GATE Questions

01. GATE (CSE) 1987, Q.1

(xv) In a circular linked list organization, insertion of a record involves modification of (2)

A. One pointer
B. Two pointers
C. Three pointers
D. No pointer

(xviii) Let P be a quick sort program to sort number in ascending order. Let t_1 and t_2 be the time taken by the program for the inputs [1 2 3 4 5] and [5 4 3 2 1] respectively. Which of the following holds? (2)

A. $t_1 = t_2$
B. $t_1 > t_2$
C. $t_1 < t_2$
D. $t_1 = t_2 + 5 \log 5$

02. GATE (CSE) 1987, Q.6(b)

Construct a binary tree whose preorder traversal is K L N M P R Q S T and inorder traversal is N L K P R M S Q T (6)

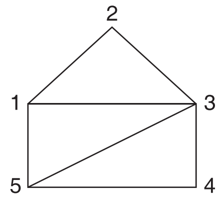
03. GATE (CSE) 1987, Q.9

(a) How many binary relations are there on a set A with n elements? (2)

(b) How many one-to-one functions are there from a set A with n elements onto itself? (2)

(c) Show that the number of odd degree vertex in a finite graph is even. (3)

(d) Specify an adjacency-lists representation of the undirected graph. (3)



04. GATE (CSE) 1987, Q.10

(a) Solve the recurrence equations (2)

$$T(n) = T(n - 1) + n$$
$$T(1) = 1$$

(b) What is the generating function G(z) for the sequence of Fibonacci numbers? (2)

05. GATE (CSE) 1988, Q.1 (iii)

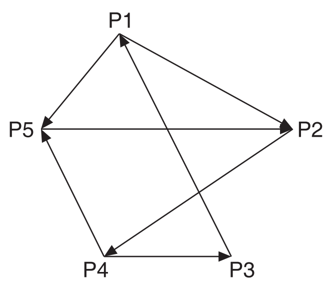
Quick sort is ………………. efficient than heapsort in the worst case. (2)

06. GATE (CSE) 1988, Q.2

Answer the following question briefly.

(i) If the transportation problem is solved using some version of the simplex algorithm, under what conditions will the solution always have integer values? (2)

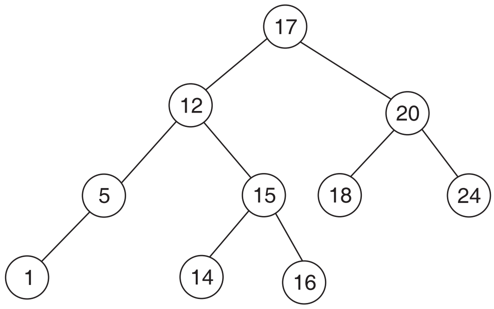
(xvi) Write the adjacency matrix representation of the graph given in figure below: (2)



07. GATE (CSE) 1988, Q.7

(i) Define the height of a binary tree or sub-tree and also define a height balanced (AVL) tree. (2)

(ii) Mark the balance factor of each mode on the tree given in Figure 7.1 and state whether it is height-balanced. (2)



(iii) Into the same tree given in 7(ii) above, insert the integer 13 and show the new balance factors that would arise if the tree is no rebalanced. Finally, carry the required rebalancing of the tree and show the new tree with the balance factors on each mode. (6)

08. GATE (CSE) 1988, Q.13(iv)

Solve the recurrence equations (2)

$$T(n) = T(n/2) + 1$$
$$T(1) = 1$$

09. GATE (CSE) 1989, Q.1(vii)

A hash table with ten buckets with one slot per bucket is shown in **Figure 1**, with the symbols S1 to S7 entered into it using some hashing function with linear probing. The worst case number of comparison required when the symbol being searched is not in the table is .... (2)

0	S7
1	S1
2	
3	S4
4	S2
5	
6	S5
7	
8	S6
9	S3

Figure 1

10. GATE (CSE) 1989, Q.2(iii)

Match the pair in the following questions: (2)

(A)	O(log n)	(p)	Heap sort
(B)	O(n)	(q)	Depth-first-search
(C)	O(nlog n)	(r)	Binary search
(D)	$O(n^2)$	(s)	Selection of kth smallest element in a set of n elements

11. GATE (CSE) 1989, Q.3(ix) (2)

Which one of the following statement(s) is/are FALSE? (2)

(A) Overlaying is used to run a program which is longer than the address space of the computer.

(B) Optimal binary search tree construction can be performed efficiently by using dynamic programming

(C) Depth-first search cannot be used to find connected component of a graph.

(D) Given the prefix and postfix walks over a binary tree, the binary tree can be uniquely constructed.

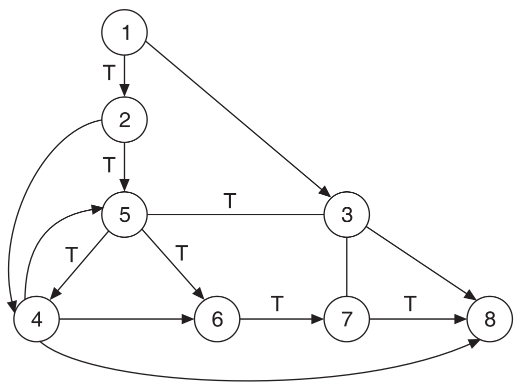
12. GATE (CSE) 1989, Q.4

Provide the short answer to the following questions:

(i) How many substrings (of all length inclusive) can be formed from a character string of length n? Assume all characters to be distinct. Prove your answer. (2)

(ii) Compute the postfix equivalent of the following infix arithmetic expression where a+b*c+d*e↑f; where ↑ represents exponentiation. Assume normal operator precedence. (2)

(vii) In the graph shown below, the depth-first spanning tree edges are marked with 'T'. Identify the forward, backward and cross edges. (2)



13. GATE (CSE) 1989, Q.9

An input file has 10 records with keys given below:

25 7 34 2 70 9 61 16 49 19

This is to be sorted in non-decreasing order.

(i) Sort the input file using QUICKSORT by correctly positioning the first element of the file/subfile. Show the subfiles obtained at all intermediate steps. Use square brackets to demarcate subfiles. (6)

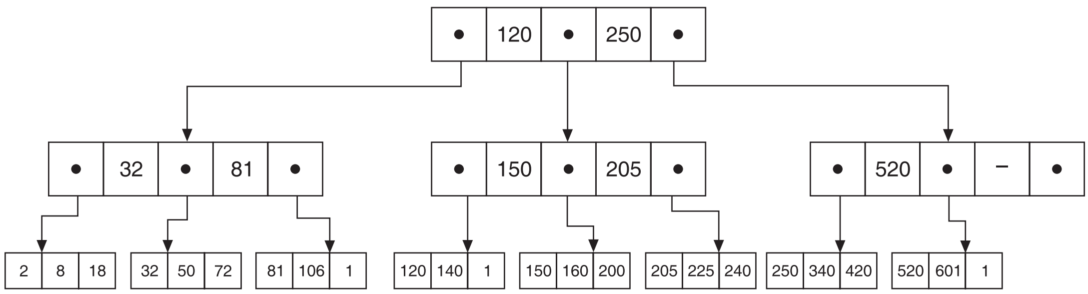
(ii) Sort the input file using 2-way-MERGESORT showing all major intermediate steps. Use square brackets to demarcate subfiles. (4)

14. GATE (CSE) 1989, Q.10(a)

Will recursion work correctly in a language with static allocation of all variables? Explain. (3)

15. GATE (CSE) 1989, Q.12(a)

The following figure shows a B-tree where key values are indicated in the records. Each block can hold upto three records. A record with a key value 34 is inserted into the B-tree. Obtained the modified B-tree after insertion. (6)



16. GATE (CSE) 1989, Q.13(b)

Find a solution to the following recurrence equation: (4)

$$T(n) = \sqrt{n} + T(n/2)$$
$$T(1) = 1$$

17. GATE (CSE) 1990, Q.2

Match the pair in the following questions.

(v) (2)

(A) Pointer data type	(p) Type conversion
(B) Activation record	(q) Dynamic data structure
(C) Repeat	(r) Recursion
(D) Coercion	(s) Nondeterministic loop

(vii) (2)

(A) Strassen's matrix multiplication algorithm	(p) Greedy algorithm
(B) Kruskal's minimum spanning tree algorithm	(q) Dynamic programming
(C) Bi-connected components algorithm	(r) Divide-and-Conquer
(D) Floyd's shortest path algorithm	(s) Depth-first search

(viii) (2)

(A) Heap construction	(p) $\Omega(n\log_{10} n)$
(B) Constructing hash table with linear probing	(q) O(n)
(C) AVL tree construction	(r) $O(n^2)$
(D) Digital trie construction	(s) $O(n \log_2 n)$

18. GATE (CSE) 1990, Q.3

Choose the correct alternatives (more than one may be correct):

(iii) The number of rooted binary trees with n nodes is: (2)

(A) Equal to the number of ways of multiplying (n + 1) matrices.

(B) Equal to the number of ways of arranging n out of 2n distinct elements.

(C) Equal to $\frac{1}{(n+1)}\binom{2n}{n}$

(D) Equal to n!

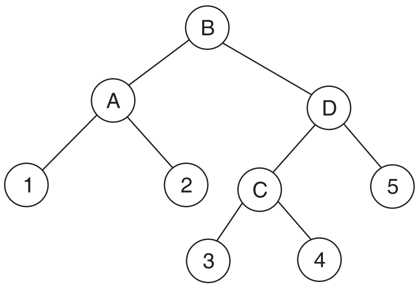
(v) The complexity of comparison based sorting algorithm is: (2)

(A) $\theta(n \log n)$ (B) $\theta(n)$

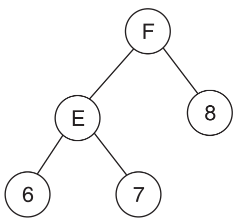
(C) $\theta(n^2)$ (D) $\theta(n\sqrt{n})$

19. GATE (CSE) 1990, Q.13

(a) Consider the height balanced tree T_1, with values stored at only the leaf nodes shown in the given figure



(i) Show how to merge to the tree T_1 elements from tree T_2 shown in the given figure using the node D of tree T_1: (3)



(ii) What is the time complexity of a merge operation on balanced trees T_1 and T_2 where T_1 and T_2 are of height h_1 and h_2 respectively, assuming rotation scheme are given. Give reasons. (3)

(b) Consider a hash table with chaining scheme for overflow handling:

(i) What is the worst-case timing complexity of inserting n elements into such a table? (2)

(ii) For what type of instances does this hashing scheme take the worst case time for insertion? (2)

20. GATE (CSE) 1990, Q.16

The following algorithm (written in pseudo-Pascal) works on a undirected graph G

```
Program Explore (G)
   procedure Visit (u)
        begin
             if Adj (u) is not empty
                  { comment : Adj (u) is the list of edges incident to u}
             then
                  begin
                            select an edge from Adj (u);
                            Let an edge e = (u, v);
                            remove e from Adj (u) and Adj (v);
                            Visit (v);
                  end
             else
                  mark u as a finished vertex and remove u from LIST;
                  {Comment : LIST is the set of vertices in the graph}
        end;
begin
        while LIST is not empty
             do
                  begin
                       Let v ∈ LIST;
                       Visit (v);
                  end
end
```

Note: Initially Adj (u) is the list of all edges incident to u and LIST is the set of all vertices in the graph. They are globally accessible.

What kinds of sub-graphs are obtained when this algorithm traverses the graphs G1 and G2 shown in Figure 1 and Figure 2, respectively? (5)

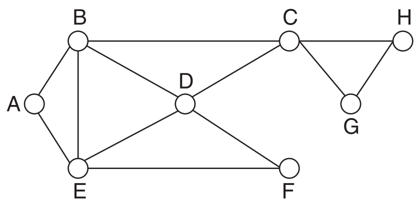


Figure 1

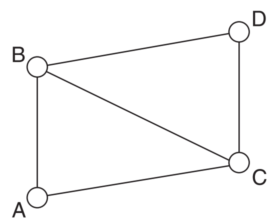


Figure 2

(a) What is the commonly known traversal of graphs that can be obtained from the sub-graphs generated by *Program Explore*? (2)

(b) Show that the time complexity of the procedure is O(v + e) for a graph with v vertices and e edges, given that each vertex can be accessed and removed from LIST in const time. Also show that all the edges of the graph are traversed. (3)

21. GATE (SEA: Computational Method) 1990

I.1 Choose the correct alternatives (Exactly one choice is correct) and write the corresponding letters only:

1.1 The maximum number of nodes in a binary tree of level k, $k \geq 1$ is (2)

(A) $2^k + 1$

(B) $2^k - 1$

(C) 2^{k-1}

(D) $2^{k-1} - 1$

1.16 The average case complexity of quick sort algorithm for sorting n elements is (2)

(A) (n log log n)

(B) (n^2)

(C) (n log n)

(D) (n $\log^2$ n)

I.3 Construct a binary tree whose preorder and inorder sequences are A B M H E O C P G J D K L I N F and H M C O E B A G P K L D I N J F respectively, where A, B, C, D, E, ………. are the labels of the tree nodes. Is it unique? (3)

I.4 Give the necessary number of passes and interchanges to sort the sequence 7, 21, 6, 8, 30, 18, 4, 12 in increasing order by using bubble sort method. (4)

I.8 The following incomplete Pascal procedure merges two sorted lists

(x[l], x[l+1], ……., x[m], $m > l$ and

(y[i], y[i+1], ……., y[j], $j > i$ where

x[l].key ≤ x[l+1].key ≤ ………….. ≤ x[m].key

and

y[i].key ≤ y[i+1].key ≤ ………….. ≤ y[j].key and it obtains in a sorted list

(z[1], z[2], ………. z[k] where $k = m + j - l - i + 2$.

Complete the procedure by replacing each '?' by the appropriate operator from the procedure set {>, <, =>, <=, <>, or, and, not}

procedure **MERGE** (var x, y, z: a file; l, m, i, j: integer); var k, s, t, u: integer;

```
begin
   s: = l;
```

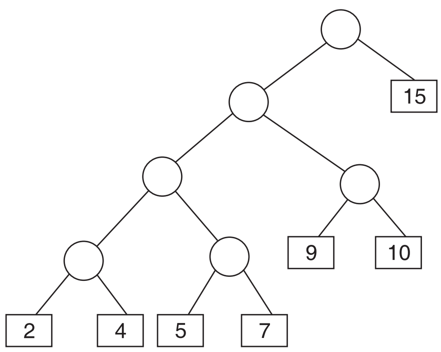
```
        k: = 1;
        u: = I;
        while[(s?m)?(j?u)] do
             begin
                  if x[s].key?y[u].key
                       then
                            begin
                                 z[k]: = x[s];
                                 s: = s+1
                            end
                       else
                            begin
                                 z[k]: = y[u];
                                 u: = u+1
                            end
                  k: = k+1;
             end
        if s ? m
             then
                            for t: = u to j do
                            z[k + t − u]: = y[t]
             else
                            for t: = s to m do
                            z[k + t − s]: = x[t]
    end;
```

22. GATE (CSE) 1991, Q.1

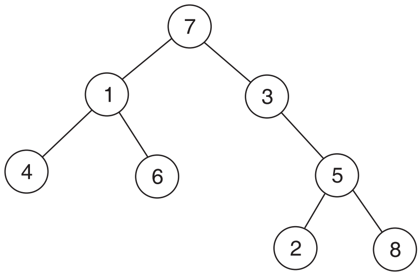
Fill in the blanks:

(vii) The minimum number of comparisons required to sort 5 elements is ______________. (2)

(viii) The weighted external path length of the binary tree in the given figure is ______________. (2)



(ix) If the binary tree in the following figure is traversed in inorder, then the order in which the nodes will be visited is ______________. (2)



(x) Consider the following recursive definition of fib: (2)

fib (n) : = if n = 0 then 1
else if n = 1 then 1
else fib (n–1) + fib (n–2)

The number of times fib is called (including the first call) for an evaluation of fib (7) is ______________.

(xv) The maximum number of possible edges in an undirected graph with n vertices and k components is ______________. (2)

23. GATE (CSE) 1991, Q.2

Match the pairs in the following question by writing the corresponding letters only. (2)

A. The number of distinct binary trees with n nodes (P) $\frac{n!}{2}$

B. The number of binary string of length 2n with equal number of 0's and 1's (Q) $\binom{3n}{n}$

C. The number of even permutations of n objects (R) $\binom{2n}{n}$

D. The number of binary string of length 6n Which are palindromes with 2n 0's (S) $\frac{1}{n+1}\binom{2n}{n}$

24. GATE (CSE) 1991, Q.3

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

(vi) Kruskal's algorithm for finding a minimum spanning tree of a weighted graph G with n vertices and m edges has the time-complexity of: (2)

A. (n^2)
B. (m n)
C. (m + n)
D. (m log n)
E. (m^2)

(vii) The following sequence of operations is performed on a stack: (2)

PUSH (10), PUSH (20), POP, PUSH (10), PUSH (20), POP, POP, POP, PUSH (20), POP.

The sequence of values popped out is:

A. 20, 10, 20, 10, 20
B. 20, 20, 10, 10, 20
C. 10, 20, 20, 10, 20
D. 20, 20, 10, 20, 10
E. None of the above

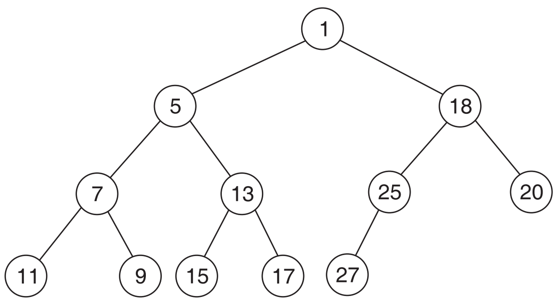
25. GATE (CSE) 1991, Q.14

Consider the binary tree in the given figure:

(a) What structure is represented by the binary tree? (1)

(b) Give the different steps for deleting the node with key 5 so that the structure is preserved. (2)

(c) Outline a procedure in the pseudo-code to delete an arbitrary node from such a binary tree with n nodes that preserves the structure. What is the worst case complexity of your procedure? (3)



26. GATE (CSE) 1991, Q.16(b)

Show that all vertices in an undirected finite graph cannot have distinct degrees, if the graph has at least two vertices. (5)

27. GATE (SEA: Computational Method) 1991

Choose the correct alternatives (exactly one choice is correct) and write the corresponding letters only:

I1.1 The number of different ordered trees with 3 nodes labelled Y, Y, Z are (2)

(A) 16
(B) 8
(C) 12
(D) 24

I1.16 The worst-case time complexity of mergesort for sorting n elements is (2)

(A) (n^2)
(B) (n log n)
(C) $(n^2 \log n)$
(D) (log n)

I3(b) Let A[1: n, 1:n] be a n × n matrix such that A [I, j] = 0 if | i – j | > 1. The entries A [i, j] for which | i – j | ≤ 1 are stored in a one-dimensional array B [1: 3n–2] row-wise. Thus, A[1, 1] is stored in B[1], A[1, 2] in B[2], and so on. Give the formula for computing the index K in array B of an element A[i, j] in terms of i and j. (4)

I4(a) If a tree has n_1 nodes of degree 1, n_2 nodes of degree 2, …. n_m nodes of degree m, give a formula for the number of terminal nodes n0 of the tree in terms of n_1, n_2, …., n_m. (4)

I5(a) Consider three pegs A, B, C and four disks of different sizes. Initially, the four disks are stacked on peg A, in order of decreasing size. The task is to move all the disks from peg A to peg C with the help of peg B. The moves are to be made under the following constraints:

[i] In each step, exactly one disk is moved from one peg to another.

[ii] A disk cannot be placed on another disk of smaller size. If we denote the movement of a disk from one peg to another by y → y, where y, y are A, B or C, then represent the sequence of the minimum number of moves to accomplish this as a binary tree with node labels of the form (y → y) such that the inorder traversal of the tree gives the correct sequence of the moves. If there are n disks, derive the formula for the total number of moves required in terms of n: (4)

27. GATE (CSE) 1992, Q.1

Fill in the blanks.

(ix) Complexity of Kruskal's algorithm for finding the minimum spanning tree of a undirected graph containing n vertices and m edges, if the edges are sorted is, __________. (2)

(x) Maximum number of edges in a planner graph with n vertices is __________. (2)

28. GATE (CSE) 1992, Q.2

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

(vii) A 2-3 tree is a tree such that (2)

(a) all internal nodes have either 2 or 3 children

(b) all paths from root to the leaves have the same length.

