve, the rate of super elevation is e. While negotiating the curve a vehicle comes to a stop. It is seen that the stopped vehicle does not slide inwards (in the radial direction). The coefficient of side friction is f. Which of the following is true?

(A) $e \le f$ (B) $f < e < 2f$ (C) $e \ge 2f$ (D) None of the above

Answer: (A)

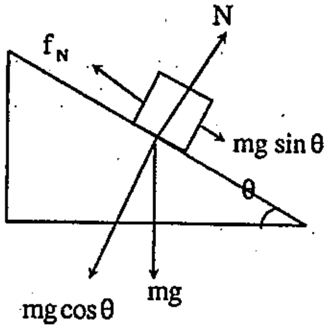
Exp: $f_N \ge mg \sin\theta$

$\Rightarrow f\,(mg \cos\theta) = mg \sin\theta$

$\Rightarrow f \ge \tan\theta$

$\Rightarrow f \ge e$

$\Rightarrow e \le f$



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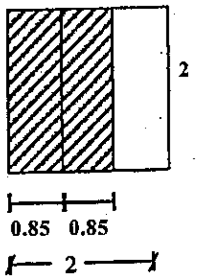


For one way shear (eccentricity) area to be reduced

Reduced area of footing = $2\times1.7 = 3.4m^2$

Load carrying capacity = $132.364 \times 3.4 = 450$.kN

53. In a catchment, there are four rain-gauge stations, P, Q, R, and S. Normal annual precipitation values at these stations are 780 mm, 850 mm, 920 mm, and 980 mm, respectively. In the year 2013, stations Q, R, and S, were operative but P was not. Using the normal ratio method, the precipitation at station P for the year 2013 has been estimated as 860 mm. If the observed precipitation at stations Q and R for the year 2013 were 930 mm and 1010 mm, respectively; what was the observed precipitation (in mm) at station S for that year?

Answer: 1076.2

Exp: $$\frac{P_s}{N_s}=\frac{1}{3}\left[\frac{P_P}{N_P}+\frac{P_Q}{N_Q}+\frac{P_R}{N_R}\right]$$

$$\Rightarrow \frac{P_s}{980}=\frac{1}{3}\left[\frac{860}{780}+\frac{930}{850}+\frac{1010}{920}\right]$$

$$\Rightarrow P_s = 1076.20 \text{ mm}$$

54. The acceleration-time relationship for a vehicle subjected to non-uniform acceleration is, $\frac{dv}{dt}=(\alpha-\beta v_0)e^{-\beta t}$

Where, v is the speed in m/s, t is the time in s, α and β are parameters, and v_0 is the initial speed in m/s. If the accelerating behavior of a vehicle, whose drive intends to overtake a slow moving vehicle ahead, is described as,

$$\frac{dv}{dt}=(\alpha-\beta v)$$

Considering $\alpha = 2 m/s^2$, $\beta = 0.05 s^{-1}$ and $\frac{dv}{dt}$ $1.3 m./s^2$ = at t = 3 s, the distance (in m) travelled by the vehicle in 35 s is ___________.

Answer: 900.83

Exp: $$\frac{dV}{dt}=(\alpha-\beta v_0)e^{-\beta T}$$

$$\Rightarrow \lambda^3 - 4\lambda^2 + 5\lambda - 2 = 0$$

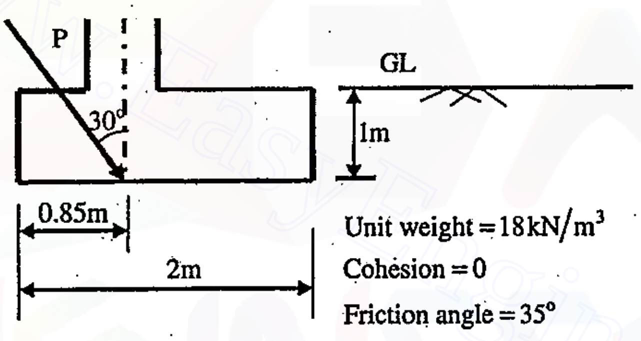
$$(\lambda - 1)(\lambda^2 - 3\lambda + 2) = 0$$

$$(\lambda - 1)(\lambda - 1)(\lambda - 2) = 0$$

$$\lambda = 1.2$$

52. A square footing (2mx 2m) is subjected to an inclined point load, P as shown in the figure below. The water table is located well below the base of the footing. Considering one-way eccentricity, the net safe load carrying capacity of the footing for a factor of safety of 3.0 is __________ kN.

The following factors may be used. Bearing capacity factors: Nq = 33.3, N_γ 37.16; = Shape factors: F_{qs} $F_{\gamma s}$ 1.314; = = Depth factors: $F_{qd} = F_{\gamma d}$ = 1.113; Inclination factors: F_{qi} = 0.444, $F_{\gamma i}$ = 0.02



Answer: 450

Exp: $q_{safe} = \dfrac{q_{nu}}{3}$

$q_{nu} = cN_c + qN_q + 0.5\ \gamma BN_\gamma$ - 8 Δ

C = 0

$q_{nu} = q\ (N_q - 1) + 0.5\ \gamma\ BN_\gamma$

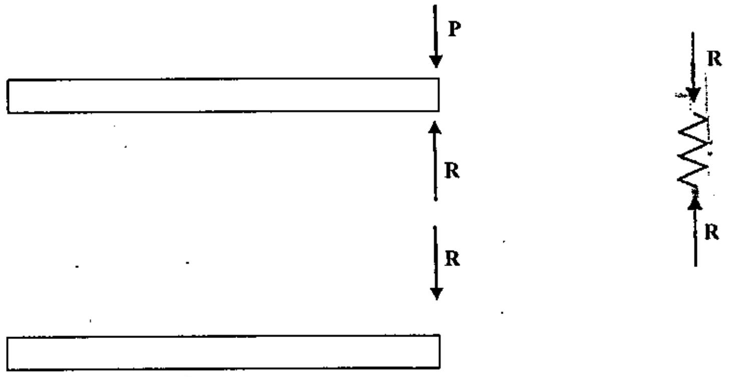
$$q_{ns} = \frac{1}{3}\ (q\ (N_q - 1)\ F_{qs} \times F_{qd} + F_{qp} + 0.5\gamma BN_\gamma \times F_{\gamma s} \times F_{\gamma o} \times F_{\gamma p})$$

$$q_{ns} = \frac{1}{3}\left(18\times1(33.3-1)\times1.314\times1.113\times0.444+\frac{1}{2}\times2\times18\times 37.16\times1.314\times1.113\times0.02\right)$$

$$= \frac{397.03}{3} = 132.364\ kN/m^2$$

Answer: 33.33

Exp:



$$\Delta = \frac{R}{K}$$

$$= \frac{R}{3EI} \times 2L^3$$

Net deflection of upper beam = deflection of spring

$$\frac{PL^3}{3EI} - \frac{RL^3}{3EI} = \frac{2RL^3}{3EI}$$

$$\Rightarrow \frac{PL^3}{3EI} = \frac{3RL^3}{3EI} \Rightarrow R = \frac{P}{3} = 33.33\%$$