The number of internal nodes of a 2-3 tree having 9 leaves could be

(A) 4
(B) 5
(C) 6
(D) 7

(vii) A non-planer graph with minimum number of vertices has (2)

(A) 9 edges, 6 vertices
(B) 6 edges, 4 vertices
(C) 10 edges, 5 vertices
(D) 9 edges, 5 vertices

(viii) Following algorithm (s) can be used to sort n integers in the range [1….n3] in O (n) time (2)

(A) Heap sort
(B) Quick sort
(C) Merge sort
(D) Radix sort

29. GATE (CSE) 1992, Q.3

Write short answers to the following.

(iii) How many edges are there in a forest with p components having n vertices in all? (2)

(iv) Assume that the last element of the set is used as partition element in Quick sort. If n distinct elements from the set [1…n] are to be sorted, give an input for which Quick sort takes maximum time. (2)

30. GATE (CSE) 1992, Q.7

Consider the function F(n) for which the pseudo code is given below:

```
Function F (n)
begin
F1 ← 1
If (n = 1) then F ← 3
    else For I = 1 to n do
        begin
            C ← 0
            For j = 1 to F (n–1) do
                begin C ← C+1 end
            F1 = F1*C
        end
```

F = F1
end
[n is positive integer greater than zero].

(a) Derive a recurrence relation for F(n). (4)

(b) Solve the recurrence relation for a closed form solution of F(n). (6)

31. GATE (CSE) 1992, Q.9

Suggest a data structure for representing a subset S of integers from 1 to n. Following operations on the set S are to be performed in constant time (independent of cardinality of S) (10)

(iii) MEMBER (Y): Check whether Y is in the set S or not

(iv) FIND-ONE (S): If S is non-empty, return one element of the set S (any arbitrary element will do)

(v) ADD(Y): Add integer y to set S

(vi) DELETE(Y): Delete integer y from S

Give pictorial examples of your data structure. Give routines for these operations in an English-like language. You may assume that the data structure has been suitably initialized. Clearly state your assumptions regarding initialization. (10)

32. GATE (SEA: Computational Method) 1992

Choose the correct alternatives (exactly one choice is correct) and write the corresponding letters only:

I1.(a) Suppose one character at a time comes as an input from a string of letters. There is an option either to (i) print the incoming letter or to (ii) put the incoming letter on to a stack. Also a letter from top of the stack can be popped out at any time and printed. The total number of total distinct words that can be formed out of a string of three letters in this fashion, is (2)

(A) 3
(B) 4
(C) 5
(D) 6

I2.(d) A *K*-ary tree is such that every node has either *K* sons or no sons. If *L* and *I* are the number of leaves and internal nodes respectively, then express *L* in terms of *K* and *I*. (2)

I8. Consider three pegs A, B, C and four disks of different sizes. Initially, the four disks are stacked on peg A, in order of decreasing size. The task is to move all the disks from peg A to peg C with the help of peg B. The moves are to be made under the following constraints: (5)

(i) In each step, exactly one disk is moved from one peg to another.

(ii) A disk cannot be placed on another disk of smaller size.

If we denote the movement of a disk from one peg to another by y → y, where y, y are A, B or C, then represent the sequence of the minimum number of moves to accomplish this as a binary tree with node labels of the form (y → y) such that the inorder traversal of the tree gives the correct sequence of the moves.

33. GATE (CSE) 1993, Q.8.1

Consider a simple connected graph G with n vertices and n edges (n>2). Then which of the following statements are true? (2)

(a) G has no cycles
(b) The graph obtained by removing any edges from G is not considered connected
(c) G has at least one cycle
(d) The graph obtained by removing any two edges from G is not considered connected
(e) None of the above.

34. GATE (CSE) 1993, Q.13

Consider a singly linked list having n nodes. The data items d_1, d_2, …., d_n are stored in the n nodes. Let Y be a pointer to the jth node ($1 \le j \le n$) in which d_j is stored. A new data item d stored in a node with address Y is to be inserted. Give an algorithm to insert d into the list to obtain a list having items d_1, d_2, ……, d_{j-1}, d, d_j, …..d_n in that order without using the header. (5)

35. GATE (CSE) 1993, Q.15

Consider the recursive algorithm given below.

```
procedure bubblesort(n)
var I, j: index; temp: item;
begin
    for i:= 1 to n – 1 do
    if [A[i] > A[i+1] then
        begin
            temp    := A[i];
            A[i]    := A[i+1];
            A[i+1]  := temp;
        end
    bubblesort(n–1)
end
```

Let a_n be the number of times the 'if…then…' statement gets executed when the algorithm is run with value n. Set up the recurrence relation by defining an in terms of a_{n-1}. Solve for a_n. (5)

36. GATE (CSE) 1993, Q.26

A stack is used to pass parameters to procedures in a procedure call. (5)

(a) If a procedure P has two parameters as described in procedure definition:

```
procedure P(var x: integer; y: integer);
```

and if P is called by:

P(a,b)

State precisely in a sentence what is pushed onto stack for parameters a and b.

(b) In the generated code for the body of procedure P, how will the addressing of formal parameters y and y differ? (2)

37. GATE (CSE) 1994, Q.1

Choose one of the alternatives for the following questions (2 marks each)

1.5 The number of distinct simple graphs with up to three nodes is

(A) 15
(B) 10
(C) 7
(D) 9

1.6 The recurrence relation that arises in relation to the complexity of binary search is

(A) T(n) = T(n/2) + k, k is a constant
(B) T(n) = 2T(n/2) + k, k is a constant
(C) T(n) = T(n/2) + log n
(D) T(n) = T(n/2) + n.

1.11 In a compact single dimensional array representation for lower triangular matrices (i.e., all the elements above the diagonal are zero) of size n y n, non-zero elements (i.e., elements of the lower triangle) of each row are stored one after another, starting from the first row, the index of the (i, j)th elements of the lower triangular matrices in this new representation is

(A) i + j
(B) i + j – 1
(C) j + $\frac{i(i-1)}{2}$
(D) i + $\frac{j(j-1)}{2}$

1.14 Which of the following permutation can be obtained in the output (in the same order) using a stack assuming that the input is the sequence 1, 2, 3, 4, 5 in that order?

(A) 3, 4, 5, 1, 2
(B) 3, 4, 5, 2, 1
(C) 1, 5, 2, 3, 4
(D) 5, 4, 3, 1, 2

1.15 The number of substrings (of all lengths inclusive) that can be formed from a character string of length n is

(A) n
(B) n^2
(C) $\frac{n(n-1)}{2}$

(D) $\dfrac{n(n+1)}{2}$

1.17 Linked lists are not suitable for data structures for which one of the following problems?

(A) Insertion sort
(B) Binary search
(C) Radix sort
(D) Polynomial manipulation

1.19 Which of the following algorithm design techniques is used in the quicksort algorithm?

(A) Dynamic programming
(B) Backtracking
(C) Divide and conquer
(D) Greedy method.

1.22 Which one of the following statements is false?

(A) Optimal binary search tree construction can be performed efficiently using dynamic programming
(B) Breadth-first search cannot be used to find converted components of a graph
(C) Given the prefix and postfix walks over a binary tree, the binary tree cannot be uniquely constructed
(D) Depth-first search cannot be used to find converted components of a graph

1.23 Consider the following two functions:

$$g1\,(n) = \begin{cases} n^3 & \text{for } 0 \le n \le 10{,}000 \\ n & \text{for } n \ge 10{,}000 \end{cases}$$

$$g1\,(n) = \begin{cases} n & \text{for } 0 \le n \le 100 \\ n^3 & \text{for } n > 100 \end{cases}$$

Which of the following is true?

(A) g1 (n) is O(g2 (n))
(B) g1 (n) is O(n^3)
(C) g2 (n) is O(g1 (n))
(D) g2 (n) is O(n)

38. GATE (CSE) 1994, Q.2.5

Fill in the blanks: (2)

The number of edges in a regular graph of degree d and n vertices are ……………

39. GATE (CSE) 1994, Q.5

A 3-ary tree is a tree in which every internal node has exactly three children. Use the induction to prove that the number of leaves in a 3-ary tree with n internal nodes is 2(n – 1) + 3. (5)

40. GATE (CSE) 1994, Q.7

An array A contains n integers in locations A[0], A[1], ….., A[n – 1]. It is required to shift the elements of the array cyclically to the left by K places, where $1 \leq K \leq n - 1$. An incomplete algorithm for doing this in linear time, without using another array is given below. Complete the algorithm in the blanks. Assume all variables are suitably declared.

```
min: = n;
i: = 0;
while ________________________ do
begin
    temp: = A[i];
    j: = i;
    while ________________________ do
    begin
        A[j]: = ______________________;
        j: = (j+K) mod n;
        if j < min then
            min: = j;
    end;
    A[n + i – K) mod n]: = ______________________;
    i: = ………………………….;
end;
```

41. GATE (CSE) 1994, Q.8

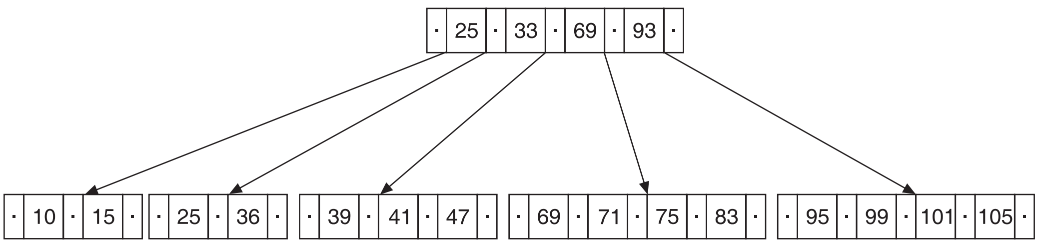
A rooted tree with 12 nodes has its nodes numbered 1 12 in pre-order. When the tree is traversed in post order, the nodes are visited in the order 3, 5, 4, 2, 7, 8, 6, 10, 11, 12, 12, 9, 1. (5)

Reconstruct the original tree from thus information, that is, find the parent of each node, and show the tree diagrammatically.

42. GATE (CSE) 1994, Q.14

Consider the B^+ tree of order d shown in Fig. 7. (A B^+ tree of order d contains between d and 2d keys in each node).

(a) Draw the resulting B^+-tree after 100 is inserted in the tree shown in the figure below (4)



(b) For a B^+-tree of order d with n leaf nodes, the number of nodes accessed during a search is 0 (-——). (2)

43. GATE (CSE) 1994, Q.21

Consider the following recursive function (5)

```
function fib (n: integer); integer;
begin
        if (n = 0) or (n = 1) then fib: = 1
        else fib (n–1) + fib (n–2)
end;
```

The above function is run on a computer with stack of 64 bytes. Assuming that only return address and parameter are passed on the stack, and that an integer value and an address take 2 bytes each, estimate the maximum value of n for which the stack will not overflow. Give reasons for your answer. (5)

44. GATE (CSE) 1994, Q.24

An independent set in a graph is a subset of vertices such that no two vertices in the subset are connected by an edge. An incomplete scheme for greedy algorithm to find a maximum independent set in a tree is given below:

```
V: = Set of all vertices in a tree;
I: = ϕ do
begin
        select a vertex u ∈ V such that
        ________________ ;
        V: = V –{u};
        If u is such that
        ______________ then I: = I U{u}
end;
Output (I);
```

Complete the algorithm by specifying the property of vertex u in each case. (4)
What is the time complexity of the algorithm? (1)

45. GATE (CSE) 1994, Q.25

An array A contains n integers in non-decreasing order, $A[1] \le A[2] \le \ldots \le A[n]$. Describe, using Pascal-like pseudo code, a linear time algorithm to find i, j such that $A[i] + A[j]$ = a given integer M, if such i, j exist. (5)

46. GATE (CSE) 1994, Q.26

A queue Q containing n items and an empty stack S are given. It is required to transfer all the items from the queue to the stack, so that the item at the front of the queue is on the top of the stack, and the order of all the other items is preserved. Show how this can be done in O(n) time using only a constant amount of additional storage. Note that the only operations which can be performed on the queue and stack are Delete, Insert, Push and Pop. Do not assume any implementation of the queue or stack. (5)

47. GATE (CSE) 1995, Q.1

Choose the correct alternative for each part. (<u>Each part carries 1 mark</u>)

1.5 Merge sort uses:

(a) Divide-and-conquer strategy
(b) Backtracking approach
(c) Heuristic search
(d) Greedy approach

1.16 For merging two sorted lists of size m and n into a sorted list of size m + n, we require comparisons of

(a) O(m)
(b) O(n)
(c) O(m + n)
(d) O(log m + log n)

1.17 A binary tree T has n leaf nodes. The number of nodes of degree 2 in T is

(a) $\log_2 n$
(b) n – 1
(c) n
(d) 2^n

1.25 The minimum number of edges in a connected cyclic graph on n vertices is

(A) n – 1
(B) n
(C) n + 1
(D) none of the above

48. GATE (CSE) 1995, Q.2

Choose the correct alternative for each part. (<u>Each part carries 1 mark</u>)

2.21 The postfix expression for the infix expression A + B*(C+D)/F + D*E is:

(a) AB+CD+*F/D+E*
(b) ABCD+*F/DE*++
(c) A*B+CD/F*DE++
(d) A+*BCD/F*DE++

2.22 Which of the following statements is true?

I. As the number of entries in a hash table increases, the number of collision increases
II. Recursive programs are efficient
III. The worst-case complexity for quick sort is $O(n^2)$
IV. Binary search using a linear linked list is efficient

(a) I and II
(b) II and III
(c) I and IV
(d) I and III

49. GATE (CSE) 1995, Q.6

What is the number of binary trees with 3 nodes which when traversed in post-order give the sequence A, B, C? Draw all these binary trees. (5)

50. GATE (CSE) 1995, Q.12

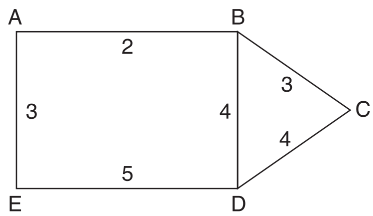
Consider the following sequence of numbers

92, 37, 52, 12, 11, 25

Use bubble sort to arrange the sequence in ascending order. Give the sequence at the end of each of the first five passes. (5)

51. GATE (CSE) 1995, Q.22

How many minimum spanning trees does the following graph have? Draw them (weights are assigned to the edges). (5)



52. GATE (CSE) 1995, Q.24

Prove that in finite graph, the number of vertices of odd degree is always even. (4)

53. GATE (CSE) 1996, Q.1

Write in your answer book the correct or the most appropriate answer to the following multiple choice questions by writing the corresponding letter A, B, C or D against the sub-question number. (***Each carrying 1 mark***)

1.11 Which of the following is false?

(A) $100\ n \log n = O\left(\frac{n \log l}{100}\right)$

(B) $\sqrt{\log n} = O(\log \log n)$

(C) if $0 < x < y$ then $n^x = O(n^y)$

(D) $2^n \neq O(n^k)$

1.12 Consider the following statements.

(i) First-in-first-out types of computations are efficiently supported by STACKS.

(ii) Implementing LISTS on linked lists is more efficient than implementing LISTS on an array for almost all the basic LIST operations.

(iii) Implementing QUEUES on a circular is more efficient than implementing QUEUES

(iv) Last-in-first-out QUEUES type of computations are efficiently supported by QUEUES.

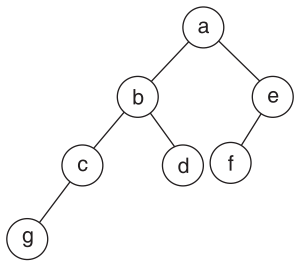
Which of the following is correct?

(A) (ii) and (iii) are true (B) (i) and (ii) are true
(C) (iii) and (iv) are true (D) (ii) and (iv) are true

1.13 An advantage of chained hash table (external hashing) over open addressing scheme is:

(A) Worst-case complexity of search operations is less
(B) Space used is less
(C) Deletion is easier
(D) None of the above

1.14 In the balanced binary tree in the figure given below, how many nodes will become unbalanced when a node is inserted as a child of the node "g"?



(A) 1
(B) 3
(C) 7
(D) 8

1.15 Which of the following sequences denotes the post-order traversal sequence of the tree of question 1.14?

(A) f e g c d b a
(B) g c b d a f e
(C) g c d b f e a
(D) f e d g c b a

54. GATE (CSE) 1996, Q.2

Write in your answer book the correct or the most appropriate answer to the following multiple choice questions by writing the corresponding letter A, B, C or D against the sub-question number. (***Each carrying 2 marks***)

2.11 The minimum number of interchanges needed to convert the array

89, 19, 40, 17, 12, 10, 2, 5, 7, 11, 6, 9, 70

into a heap with the maximum element at the root node is

(A) 0
(B) 1
(C) 2
(D) 3

2.12 The recurrence relation

$$T(1) = 2$$

$$T(n) = 3T\left(\frac{n}{4}\right) + n$$

has the solution T(n) equal to

(A) O(n) (B) O(log n)

(C) $O(n^{3/4})$ (D) none of the above

2.13 The average number of key comparisons done in successful sequential search in a list of length n is

(A) log n (B) $\frac{n-1}{2}$

(C) $\frac{n}{2}$ (D) $\frac{n+1}{2}$

2.14 A binary search tree is generated by inserting in order the following integers:

50, 15, 62, 5, 20, 58, 91, 3, 8, 37, 60, 24

The number of nodes in the left sub-tree and right sub-tree of the root is respectively is

(A) (4, 7) (B) (7, 4)

(C) (8, 3) (D) (3, 8)

2.15 Quick sort is run on two inputs shown below to sort in ascending order

(i) 1, 2, 3, …… n

(ii) n, n – 1, n – 2, ……., 1

Let C1 and C2 be the number of comparisons made for inputs (i) and (ii) respectively. Then,

(A) C1 < C2

(B) C1 > C2

(C) C1 = C2

(D) We cannot say anything for arbitrary n

54. GATE (CSE) 1996, Q.4

A binary search tree is used to locate the number 43. Which of the following probe sequences are possible and which are not? Explain. (5)

(A)	61	52	14	17	40	43
(B)	2	3	50	40	60	43
(C)	10	65	31	48	37	43
(D)	81	61	52	14	41	43
(E)	17	77	27	66	18	43

55. GATE (CSE) 1996, Q.9

The Fibonacci sequence $\{f_1, f_2, f_3, \ldots, f_n\}$ is defined by the following recurrence: (5)

$$f_{n+2} = f_{n+1} + f_n,\ n \geq 1;\ f_2 = 1;\ f_1 = 1;$$

Prove by induction that every third element of the sequence is even.

56. GATE (CSE) 1996, Q.14

A two-dimensional array A[1..n][1..n] of integers is partially sorted if

For all i, j ∈ [1…., n–1]   A[i][j] < A[i][j+1] and.
A[i][j] < A[i+1][j]

Fill in the blanks:

The smallest item in the array is at A[i][j] where *i* = ______ and j = ______. (1)

The smallest item is deleted. Complete the following O(n) procedure to insert item x (which is guaranteed to be smaller than any item in the last row or column) still keeping A partially sorted. (4)

```
procedure      insert(x: integer);
var            i, j: integer;
begin
     i:= 1; j:= 1; A[i][j]:= x;
     while ( [ x>        ]        [ x>        ]
          if A[i+1][j] < A[i][j]          then begin
               [i][j]:= A[i+1][j]; i:= i+1;
     end
     else begin
                    [                    ]
     end
     A[i][j]:= [      ]
end
```

57. GATE (CSE) 1996, Q.15

Insert the characters of the string K R P C S N Y T J M into a hash table of size 10. Use the hash function

$$h(x) = (\text{ord}(x) - \text{ord}(\text{'a'}) + 1) \bmod 10$$

and linear probing to resolve collisions.

(a) Which insertions cause collisions? (2)

(b) Display the final hash table. (3)

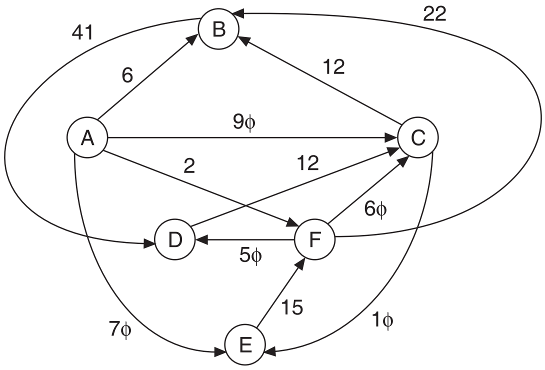
58. GATE (CSE) 1996, Q.16

A complete undirected, weighted graph G is given on the vertex set {0, 1, .., n–1} for any fixed 'n'. Draw the minimum spanning tree of G if

(a) The weight of the edge (u, v) is $|u - v|$ (2)
(b) The weight of the edge (u, v) is $u + v$ (3)

59. GATE (CSE) 1996, Q.17

Let G be the directed, weighted graph shown below



We are interested in the shortest paths from A

(a) Output the sequence of vertices identified by the Dijkstra's algorithm for single source shortest path when the algorithm is started at node A. (2)

(b) Write down the sequence of vertices in the shortest path from A to E. (2)

(c) What is the cost of shortest path from A to E? (1)

60. GATE (CSE) 1997, Q.1

The question contains 10 subparts, each carrying 1 mark. Each subpart contains a multiple choice question. Write in your answer book the subpart number and the letter A, B, C or D corresponding to the most appropriate answer.