51. The smallest and largest Eigen values of the following matrix are:

$$\begin{bmatrix} 3 & -2 & 2 \\ 4 & -4 & 6 \\ 2 & -3 & 5 \end{bmatrix}$$

(A) 1.5 and 2.5 (B) 0.5 and 2.5 (C) 1.0 and 3.0 (D) 1.0 and 2.0

Answer: (D)

Exp: Let $A = \begin{bmatrix} 3 & -2 & 2 \\ 4 & -4 & 6 \\ 2 & -3 & 5 \end{bmatrix}$

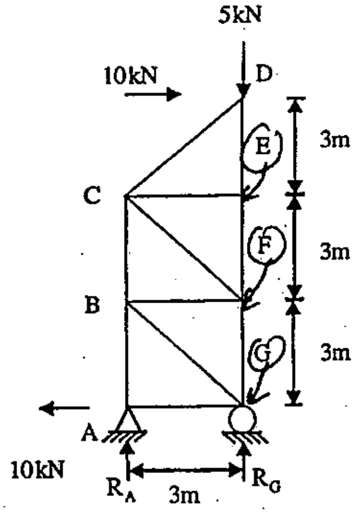
Characteristic equation is

$|A-\lambda I| = 0$

$$\Rightarrow \begin{vmatrix} 3-\lambda & -2 & 2 \\ 4 & -4-\lambda & 6 \\ 2 & -3 & 5-\lambda \end{vmatrix} = 0$$

Answer: 5

Exp:

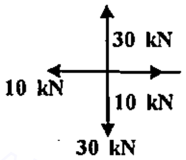


$R_A \times 3 + 10 \times 9 = 0$

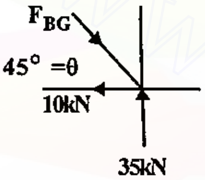
$\Rightarrow R_A = -30$ kN

$R_G = 35$ kN

Taking joint A



Joint G



$\Sigma H = 0 \quad F_{BG} \cos 45° = 10$

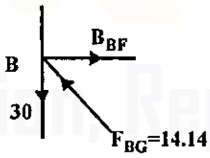
$$F_{BG} = \frac{10}{\cos 45} = 14.14 \text{ kN}$$

Joint B

$\Sigma H = 0,$

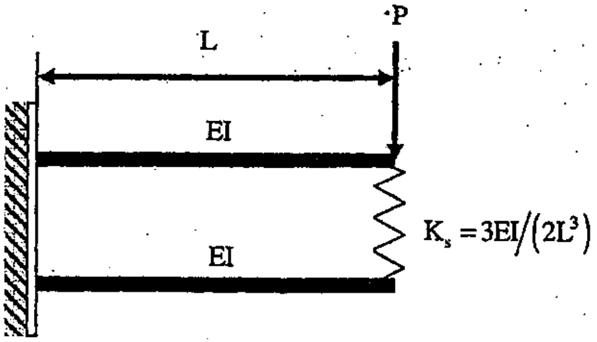
$F_{BG} \cos 45° = F_{BF}$

$\therefore F_{BF} = 10$ kN



$$U = \frac{F^2 \times L}{2A_E} = \frac{10 \times 10 \times 3}{2 \times 30} = 5\text{kN} - \text{m}$$

50. Two beam are connected by linear spring as shown in the following figure. For a load P as shown in the figure, the percentage of the applied load P carried by the spring is __________.



48. In a region with magnetic declination of 2°E, the magnetic Fore bearing (FB) of a line AB was measured as N79°50′E. There was a local attraction at A. To determine the correct magnetic bearing of the line, a point O was selected at which there was no local attraction. The magnetic FB of line AO and OA were observed to be ₒ S52 40′E and ₒ N50 20′W, respectively. What is the true FB of line AB?

(A) N81°50′E (B) N82°10′E (C) N84°10′E (D) N77°50′E

Answer: (C)

Exp: δ = 2°E

Magnetic F.B. of AB = N79°50'E = 79°50.

Correct FB of OA = N50°20'W = 309°40'

∴ Correct B.B of OA = 129°40'

∵ observed F.B. of AO = observed BB of OA

= S 52°40'E =127°20'

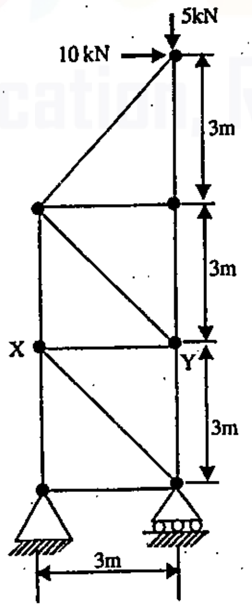
Error = M.V- T.V = -2°20'

Correction + 2°20'

T.B. of FB of AB = N79°50'E + 2 + 2°20'

= N84°10'E

49. For the 2D truss with the applied loads shown below, the strain energy in the member XY is __________ kN-m. For member XY, assume AE = 30 kN, where A is cross-section area and E is the modulus of elasticity.



47. A non-homogenous soil deposit consists of a silt layer sandwiched between a fine-sand layer at top and a clay layer below. Permeability of the silt layer is 10 times the permeability of the clay layer and one-tenth of the permeability of the sand layer. Thickness of the silt layer is 2 time the thickness of the sand layer and two-third of the thickness of the clay layer. The ratio of equivalent horizontal and equivalent vertical permeability of the deposit is ________.