1.4 The concatenation of two lists is to be performed in O(1) time. Which of the following implementations of a list should be used?

(A) singly linked list (B) doubly linked list
(C) circular doubly linked list (D) array implementation of list

1.5 The correct matching for the following pairs is

(A) All pairs shortest paths (1) Greedy
(B) Quick sort (2) Depth first search
(C) Minimum weight spanning tree (3) Dynamic programming
(D) Connected component (4) Divide-and-conquer

(A) a – 2, b – 4, c – 1, d – 3 (B) a – 3, b – 4, c – 1, d – 2
(C) a – 3, b – 4, c – 2, d – 1 (D) a – 4, b – 1, c – 2, d – 3

1.7 Which of the following is essential for converting an infix expression to the postfix form efficiently?

(A) An operator stack
(B) An operand stack

(C) An operand stack and an operator stack
(D) A parse tree

1.10 Heap allocation is required for languages

(A) that support recursion
(B) that support dynamic data structures
(C) that use dynamic scope rules
(D) none of the above

61. GATE (CSE) 1997, Q.4

The question contains 10 subparts, each carrying 2 marks. Each subpart contains a multiple choice question. Write in your answer book the subpart number and the letter A, B, C or D corresponding to the most appropriate answer.

4.5 A binary search tree contains the values 1, 2, 3, 4, 5, 6, 7, 8. The tree is traversed in pre-order and the values are printed out. Which of the following sequences is a valid output?

(A) 5 3 1 2 4 7 8 6
(B) 5 3 1 2 6 4 8 7
(C) 5 3 2 4 1 6 7 8
(D) 5 3 1 2 4 7 6 8

4.6 Let T(n) be the function defined by T(1) = 1, $T(n) = 2T\left(\left\lfloor \frac{n}{2} \right\rfloor\right) + \sqrt{n}$ for $n \geq 2$.

Which of the following statements is true?

(A) $T(n) = O(\sqrt{n})$
(B) $T(n) = O(n)$
(C) $T(n) = O(\log n)$
(D) None of the above

4.7 A priority queue Q is used to implement a stack S that stores characters. PUSH(C) is implemented as INSERT(Q, C, K) where K is an appropriate integer key chosen by the implementation. POP is implemented as DELETEMIN(Q). For a sequence of operations, the keys chosen are in

(A) non-increasing order
(B) non-decreasing order
(C) strictly increasing order
(D) strictly decreasing order

62. GATE (CSE) 1997, Q.6

Let G be a graph with 100 vertices numbered 1 to 100. Two vertices i and j are adjacent iff $|i - j| = 8$ or $|i - j| = 12$. The number of connected components in G is

(A) 8
(B) 4
(C) 12
(D) 25

63. GATE (CSE) 1997, Q.9

Consider a graph whose vertices are points in the plane with integer co-ordinates (x,y) such that $1 \leq x \leq n$ and $1 \leq y \leq n$, where $n \geq 2$ is an integer. Two vertices (x_1, y_1) and (x_2, y_2) are adjacent iff $|x_1 - x_2| \leq 1 \vee |y_1 - y_2| \leq 1$. The weight of an edge $\{(x_1, y_1), (x_2, y_2)\}$ is $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$.

(a) What is the weight of a minimum weight spanning tree in this graph? Write only the answer without any explanations. (2)

(b) What is the weight of a maximum weight spanning tree in this graph? Write only the answer without any explanations. (3)

64. GATE (CSE) 1997, Q.12

Consider a hash table with n buckets, where external (overflow) chaining is used to resolve collisions. The hash function is such that the probability that a key value is hashed to a particular bucket is $\frac{1}{n}$. The hash table is initially empty and K distinct values are inserted in the table.

(a) What is the probability that bucket number 1 is empty after the K^{th} insertion? (1)

(b) What is the probability that no collision has occurred in any of the K insertions? (2)

(c) What is the probability that the first collision occurs at the K^{th} insertion? (2)

65. GATE (CSE) 1997, Q.15

Consider the following function.

```
Function F(n, m: integer): integer;
     begin
          if(n <= 0) or (m <= 0) then
               F:= 1
          else
               F:= F(n–1, m) + F(n, m–1);
          end
```

Use the recurrence relation $\binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1}$ to answer the following questions. Assume n, m are positive integers. Write only the answer without any explanation.

(a) What is the value of F(n, 2)? (2)

(b) What is the value of F(n, m)? (2)

(c) How many recursive calls are made to the function F, including the original call, when evaluating F(n, m)? (1)

66. GATE (CSE) 1997, Q.16

A size balanced binary tree is a binary tree in which for every node, the difference between the number of nodes in the left and right sub-tree is at most 1. The distance of a node from the root is the length of the path from the root to the node. The height of a binary tree is maximum distance of a leaf node from the root.

(a) Prove, by using induction on h, that a size-balanced binary tree of height h contains at least 2^h nodes. (3)

(b) In a size-balanced binary tree of height $h \geq 1$, how many nodes are at distance $h - 1$ from the root? Write only the answer without any explanation. (2)

67. GATE (CSE) 1997, Q.18

Consider the following piece of 'C' code fragment that removes duplicates from an ordered list of integers

```
struct node {
     int val;
     struct node *next;
     };
typedef struct node Node;
Node *remove-duplicates(Node *head, int *j)
{
     Node *t1, *t2;
     *j = 0;
     t1 = head;
     if(t1 !=NULL) t2 = t1 →next;
     else return head;
     *j = 1;
     if(t2 ==NULL) return head;
     while(t2 != NULL)
     {
          if(t1.val != t2.val)  ————————→ S1
          {
               (*j)++; t1→next = t2; t1 = t2;  ————→ S2
          }
               t2 = t2 →next;
     }
     t1→next = NULL;
     return head;
}
```

Assume the list contains n elements ($n \geq 2$) in the following questions.

(a) How many times is the comparison in statement S1 made? (1)

(b) What is the minimum and maximum number of times statements marked S2 get executed? (2)

(c) What is the significance of the value in the integer pointed to by j when the function completes? (2)

68. GATE (CSE) 1997, Q.19

A B^+ -tree of order d is a tree in which each internal node has between d and 2d key values. An internal node with M key values has M+1 children. The root (if it is an internal node) has between 1 and 2d key values. The distance of a node from the root is the length of the path from the root to the node. All leaves are at the same distance from the root. The height of the tree is the distance of a leaf from the root.

(a) What is the total number of key values in the internal nodes of a B^+ -tree with l leaves ($l \geq 2$)? (2)

(b) What is the maximum number of internal nodes in a B^+ -tree of order 4 with 52 leaves? (1)

(c) What is the minimum number of leaves in a B^+ -tree of order d and height h $(h \geq 1)$? (2)

69. GATE (CSE) 1998, Q.1

The question consists of 35 (**Thirty five**) multiple choice questions, each carrying 1 mark. The answers to the multiple choice questions MUST be written only in the boxes corresponding to the questions in the first page of the answer book.

1.21 Which of the following algorithm design techniques is used in finding all pairs of shortest distances in a graph?

(a) Dynamic programming
(b) Backtracking
(c) Greedy
(d) Divide-and-Conquer

1.22 Give the correct matching for the following pairs.

(A) O (log n)	(P) Selection
(B) O (n)	(Q) Insertion sort
(C) O (n log n)	(R) Binary search
(D) $O(n^2)$	(S) Merge sort

(a) A – R, B – P, C – Q, D – S
(b) A – R, B – P, C – S, D – Q
(c) A – P, B – R, C – S, D – Q
(c) A – P, B – S, C – R, D – S

1.23 How many substrings of different lengths (non-zero) can be formed from a character string of length n?

(a) n
(b) n^2
(c) 2^n
(d) n(n+1)/2

1.24 Which of the following statements is false?

(a) A tree with n nodes has (n – 1) edges.

(b) A labelled rooted binary tree can be uniquely constructed given its post-order and pre-order traversal results.

(c) A complete binary tree with n internal nodes has (n + 1) leaves.

(d) The maximum number of nodes in a binary tree of height h is $(2^{h+1} - 1)$.

70. GATE (CSE) 1998, Q.2

The question consists of 20 (**Twenty**) multiple choice questions, each carrying 2 marks. The answers to the multiple choice questions MUST be written only in the boxes corresponding to the questions in the second page of the answer book.

2.11 A complete n-ary tree is one in which every node has 0 or n sons. If x is the number of internal nodes of a complete n-ary tree, the number of leaves in it is given by

(a) x(n – 1) + 1
(b) xn – 1
(c) xn + 1
(d) x(n + 1)

2.12 What value would be the following function return for the input x = 95?

```
Function fun(x: integer):integer;
        begin
                if x > 100 then fun:= x – 10
                else fun:= fun(fun (x + 11))
        end;
```

(a) 89 (b) 90
(c) 90 (d) 92

2.11 Let A be a two-dimensional array declared as follows:

A: array [1 … 10] [1 … 15] of integer;

Assuming that each integer takes one memory locations the array is stored in row-major order and the first element of the array is stored at location 100, what is the address of element A[i][j]?

(a) 15i + j + 84 (b) 15j + i + 84
(c) 10i + j89 (d) 10j + i + 89

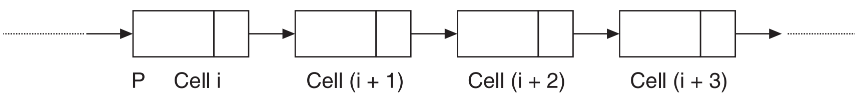
71. GATE (CSE) 1998, Q.6(a)

Solve the recurrence relation (2)

$$x_n = 2x_n - 1, \quad n > 1$$
$$x_1 = 2$$

72. GATE (CSE) 1998, Q.17

(a) Let p be a pointer as shown in the figure in a singly linked list. (2)



What do the following assignment statements achieve?

q: = p → next
p → next: = q → next
q → next: = (q → next) → next
(p → next) → next: = q

(b) Compute the postfix equivalent of the following infix expression. (2)

3 * log (x + 1) – a/2

73. GATE (CSE) 1998, Q.19

Draw the binary tree with the node labels a, b, c, d, e, f and g for which the inorder and postorder traversals result in the following sequences (5)

Inorder	a f b c d g e
Postorder	a f c g e d b

74. GATE (CSE) 1999, Q.1

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 1 mark. For each question, four options are provided, out of which exactly one is correct. Write only the correct option for each question ONLY in the box provided for the question in the first sheet of the answer book.

1.12 A sorting technique is called *stable* if

(A) It takes O(nlog n) time
(B) It maintains the relative order of occurrence of non-distinct elements
(C) It uses divide and conquer paradigm
(D) It takes O(n) space

1.13 Suppose we want to arrange the n numbers stored in an array such that all negative values occur before all positive ones. Minimum number of exchanges required in worst case is:

(A) n – 1 (B) n
(C) n + 1 (D) none of the above

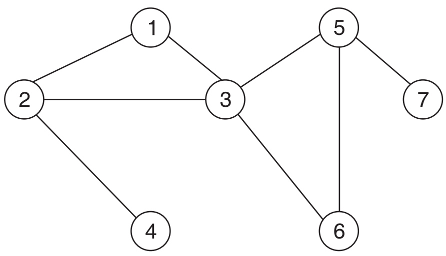
1.14 If one uses straight two-ways merge sort algorithm to sort the following elements in ascending order

20, 47, 15, 8, 9, 4, 40, 30, 12, 17

then the order of these elements after the second pass of the algorithm is:

(A) 8, 9, 15, 20, 47, 4, 12, 17, 30, 40
(B) 8, 15, 20, 47, 4, 9, 30, 40, 12, 17
(C) 15, 20, 47, 4, 8, 9, 12, 30, 40, 17
(D) 4, 8, 9, 15, 20, 47, 12, 17, 30, 40

1.15 The number of articulation points of the following graph is:



(A) 0 (B) 1
(C) 2 (D) 3

1.16 If n is a power of 2, then the minimum number of multiplications needed to compute a^n is:

(A) $\log_2 n$ (B) $\sqrt{n}$
(C) n – 1 (D) n

1.25 Which of the following is correct?

(A) B-trees are for storing data on disk and B^+ trees are for main memory
(B) Range queries are faster on B^+ trees
(C) B-trees are for primary indexes and B^+ trees are for secondary indexes
(D) The height of a B^+ tree is independent of the number of records.

75. GATE (CSE) 1999, Q.2

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 2 marks. For each question, 4 options are provided out of which one or more are correct. Write **ALL** the correct options for each question **ONLY** in the box provided for the question in the second sheet of the answer book. Credit will be given only if all and only the correct options are written.

2.20 The minimum number of record movements required to merge five files A (with 10 records), B(with 20 records), C(with 15 records), D(with 5 records) and E(with 25 records) is

(A) 165 (B) 90
(C) 75 (D) 65

2.21 If T1 = O(1), give the correct matching for the following pairs:

(M) $T_n = T_{n-1} + n$ (U) $T_n = O(n)$
(N) $T_n = T_{n/2} + n$ (V) $T_n = O(n\log n)$
(O) $T_n = T_{n/2} + n \log n$ (W) $T_n = O(n^2)$
(P) $T_n = T_{n-1} + \log n$ (X) $T_n = O(\log^2 n)$

(A) M – W, N – V, O – U, P – X
(B) M – W, N – U, O – V, P – V
(C) M – V, N – W, O – X, P – U
(D) M – W, N – U, O – V, P – X

2.20 Consider the following C function definition

```
int Trial(int a, int b, int c)
{
        if((a >= b) && (c < b)) return b;
        else if (a >= b) return Trial(a, c, b);
        else return Trial (b, a, c)
}
```

The function Trial:

(A) Finds the maximum of a, b and c
(B) Finds the minimum of a, b and c
(C) Finds the middle number of a, b and c
(D) Finds none of the above

76. GATE (CSE) 1999, Q.CS8

Let A be a n × n matrix such that the elements in each row and each column are arranged in ascending order. Draw a decision tree which finds 1st, 2nd and 3rd smallest elements in minimum number of comparisons. (5)

77. GATE (CSE) 1999, Q.CS11

(a) Consider the following algorithm. Assume, procedure A and procedure B take O(1) and O(1/n) unit of time, respectively. Derive the time complexity of the algorithm in O-notation. (3)

```
algorithm what(n)
     begin
          if n = 1 then call A
          else begin
               what(n-1)
               call B(n)
               end
     end.
```

(b) Write a constant time algorithm to insert a node with data D just before the node with address p of a singly linked list. (2)

78. GATE (CSE) 1999, Q.CS12

(a) In a binary tree, a full node is defined to be a node with 2 children. Use the induction on the height of the binary tree to prove that the number of full nodes plus one is equal to the numbers of leaves. (3)

(b) Draw the min-heap that results from insertion of the following elements in order into an initially empty min-heap: 7, 6, 5, 4, 2, 3, 1. Show the result after the deletion of the root of this heap. (2)

79. GATE (CSE) 2000, Q.1

The question consists of 23 (**Twenty three**) multiple choice questions, each carrying 1 mark. For each question, four options are provided out of which exactly one is correct. Write only the correct option for each question ONLY in the box provided for the question in the **first** sheet of the answer book.

1.13 The most appropriate matching for the following pairs

(X): Depth-first search	1: heap
(Y): Breadth-first search	2: queue
(Z): Sorting	3: stack

(A) X – 1, Y – 2, Z – 3
(B) X – 3, Y – 1, Z – 2
(C) X – 3, Y – 2, Z – 1
(D) X – 2, Y – 3, Z – 1

1.14 Consider the following nested representation of binary trees: (X Y Z) indicates Y Z are the left and right subtrees, respectively, of node X. Note that Y and Z may be NULL, or further nested. Which of the following represents a valid binary tree?

(A) (1 2 (4 5 6 7))
(B) (1 ((2 3 4) 5 6) 7)
(C) (1 (2 3 4) (5 6 7))
(D) (1 (2 3 NULL) (4 5))

1.15 Let s be a sorted array of n integers. Let t(n) denote the time taken for the most efficient algorithm to determine if there are two elements with sum less than 1000 in s. Which of the following statements is true?

(A) T(n) is O(1)
(B) $n \le t(n) \le n \log_2 n$
(C) $n \log_2 n \le t(n) < \binom{n}{2}$
(D) $t(n) = \binom{n}{2}$

80. GATE (CSE) 2000, Q.2

The question consists of 26 (**Twenty six**) multiple choice questions, each carrying 2 marks. For each question, 4 options are provided out of which only one is correct. Write the correct options for each question **ONLY** in the box provided for the question in the second sheet of the answer book.

2.15 Suppose you are given an array ***s***[1 .. n] and a procedure *reverse*(s, i, j) which reverses the order of elements in ***s*** between positions i and j (both inclusive). What does the following sequence do, where $1 \le k < n$

reverse(***s***, 1, k);
reverse(***s***, k+1, n);
reverse(***s***, 1, n);

(A) Rotates ***s*** left by k positions
(B) Leaves ***s*** unchanged
(C) Reverses all elements of ***s***
(D) None of the above

2.16 Let LASTPOST, LASTIN and LASTPRE denotes the last vertex visited in a postorder, inorder and preorder traversal respectively, of a completely binary tree. Which of the following is always true?

(A) LASTIN = LASTPOST
(B) LASTIN = LASTPRE
(C) LASTPRE = LASTPOST
(D) None of the above

2.17 Consider the following functions

$$f(n) = 3n^{\sqrt{n}}$$
$$g(n) = 2^{\sqrt{n}\log_2 n}$$
$$h(n) = n!$$

Which of the following is always true?

(A) h(n) is O(f(n))
(B) h(n) is O(g(n))

(C) g(n) is not O(f(n))
(D) f(n) is O(g(n))

2.18 Let G be an undirected graph with distinct edge weights. Let e_{max} be the edge with maximum weight and e_{min} the edge with minimum weight.
Which of the following is **false**?

(A) Every minimum spanning tree of G must contain e_{min}
(B) If e_{max} is an minimum spanning tree, then its removal must disconnect G
(C) No minimum spanning tree contains e_{max}
(D) G has a unique minimum spanning tree

2.19 Let G be an undirected graph. Consider a depth first traversal G, and let T be the resulting depth first search tree. Let u be a vertex in G and v be the first new (unvisited) vertex visited after visiting u in the traversal. Which of the following is always true?

(A) {u, v} must be an edge in G, and u is descendent of v in T
(B) {u,v} must be an edge in G, and v is descendent of u in T
(C) If {u,v} is not an edge in G, then u is leaf in T
(D) If {u,v} is not an edge in G, then u and v must have the same parent in T

81. GATE (CSE) 2000, Q.CS13

Suppose a stack implementation supports, in addition to PUSH and POP, an operation REVERSE, which reverses the order of the elements on the stack.

(a) To implement a queue using the above stack implementation, show how to implement ENQUEUE using a single operation and DEQUEUE using a sequence of 3 operations (2)

(b) The following postfix expression, containing single digit operands and arithmetic operators + and *, is evaluated using a stack.

5 2 * 3 4 + 5 2 * * +

Show the contents of the stack

(i) After evaluating 5 2 * 3 4 +
(ii) After evaluating 5 2 * 3 4 + 5 2
(iii) At the end of evaluation (3)

82. GATE (CSE) 2000, Q.CS15

Suppose you are given arrays p[1 … N] and q[1 … N] both uninitialized (that is, each location may contain an arbitrary value), and a variable count, initialized to 0. Consider the following procedure **set** and **iset**.

```
set (i)
    {count = count +1;
    q[count] = i
    ;p[i] = count;
}
```

```
iset (i) {
    if (p[i] ≤ 0 or p[i] >count)
        return false;
    if (q[p[i]] ≠ i)
        return false;
    return true;
}
```

(a) Suppose we make the following sequence of calls:

set(7); **set**(3); **set**(9);

After the sequence of calls, what is the value of count, and what do q[1], q[2], q[3], p[7], p[3], and p[9] contain? (3)

(b) Complete the following statement "*the first count elements of ________ contain values I such that* ***set*** *(__________) has been called*" (1)

(c) Show that if **set**(i) has not been called for some i, then regardless of what p[i] contains, **iset**(i) will return false. (1)

83. GATE (CSE) 2000, Q.CS16

A recursive program to compute Fibonacci numbers is shown below. Assume you are also given an array f[0 … M] with all elements initialized to 0.

```
    fib (n)  {
    if (n > M) error ();
    if (n= =0) return 1;
    if (n= =1) return 1;
    if ( [        ]                  (1)
        return [        ]            (2)
    t = fib(n - 1) + fib (n - 2);
    [        ]                       (3)
    return t;
}
```

(a) Fill in the boxes with expressions/statements to make **fib()** store and reuse computed Fibonacci values. Write the box number and the corresponding contents in your answer book. (3)

(b) What is the time complexity of the resulting program when computing **fib(n)**? (2)

84. GATE (CSE) 2000, Q.CS17

An array contains four occurrences of 0, five occurrences of 1 and three occurrences of 2 in any order. The array is to be stored using swap operations (elements that are swapped need not be adjacent).

(a) What is the minimum number of swaps needed to sort such an array in the worst case? (2)

(b) Give an ordering of elements in the above array so that the minimum number of swaps needed to sort the array is the maximum. (3)

85. GATE (CSE) 2000, Q.CS21

(a) Suppose you are given an empty B^+ - tree where each node (leaf and internal) can stored up to 5 key values. Suppose values 1, 2, …, 10 are inserted, in order into the tree. Show the tree pictorially (1)

(i) after 6 insertions, and

(ii) after all 10 insertions

Do not show the intermediate stages.

(b) Suppose instead of splitting a node when it is full, we try to move a value to the left sibling. If there is no left sibling, or the left sibling is full, we split the node. Show the tree after values 1, 2, …, 9 have been inserted. Assume, as in (a), that each node can hold up to 5 keys. (2)

(c) In general, suppose a B^+ - tree node can hold a maximum of m keys, and you insert a long sequence of keys in increasing order. Then what approximately is the average number of keys in each leaf level node (2)

(i) in the normal case, and

(ii) with insertion as in (b).

86. GATE (CSE) 2001, Q.CS1

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 1 mark. For each question, four options are provided out of which exactly one is correct. Answer each sub-question by darkening the bubble on the ORS using soft HB pencil. Do not use ORS for rough work. You may like to use the answer book for any rough work if needed.

1.14 Randomized quick sort is an extension of quick sort where the pivot is chosen randomly. What is the worst-case complexity of sorting n numbers using randomized quick sort?

(A) O(n) (B) O(n log n)
(C) $O(n^2)$ (D) O(n!)

1.15 Consider an array representation of an n element binary heap where the elements are stored from index 1 to n of the array. For the element stored at index i of the array ($i \leq n$), the index of the parent is

(A) i – 1 (B) $\lfloor i/2 \rfloor$
(C) $\lceil i/2 \rceil$ (D) (i+1)/2

1.16 Let $f(n) = n^2 \log n$ and $g(n) = n(\log)^{10}$ be without positive functions of n. Which of the following statements is correct?

(A) $f(n) = O(g(n))$ and $g(n) \neq O(f(n))$
(B) $g(n) = O(f(n))$ and $f(n) \neq O(g(n))$
(C) $f(n) \neq O(g(n))$ and $g(n) \neq O(f(n))$
(D) $f(n) = O(g(n))$ and $g(n) = O(f(n))$

87. GATE (CSE) 2001, Q.CS2

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 2 marks. For each question, four options are provided out of which exactly one is correct. Answer each sub-question by darkening the bubble on the ORS using soft HB pencil. Do not use ORS for rough work. You may like to use the answer book for any rough work if needed.

2.14 Consider an undirected unweighted graph G. Let a breadth-first traversal of G be done starting from a node r. Let d(r, u) and d(r, v) be the lengths of the shortest paths from r to u and v respectively in G. If u is visited before v during the breadth-first traversal, which of the following is correct?

(A) $d(r, u) < d(r, v)$ (B) $d(r, u) > d(r, v)$
(C) $d(r, u) \leq d(r, v)$ (D) None of the above

2.15 How many undirected graphs (not necessarily connected) can be constructed out of a given set And = $\{v_1, v_2, \ldots, v_n\}$ of n vertices?

(A) $n(n - 1)/2$ (B) 2^n
(C) $n!$ (D) $2^{n(n - 1)/2}$

2.16 What is the minimum number of stacks of size n required to implement a queue of size n?

(A) One (B) Two
(C) Three (D) Four

88. GATE (CSE) 2001, Q.CS14

(a) Insert the following keys one by one into a binary search tree in order specified. (2)

15, 32, 20, 9, 3, 25, 12, 1

Show the final binary search tree after insertions.

(b) Draw the binary search tree after deleting 15 from it. (1)

(c) Complete the statements S1, S2 and S3 in the following function so that the function computes the depth of a binary tree rooted at t. (2)

```
typedef struct tnode {
     int key;
     struct tnode *left, *right;
} *Tree;
int depth (Tree t)
{
     int x,y;
     if (t = = NULL) return 0;
     x = depth(t →left);
S1: ________________;
S2: if(x > y) return __________;
S3: else return __________;
}
```

89. GATE (CSE) 2001, Q.CS15

Consider a weighted undirected graph with vertex set And = $\{n_1, n_2, n_3, n_4, n_5, n_6\}$ and edge set E = $\{(n_1, n_2, 2), (n_1, n_3, 8), (n_1, n_6, 3), (n_2, n_4, 4), (n_2, n_5, 12), (n_3, n_4, 7), (n_4, n_5, 9), (n_4, n_6, 4)\}$. The third value in each tuple represents the weight of the edge specified in the tuple.

(a) Lists the edges of a minimum spanning tree of the graph. (2)

(b) How many distinct minimum spanning tree does this graph have? (1)

(c) Is the minimum among the edge weights of a minimum spanning tree unique over all possible minimum spanning trees of a graph? (1)

(d) Is the maximum among the edge weights of a minimum spanning tree unique over all possible minimum spanning trees of a graph? (1)

90. GATE (CSE) 2001, Q.CS22

We wish to construct a B^+ tree with fan-out (the number of pointers per node) equal to 3 for the following set of key values:

80, 50, 10, 70, 30, 100, 90

Assume that the tree is initially empty and the values are added in the order given

(a) Show the tree after insertion of 10, after insertion of 30, and after insertion of 90. Intermediate trees need not be shown. (3)

(b) The key values 30 and 10 are now deleted from the tree in that order. Show the tree after each deletion. (2)

91. GATE (CSE) 2002, Q.CS1

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 1 mark. For each question, four options are provided. Choose the most appropriate alternative and darken its bubble ORS using soft HB pencil. Do not darken more than one bubble. Do not use ORS for rough work. You may like to use the answer book for any rough work if needed.

1.3 The solution of the recurrence equation $T(2^k) = 3T(2^{k-1}) + 1$, $T(1) = 1$ is

(A) 2k (B) $(3^{k+1} - 1)/2$

(C) $3^{\log_2 k}$ (D) $2^{\log_3 k}$

1.4 The minimum number of colours required to colour the vertices of a cycle with n nodes in such a way that no two adjacent nodes have the same colour is:

(A) 2 (B) 3

(C) 4 (D) $n - 2\lfloor n/2 \rfloor + 2$

1.5 In the worst case, the number of comparisons needed to search a singly linked list of length n for a given element is

(A) $\log_2 n$ (B) n/2

(C) $\log_2 n - 1$ (D) n

1.25 The maximum number of edges in a n-node undirected graph without self loops is

(A) n^2 (B) n(n – 1)/2
(C) n – 1 (D) (n+1)(n)/2

92. GATE (CSE) 2002, Q.CS2

The question consists of 25 (**Twenty five**) multiple choice questions, each carrying 2 marks. For each question, four options are provided out of which exactly one is correct. Answer each sub-question by darkening the bubble on the ORS using soft HB pencil. Do not darken more than one bubble. Do not use ORS for rough work. You may like to use the answer book for any rough work if needed.

2.8 Consider the following declaration of a two-dimensional array in C:

Char a[100][100];

Assuming that the main memory is byte addressable and that the array is stored starting from address 0, the address of a[40][50] is

(A) 4040 (B) 4050
(C) 5040 (D) 5050

2.9 The number of leaf nodes in a rooted tree of n nodes, with each node having 0 or 3 children is:

(A) n/2 (B) (n – 1)/3
(C) (n – 1)/2 (D) (2n + 1)/3

2.10 Consider the following algorithm for searching a given number x in an unsorted array A[1...n] having n distinct values:

1. Choose an i uniformly at random from 1 ... n;
2. If A[i] = x then Stop else Goto 1;

Assuming that x is present in A, what is the expected number of comparisons made by the algorithm before it terminates?

(A) n (B) n – 1
(C) 2n (D) n/2

2.11 The running time of the following algorithm

Procedure A(n)

If n <= 2 return(1) else return $\left(A\left(\left\lceil\sqrt{n}\right\rceil\right)\right)$;

is best described by

(A) O(n) (B) O(log n)
(C) O(log log n) (D) O(1)

2.12 A weight balanced tree is a binary tree in which for each node, the number of nodes in the left sub-tree is at least half and at most twice the number of nodes in the right sub-tree. The maximum possible height (number of nodes on the path from the root to the furthest leaf) of such a tree on n nodes is best described by which of the following:

(A) $\log_2 n$ (B) $\log_{4/3} n$
(C) $\log_3 n$ (D) $\log_{3/2} n$

2.23 A B^+ -tree index is to be built on the Name attribute of the relation STUDENT. Assuming that all student names are of length 8 bytes, disk blocks are of size 512 bytes, and index pointers are of size 4 bytes. Given this scenario, what would be the best choice of the degree (i.e. the number of pointers per node) of the B^+ -tree?

(A) 16 (B) 42
(C) 43 (D) 44

93. GATE (CSE) 2002, Q.CS6

Draw all binary trees having exactly three nodes labelled A, B, and C on which preorder traversal gives the sequence C, B, A. (5)

94. GATE (CSE) 2002, Q.CS11

The following recursive function in C is a solution to the towers of Hanoi problem. (5)

```
Void move(int n, char A, char B, char C)
{
    if(...............) {
        move(...............);
        printf("Move disk %d from pole %c to pole %c\n", n , A, C);
        move(...............);
    }
}
```

Fill in the dotted parts of the solution.

95. GATE (CSE) 2002, Q.CS12

Fill in the blanks in the following template of an algorithm to compute all pairs of shortest path lengths in a directed graph G with n*n adjacency matrix A. A[i, j] equals 1 if there is an edge in G from i to j, and 0 otherwise.

```
INITIALIZATION: For I = 1 … n
    {For j = 1 … n
        {If A[i,j] = 0 then P[i, j] = ________ else P[i,j] = _______;}
    }
ALGORITHM: For i = 1 ... n
    { For j = 1 … n
        { For k = 1 … n
            {P[ _, _ ] = min{ ____________};}
        }
    }
```

(a) Copy the complete line containing the blanks in the Initialization step and fill in the blanks. (1)

(b) Copy the complete line containing the blanks in the Initialization step and fill in the blanks. (3)

(c) Fill in the blank: The running time of the algorithm is O(_____) (1)

96. GATE (CSE) 2002, Q.CS17

(a) The following table refers to search times for a key in B-trees and B^+-trees.

B-tree		B+-tree	
Successful Search	Unsuccessful Search	Successful Search	Unsuccessful Search
X1	X2	X3	X4

A successful search means that the key exists in the database and unsuccessful means that it is not present in the database. Each of the entries X_1, X_2, X_3, and X_4 can have a value of either *constant* or *variable*: *Constant* means that the search time is the same, independent of the specific key value, whereas variable means that it is depend on the specific key value chosen for the search

Give the correct values for the entries $X_{1,}$ X_2, X_3, and X_4 (for example, X_1 = Constant, X_2 = Constant, X_3 = Constant, X_4 = Constant).

[GATE questions of 2003 and onwards are of MULTIPLE CHOICE QUESTION types. Q.1 – Q.30/25/20 each carrying one mark and the rest carrying two marks. Negative marking 25%]

97. GATE (CSE) 2003, Q.4

Let A be a sequence of 8 distinct integers sorted in ascending order. How many distinct pairs of sequences, B and are there such that (i) each is sorted in ascending order, (ii) B has 5 and C has 3 elements, and (iii) the result of merging B and C gives A?

(A) 2 (B) 30

(C) 56 (D) 256

98. GATE (CSE) 2003, Q.6

Let A T(n) be the number of different binary search trees on n distinct elements. Then $T(n) = \sum_{k=1}^{n} T(k-1)T(x)$, where x is

(A) n – k + 1 (B) n – k

(C) n – k – 1 (D) n – k – 1

99. GATE (CSE) 2003, Q.8

Let G be an arbitrary graph with n nodes and k components. If a vertex is removed from G, the number of components in the resultant graph must necessarily lie between

(A) k and n (B) k – 1 and k + 1

(C) k – 1 and n – 1 (D) k + 1 and n – k

100. GATE (CSE) 2003, Q.19

Suppose the numbers 7, 5, 1, 8, 3, 6, 0, 9, 4, 2 are inserted in that order into an initially empty binary search tree. The binary search tree uses the usual ordering on natural numbers. What is the inorder traversal sequence of the resultant tree?

(A) 7 5 1 0 3 2 4 6 8 9
(B) 0 2 4 3 1 6 5 9 8 7
(C) 0 1 2 3 4 5 6 7 8 9
(D) 9 8 6 4 2 3 0 1 5 7

101. GATE (CSE) 2003, Q.20

Consider the following three claims

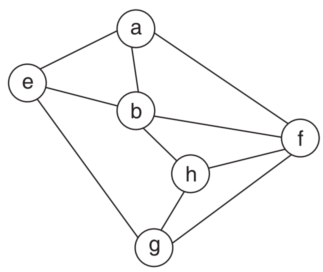
I $(n+k)^m = \Theta(n^m)$, where k and m are constants
II $2^{n+1} = O(2^n)$
III $2^{2n} = O(2^n)$

Which of these claims are correct?

(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

102. GATE (CSE) 2003, Q.21

Consider the following graph



Among the following sequences

I a b e g h f
II a b f e h g
III a b f h g e
IV a f g h b e

which are the depth-first traversals of the above graph?

(A) I, II and IV only
(B) I and IV only
(C) II, III and IV only
(D) I, III and IV only

103. GATE (CSE) 2003, Q.22

The usual implementation of insertion sort to sort an array uses linear search to identify the position where an element is to be inserted into already sorted part of the array. If, instead, we use binary search to find the position, the worst-case running time will

(A) remain $\Theta(n^2)$
(B) become $\Theta(n (\log n)^2)$
(C) become $\Theta(n \log n)$
(D) become $\Theta(n)$

104. GATE (CSE) 2003, Q.23

In heap with n elements with the smallest element at the root, the 7th smallest element can be found in time

(A) Θ(n log n) (B) Θ(n)
(C) Θ(log n) (D) Θ(1)

105. GATE (CSE) 2003, Q.35

Consider the following recurrence relation

$$T(1) = 1$$
$$T(n+1) = T(n) + \lfloor \sqrt{n+1} \rfloor \text{ for all } n \geq 1$$

The value of $T(m^2)$ for $m \geq 1$ is

(A) $\frac{m}{6}(21m - 39) + 4$

(B) $\frac{m}{6}(4m^2 - 3m + 5)$

(C) $\frac{m}{2}(3m^{2.5} - 11m + 20) - 5$

(D) $\frac{m}{6}(5m^5 - 34m^2 + 137m - 104) + \frac{5}{6}$

106. GATE (CSE) 2003, Q.36

How many perfect matchings are there in a complete graph of 6 vertices?

(A) 15 (B) 24
(C) 24 (D) 60

Note: The following information pertains to Q.61 and Q.62.
In a permutation $a_1 \ldots a_n$ of n distinct integers, an inversion is a pair (a_i, a_j) such that $i < j$ and $a_i > a_j$.

107. GATE (CSE) 2003, Q.61

If all permutations are equally likely, what is the expected number of inversions in a randomly chosen permutation of 1 … n?

(A) n(n – 1)/2 (B) n(n – 1)/4
(C) n(n + 1)/4 (D) $2n \lfloor \log_2 n \rfloor$

108. GATE (CSE) 2003, Q.62

What would be the worst-case time complexity of insertion sort algorithm, if the inputs are restricted to permutations of 1 … n with at most n inversions?

(A) $\Theta(n^2)$ (B) Θ(n log n)
(C) $\Theta(n^{1.5})$ (D) Θ(n)

109. GATE (CSE) 2003, Q.63

A data structure is required for storing a set of integers such that each of the following operations can be done in O(log n) time, where n is the number of elements in the set.

I Deletion of the smallest element
II Insertion of an element if it is not already present

Which of the following data structure can be used for this purpose?

(A) A heap can be used but not a balance binary search tree
(B) A balance binary search tree can be used but not a heap
(C) Both balance binary search tree and heap can be used
(D) Neither balance binary search tree nor heap can be used

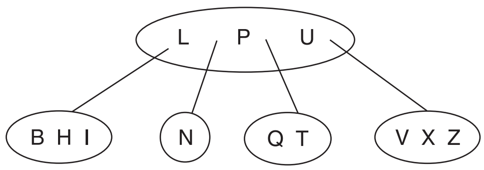
110. GATE (CSE) 2003, Q.64

Let S be a stack of size n ≥ 1. Starting with the empty stack, suppose we Push the first n natural numbers in sequence, and then perform n Pop operations. Assume that Push and POP operations take X seconds each, and Y seconds elapse between the end of one such stack operation and the start of the next operation. For m ≥ 1, define the stack-life of m as the time elapsed from the end of Push(m) to the start of the Pop operation that removes m from S. The average stack-life of an element of this stack is

(A) n(X + Y)
(B) 3Y + 2X
(C) N(X + Y) – X
(D) Y + 2X

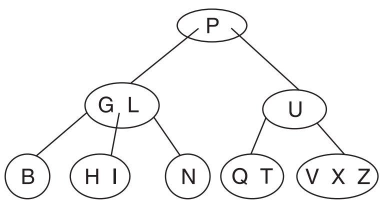
111. GATE (CSE) 2003, Q.65

Consider the following 2 – 3 – 4 tree (i.e. B-tree with a minimum degree of two) in which each data item is a letter. The usual alphabetical ordering of letters is used in constructing the tree.

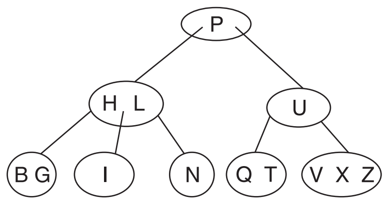


What is the result of inserting G in the above tree?

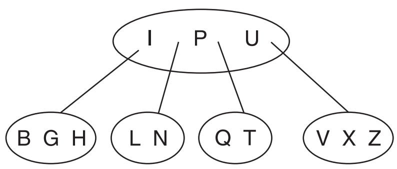
(A)



(B)



(C)



(D) None of the above

112. GATE (CSE) 2003, Q.66

The cube root of a natural number n is defined as the largest natural number such that m3 ≤ n. The complexity of computing the cube root of n (n is represented in binary notation) is

(A) $O(n)$ but not $O(n^{0.5})$
(B) $O(n^{0.5})$ but not $O(\log n)^k)$ for any constant $k > 0$
(C) $O(\log n)^k)$ for some constant $k > 0$, but not $O(\log \log n)^m)$ for any constant $m>0$
(D) $O(\log \log n)^k)$ for some constant $k > 0.5$, but not $O(\log \log n)^{0.5})$

113. GATE (CSE) 2003, Q.67

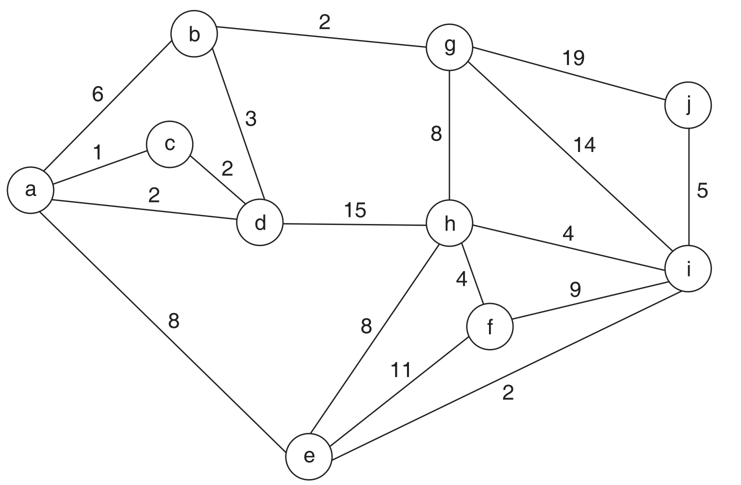
Let G = (V, E) be an undirected graph with a subgraph $G_1 = (V_1, E_1)$. Weights are assigned to edges of G as follows.