Answer: 10.967

Exp:

H_1	(1)	K_1	fine sand
H_2	(2)	K_2	silt
H_3	(3)	K_3	clay

$$k_2 = 10k_3 = \frac{1}{10}k_1$$

$$\Rightarrow k_1 = 10k_2$$

$$= 10 \times 10k_3$$

$$k_1 = 100\ k_3$$

$$k_1 = 10k_2$$

$$H_2 = \frac{2}{3}H_3 \Rightarrow H_3 = \frac{3}{2}H_2 = \frac{3}{2}\times 2H_1 = 3H_1$$

$$H_3 = 3H_1$$

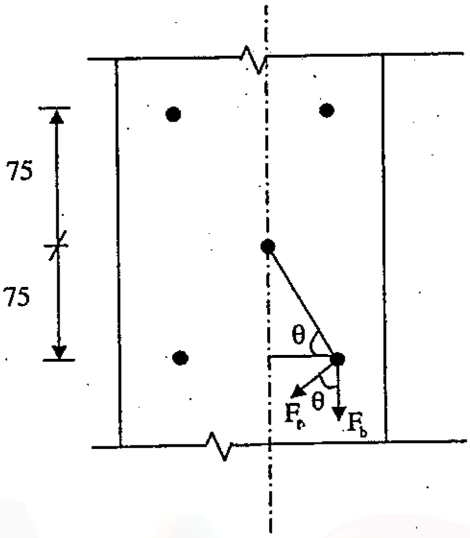
$$K_x = \frac{K_1H_1 + K_2H_2 + K_3H_3}{H_1 + H_2 + H_3} = \frac{k_1H_1 + \frac{1}{10}K_1 \times 2H_1 + \frac{1}{100}K_1 \times 3H_1}{H_1 + 2H_1 + 3H_1}$$

$$k_x = \frac{\left(1 + \frac{2}{10} + \frac{3}{100}\right)K_1H_1}{6H_1} = \frac{123}{100 \times 6}K_1$$

$$k_y = \frac{H_1 + H_2 + H_3}{\frac{H_1}{K_1} + \frac{H_2}{K_2} + \frac{H_3}{K_3}} = \frac{6H_1}{\frac{H_1}{K_1} + \frac{2H_1 \times 10}{K_1} + \frac{3H_1 \times 100}{K_1}} = \frac{6}{321}K_1$$

$$\frac{K_x}{K_y} = \frac{123}{100 \times 6} \times \frac{321}{6} = 10.967$$

Answer: 156.20



Exp: $F_D = \frac{P}{n} = \frac{100}{5} = 20\text{kN}$

$$F_R = \sqrt{F_D^2 + F_t^2 + 2 \times F_D \times F_t \cos\theta}$$

$$= \sqrt{(20)^2 + (141.42)^2 + 2 \times 20 \times 141.42 \times \frac{1}{\sqrt{2}}}$$

= 156.20 kN

$$\cos\theta = \frac{1}{\sqrt{2}}$$

$\Rightarrow \theta = 45°.$

46. Consider a primary sedimentation tank (PST) in a water treatment plant with surface Overflow Rate (SOR) of 40 $m^3/m^2/d$. The diameter of the spherical particle which will have 90 percent theoretical removal efficiency in this tank is __________ µm. Assume that settling velocity of the particles in water is described by Stokes's Law. Given Density of water = 1000 kg/m^3; Density of particle = 2650 kg/m^3; g = 9.81 m^2/s

Kinematic viscosity of water (v) = 1.10×10^{-6} m^2/s

Answer: 22.58

Exp: $\% \text{ removal} = \frac{V_s}{V_s} \times 100$

$V_s' = 0.9\ V_s$

$$= \frac{0.9 \times 40}{86400} \text{m/s}$$

$$\Rightarrow \frac{1}{18} \times d^2 \times \frac{g}{\mu}(\rho_s - \rho_w) = \frac{0.9 \times 40}{86400}$$

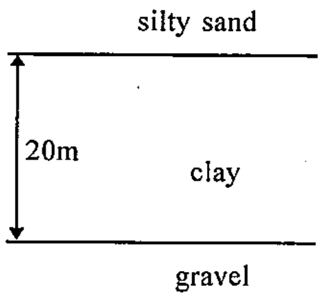
$$\Rightarrow d = \sqrt{\frac{0.9 \times 40 \times 18 \times V.\rho_w}{86480(G_s - 1) \times \rho_w \times g}}$$

$\Rightarrow$d =22.58…m

Where Tv is the time factor and U is the degree of consolidation in %.

If the coefficient of consolidation of the layer is 0.003 cm2/s, the deposit will experience a total of 50 mm settlement in the next ________ years.

Answer: 4.43



Exp: $T_v = \frac{C_v . t}{H^2} = \frac{0.003 \times (2 \times 365 \times 24 \times 3600)}{\left(\frac{20}{2} \times 100\right)^2}$

$= 0.189$

$T_v = \frac{\pi}{4} U^2 = 0.189 \Rightarrow U = 0.49 \le 60\%$

Degree of consolidation for 50 mm settlement

$= \frac{50}{30} \times 0.49 = 0.8166 = 81.7\ \% > 60\%$

$\Rightarrow T_v = 1.784 = 0.933 \log_{10}(100 - U)$

$= 0.608 = \frac{C_v \times t}{d^2}$

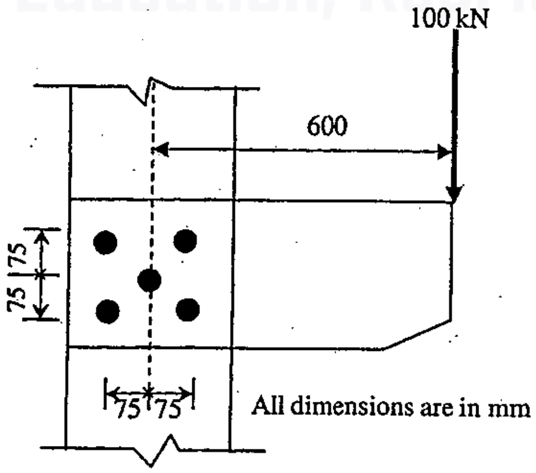
$\Rightarrow t = \frac{0.608 \times H^2}{0.003 \times 10^{-4}} = \frac{0.608 \times (10)^2}{0.003 \times 10^{-4}} s$

$= 202666667$ s

$= 6.43$ yr

Additional number of years $6.43 - 2 = 4.43$ years

45. A bracket plate connected to a column flange transmits a load of 100 kN as shown in the following figure. The maximum force for which the bolts should be designed is ________ kN.



$S_f = 6.92 \times 10^{-3}$

$$\frac{dy}{dx} = \frac{\frac{1}{1000} - 6.92 \times 10^{-3}}{1 - (1.79)^2} = 3.2 \times 10^{-3} = 0.0032$$

42. In a survey work, three independent angles X, Y and Z were observed with weights W_x, W_y, W_z, respectively. The weight of the sum of angles X, Y and Z is given by:

(A) $1 \Big/ \left(\frac{1}{W_x} + \frac{1}{W_y} + \frac{1}{W_z}\right)$

(B) $\left(\frac{1}{W_x} + \frac{1}{W_y} + \frac{1}{W_z}\right)$

(C) $W_x + W_y + W_z$

(D) $W_x^2 + W_y^2 + W_z^2$

Answer: (A)

43. A hydraulic jump is formed in a 2m wide rectangular channel which is horizontal and frictionless. The post-jump depth and velocity are 0.8 m and 1 m/s, respectively. The prejump velocity is ________ m/s. (use = 10 m/s^2).

Answer: 4.94

Exp: B = 2m, y_2 = 0.8m, U = 1m / s

$$F_2 = \frac{U_2}{\sqrt{g.y_2}} = \frac{1}{\sqrt{10 \times 0.8}} = 0.35$$

$$\frac{y_1}{y_2} = -\frac{1}{2} + \frac{1}{2}.\sqrt{1 + 8F_2^2}$$

$$\Rightarrow \frac{y_1}{0.8} = -\frac{1}{2} + \frac{1}{2}.\sqrt{1 + 8 \times (3.5)^2} = 0.203$$

$\Rightarrow y_1 = 0.203 \times 0.8 = 0.162$ m

$Q = B.y_2 \,.\, V_2 = B.y_1 \, V_1$

$\Rightarrow 0.8 \times 1 = 0.162 \times V_1$

$\Rightarrow V_1 = 4.94$ m/s.

44. A 20 m thick clay layer is sandwiched between a silty sand layer and a gravelly sand layer. The layer experiences 30 mm settlement in 2 years.

Given

$$T_v = \begin{cases} \frac{\pi}{4}\left(\frac{U}{100}\right)^2 & \text{for } U \le 60\% \\ 1.781 - 0.933 \log_{10}(100 - U) & \text{for } U > 60\% \end{cases}$$

Exp: $f(z)=\dfrac{9}{(z-1)(z+2)^2}$

z = 1 is a simple pole

z = –2 is a pole of order 2

$$[\text{Res}\, f(z)]_{z=1}=\lim_{z\to 1}(z-1)\frac{9}{(z-1)(z+2)^2}$$

$$=\frac{9}{9}=1$$

$$[\text{Res}\, f(z)]_{z=2}=\frac{1}{1!}\lim_{z\to 2}\left[(z-2)^2\frac{9}{(z-1)(z+2)^2}\right]$$

$$=\lim_{z\to -2}\frac{-9}{(z-1)^2}$$

$$=\frac{-9}{9}=-1$$

41. A short reach of a 2 m wide rectangular open channel has its bed level rising in the direction of flow at a slope of 1 m in 10000. It carries a discharge of 4 m3/s and its Manning's roughness coefficient is 0.01. The flow in this reach is gradually varying. At a certain section in this reach, the depth of flow was measured as 0.5m. The rate of change of the water depth with distance, dy/dx, at this section is ________ (use $g = 10\ m/s^2$).

Answer: 0.0032

Exp: Adverse slope $= -\dfrac{1}{10000}$

$\theta = 4\ m^3/s$, n 0.01, y = 0.5m

$$\frac{dy}{dx}=\frac{S_0-S_f}{1-F_l^2}$$

$$F_r=\frac{V}{\sqrt{gy}}=\frac{Q}{By\sqrt{gy}}==\frac{4}{2\times0.5\times\sqrt{10\times5}}=1.79$$

$$Q=\frac{1}{n}AR^{2/3}S_f^{1/2}$$

$$S_f^{1/2}=\frac{Q\times n}{A\times R^{2/3}}=\frac{4\times0.01}{2\times0.5\times\left(\dfrac{2\times0.5}{2+1}\right)^{2/3}}$$

The vehicle requires 174 m to slow down to 30 km/hr

So, minimum distance, X = 174 – 32 = 142 m.

39. The quadric equation $x^2 - 4x + 4 = 0$ is to be solved numerically, starting with the initial guess $x_0 = 3$. The Newton-Raphson method is applied once to get a new estimate and then the Secant method is applied once using the initial guess and this new estimate. The estimated value of the root after the application of the Secant method is ________.

Answer: 2.333

Exp: $f(x) = x^2 - 4x+4$

$x_0 = 3$

$f'(x) = 2x - 4$

By Newton Raphson method $x_1 = x_0 - \dfrac{f(x_0)}{f'(x_0)}$

$$= 3 - \frac{1}{2} = 2.5$$

For secant method let $x_0 = 2.5$ and $x_1 = 3$

By secant method $x_2 = x_1 - \dfrac{x_1 - x_0}{f(x_1) - f(x_0)} f(x_1)$

$$= 3 - \frac{(3-2.5)}{f(3) - f(2.5)} f(3)$$

$$= 3 - \frac{0.5}{1-(0.25)} \times 1$$

$$= 3 - \frac{0.5}{0.75}$$

$$= 3 - 0.6667$$

$$= 2.333$$

40. Consider the following complex function:

$$f(z) = \frac{9}{(z-1)(z-2)^2}$$

Which of the following one of the residues of the above function?