A single-source shortest path algorithm is executed on the weighted graph (V, E, what) with an arbitrary vertex v_1 of V_1 as the source. Which of the following can always be inferred from the path costs computed?

(A) The number of edges in the shortest paths from v_1 to all vertices of G
(B) G_1 is connected
(C) V_1 forms a clique in G
(D) G_1 is a tree

114. GATE (CSE) 2003, Q.68

What is the weight of a minimum spanning tree of the following graph?



(A) 29 (B) 31
(C) 38 (D) 41

115. GATE (CSE) 2003, Q.69

Let G = (V, E) be a directed graph with n vertices. Path from v_i to v_j in G is a sequence of vertices $(v_i, v_{i+1}, \ldots v_j)$ such that $(v_k, v_{k+1}) \in E$ for all k in I through j – 1. A simple path is the path in which no vertex appears more than once.

Let A be an $n \times n$ array initialized as follows.

$$A[j, k] = \begin{cases} 1 & \text{if } (j, k) \in E \\ 0 & \text{otherwise} \end{cases}$$

Consider the following algorithm.

```
for i = 1 to n
        for j = 1 to n
                for k = 1 to n
                        A[j, k] = max(A[j, k], A[j, i] + A[i, k]);
```

Which of the following statements is necessarily true for all j and k after termination of the above algorithm?

(A) $A[j, k] \leq n$

(B) If $A[j, j] \geq n-1$, then G has a Hamiltonian cycle

(C) If there exists a path from j to k, A[j, k] contains the longest path length from j to k

(D) If there exists a path from j to k, every simple path from j to k contains at most A[j, k] edges.

116. GATE (CSE) 2004, Q.3

A single array A[1 .. MAXSIZE] is used to implement two stacks. The two stacks grow from opposite ends of the array. Variables top1 and top2 (top1 < top2) point to the location of the topmost element in each of the stacks. If the space is to be used efficiently, the condition for 'stack full' is

(a) (top1 = MAXSIZE/2) and (top2 = MAXSIZE/2 + 1)
(b) top1 + top2 = MAXSIZE
(c) (top1 = MAXSIZE/2) or (top2 = MAXSIZE)
(d) top1 = top2 – 1

117. GATE (CSE) 2004, Q.4

The following numbers are inserted into an empty binary search tree in the given order: 10, 1, 3, 15, 12, 16. What is the height of the binary search tree (the height is the maximum distance of a leaf node from the root)?

(A) 2
(B) 3
(C) 4
(D) 6

118. GATE (CSE) 2004, Q.5

The best data structure to check whether an arithmetic expression has balanced parenthesis is a

(A) Queue
(B) Stack
(C) Tree
(D) List

119. GATE (CSE) 2004, Q.6

Level order traversal of a rooted tree can be done by starting the root and performing

(A) Preorder traversal
(B) Inorder traversal
(C) Depth-first search
(D) Breadth-first search

120. GATE (CSE) 2004, Q.7

Given the following input (4322, 1334, 1471, 9679, 1989, 6171, 6173, 4199) and the hash function x mod 10, which of the following statements are true?

(i) 9679, 1989, 4199 hash to the same value
(ii) 1471, 6171 hash to the same value
(iii) All elements hash to the same value
(iv) Each elements hash to different value

(A) (i) only
(B) (ii) only
(C) (i) and (ii) only
(D) (iii) or (iv)

121. GATE (CSE) 2004, Q.29

The tightest lower bound on the number of comparisons, in the worst case, for comparison-based sorting is of the order of

(A) n
(B) n^2
(C) n log n
(D) $n \log^2 n$

122. GATE (CSE) 2004, Q.35

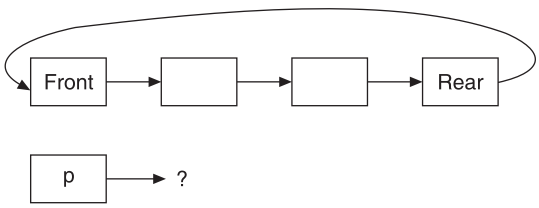
Consider the label sequences obtained by the following pairs of traversals on a labelled binary tree. Which of these pairs identify a tree uniquely?

(i) Preorder and postorder
(ii) Inorder and postorder
(iii) Preorder and inorder
(iv) Level order and postorder

(A) (i) only
(B) (i), (iii)
(C) (iii) only
(D) (iv) only

123. GATE (CSE) 2004, Q.36

A circularly linked list is used to represent a queue. A single variable p is used to access the queue. To which node should p point such that both the operations enQueue and deQueue can be performed in constant time?

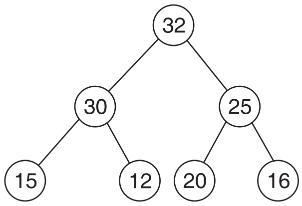


(A) Rear node
(B) Front node
(C) Not possible with a single pointer
(D) Node next to front

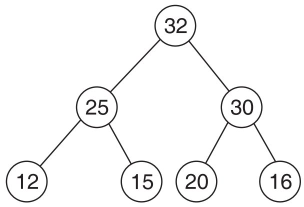
124. GATE (CSE) 2004, Q.37

The elements 32, 15, 20, 30, 12, 25, 16 are inserted one by one in the given order into a max heap. The resultant max heap is

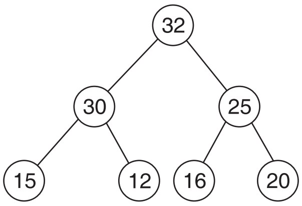
(A)



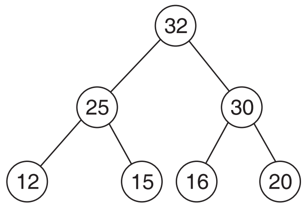
(B)



(C)



(D)



125. GATE (CSE) 2004, Q.38

Assume that the operators +, –, × are left associative and ^ is right associative. The order of precedence (from highest to lowest) is ^, ×, +, –. The postfix expression corresponding to the infix expression a+b×c-d^e^f is

(A) abc×+def ^ ^ –
(B) abc×+de ^ f ^ –
(C) ab+c×d–e ^f ^
(D) –+a×bc ^ ^ def

126. GATE (CSE) 2004, Q.39

Two matrices M_1 and M_2 are to be stored in arrays A and B respectively. Each array can be stored either in row-major or column-major order in contiguous memory locations. The time complexity of an algorithm to compute $M_1 \times M_2$ will be:

(A) Best if A is in row-major, and B is in column-major order
(B) Best if both are in row-major order
(C) Best if both are in column-major order
(D) Independent of the storage scheme

127. GATE (CSE) 2004, Q.40

Suppose each set is represented as a linked list with elements in arbitrary order. Which of the operations among union, intersection, membership, and cardinality will be the slowest?

(A) union only
(B) intersection, membership
(C) membership, cardinality
(D) union, intersection

128. GATE (CSE) 2004, Q.42

What does the following algorithm approximate? (Assume $m > 1$, $\in > 0$).

```
x = m;
y = 1;
while (x - y > ∈)
     {    x = (x + y) / 2;
```

```
                y = m / x
            }
        print (x);
```

(A) log m
(B) m^2
(C) $m^{1/2}$
(D) $m^{1/3}$

129. GATE (CSE) 2004, Q.43

Consider the following C program segment:

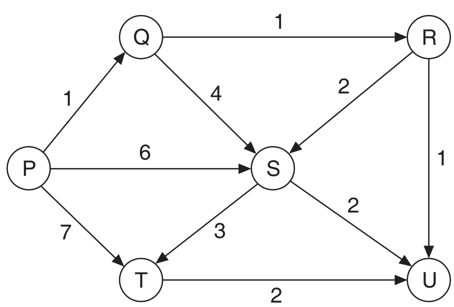
```
struct CellNode{
    struct CellNode *leftChild;
    int element;
    struct CellNode *rightChild;
    };
int Dosomething(struct CellNode *ptr)
{
    int value = 0;
    if(ptr != NULL)
        {   if(ptr -> leftChild != NULL)
                value = 1 + DoSomething (ptr -> leftChild);
            if(ptr -> rightChild != NULL)
                value = max(value, 1 + DoSomething (ptr -> rightChild);
        }
}
```

The value returned by the function DoSomething when a pointer to the root of a non-empty tree is passed as argument is:

(A) The number of leaf nodes in the tree
(B) The number of nodes in the tree
(C) The number of internal nodes in the tree
(D) The height of the tree

130. GATE (CSE) 2004, Q.44

Suppose we run Dijkstra's single source shortest path algorithm on the following edge-weighted directed graph with vertex P as the source.



In what order do the nodes get included into the set of vertices for which the shortest path distances are finalized?

(A) P, Q, R, S, T, U
(B) P, Q, R, U, S, T
(C) P, Q, R, U, T, S
(D) P, Q, T, R, U, S

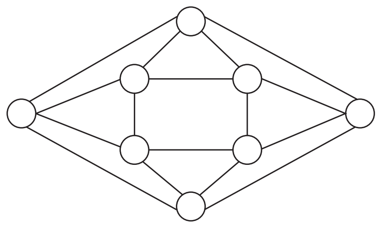
131. GATE (CSE) 2004, Q.52

The order of an internal node in a B^+ tree index is the maximum number of children it can have. Suppose that a child pointer takes 6 bytes, the search field takes 14 bytes, and the block size is 512 bytes. What is the order of the internal node?

(A) 24
(B) 25
(C) 26
(D) 27

132. GATE (CSE) 2004, Q.77

The minimum number of colours required to colour the following graph, such that no two adjacent vertices are assigned the same colour, is



(A) 2
(B) 3
(C) 4
(D) 5

133. GATE (CSE) 2004, Q.78

Two n bit binary strings S_1 and S_2, are chosen randomly with uniform probability. The probability that the hamming distance between these strings (the number of positions where the two strings differ) is equal to d is

(A) $\frac{{}^nC_d}{2^n}$
(B) $\frac{{}^nC_d}{2^d}$
(C) $\frac{d}{2^n}$
(D) $\frac{1}{2^d}$

134. GATE (CSE) 2004, Q.79

How many graphs on n-labelled vertices exist which have at least $(n^2 - 3n)/2)$ edges?

(A) ${}^{(n^{\wedge}2-n)/2}C_{(n^{\wedge}2-3n)/2}$
(B) $\sum_{k=0}^{(n^{\wedge}2-3n)/2} {}^{(n^{\wedge}2-n)}C_k$
(C) ${}^{(n^{\wedge}2-n)/2}C_n$
(D) $\sum_{k=0}^{n} {}^{(n^{\wedge}2-n)/2}C_k$

135. GATE (CSE) 2004, Q.81

Let $G_1 = (V, E_1)$ and $G_2 = (V, E_2)$ be connected graphs on the same vertex set V with more than two vertices. If $G_1 \cap G_2 = (V, E_1 \cap E_2)$ is not a connected graph, then the graph $G_1 \cup G_2 = (V, E_1 \cup E_2)$

(A) cannot have a cut vertex
(B) must have a cycle
(C) must have a cut-edge (bridge)
(D) has chromatic number strictly greater than those of G_1 and G_2

136. GATE (CSE) 2004, Q.82

Let A[1 … n] be an array storing a bit (1 0r 0) at each location, and f(m) is a function whose time complexity is $\Theta(m)$. Consider the following program fragment written in a C like language:

```
counter = 0;
for (i = 1; i <= n; i++)
     {    if (A[i] == 1) counter++;
          else { f(counter); counter = 0;}
     }
```

The complexity of this program fragment is

(A) $\Omega(n^2)$
(B) $\Omega(n \log n)$ and $O(n^2)$
(C) $\Theta(n)$
(D) $O(n)$

137. GATE (CSE) 2004, Q.83

The time complexity of the following C function is (assume $n > 0$):

```
int recursive (int n) {
     if (n = = 1)
          return (1);
     else { f(counter); counter = 0;}
          return (recursive (n - 1) + recursive (n - 1));
     }
```

The complexity of this program fragment is

(A) $O(n)$
(B) $O(n \log n)$
(C) $O(n^2)$
(D) $O(2^n)$

138. GATE (CSE) 2004, Q.84

The recurrence equation

$$T(1) = 1$$
$$T(n) = 2T(n-1) + n, \; n \geq 2$$

evaluates to

(A) $2^{n+1} - n - 2$
(B) $2^n - n$
(C) $2^{n+1} - 2n - 2$
(D) $2^n + n$

139. GATE (CSE) 2004, Q.85

A program takes as input a balance binary search tree with n leaf nodes and computes the value of a function g(x) for each node x. If the cost of computing g(x) is minimum {no. of leaf nodes in left-subtree of x, no. of leaf-nodes in right-subtree of x}, then the worst-time case complexity of the program is

(A) $\Theta(n)$ (B) $\Theta(n \log n)$
(C) $\Theta(n^2)$ (D) $\Theta(n^2 \log n)$

140. GATE (IT) 2004, Q.5

What is the number of edges in an acyclic undirected graph with n vertices?

(A) n – 1 (B) n
(C) n + 1 (D) 2n – 2

141. GATE (IT) 2004, Q.13

Let P be a singly linked list. Let Q be the pointer to an intermediate node x in the list. What is the worst-case time complexity of the best-known algorithm to delete the node x from the list?

(A) O(n) (B) $O(\log^2 n)$
(C) O(log n) (D) O(1)

142. GATE (IT) 2004, Q.37

What is the number of vertices in an undirected connected graph with 27 edges, 6 vertices of degree 2, 3 vertices of degree 4 and remaining of degree 3?

(A) 10 (B) 11
(C) 18 (D) 19

143. GATE (IT) 2004, Q.52

A program attempts to generate as many permutations as possible of the string 'abcd' by pushing the characters a, b, c, d in the same order onto a stack, but it may pop off the top character at any time. Which one of the following strings CANNOT be generated using this program?

(A) abcd (B) dcba
(C) cbad (D) cabd

144. GATE (IT) 2004, Q.53

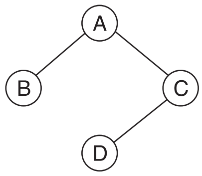
An array of integers of size n can be converted into a heap by adjusting the heaps rooted at each internal node of the complete binary tree starting at the node $\lfloor (n-1)/2 \rfloor$, and doing this adjustment up to the root node (root node is at index 0) in the order $\lfloor (n-1)/2 \rfloor$, $\lfloor (n-3)/2 \rfloor$, …, 0. The time required to construct a heap in this manner is

(A) O(log n) (B) O(n)
(C) O(n log log n) (D) O(n log n)

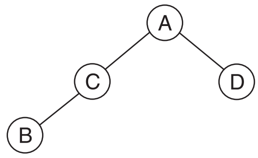
145. GATE (IT) 2004, Q.54

Which of the following binary trees has its inorder and preorder traversals as BCAD and ABCD, respectively?

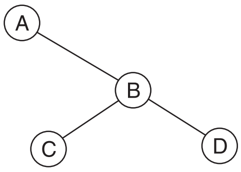
(A)



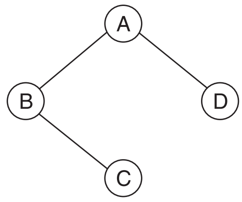
(B)



(C)



(D)



146. GATE (IT) 2004, Q.55

Let f(n), g(n) and h(n) be functions defined for positive integers such that f(n) = O(g(n)), g(n) ≠ O(f(n)), g(n) = O(h(n)) and h(n) = O(g(n)). Which one of the following statements is FALSE?

(A) f(n) = O(g(n) + h(n))

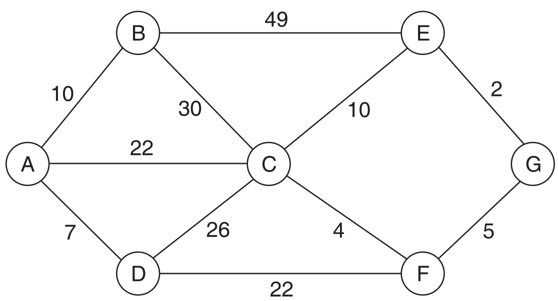
(B) f(n) = O(h(n))

(C) h(n) ≠ O(f(n))

(D) f(n)h(n) ≠ O(g(n)h(n)

147. GATE (IT) 2004, Q.56

Consider the undirected graph below.



Using Prim's algorithm to construct a minimum spanning tree starting with node A, which one of the following sequences of edges represents a possible order in which the edges would be added to construct the minimum spanning tree?

(A) (E, G), (C, F), (F, G), (A, D), (A, B), (A, C)

(B) (A, D), (A, B), (A, C), (C, F), (G, E), (F, G)

(C) (A, B), (A, D), (D, F), (F, G), (G, E), (F, C)

(D) (A, D), (A, B), (D, F), (F, C), (F, G), (G, E)

148. GATE (IT) 2004, Q.57

Consider a list of recursive algorithms and a list of recurrence relations as shown below. Each recurrence relation corresponds to exactly one algorithm and is used to derive the time complexity of the algorithm.

P.	Binary search	I.	$T(n) = T(n-k) + T(k) + cn$
Q.	Merge sort	II.	$T(n) = 2T(n-1) + 1$
R.	Quick sort	III.	$T(n) = T(n/2) + cn$
S.	Tower of Hanoi	IV.	$T(n) = T(n/2) + 1$

(A) P – II, Q – III, R – IV, S – I

(B) P – IV, Q – III, R – I, S – II

(C) P – III, Q – II, R – IV, S – I

(D) P – IV, Q – II, R – I, S – III

149. GATE (CSE) 2005, Q.2

An Abstract Data Type (ADT) is:

(A) Same as the abstract class

(B) A data type that cannot be instantiated

(C) A data type for which only the operations defined on it can be used, but none else

(D) All of the above

150. GATE (CSE) 2005, Q.5

A program P reads in 500 integers in the range [0, 100] representing the scores of 500 students. It then prints the frequency of each score above 50. What would be the best way for P to store the frequencies?

(A) An array of 50 numbers

(B) An array of 100 numbers

(C) An array of 500 numbers

(D) A dynamically allocated array of 550 numbers

151. GATE (CSE) 2005, Q.6

An undirected graph G has n nodes. Its adjacency matrix is given by an $n \times n$ square matrix whose (i) diagonal elements are 0s and (ii) non-diagonal elements are 1s. Which one of the following is TRUE?

(A) Graph G has no minimum spanning tree (MST)

(B) Graph G has a unique MST of cost $n - 1$

(C) Graph G has multiple distinct MSTs, each of cost $n - 1$

(D) Graph G has multiple minimum spanning trees of different costs.

152. GATE (CSE) 2005, Q.7

The time complexity of computing the transitive closure of a binary relation on a set of n elements is known to be:

(A) $O(n)$

(B) $O(n \log n)$

(C) $O(n^{3/2})$

(D) $O(n^3)$

153. GATE (CSE) 2005, Q.11

Let G be a simple connected graph with 13 vertices and 19 edges. Then, the number of faces in the planar embedding of the graph is:

(A) 6 (B) 8
(C) 9 (D) 13

154. GATE (CSE) 2005, Q.33

In postorder traversal of a given binary search tree, T produces the following sequence of keys

10, 9, 23, 22, 27, 25, 15, 50, 95, 60, 40, 29

Which one of the following sequences of keys can be the result of an inorder traversal of tree T?

(A) 9, 10, 15, 22, 23, 25, 27, 29, 40, 50, 60, 95
(B) 9, 10, 15, 22, 40, 50, 60, 95, 23, 25, 27, 29
(C) 29, 15, 9, 10, 25, 22, 23, 27, 40, 60, 50, 95
(D) 95, 50, 60, 40, 27, 23, 22, 25, 10, 9, 15, 29

155. GATE (CSE) 2005, Q.34

A Priority-Queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is given below:

10, 8, 5, 3, 2

Two new elements '1' and '7' are inserted in the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

(A) 10, 8, 7, 5, 3, 2, 1 (B) 10, 8, 7, 2, 3, 1, 5
(C) 10, 8, 7, 1, 2, 3, 5 (D) 10, 8, 7, 3, 2, 1, 5

156. GATE (CSE) 2005, Q.35

How many distinct binary search trees can be created out of 4 distinct keys?