(A) –1 (B) 9/16 (C) 2 (D) 9

Answer: (A)

37. Two reservoirs are connected through a 930 m long, 0.3 m diameter pipe, which has a gate valve. The pipe entrances is sharp (loss coefficient = 0.5) and the valve is half-open (loss coefficient = 5.5). The head difference between the two reservoirs is 20 m. Assume the friction factor for the pipe as 0.03 and $g = 10\ m/s^2$. The discharge in the pipe accounting for all minor and major losses is ________ m^3/s.

Answer: 0.1413

Exp: Total loss = 20 m

$$\Rightarrow 20 = \frac{0.5\times v^2}{2g} + \frac{f\times L}{d}\times\frac{v^2}{2g} + \frac{v^2}{2g}$$

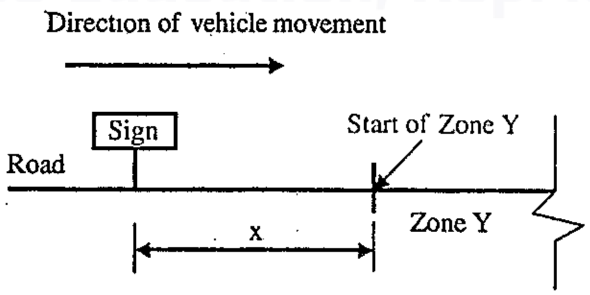
$$\Rightarrow 20\times 2\times 10 = 0.5\,v^2 + \frac{0.03\times 930\times v^2}{0.3} + 5.5v^2 + v^2$$

$$\Rightarrow v^2 = \frac{400}{100} = 4$$

$$\Rightarrow v = 2m/s$$

$$Q = \frac{\pi}{4}\times d^2\times v = \frac{\pi}{4}\times(0.3)^2\times 2 = 0.1413\, m^3/s$$

38. A sign is required to be put up asking drivers to slow down to 30 km/h before entering Zone Y (see figure). On this road, vehicles require 174 m to slow down to 30 km/h (the distance of 174 m includes the distance travelled during the perception-reaction time of drivers). The sign can be read by 6/6 vision drivers from a distance of 48 m. The sign is placed at distance of x m from the start of Zone Y so that even a 6/9 vision driver can slow down to 30 km/h before entering the zone. The minimum value of x is ________ m.



Answer: 142

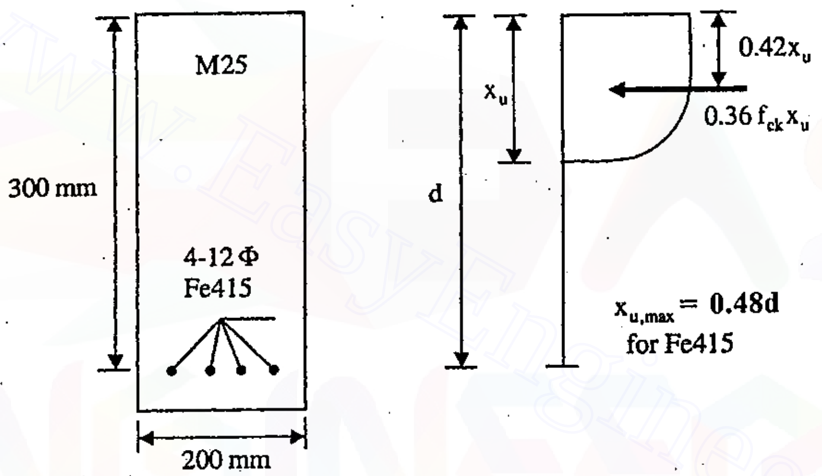
Exp: For a 6/6 person, driver can see from a distance of 48 m.

For a 6/9 person, driver can see from distance $48\times\frac{6}{9} = 32\,m$

Exp: $\frac{\rho VD}{\mu} = Re \rightarrow$ dimensionles parameter

$$\frac{F_D\left(kg - m/s^2\right)}{\rho\left(\frac{kg}{m^3}\right)V^2\left(\frac{m^2}{s^2}\right)\times D^2\left(m^2\right)} \rightarrow \text{dimensionless parameter}$$

36. Consider the singly reinforced beam section given below (left figure). The stress block parameters for the cross-section from IS:456-2000 are also given below (right figure). The moment of resistance for the given section by the limit state method is ________ kN-m.



Answer: 42.82

Exp: $A_{st} = 4 \times \frac{\pi}{4} \times (12)^2 = 453\ mm^2$

$0.36\ f_{ck}.b.x_u = 0.87\ f_y\ A_{st}$

$$\Rightarrow x_u = \frac{0.87\ f_y\ A_{st}}{0.36\ f_{ck}.\ b} = \frac{0.87 \times 415 \times 453}{0.36 \times 25 \times 200}$$

$= 90.86$ mm

$x_{u \cdot max} = 0.48\ d$

$= 0.4 \times 300 = 120$ mm

$x_u < x_{u.max}$ so U.R. section

$M_u = 0.87 \times f_y \times A_{st} \times (d - 0.42\ x_u)$

$= 0.87 \times 415 \times 453 \times (300 - 0.42 \times 90.86) = 42.82$ kNm

Time(hr)	0	2	4	6	8	10	12	14	16	18	20	22	24
Unit hydrograph ordinate(m^3/s)	0	0.6	3.1	10	13	9	5	2	0.7	0.3	0.2	0.1	0

Answer: 22

Exp:

Time	UHO	S-curve Addition	S_A
0	0		0
2	0.6		0.6
4	3.1	0	3.1
6	10	0.6	10.6
8	13	3.1	16.1
10	9	10.6	19.6
12	5	16.1	21.1
14	2	19.6	21.6
16	0.7	21.1	21.8
18	0.3	21.6	21.9
20	0.2	21.8	22
22	0.1	21.9	22
24	0	22	22

Maximum S-curve ordinate is 22.

35. The drag force, F_D, on a sphere kept in a uniform flow field depends on the diameter of the sphere, D; flow velocity, V; fluid density, ρ; and dynamic viscosity, μ. Which of the following options represents the non-dimensional parameters which could be used to analyze this problem?

(A) $\frac{F_D}{VD}$ and $\frac{\mu}{\rho VD}$

(B) $\frac{F_D}{\rho VD^2}$ and $\frac{\rho VD}{\mu}$

(C) $\frac{F_D}{\rho V^2D^2}$ and $\frac{\rho VD}{\mu}$

(D) $\frac{F_D}{\rho V^3D^3}$ and $\frac{\mu}{\rho VD}$

Answer: (C)

Exp: $\frac{V}{1+e}=\frac{V_x}{1+e_1}=\frac{V_y}{1+e_2}=\frac{V}{1+e_3}$

$\gamma_d=\frac{G}{1+e}\cdot\gamma_w \Rightarrow 16.2=\frac{2.67}{1+e}\times 10$

$\Rightarrow e = 0.648$

$\frac{5000}{1.648}=\frac{V_x}{1.6}=\frac{V_y}{1.7}=\frac{V_z}{1.64}$

$\Rightarrow$ Vx = 4854.36 m^3

Vy = 5157.76 m^3

Vz = 4975.73 m3

Let, C = cost of excavation per m^3

C_x = C × 4854.36 + 2C × 140 × 4854.36 = 1.364 × 10^6 C

C_y = C × 5157.76 + 2C × 80 × 5157.76 = 0.83 × 10^6 C

Cz = C × 4975.73 + 2C × 100 × 4975.33 = 1.0 × 10^6 C

Total cost of site Y is minimum..

33. The concentration of Sulfur Dioxide (SO_2) is ambient atmosphere was measured as $30\mu g / m^3$. Under the same conditions, the above SO^2 concentration expressed in ppm is ___.

Given : 3 P / (RT) = 41.6mol / m^3 ; where P=Pressure; T=Temperature ; R=universal gas constant; Molecular weight of SO^2 = 64.

Answer: 0.0133

Exp: 1 m^3 of air has 30 µg SO_2

10^6 m^3 of air has 30g SO_2

$= \frac{30}{64\times 41.6}$ mol SO_2

$V=\frac{nRT}{P}=\frac{n}{P/RT}=\frac{30/64}{41.6}\frac{mol}{mol/m^3}$

Concentration of SO in ppm 0.0113ppm

34. The 4-hr unit hydrograph for a catchment is given in the table below. What would be the maximum ordinate of the S-curve 3 (in m^3/s) derived from this hydrograph?

Answer: 51

Exp: $\frac{M_c}{\rho_c}+\frac{M_s}{\rho_s}+\frac{M_a}{\rho_a}+V_w+V_a=1$

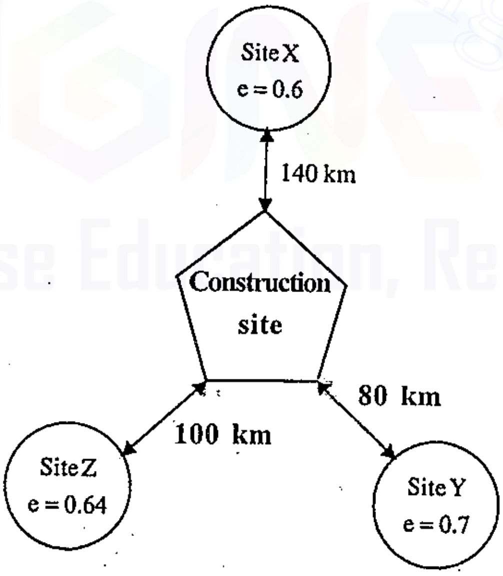
$$\Rightarrow \frac{368}{3.14\times1000}+\frac{606}{2.67\times1000}+\frac{1155}{2.74\times1000}+V_v=1.0$$

$$\Rightarrow 0.117 + 2.227 + 0.421 + 0.184 + V_v = 1.0$$

$$\Rightarrow V_v = 0.051$$

$$= 0.051 \times 1000 = 51 = 50.32\ 1/m^3$$

32. An earth embankment is to be constructed with compacted cohesionless soil. The volume of the embankment is 5000 m^3 and the target dry unit weight is 16.2 kN/m^3.Three nearby sites (see figure below) have been identified from where the required soil can be transported to the construction site. The void ratios (e) of different sites are shown in the figure. Assume the specific gravity of soil to be 2.7 for all three sites. If the cost of transportation per km is twice the cost of excavation per m^3 of borrow pits, which site would you choose as the most economic solution? (Use unit Weight of water =10 kN / m^3) .



(A) Site X (B) Site Y (C) Site Z (D) Any of the sites

Answer: (B)

$$\Delta\sigma_0 = \frac{1500}{\frac{\pi}{4}(3+6+6)^2} = 8.488\ \text{kN/m}^2$$

$= 0.0532$ m

$\Delta H = 53.236$ mm

30. Consider the following differential equation:

Which of the following is the solution of the above equation (c is an arbitrary constant)?

(A) $\frac{x}{y}\cos\frac{y}{x} = c$ (B) $\frac{x}{y}\sin\frac{y}{x} = c$ (C) $xy\cos\frac{y}{x} = c$ (D) $xy\sin\frac{y}{x} = c$

Answer: (C)

Exp: Given D.E

$$x\,(ydx + xdy)\cos\frac{y}{x} = y\,(xdy - ydx)\sin\frac{y}{x}$$

$$\Rightarrow (ydx + xdy)\cos\frac{y}{x} + \left(-\sin\frac{y}{x}\right) y\,(xdy - ydx) = 0$$

$$\Rightarrow (ydx + xdy)\cos\left(\frac{y}{x}\right) + \left(-\sin\frac{y}{x}\right)\frac{y(xdy - ydx)}{x} = 0$$

$$\Rightarrow (ydx + xdy)\cos\left(\frac{y}{x}\right) + (xy)\left(-\sin\frac{y}{x}\right)\left(\frac{(xdy - ydx)}{x^2}\right) = 0$$

By observing, the above equation is $d\left((xy)\cos\frac{y}{x}\right) = 0$

Byintegrating,xycos $\left(\frac{y}{x}\right) = c$

31. The composition of an air-entrained concrete is given below:

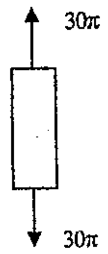
Water	:	184 kg / m
Ordinary PortlandCement(OPC)	:	368 kg / m
Sand	:	606kg / m
Coarse aggregate	:	1155 kg / m

Assume the specific gravity of OPC, sand and coarse aggregate to be 3.14, 2.67 and 2.74, respectively, The air content is________ liters/ m^3 .