(A) 5 (B) 14
(C) 24 (D) 42

157. GATE (CSE) 2005, Q.36

In a complete k-ary tree, every internal node has exactly k children. The number of leaves in such a tree with n internal nodes is:

(A) nk (B) $(n-1)k + 1$
(C) $n(k - 1) + 1$ (D) $n(k - 1)$

158. GATE (CSE) 2005, Q.37

Suppose $T(n) = 2T(n/2) + n$, $T(0) = T(1) = 1$

Which of the following is FALSE?

(A) $T(n) = O(n^2)$ (B) $T(n) = \Theta(n \log n)$
(C) $T(n) = \Omega(n^2)$ (D) $T(n) = O(n \log n)$

159. GATE (CSE) 2005, Q.38

Let G(V, E) be an undirected graph with positive edge weights. Dijkstra's single source shortest path algorithm can be implemented using heap data structure with time complexity:

(A) $O(|V|^2)$
(B) $O(|E| + |V| \log |V|)$
(C) $O(|V| \log |V|)$
(D) $O((|E| + |V|) \log |V|)$

160. GATE (CSE) 2005, Q.39

Suppose there are $\lceil \log n \rceil$ sorted lists of $\left\lfloor \frac{n}{\log n} \right\rfloor$ elements each. The time complexity of producing a sorted list of all these elements is: (Hint: Use a heap data structure)

(A) $O(n \log \log n)$
(B) $\Theta(n \log n)$
(C) $\Omega(n \log n)$
(D) $\Omega(n^{3/2})$

161. GATE (CSE) 2005, Q.81

Statement for Linked Answer Questions 81a & 81b:

Consider the following C function:

```
double foo (int n) {
     int i;
     double sum;

     if (n = = 0) return 1.0;
     else {
          sum = 0.0;
          for(i = 0; I < n; i++)
               sum += foo(i);
          return sum;
     }
}
```

Q.81a The space complexity of the above function is:

(A) O(1)
(B) O(n)
(C) O(n!)
(D) $O(n^n)$

Q.81b Suppose we modify the above function foo() and store the values of foo (i), 0 < = i < n, as and when they are computed. With this modification, the time complexity for function foo() is significantly reduced. The space complexity of the modified function would be:

(A) O(1)
(B) O(n)
(C) $O(n^2)$
(D) O(n!)

162. GATE (CSE) 2005, Q.82

Statement for Linked Answer Questions 82a & 82b:

Let s and t be two vertices in a undirected graph G = (V, E) having distinct positive edge weights. Let [X, Y] be partition of V such that $s \in X$ and $t \in Y$. Consider the edge e having the minimum weight amongst all those edges that have one vertex in X and one vertex in Y.

(a) The edge e must definitely belong to:

(A) The minimum weighted spanning tree of G
(B) The weighted shortest path from s to t
(C) Each path from s to t
(D) The weighted longest path from s to t

(b) Let the weight of an edge e denote the congestion on that edge. The congestion on a path is defined to be the maximum of the congestions on the edges of the path. We wish to find the path from s to t having minimum congestion. Which of the following paths is always such a path of minimum congestion?

(A) A path from s to t in the minimum weighted spanning tree
(B) A weighted shortest path from s to t
(C) An Euler walk from s to t
(D) A Hamiltonian path from s to t

163. GATE (IT) 2005, Q.12

The numbers 1, 2, …, n are inserted in a binary search tree in some order. In the resulting tree, the right subtree of the root contains p nodes. The first number to be inserted in the tree must be

(A) 134 (B) 133
(C) 124 (D) 123

164. GATE (IT) 2005, Q.13

A function f defined on stacks of integers satisfies the following properties.

$f(\phi) = 0$ and

$f(push(\mathbf{S}, i) = max(f(\mathbf{S}), 0) + i$ for all stacks **S** and integers i.

If a stack **S** contains the integers 2, –3, 2, –1, 2 in order from bottom to top, what is f(**S**)?

(A) 6 (B) 4
(C) 3 (D) 2

165. GATE (IT) 2005, Q.14

In depth-first traversal of a graph G with n vertices, k edges are marked as tree edges. The number of connected components in G is

(A) k (B) k + 1
(C) n – k – 1 (D) n – k

166. GATE (IT) 2005, Q.15

In the following table, the left column contains the names of standard graph algorithms and the right column contains the time complexities of the algorithms. Match each algorithm with its time complexity.

1: Bellman-Ford algorithm 2: Kruskal's algorithm 3: Floyd-Warshall algorithm 4: Topological sorting	A: O(m log n) B: $O(n^3)$ C: O(nm) D: O(n + m)

(A) 1 → C, 2 → A, 3 → B, 4 → D
(B) 1 → B, 2 → D, 3 → C, 4 → A
(C) 1 → C, 2 → D, 3 → A, 4 → B
(D) 1 → B, 2 → A, 3 → C, 4 → D

167. GATE (IT) 2005, Q.16

A hash table contains 10 buckets and uses linear probing to resolve collisions. The key values are integers and the hash function used is key % 10. If the values 43, 165, 62, 123, 142 are inserted in the table, in what location would the key value 142 be inserted?

(A) 2
(B) 3
(C) 4
(D) 6

168. GATE (IT) 2005, Q.50

In a binary tree, for every node the difference between the number of nodes in the left and right subtrees is at most 2. If the height of the tree is h . 0, then the minimum number of nodes in the tree is

(A) 2^{h-1}
(B) $2^{h-1} + 1$
(C) $2^{h-1} - 1$
(D) 2^h

169. GATE (IT) 2005, Q.51

Let T(n) be a function defined by the recurrence

$$T(n) = 2T(n/2) + \sqrt{n} \text{ for } n \geq 2 \text{ and}$$
$$T(1) = 1$$

Which of the following statements is TRUE?

(A) $T(n) = \Theta(\log n)$
(B) $T(n) = \Theta(\sqrt{n})$
(C) $T(n) = \Theta(n)$
(D) $T(n) = \Theta(n \log n)$

170. GATE (IT) 2005, Q.52

Let G be a weighted undirected graph and e be an edge with maximum weight in G. Suppose there is minimum weight spanning tree in G containing edge e. Which of the following statements is always true?

(A) There exists a cutest in G having all edges of maximum weight.
(B) There exists a cycle in G having all edges of maximum weight.
(C) Edge e can be contained in a cycle.
(D) All edges in G have the same weight.

171. GATE (IT) 2005, Q.54

The following C function takes a singly linked list of integers as a parameter and rearranges the elements of the list. The list is represented as pointer to structure. The function is called with the list containing integers 1, 2, 3, 4, 5, 6, 7 in the given order. What will be the contents of the list after the function completes?

```
struct node {int value; struct node *next;};
void rearrange(struct node *list) {
     struct node *p, *q;
     int temp;
     if(!list || !list '! next) return;
     p = list; q = list → next;
     while(q) {
          temp = p → value;
          p → value = q → value;
          q → value = temp;
          p = q → next;
          q = p? p → next : 0;
     }
}
```

(A) 1, 2, 3, 4, 5, 6, 7
(B) 2, 1, 4, 3, 6, 5, 7
(C) 1, 3, 2, 5, 4, 7, 6
(D) 2, 3, 4, 5, 6, 7, 1

174. GATE (IT) 2005, Q.55

A binary search tree contains the numbers 1, 2, 3, 4, 5, 6, 7, 8. When the tree is traversed in preorder and the values in each node printed out, the sequence of values obtained is 5, 3, 1, 2, 4, 6, 8, 7. If the tree is traversed in postorder, the sequence obtained would be

(A) 8, 7, 6, 5, 4, 3, 2, 1
(B) 1, 2, 3, 4, 8, 7, 6, 5
(C) 2, 1, 4, 3, 6, 7, 8, 5
(D) 2, 1, 4, 3, 7, 8, 6, 5

175. GATE (IT) 2005, Q.56

Let G be a directed graph whose vertex set is the set of number from 1 to 100. There is an edge from a vertex i to a vertex j iff either j = i + 1 or j = 3i. The minimum number of edges in a path in G from vertex 1 to 100 is:

(A) 4
(B) 7
(C) 23
(D) 99

176. GATE (IT) 2005, Q.58

Let a be an array containing n integers in increasing order. The following algorithm determines whether there are two distinct numbers in the array whose difference is a specified number S > 0.

```
     i = 0; j = 1;
     while(j < n) {
          if (E) j++;
```

```
        else if ( a[j] - a[i] = = S) break;
        else i++;
    }
    if (j < n) printf ('yes') else printf('no');
```

Choose the correct expression for E.

(A) a[j] – a[i] > S
(B) a[j] – a[i] < S
(C) a[i] – a[j] < S
(D) a[i] – a[j] > S

177. GATE (IT) 2005, Q.59

Let a and b be two sorted arrays containing n integers each, in non-decreasing order. Let c be a sorted array containing 2n integers obtained by merging the two arrays a and b. Assuming the arrays are indexed starting from 0. Consider the following four statements.

I a[i] ≥ b[i] => c[2i] ≥ a[i]
II a[i] ≥ b[i] => c[2i] ≥ b[i]
III a[i] ≥ b[i] => c[2i] ≤ a[i]
IV a[i] ≥ b[i] => c[2i] ≤ a[i]

Which of the following is TRUE?

(A) Only I and II
(B) Only I and IV
(C) Only II and III
(D) Only III and IV

178. GATE (CSE) 2006, Q.10

In a binary max heap containing n numbers, the smallest element can be found in time

(A) Θ(n)
(B) Θ(log n)
(C) Θ(log log n)
(D) Θ(1)

179. GATE (CSE) 2006, Q.11

Consider a weighted complete graph G on the vertex set $\{v_1, v_2, \ldots, v_n\}$ such that the weight of the edge (v_{i-}, v_j) is $2|i - j|$. The weight of a minimum spanning tree of G is

(A) n – 1
(B) 2n – 2
(C) $\binom{n}{2}$
(D) n^2

180. GATE (CSE) 2006, Q.12

To implement Dijkstra's shortest path algorithm on undirected graphs so that it runs in linear time, the data structure to be used is

(A) Queue
(B) Stack
(C) Heap
(D) B–Tree

181. GATE (CSE) 2006, Q.13

A scheme for sorting binary trees in an array X is as follows. Indexing of X starts at 1 instead of 0. The root is stored at X[1]. For a node stored at X[i], the left child, if any is stored in X[2i] and the right child, if any, in X[2i + 1]. To be able to store any binary tree on n vertices the minimum size of X should be

(A) $\log_2 n$
(B) n
(C) 2n + 1
(D) $2^n - 1$

182. GATE (CSE) 2006, Q.14

Which one of the following in place sorting algorithms needs the minimum number of swaps?

(A) Queue sort
(B) Insertion sort
(C) Selection sort
(D) Heap sort

183. GATE (CSE) 2006, Q.15

Consider the following C-program fragment in which i, j, and n are integer variables.

```
for (i = n, j = 0; i > 0; i / = 2, j + = i);
```

Let val(j) denote the value stored in the variable j after termination of the loop. Which of the following is true?

(A) val(j) = $\Theta(\log n)$
(B) val(j) = $\Theta(\sqrt{n})$
(C) val(j) = $\Theta(n)$
(D) val(j) = $\Theta(n \log n)$

184. GATE (CSE) 2006, Q.16

Let S be an NP–complete problem and Q and R be two other problems not known to NP. Q is polynomial–time reducible to S and S is polynomial–time reducible to R. Which one of the following statements is true?

(A) R is NP-complete
(B) R is NP hard
(C) Q is NP-complete
(D) Q is NP hard

185. GATE (CSE) 2006, Q.17

An element in an array *X* is called a leader if it is greater than all elements to the right of it in *X*. The best algorithm to find all leader in an array

(A) Solves it in linear time using a left to right pass of the array
(B) Solves it in linear time using a right to left pass of the array
(C) Solves it using divide and conquer in time $\Theta(n \log n)$
(D) Solves it in time $\Theta(n^2)$

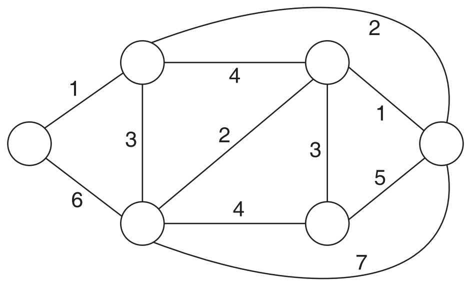
186. GATE (CSE) 2006, Q.21

For each element in a set of size 2n, an unbiased coin is tossed. The 2n coin tosses are independent. An element is chosen if the corresponding coin toss were head. The probability that exactly n elements are chosen is

(A) $\dfrac{\binom{2n}{n}}{4^n}$
(B) $\dfrac{\binom{2n}{n}}{2^n}$
(C) $\dfrac{1}{\binom{2n}{n}}$
(D) $\dfrac{1}{2}$

187. GATE (CSE) 2006, Q.47

Consider the following graph



Which one of the following cannot be the sequence of edges added, in that order, to a minimum spanning tree using Kruskal's algorithm?

(A) (a-b), (d-f), (b-f), (d-c), (d-e)
(B) (a-b), (d-f), (d-c), (b-f), (d-e)
(C) (d-f), (a-b), (d-c), (b-f), (d-e)
(D) (d-f), (a-b), (b-f), (d-e), (d-c)

188. GATE (CSE) 2006, Q.48

Let *T* be a depth-first search tree in an undirected graph *G*. Vertices u and v are leaves of this tree *T*. The degrees of both u and v in *G* are at least 2. Which one of the following statements is true?

(A) There must exist a vertex w adjacent to both u and v in G
(B) There must exist a vertex w whose removal disconnects u and v in G
(C) There must exist a cycle in G containing u and v
(D) There must exist a cycle in G containing u and v and all its neighbours in G

189. GATE (CSE) 2006, Q.49

An implementation of queue Q, using stacks S1 and S2 is given below:

```
void insert (Q, x) {
     push (S1, x);
}
void delete (Q) {
     if (stack-empty (S2)) then
          if (stack-empty (S1)) then {
               print (" Q is empty");
               return;
          }
          else while (! (stack-empty (S1))) then {
                    x = pop (S1);
                    push (S2, x);
          }
     x = pop (S2);
}
```

Let *n* insert and *m* ($\leq n$) delete operations be performed in an arbitrary order on an empty queue Q. Let *x* and *y* be the number of push and pop operations performed respectively in the process. Which one of the following is true for all *m* and *n*?

(A) $n + m \leq x < 2n$ and $2m \leq y \leq n + m$
(B) $n + m \leq x < 2n$ and $2m \leq y \leq 2n$
(C) $2m \leq x < 2n$ and $2m \leq y \leq n + m$
(D) $2m \leq x < 2n$ and $2m \leq y \leq 2n$

190. GATE (CSE) 2006, Q.50

A set X can be represented by an array x[n] as follows:

$$x[i] = \begin{cases} 1 & \text{if } i \in X \\ 0 & \text{otherwise} \end{cases}$$

Consider the following algorithm in which x, y and z are boolean arrays of size n:

```
Algorithm zzz (x[ ], y[ ], z[ ]) {
     int I;
     for (i = 0; i< n; ++i)
          z[i] = x[i] ^ ~ y[i] v (~ x[i] ^ y[i])
}
```

The set Z computed by the algorithm is

(A) $(X \cup Y)$
(B) $(X \cap Y)$
(C) $(X - Y) \cap (Y - X)$
(D) $(X - Y) \cup (Y - X)$

191. GATE (CSE) 2006, Q.51

Consider the following recurrence:

$$T(n) = 2T\left(\left\lceil \sqrt{n} \right\rceil\right) + 1, \; T(1) = 1$$

Which one of the following is true?

(A) $T(n) = \Theta(\log n)$
(B) $T(n) = \Theta(\sqrt{n})$
(C) $T(n) = \Theta(n)$
(D) $T(n) = \Theta(n \log n)$

192. GATE (CSE) 2006, Q.52

The median of n elements can be found in $O(n)$ time. Which one of the following is correct about the complexity of quick sort, in which median is selected as pivot?

(A) $\Theta(n)$
(B) $\Theta(n \log n)$
(C) $\Theta(n^2)$
(D) $\Theta(n^3)$

193. GATE (CSE) 2006, Q.53

Consider the following C-function in which a[n] and b[n] are two sorted integer arrays and c[n + m] be another array.

```
void xyz (int a[ ], int b[ ], int c[ ]) {
     int i, j, k;
     i = j = k = 0;
     whle (i < n) && (j< m))
```

```
                if (a [i] < b[j] ) c [ k++ ] = a [ i++ ];
                else c [ k++ ] = b [ j++ ];
        }
```

Which of the following condition(s) hold(s) after the termination of the while loop?

(i) $j < m$, $k = n + j - 1$, and $a[n-1] \le b[j]$ if $i = n$

(ii) $i < n$, $k = m + i - 1$, and $b[m-1] \le a[i]$ if $j = m$

(A) only (i)
(B) only (ii)
(C) either (i) or (ii) but not both
(D) neither (i) nor (ii)

194. GATE (CSE) 2006, Q.54

Given two arrays of numbers $a_1, \ldots, a_n$ and $b_1, \ldots, b_n$ where each number is 0 or 1, the fastest algorithm to find the largest span (i, j) such that

$a_i + a_{i+1} + \ldots + a_j = b_i + b_{i+1} + \ldots + b_j$ or report that there is no such span,

(A) Takes $O(3^n)$ and $\Omega(2^n)$ time if hashing is permitted
(B) Takes $O(n^3)$ and $\Omega(n^{2.5})$ time in the key comparison model
(C) Takes $\Theta(n)$ time and space
(D) Takes $O(\sqrt{n})$ time only if the sum of the 2n elements is an even number

195. GATE (CSE) 2006, Q.55

Consider these two functions and two statements S1 and S2 about them.

```
int work1 (int *a, int i, int j)
{
     int x = a[i + 2];
     a[j] = x +1;
     return a[i +2] - 3;
}
```

```
int work2 (int *a, int i, int j)
{
     int t1 = i + 2;
     int t2 = a[t1];
     a[j] = t2 + 1;
     return t2 - 3;
}
```

S1: The transformation from work1 to work2 is valid, i.e. for any program state and input arguments, work2 will compute the same output and have the same effect on program state as work1

S2: All transformations applied to work1 to get work2 will always improve the performance (i.e. reduce CPU time) of work2 compared to work1

(A) S1 is false and S2 is false
(B) S1 is false and S2 is true
(C) S1 is true and S2 is false
(D) S1 is true and S2 is true

196. GATE (CSE) 2006, Q.56

Consider the following code written in a pass-by reference language like FORTRAN and these statements about the code.

```
subroutine swap(ix, iy)
     it = ix
L1:  ix = iy
L2:  ix = it
     end
     ia = 3
     ib = 8
     call swap (ia, ib + 5)
     print *, ia, ib
     end
```

S1: The compiler will generate code to allocate a temporary nameless cell, initialize it to 13, and pass the address of the cell to swap

S2: On execution the code will generate a runtime error on line L1

S3: On execution the code will generate a runtime error on line L2

S4: The program will print 13 and 8

S5: The program will print 13 and

(A) S1 and S2
(B) S1 and S4
(C) S3
(D) S1 and S5

197. GATE (CSE) 2006, Q.57

Consider this C code to swap two integers and these five statements: The code

```
void swap (int *px, int *py) {
     *px = *px - *py;
     *py = *px + *py;
     *px = *py - *px
}
```

S1: will generate a compilation time error

S2: may generate a segmentation fault at runtime depending on the arguments passed

S3: correctly implements the swap procedure for all input pointers referring to integers stored in memory locations accessible to the process

S4: implements the swap procedure correctly for some but not all valid input pointers

S5: may address or subtract integers pointers

(A) S1
(B) S2 and S3
(C) S2 and S4
(D) S2 and S5

Common Data for Questions 71, 72, 73

The 2^n vertices of a graph G correspond to all subsets of size n, for $n \geq 6$. Two vertices of G are adjacent if and only if the corresponding sets intersect in exactly two elements.