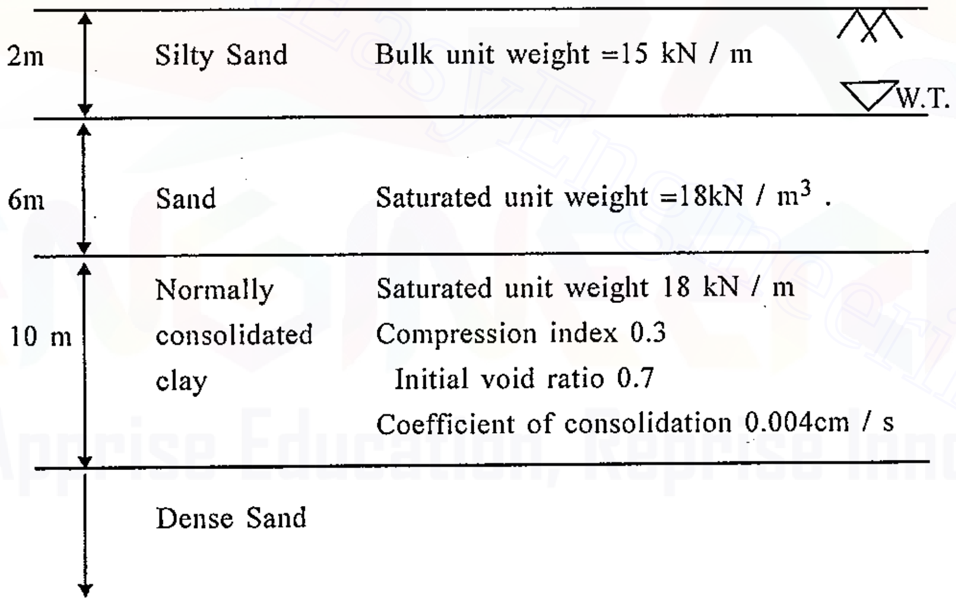
$$= \frac{4\times 30\pi\times 10^3\times 1500}{\pi\times 10\times 10\times 2\times 10^5}$$

$= 9$ mm

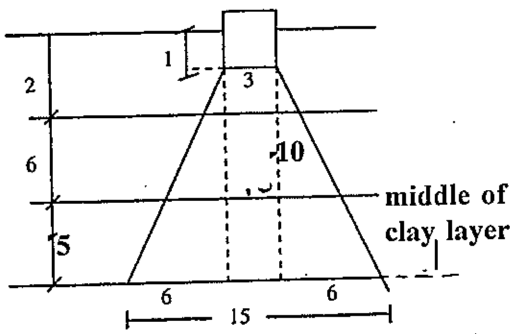
$\Delta = \Delta_1 + \Delta_2 = 15$ mm



29. A water tank is to be constructed on the soil deposit shown in the figure below. A circular footing of diameter 3m and depth of embedment 1m has been designed to support the tank. The total vertical load to be taken by the footing is 1500 kN. Assume the unit weight of water as $10 kN/m^3$ and the load dispersion pattern as 2V:1H. The expected settlement of the tank due to primary consolidation of the clay layer is ____ mm.



Answer: 53.236



Exp: Settlement $= \frac{C_c}{1+e_0} H_0 \log\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right)$

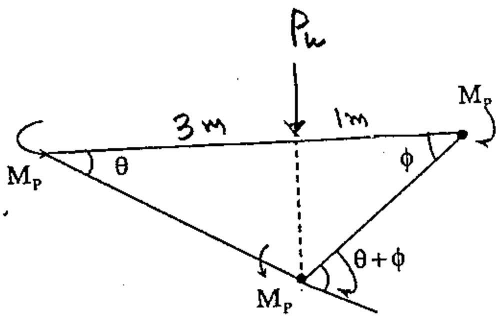
$\sigma_0 = 15 \times 2 + (18 - 10) \times 6 + (18 - 10) \times 5$

$= 118 kN/m^2$

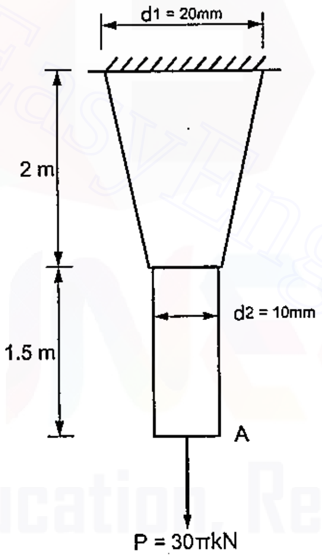
$$\Rightarrow \quad 10M_p \cdot \theta + P_U \times 3\theta \times \frac{L}{4}$$

$$\Rightarrow \quad P_U = \frac{40}{3} \cdot \frac{M_p}{L} = 13.33 \frac{M_p}{L}$$

So, C = 13.33



28. A tapered circular rod of diameter varying from 20 mm to 10 mm is connected to another uniform circular rod of diameter 10 mm as shown in the following figure. Both bars are made of same material with the modulus of elasticity, $E = 2 \times 10^5$ MPa. When subjected to a load $P = 30\pi$ kN, the deflection at point A is ____ mm.



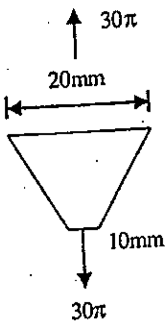
Answer: 15

Exp: $\Delta_1 = \frac{4P.L}{\pi d_1 d_2 \times E}$

$$= \frac{4 \times 30\pi \times 10^3 \times 2000}{\pi \times 20 \times 10 \times 2 \times 10^5}$$

$= 6$ mm

$$\Delta_2 = \frac{P \times L}{A.E}$$



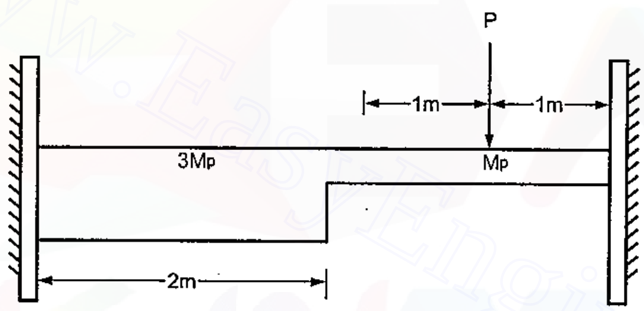
directionalderivative $= \nabla u . \hat{a}$

$$= (4i - 12j + 3k).\frac{(i + j - 2k)}{\sqrt{6}}$$

$$= \frac{4 - 12 - 6}{\sqrt{6}}$$

$$= \frac{-14}{\sqrt{6}} = -5.72$$

27. For formation of collapse mechanism in the following figure, the minimum value of P_u is cM_p/L. M_p and $3M_p$ denote the plastic moment capacities of beam sections as shown in this figure. The value of c is ____ .



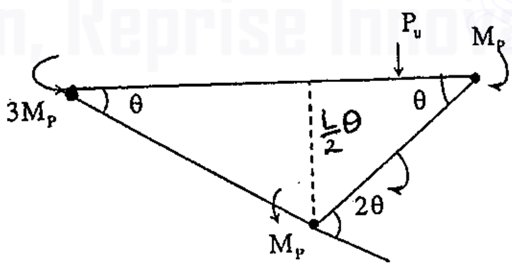
Answer: 13.33

Exp: **Mechanism-I**

$$4M_p . \theta + M_p (2\theta) + MP.\theta = P_U \times \frac{L}{4} \times \theta$$

$$\Rightarrow 6M_p.\theta = P_U.\frac{L}{4}.\theta$$

$$\Rightarrow P_U = 24\frac{M_P}{L}$$



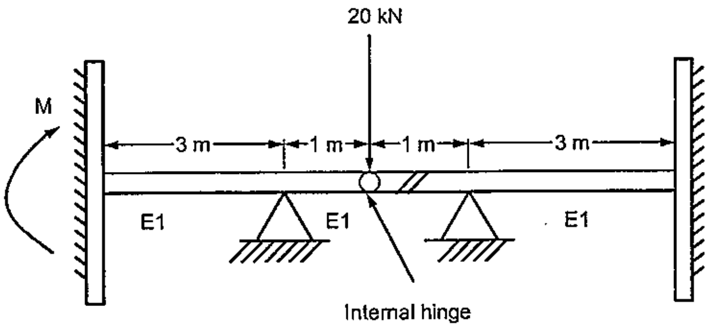
Mechanism-II

1.q = 3.q f = 3q

$$3M_p . \theta + M_p (\theta + \phi) + M_p .\theta = P_U \times \frac{L}{4} \phi$$

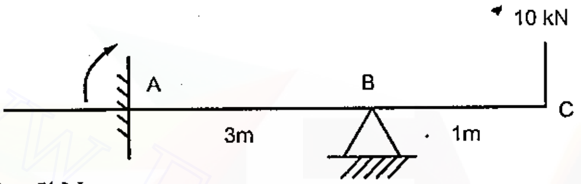
$$\Rightarrow 3M_p . \theta + M_p (\theta + 3\theta) + M_p .3\theta = P_U \times 3\theta \times \frac{L}{4}$$

25. For the beam shown below, the value of the support moment M is ____ kN-m.



Answer: 5

Exp:



$$M_A = \frac{10 \times 1}{2} = 5 kN - m$$

$M_{BC} = 10 \times 1 = -10$ kN.m

$\therefore$ $M_{BA} = +10$ kN.m

$\therefore$ $M_{AB} = \frac{10}{2}$ kN.m (half moment carry over)

Q. No. 26-55 carry Two Marks Each

26. The directional derivative of the field $u(x, y, z) = x^2 - 3yz$ in the direction of the vector $(\hat{i} + \hat{j} - 2\hat{k})$ at point (2, –1, 4) is ____ .

Answer: -5.72

Exp: Let $u(x, y, z) = x^2 - 3yz$

$\vec{a} = i + j - 2k$ and P (2, –1, 4)

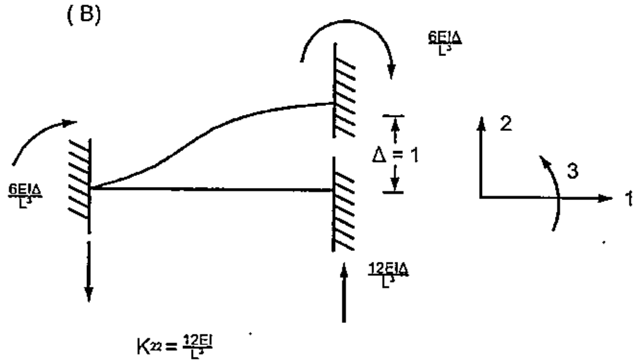
$$\nabla u = i\frac{\partial u}{\partial x} + j\frac{\partial u}{\partial y} + k\frac{\partial u}{\partial z}$$

$= 12x + j(-3z) + k(-3y)$

$$\nabla u|_{(2,-1,4)} = 4i - 12j + 3k$$

$$|\vec{a}| = \sqrt{1+1+4} = \sqrt{6}$$

Exp:



22. The penetration value of a bitumen sample tested at 25°C is 80. When this sample is heated to 60 °C and tested again, the needle of the penetration test apparatus penetrates the bitumen sample by d mm. The value of d CANNOT be less than ____ mm.

Answer: 8

23. The development length of a deformed reinforcement bar can be expressed as $(1/k)(\phi\sigma_s / \tau_{bd})$. From the IS:456-2000, the value of k can be calculated as ____ .

Answer: 6.4

Exp: $L_d = \dfrac{\phi\sigma_s}{4\tau_{bd}}$ But for deformed bars τ_{bd} is increased by 60%.

So,

$$Ld = \frac{\phi\sigma_{st}}{4\times1.6\times\tau_{bd}} = \frac{\phi\sigma_s}{6.4\,\tau_{bd}}$$

So, k = 6.4.

24. Total Kjeldahl Nitrogen (TKN) concentration (mg/L as N) in domestic sewage is the sum of the concentrations of:

(A) organic and inorganic nitrogen in sewage

(B) organic nitrogen and nitrate is sewage

(C) organic nitrogen and ammonia is sewage

(D) ammonia and nitrate in sewage

Answer: (C)

Exp: Total Kjeldahl Nitrogen (TKN) = Ammonia (60%) + Organic Nitrogen (40%)