198. GATE (CSE) 2006, Q.71

The number of vertices of degree zero in G is

(A) 1 (B) n

(C) n + 1 (D) 2^n

199. GATE (CSE) 2006, Q.72

The maximum degree of a vertex in G is

(A) $\binom{n/2}{2} 2^{n/2}$ (B) 2^{n-2}

(C) $2^{n-3} \times 3$ (D) 2^{n-1}

200. GATE (CSE) 2006, Q.73

The number of connected components in G is

(A) 2 (B) n + 2

(C) $2^{n/2}$ (D) $\frac{2^n}{n}$

201. GATE (IT) 2006, Q.9

In a binary tree, the number of internal nodes of degree 1 is 5, and the number of internal nodes of degree 2 is 10. The number of leaf nodes in the binary tree is

(A) 10 (B) 11

(C) 12 (D) 15

202. GATE (IT) 2006, Q. 10

A problem in NP is NP-complete if

(A) it can be reduced to the 3-SAT problem in polynomial time

(B) 3-SAT problem can be reduced to it in polynomial time

(C) it can be reduced to any other problem in NP in polynomial time

(D) some problem in NP can be reduced to it in polynomial time

203. GATE (IT) 2006, Q. 11

If all the edge weights of an undirected graph are positive, then any subset of edges that connects all the vertices and has minimum total weight is a

(A) Hamiltonian cycle (B) grid

(C) hypercube (D) tree

204. GATE (IT) 2006, Q.25

Consider the undirected graph G defined as follows. The vertices of G are bit strings of length n. We have an edge between vertex u and vertex v if and only if u and v differ in exactly one bit position (in other words, v can be obtained from u by flipping a single bit). The ratio of the chromatic number of G to the diameter of G is

(A) $1/2^{n-1}$
(B) 1/n
(C) 2/n
(D) 3/n

205. GATE (IT) 2006, Q. 44

Which of the following sequences of array elements forms a heap?

(A) {23, 17, 14, 6, 13, 10, 1, 12, 7, 5}
(B) {23, 17, 14, 6, 13, 10, 1, 5, 7, 12}
(C) {23, 17, 14, 7, 13, 10, 1, 5, 6, 12}
(D) {23, 17, 14, 7, 13, 10, 1, 12, 5, 7}

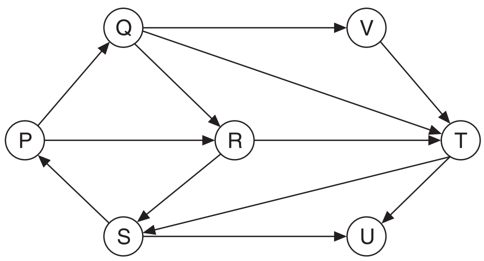
206. GATE (IT) 2006, Q. 45

Suppose that we have numbers between 1 and 100 in a binary search tree and want to search for the number 55. Which of the following sequences CANNOT be the sequence of nodes examined?

(A) {10, 75, 64, 43, 60, 57, 55}
(B) {90, 12, 68, 34, 62, 45, 55}
(C) {9, 85, 47, 68, 43, 57, 55}
(D) {79, 14, 72, 56, 16, 53, 55}

207. GATE (IT) 2006, Q. 46

Which of the following is the correct decomposition of the directed graph given below into its strongly connected components?



(A) {P, Q, R, S}, {T}, {U}, {V}
(B) {P, Q, R, S, T, V}, {U}
(C) {P, Q, S, T, V}, {R}, {U}
(D) {P, Q, R, S, T, U, V}

208. GATE (IT) 2006, Q. 47

Consider the depth-first search of an undirected graph with 3 vertices P, Q and R. Let discovery time $d(u)$ represent the time instant when the vertex u is first visited, and finish time $f(u)$ represent the time instant when the vertex u is last visited. Given that

$d(P)$ = 5 units $f(P)$ = 12 units
$d(Q)$ = 6 units $f(Q)$ = 10 units
$d(R)$ = 14 units $f(R)$ = 18 units

Which of the following statements is TRUE about the graph?

(A) There is only one connected component
(B) There are connected components, and P and R are connected

(C) There are connected components, and Q and R are connected
(D) There are connected components, and P and Q are connected

209. GATE (IT) 2006, Q. 50

Which one of the choices given below would be printed when the following program is executed?

```
#include<stdio.h>
void swap(int *x, int *y)
{
     static int *temp;
     temp = x;
     x = y;
     y = temp;
}
void printab( )
{
     static int i, a = -3, b = -6;
     i = 0;
     while (i<=0)
     {
          if ((i++)%2 = = 1) continue;
          a = a + i;
          b = b + i;
     }
     swap(&a, &b);
     printf("a = %d, b=%d\n", a, b);
}
main( )
{
     printab( );
     printab( );
}
```

(A) a = 0, b = 3
a = 0, b = 3

(B) a = 3, b = 0
a = 12, b = 9

(C) a = 3, b = 6
a = 3, b = 6

(D) a = 6, b = 3
a = 15, b = 12

210. GATE (IT) 2006, Q. 51

Which one of the choices given below would be printed when the following program is executed?

```
#include<stdio.h>
int a1[] = {6, 7, 8, 18, 34, 67};
int a2[] = {23, 56, 28, 29};
int a3[] = {-12, 27, -31};
int *x[] = {a1, a2, a3};
void print( int *a[])
{
```

```
        printf("%d,", a[0][2]);
        printf("%d,", *a[2]);
        printf("%d,", *++a[0]);
        printf("%d,", *(++a)[0]);
        printf("%d,", a[-1][+1]);
}
main( )
{
        print(x);
}
```

(A) 8, –12, 7, 23, 8
(B) 8, 8, 7, 23, 7
(C) –12, –12, 27, –31, 23
(D) –12, –12, 27, –31, 56

211. GATE (IT) 2006, Q. 52

The following function computes the value of $\binom{m}{n}$ correctly for all legal values m and n ($m \geq 1$, $n \geq 0$ and $m > n$)

```
int func( int m, int n)
{
        if (E) return 1;
        else return (func(m-1, n) + func(m-1, n-1));
}
```

(A) (n = = 0) || (m = = 1)
(B) (n = = 0) && (m = = 1)
(C) (n = = 0) || (m = = n)
(D) (n = = 0) && (m = = n)

Common data for Questions 71–73:

An array *X* of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0.

212. GATE (IT) 2006, Q. 71

The index of the parent element X[i], $i \neq 0$, is

(A) $\lfloor i/2 \rfloor$
(B) $\lceil (i-1)/2 \rceil$
(C) $\lceil i/2 \rceil$
(D) $\lceil i/2 \rceil - 1$

213. GATE (IT) 2006, Q. 72

If only the root node does not satisfy the heap property, the algorithm to convert the complete binary tree into a heap has the best asymptotic time complexity of

(A) O(n)
(B) O(log n)
(C) O(n log n)
(D) O(n log log n)

214. GATE (IT) 2006, Q.73

If the root node is at level 0, the level of element X[i], $i \neq 0$, is

(A) $\log_2 i$
(B) $\lceil \log_2 (i+1) \rceil$
(C) $\lfloor \log_2 (i+1) \rfloor$
(D) $\lceil \log_2 i \rceil$

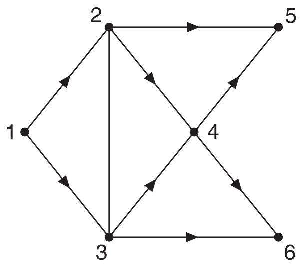
215. GATE (CSE) 2007, Q.4

Let G be the non-planar graph with the minimum possible number of edges. Then G has

(A) 9 edges and 5 vertices (B) 9 edges and 6 vertices
(C) 10 edges and 5 vertices (D) 10 edges and 6 vertices

216. GATE (CSE) 2007, Q.5

Consider the DAG with V = {1, 2, 3, 4, 5, 6}, shown below.



Which one the following is **NOT** a topological ordering?

(A) 1 2 3 4 5 6 (B) 1 3 2 4 5 6
(C) 1 3 2 4 6 5 (D) 3 2 4 1 6 5

217. GATE (CSE) 2007, Q.12

The height of a binary tree is the maximum number of edges in any root to leaf path. The maximum number of nodes in a binary tree of height h is:

(A) 2^h (B) $2^{h-1} - 1$
(C) $2^{h+1} - 1$ (D) 2^{h+1}

218. GATE (CSE) 2007, Q.13

The maximum number of binary trees that can be formed with three unlabelled nodes is:

(A) 1 (B) 5
(C) 4 (D) 3

219. GATE (CSE) 2007, Q.14

Which of the following sorting algorithms has the lowest worst-case complexity?

(A) Merge sort (B) Bubble sort
(C) Quick sort (D) Selection sort

220. GATE (CSE) 2007, Q.15

Consider the following segment of C-code:

```
int j, n;
    j = 1;
    whle ( j < = n)
        j = j * 2;
```

The number of comparisons made in the execution of the loop for any $n > 0$ is:

(A) $\lceil \log_2 n \rceil + 1$
(B) n
(C) $\lceil \log_2 n \rceil$
(D) $\lfloor \log_2 n \rfloor + 1$

221. GATE (CSE) 2007, Q.38

The following postfix expression with single digit operands is evaluated using a stack:

8 2 3 ^ / 2 3 * + 5 1 * –

Note that ^ is the exponentiation operator. The top two elements of the stack after the first *is evaluated are:

(A) 6, 1
(B) 5, 7
(C) 3, 2
(D) 1, 5

222. GATE (CSE) 2007, Q.39

The inorder and preorder traversal of a binary tree are
d b e a f c g and a b d e c f g, respectively.
The postorder traversal of the binary tree is

(A) d e b f g c a
(B) e d b g f c a
(C) e d b f g c a
(D) d e f g b c a

223. GATE (CSE) 2007, Q.40

Consider a hash table of size seven, with starting index zero, and a hash function (3x + 4) mod 7. Assuming the hash table is initially empty, which of the following is the contents of the table when the sequence 1, 3, 8, 10 is inserted into the table using closed hashing? Note that – denotes an empty location in the table.

(A) 8, –, –, –, –, –, 10
(B) 1, 8, 10, –, –, –, 3
(C) 1, –, –, –, –, –, 3
(D) 1, 10, 8, –, –, –, 3

224. GATE (CSE) 2007, Q.41

In an unweighted, undirected connect graph, the shortest path from a node S to every node is computed most efficiently, in terms of *time complexity,* by

(A) Dijkstra's algorithm starting from S.
(B) Warshall's algorithm.
(C) Performing a DFS starting from S.
(D) Performing a BFS starting from S.

225. GATE (CSE) 2007, Q.42

Consider the following C function:

```
int f(int n)
    {
        static int are = 0;
        If (n < = 0) return 1;
        If (n > 3)
            { r = n;
```

```
            return f (n - 2) + 2;
            }
        return f(n - 1) + r;
    }
```

What is the value of f(5)?

(A) 3 (B) 7
(C) 9 (D) 18

226. GATE (CSE) 2007, Q.43

A complete *n*-ary tree is a tree in which each node has n children or no children. Let *I* be the number of internal nodes and *L* be the number of leaves in a complete *n*-ary tree. If $L = 41$, and $I = 10$, what is the value of n?

(A) 3 (B) 4
(C) 5 (D) 6

227. GATE (CSE) 2007, Q.44

In the following C function, let n ≥ m.

```
int gcd(n, m)
    {
        If (n % m = = 0) return m;
        n = n % m;
        return gcd(m, n);
    }
```

How many recursive calls are made by this function?

(A) $\Theta(\log_2 n)$ (B) $\Omega(n)$
(C) $\Theta(\log_2 \log_2 n)$ (D) $\Theta(\sqrt{n})$

228. GATE (CSE) 2007, Q.45

What is the *time complexity* of the following recursive function:

```
int Dosomething (int n) {
    If (n < = 2)
        return 1;
    else
        return Dosomething floor(sqrt (n))) + n);
    }
```

(A) $\Theta(n)$ (B) $\Theta(n \log_2 n)$
(C) $\Theta(\log_2 n)$ (D) $\Theta(\log_2 \log_2 n)$

229. GATE (CSE) 2007, Q.46

Consider the following C program segment where CellNode represents a node in a binary tree:

```
struct CellNode {
   struct CellNode *leftChild;
        int element;
```

```
    struct CellNode *rightChild;
    };
    int GetValue (struct CellNode *ptr)  {
        int value = 0;
        if ( ptr ! = NULL) {
            if (( ptr → leftChild = = NULL) && ( ptr → rightChild = = NULL))
                value = 1;
            else
                value = value + GetValue(ptr → leftChild) + GetValue(ptr
                                                           → rightChild);
        }
    return (value);
}
```

The value returned by GetValue when a pointer to the root of a binary tree is passed as its argument is:

(A) The number of nodes in the tree
(B) The number of internal nodes in the tree
(C) The number of leaf nodes in the tree
(D) The height of the tree.

230. GATE (CSE) 2007, Q.47

Consider the process of inserting an element into a *Max Heap,* where the *Max Heap* is represented by an array. Suppose we perform a binary search on the path from the new leaf to the root to find the position for the newly inserted element, the number of *comparisons* performed is:

(A) $\Theta(\log_2 n)$
(B) $\Theta(\log_2 \log_2 n)$
(C) $\Theta(n)$
(D) $\Theta(n \log_2 n)$

231. GATE (CSE) 2007, Q.49

Let w be the minimum weight among all edge weights in an undirected connected graph. Let e be a specific edge of weight w. Which of the following is **FALSE**?

(A) There is a minimum spanning tree containing e.
(B) If e is not in a minimum spanning tree T, then in the cycle formed by adding e to T, all edges have the same weight.
(C) Every minimum spanning tree has an edge of weight w.
(D) e is present in every minimum spanning tree.

232. GATE (CSE) 2007, Q.50

An array of n numbers is given, where n is an even number. The maximum as well as the minimum of these n numbers needs to be determined. Which of the following is **TRUE** about the number of comparisons needed?

(A) At least 2n – c comparisons, for some constant c, are needed.
(B) At least 1.5n – 2 comparisons are needed.
(C) At least $n \log_2 n$ comparisons are needed.
(D) None of the above.

233. GATE (CSE) 2007, Q.51

Consider the following C code segment:

```
int IsPrime(n)
{
     int i, n;
     for (i = 2; i <= sqrt (n); i++)
          if(n % i = = 0)
               {printf (" Not Prime\n"); return 0;}
     return 1;
}
```

Let T(n) denote the number of times the for loop is executed by the program on input n. Which of the following is **TRUE**?

(A) $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(\sqrt{n})$

(B) $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(1)$

(C) $T(n) = O(n)$ and $T(n) = \Omega(\sqrt{n})$

(D) None of the above.

Statement for Linked Answer Questions 84 & 85

Suppose that a robot is placed on the Cartesian plane. At each step it is allowed to move either one unit up or right, i.e., if it is at (i, j) then it can move to either (i + 1, j) or (i, j +1).

234. GATE (CSE) 2007, Q.84

How many distinct paths are there for the robot to reach the point (10, 10) starting from the initial position (0,0)?

(A) $\binom{20}{10}$ (B) 2^{20}

(C) 2^{10} (D) None of the above

235. GATE (CSE) 2007, Q.84

Suppose that the robot is not allowed to traverse the line segment from (4, 4) to (5, 4). With this constraint, how many distinct paths are there for the robot to reach (10, 10) starting from (0, 0)?

(A) 2^9 (B) 2^{19}

(C) $\binom{8}{4} \times \binom{11}{5}$ (D) $\binom{20}{10} - \binom{8}{4} \times \binom{11}{5}$

236. GATE (IT) 2007, Q.25

What is the largest m such that every simple connected graph with n vertices and n edges contains at least m different spanning trees?

(A) 1 (B) 2

(C) 3 (D) n

237. GATE (IT) 2007, Q.26

Consider n jobs $J_1, J_2, \ldots, J_n$ such that job J_i has execution time t_i and a non-negative integer weight w. The weighted mean completion time of the job is defined to be $\dfrac{\sum_{i=1}^{n} w_i T_i}{\sum_{i=1}^{n} w_i}$ where T_i is the completion time of job J_i. Assuming that there is only one processor available, in what order must the job be executed in order to minimize the weighted mean completion time of the jobs?

(A) Non-decreasing order of t_i
(B) Non-increasing order of w_i
(C) Non-increasing order of $w_i t_i$
(D) Non-increasing order of with/t_i

238. GATE (IT) 2007, Q.27

The function *f* is defined as follows:

```
int f(int n) {
if (n <= 1) return 1;
else if (n % 2 = =) return f(n/2));
else return f(3n – 1);
}
```

Assuming that arbitrarily large integers can be passed as a parameter to the function, consider the following statements.

(i) The function *f* terminates for finitely many different values of $n \geq 1$.
(ii) The function *f* terminates for infinitely many different values of $n \geq 1$.
(iii) The function *f* does not terminate for finitely many different values of $n \geq 1$.
(iv) The function *f* does not terminate for infinitely many different values of $n \geq 1$

Which one of the following options is true of the above?

(A) (i) and (iii) (B) (i) and (iv)
(C) (ii) and (iii) (D) (ii) and (iv)

239. GATE (IT) 2007, Q.28

Consider a hash function that distributes keys uniformly. The hash table size is 20. After hashing of how many keys will the probability that any new key hashed collides with an existing one exceed 0.5.

(A) 5 (B) 6
(C) 7 (D) 10

240. GATE (IT) 2007, Q.29

When searching for the key value 60 in a binary search tree, nodes containing the key values 10, 20, 40, 50, 70, 80, 90 are traversed, not necessarily in the order given. How many different orders are possible in which these key values can occur on the search path from the root node containing the value 60?

(A) 35 (B) 64
(C) 128 (D) 5040

241. GATE (IT) 2007, Q.30

Suppose you are given an implementation of a queue of integers. The operations that can be performed on the queue are:

isEmpty(Q) — returns true if the queue is empty, false otherwise.
delete(Q) — deletes the element at the front of the queue and returns its value.
insert(Q, i) — inserts the integer i at the rear of the queue.

Consider the following function:

```
void f(queue Q)
{
     int i;
     if(!isEmpty (Q)) {
          i = delete(Q);
          f(Q)
          insert(Q, i);
     }
}
```

What operation is performed by the above function f?

(A) Leaves the queue Q unchanged
(B) Reverses the order of elements in the queue Q
(C) Deletes the element at the front of the queue Q and inserts it at the rear keeping the other elements in the same order
(D) Empties the queue Q.

242. GATE (IT) 2007, Q.51

Consider the following C program:

```
#include<stdio.h>
#define EOF -1
void push(int);         /* Push the argument on the stack */
int pop(void);          /* pop the top of the stack */
void flagError();
int main( )
{    int c, m, n, r;
     while ((c = getchar( )) != EOF)
     {    if (isdigit(c))
               push (c)
          else if (c = = '+') || (c = = '*'))
          {    m = pop( );
               n = pop( );
               are = (c = = '+') ? n + m : n*m;
```

```
                push(r);
            }
            else if (c != ' ')
                flagError( );
        }
        printf("%c", pop( ));
    }
```

What is the output of the program for the following input?

5 2 * 3 3 2 + * +

(A) 15 (B) 25
(C) 30 (D) 150

243. GATE (IT) 2007, Q.52

Given the following algorithm for sorting an array X of N numbers:

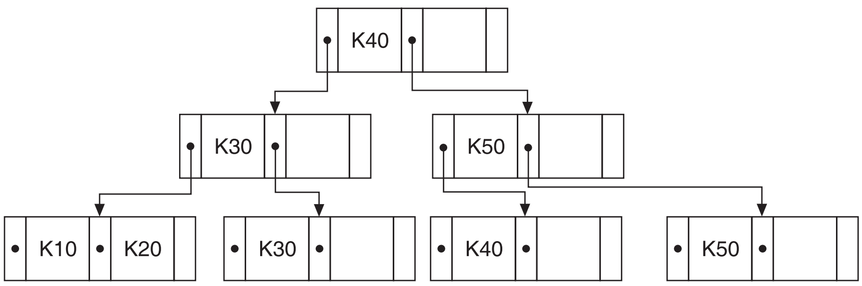
```
SUBROUTINE SORT(X, N)
    IF (N < 2)
        RETURN
    FOR ( i = 2 TO N INCREMENT BY 1)
        FOR (j = 1 TO i INCREMENT BY 1)
            IF (X[i] > X[j])
                CONTINUE
            TEMP = X[i]
            X[i] = X[j]
            X[j] = TEMP
        END FOR
    END FOR
END SUBROUTINE
```

A good approximation of Halstead's *estimated program length is*

(A) 20 (B) 50
(C) 80 (D) 110

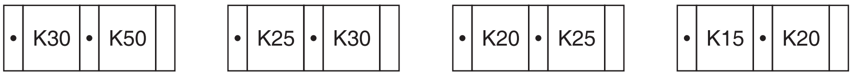
Statements for linked Answer Questions 84 & 85

Consider the B^+ tree in the adjoining figure, where each node has at most two keys and three links.



244. GATE (IT) 2007, Q.84

Keys K15 and then K25 are inserted into this tree in that order. Exactly how many of the following nodes (disregarding the links) will be present in the tree after the two insertions?

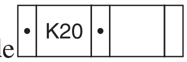


(A) 1 (B) 2
(C) 3 (D) 4

245. GATE (IT) 2007, Q.85

Now the keys K50 are deleted from the B^+ tree resulting after the two insertions made earlier. Consider the following statements about the B^+ tree resulting after this deletion.

(i) The height of the tree remains the same.

(ii) The node 

(disregarding the links) is present in the tree.

(iii) The root node remains unchanged (disregarding the links).

Which of the following option is true?

(A) Statements (i) and (ii) are true
(B) Statements (ii) and (iii) are true
(C) Statements (iii) and (i) are true
(D) All the statements are false

246. GATE (CSE) 2008, Q.6

Let r denote number system radix. The only value(s) of r that satisfy the equation $\sqrt{121_r} = 11_r$ is/are

(A) decimal 10
(B) decimal 11
(C) decimal 10 and 11
(D) any value > 2

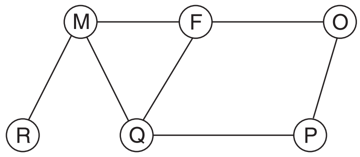
247. GATE (CSE) 2008, Q.7

The most efficient algorithm for finding the number of connected components in an undirected graph on n vertices and m edges has time complexity

(A) Θ (n)
(B) Θ (m)
(C) Θ (m + n)
(D) Θ (mn)

248. GATE (CSE) 2008, Q.19

The Breadth First Search algorithm has been implemented using the queue data structure. One possible order of visiting the nodes of the following graph is



(A) MNOPQR
(B) NQMPOR
(C) QMNPRO
(D) QMNPOR

249. GATE (CSE) 2008, Q.20

The data blocks of a very large file in the Unix file system are allocated using

(A) contiguous allocation
(B) linked allocation
(C) indexed allocation
(D) an extension of indexed allocation

250. GATE (CSE) 2008, Q.23

Which of the following statements is true for every planar graph on n vertices?

(A) The graph is connected.
(B) The graph is Eulerian.
(C) The graph has a vertex-cover of size at most $3n/4$.
(D) The graph has an independent set of size at least $n/3$.

251. GATE (CSE) 2008, Q.27

Aishwarya studies either computer science or mathematics everyday. If she studies computer science on a day, then the probability that she studies mathematics the next day is 0.6. If she studies mathematics on a day, then the probability that she studies computer science the next day is 0.4. Given that Aishwarya studies computer science on Monday, what is the probability that she studies computer science on Wednesday?

(A) 0.24
(B) 0.36
(C) 0.40
(D) 0.60

252. GATE (CSE) 2008, Q.39

Consider the following functions:

$$f(n) = 2^n$$
$$g(n) = n!$$
$$h(n) = n^{\log n}$$

Which of the following statements about the asymptotic behaviour of $f(n)$, $g(n)$, and $h(n)$ is true?

(A) $f(n) = O(g(n))$; $g(n) = O(h(n))$
(B) $f(n) = \Omega(g(n))$; $g(n) = O(h(n))$
(C) $g(n) = O(f(n))$; $h(n) = O(f(n))$
(D) $h(n) = O(f(n))$; $g(n) = \Omega(f(n))$

253. GATE (CSE) 2008, Q.40

The minimum number of comparisons required to determine if an integer appears more than $n/2$ times in a sorted array of n integers is

(A) $\Theta(n)$
(B) $\Theta(\log n)$
(C) $\Theta(\log^* n)$
(D) $\Theta(1)$

254. GATE (CSE) 2008, Q.41

A B-tree of order 4 is built from scratch by 10 successive insertions. What is the maximum number of node splitting operations that may take place?

(A) 3
(B) 4
(C) 5
(D) 6

255. GATE (CSE) 2008, Q.42

G is a graph of n vertices and $2n - 2$ edges. The edges of G can be partitioned into two edge-disjoint spanning trees. Which of the following is NOT true for G?

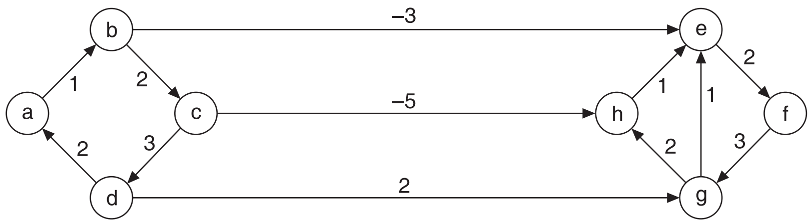
(A) For every subset of k vertices, the induced subgraph has at most $2k - 2$ edges.
(B) The minimum cut in G has at least two edges.
(C) There are two edge-disjoint paths between every pair of vertices.
(D) There are two vertex-disjoint paths between every pair of vertices.

256. GATE (CSE) 2008, Q.43

Consider the Quicksort algorithm. Suppose there is a procedure for finding a pivot element which splits the list into two sub-lists each of which contains at least one-fifth of the elements. Let $T(n)$ be the number of comparisons required to sort n elements. Then

(A) $T(n) \le 2T(n/5) + n$
(B) $T(n) \le T(n/5) + T(4n/5) + n$
(C) $T(n) \le 2T(4n/5) + n$
(D) $T(n) \le 2T(n/2) + n$

257. GATE (CSE) 2008, Q.45



Dijkstra's single source shortest path algorithm when run from vertex *a* in the above graph, computes the correct shortest path distance to

(A) only vertex *a*
(B) only vertices *a*, *e*, *f*, *g*, *h*
(C) only vertices *a*, *b*, *c*, *d*
D) all the vertices

258. GATE (CSE) 2008, Q.46

You are given the postorder traversal, *P*, of a binary search tree on the *n* elements 1, 2, ..., *n*. You have to determine the unique binary search tree that has *P* as its postorder traversal. What is the time complexity of the most efficient algorithm for doing this?

(A) $\Theta(\log n)$
(B) $\Theta(n)$
(C) $\Theta(n \log n)$
(D) none of the above, as the tree cannot be uniquely determined.

259. GATE (CSE) 2008, Q.47

We have a binary heap on *n* elements and wish to insert more elements (not necessarily one after another) into this heap. The total time required for this is

(A) $\Theta(\log n)$
(B) $\Theta(n)$
(C) $\Theta(n \log n)$
(D) $\Theta(n^2)$

260. GATE (CSE) 2008, Q.62

The following C function takes a singly-linked list of integers as a parameter and rearranges the elements of the list. The function is called with the list containing the integers 1, 2, 3, 4, 5, 6, 7 in the given order. What will be the contents of the list after the function completes execution?

```
struct node {
    int value;
    struct node *next;
};
void rearrange (struct node *list) {
```

```
    struct node *p, *q;
    int temp;

    if (!list || !list -> next) return;
    p = list; q = list -> next;
    while (q) {
        temp = p -> value; p -> value =q -> value;
        q -> value = temp; p = q -> next;
        q = p ? -> next : 0;
    }
}
```

(A) 1, 2, 3, 4, 5, 6, 7
(B) 2, 1, 4, 3, 6, 5, 7
(C) 1, 3, 2, 5, 4, 7, 6
(D) 2, 3, 4, 5, 6, 7, 1

Common Data for Questions 74 and 75:

Consider the following C functions:

```
int f1 ( int n )
{
    if (n == 0 || n == 1)
        return n;
    else
        return (2*f1(n -1) + 3 * f1(n – 2));
}
int f2 ( int n )
{
    int i;
    int X[N], Y[N], Z[N];

    X[0] = Y[0] = Z[0] = 0;
    X[1] = 1; Y[1] = 2; Z[1] = 3;
    for (i = 2; i <= n; i++) {
        X[i] = Y[i – 1] + Z[i – 2];
        Y[i] = 2 * X[i];
        Z[i] = 3 * X[i];
    }
    return X[n];
}
```

261. GATE (CSE) 2008, Q.74

The running time of `f1(n)` and `f2(n)` are

(A) $\Theta(n)$ and $\Theta(n)$
(B) $\Theta(2^n)$ and $\Theta(n)$
(C) $\Theta(n)$ and $\Theta(2^n)$
(D) $\Theta(2^n)$ and $\Theta(2^n)$

262. GATE (CSE) 2008, Q.75

`f1(8)` and `f2(8)` return the values

(A) 1661 and 1640
(B) 59 and 59
(C) 1640 and 1640
(D) 1640 and 1661

Statement for Linked Answer Questions 78 and 79:

Let x_n denote the number of binary strings of length that contain no consecutive 0s.

263. GATE (CSE) 2008, Q.78

Which of the following recurrences does satisfy?

(A) $x_n = 2x_{n-1}$
(B) $x_n = x_{\lfloor n/2 \rfloor} + 1$
(C) $x_n = x_{\lfloor n/2 \rfloor} + n$
(D) $x_n = x_{n-1} + x_{n-2}$

264. GATE (CSE) 2008, Q.79

The value of x_5 is

(A) 5
(B) 7
(C) 8
(D) 16

Statement for Linked Answer Questions 84 and 85:

Consider the following C program that attempts to locate an element x in an array Y[ ] using binary search. The program is erroneous.

```
f(int Y[10], int x) {
int i, j, k;
i = 0; j = 9;
do {
          k = (i+j)/2;
          if (Y[k] < x) I = k; else j = k;
          } while ((Y[k] != x) && (i<j):
if (Y[k] == x) printf ("x is in the array);
else printf ("x is not in the array);
}
```

265. GATE (CSE) 2008, Q.84

On which of the following contents of `Y` and `x` does the program fail?

(A) Y is [1 2 3 4 5 6 7 8 9 10] and x < 10
(B) Y is [1 3 5 7 9 11 13 15 17 19] and x < 1
(C) Y is [2 2 2 2 2 2 2 2 2 2] and x > 2
(D) Y is [2 4 5 8 10 12 14 16 18 20] and 2 < x < 20 and x is even

266. GATE (CSE) 2008, Q.85

The correction needed in the program to make it work properly is

(A) change line 6 to: if (Y[k] < x) i = k+1; else j =k-1;
(B) change line 6 to: if (Y[k] < x) i = k-1; else j = k+1;
(C) change line 6 to: if (Y[k] <= x) i = k; else j = k;
(D) change line 7 to: } while ((Y[k] == x) && (i < j));

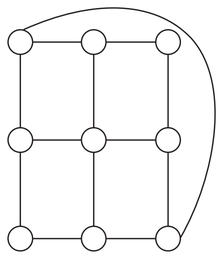
267. GATE (IT) 2008, Q.2

A sample space has two events A and B such that probabilities $P(A \cap B) = 1/2$, $P(\overline{A}) = 1/3$, $P(\overline{B}) = 1/3$. What is $P(A \cup B)$?

(A) 11/12
(B) 10/12
(C) 9/12
(D) 8/12

268. GATE (IT) 2008, Q.3

What is the chromatic number of the following graph?



(A) 2
(B) 3
(C) 4
(D) 5

269. GATE (IT) 2008, Q.12

Which of the following is TRUE?

(A) The cost of searching an AVL tree is $\theta(\log n)$ but that of a binary search tree is $O(n)$.
(B) The cost of searching an AVL tree is $\theta(\log n)$ but that of a complete binary tree is $\theta(n \log n)$.
(C) The cost of searching a binary search tree is $O(\log n)$ but that of an AVL tree is $\theta(n)$.
(D) The cost of searching an AVL tree is $\theta(n \log n)$ but that of a binary search tree is $O(n)$.

270. GATE (IT) 2008, Q.23

What is the probability that in a randomly chosen group of r people at least three people have the same birthday?

(A) $1-\dfrac{365.364\cdots\cdots(365-r+1)}{365^r}$

(B) $\dfrac{365.364\cdots\cdots(365-r+1)}{365^r}+{}^rC_2\cdot 365\cdot\dfrac{364.363\cdots\cdots(364-(r-2)+1)}{364^{r-2}}$

(C) $1-\dfrac{365.364\cdots\cdots(365-r+1)}{365^r}+{}^rC_2\cdot 365\cdot\dfrac{364.363\cdots\cdots(364-(r-2)+1)}{364^{r-2}}$

(D) $\dfrac{365.364\cdots\cdots(365-r+1)}{365^r}$

271. GATE (IT) 2008, Q.27

G is a simple undirected graph. Some vertices of G are of odd degree. Add a node v to G and make it adjacent to each odd degree vertex of G. The resultant graph is sure to be

(A) regular
(B) complete
(C) Hamiltonian
(D) Euler

272. GATE (IT) 2008, Q.43

If we use Radix Sort to sort n integers in the range $(n^{k/2}, n^k)$, for some $k > 0$ which is independent of n, the time taken would be

(A) $\theta(n)$
(B) $\theta(kn)$
(C) $\theta(n \log n)$
(D) $\theta(n^2)$

273. GATE (IT) 2008, Q.44

When $n = 2^{2k}$ for some $k \geq 9$, the recurrence relation

$T(n) = \sqrt{2}T(n/2) + \sqrt{n}, T(1) = 1$

evaluates to

(A) $\sqrt{n}\,(\log n + 1)$

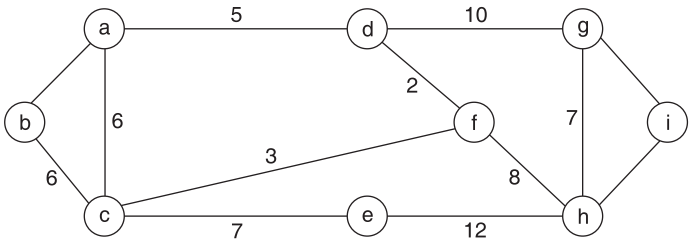
(B) $\sqrt{n}\,\log n$

(C) $\sqrt{n}\,\log \sqrt{n}$

(D) $n \log \sqrt{n}$

274. GATE (IT) 2008, Q.45

For the undirected, weighted graph given below, which of the following sequences of edges represents a correct execution of Prim's algorithm to construct a Minimum Spanning Tree?



(A) (a, b), (d, f), (f, c), (g, i), (d, a), (g, h), (c, e), (f, h)
(B) (c, e), (c, f), (f, d), (d, a), (a, b), (g, h), (h, f), (g, i)
(C) (d, f), (f, c), (d, a), (a, b), (c, e), (f, h), (g, h), (g, i)
(D) (h, g), (g, i), (h, f), (f, c), (f, d), (d, a), (a, b), (c, e)

275. GATE (IT) 2008, Q.46

The following three are known to be the preorder, inorder and postorder sequences of a binary tree. But it is not known which is which.

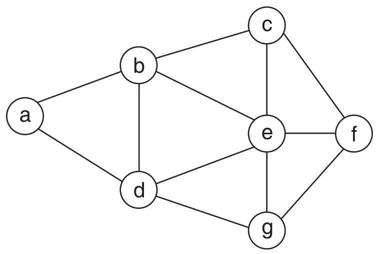
I. MBCAFHPYK
II. KAMCBYPFH
III. MABCKYFPH

Pick the true statement from the following.

(A) I and II are preorder and inorder sequences, respectively.
(B) I and III are preorder and postorder sequences, respectively.
(C) II is the inorder sequence, but nothing more can be said about the other two sequences.
(D) II and III are the preorder and inorder sequences, respectively.

276. GATE (IT) 2008, Q.47

Consider the following sequences of nodes for the undirected graph given below.



I. a b e f d g c
II. a b e f c g d
III. a d g e b c f
IV. a d b c g e f

A Depth First Search (DFS) is started at node *a*. The nodes are listed in the order they are first visited. Which all of the above is (are) possible output(s)?

(A) I and III only
(B) II and III only
(C) II, III and IV only
(D) I, II and III only

277. GATE (IT) 2008, Q.48

Consider a hash table of size 11 that uses open addressing with linear probing. Let $h(k) = k \bmod 11$ be a hash function used. A sequence of records with keys

43 36 92 87 11 4 71 13 14

is inserted into an initially empty hash table, the bins of which are indexed from zero to ten. What is the index of the bin into which the last record is inserted?

(A) 3
(B) 4
(C) 6
(D) 7

Common Data for Questions 71, 72, and 73:

A Binary Search Tree (BST) stores values in the range 37 to 573. Consider the following sequences of keys.

I. 81, 537, 102, 439, 285, 376, 305
II. 52, 97, 121, 195, 242, 381, 472
III. 142, 248, 520, 386, 345, 270, 307
IV. 550, 149, 507, 395, 463, 402, 270

278. GATE (IT) 2008, Q.71

Suppose the BST has been unsuccessfully searched for key 273. Which all of the above sequences list nodes in the order in which we could have encountered them in the search?

(A) II and III only
(B) I and III only
(C) III and IV only
(D) III only

279. GATE (IT) 2008, Q.72

Which of the following statements is TRUE?

(A) I, II and IV are inorder sequences of three different BSTs
(B) I is a preorder sequence of some BST with 439 as the root
(C) II is an inorder sequence of some BST where 121 is the root and 52 is a leaf
(D) IV is a postorder sequence of some BST with 149 as the root.

280. GATE (IT) 2008, Q.73

How may distinct BSTs can be constructed with 3 distinct keys?

(A) 4
(B) 5
(C) 6
(D) 9

Statement for Linked Answer Questions 76 and 77.

A binary tree with $n > 1$ nodes has n_1, n_2 and n_3 nodes of degree one, two and three respectively. The degree of a node is defined as the number of its neighbours.

281. GATE (IT) 2008, Q.76

n_3 can be expressed as:

(A) $n_1 + n_2 - 1$
(B) $n_1 - 2$
(C) $\left\lceil \frac{n_1 + n_2}{2} \right\rceil$
(D) $n_2 - 1$

282. GATE (IT) 2008, Q.77

Starting with the above tree, while there remains a node v of degree two in the tree, add an edge between the two neighbours of and then remove v from the tree. How many edges will remain at the end of the process?

(A) $2 * n_1 - 3$
(B) $n_2 + 2 * n_1 - 2$
(C) $n_3 - n_2$
(D) $n_2 + n_1 - 2$

283. GATE (CS&IT) 2009, Q.1

Which one of the following is TRUE for any simple connected undirected graph with more that 2 vertices?

(A) No two vertices have the same degree.
(B) At least two vertices have the same degree.
(C) At least three vertices have the same degree.
(D) All vertices have the same degree.

284. GATE (CS&IT) 2009, Q.11

What is the number of swaps required to sort n elements using selection sort, in the worst case?

(A) $\theta(n)$
(B) $\theta(n \log n)$
(C) $\theta(n^2)$
(D) $\theta(n^2 \log n)$

285. GATE (CS&IT) 2009, Q.12

Which of the following statement(s) is/are correct regarding Bellman-Ford shortest path algorithm?

P. Always finds a negative weighted cycle, if one exists.

Q. Finds whether any negative weighted cycle is reachable from the source.

(A) P only
(B) Q only
(C) Both P and Q
(D) Neither P nor Q

286. GATE (CS&IT) 2009, Q.21

An unbalanced dice (with 6 faces, numbered from 1 to 6) is thrown. The probability that the face value is odd is 90% of the probability that the face value is even. The probability of getting any even numbered face is the same.

If the probability that the face is even given that it is greater than 3 is 0.75, which one of the following options is closest to the probability that the face value exceeds 3?

(A) 0.453
(B) 0.468
(C) 0.485
(D) 0.492

287. GATE (CS&IT) 2009, Q.35

The running time of an algorithm is represented by the following recurrence relation:

$$T(n) = \begin{cases} n & n \leq 3 \\ T(n/3) + cn & \text{otherwise} \end{cases}$$

Which one of the following represents the time complexity of the algorithm?

(A) $\theta(n)$
(B) $\theta(n \log n)$
(C) $\theta(n^2)$
(D) $\theta(n^2 \log n)$

288. GATE (CS&IT) 2009, Q.36

The keys 12, 18, 13, 2, 3, 23, 5 and 15 are inserted into an initially empty hash table of length 10 using open addressing with hash function $h(k) = k \bmod 10$ and linear probing. What is the resultant hash table?

(A)

0	
1	
2	2
3	23
4	
5	15
6	
7	
8	18
9	

(B)

0	
1	
2	12
3	13
4	
5	5
6	
7	
8	18
9	

(C)

0	
1	
2	12
3	13
4	2
5	3
6	23
7	5
8	18
9	15

(D)

0	
1	
2	12, 2
3	13, 3, 23
4	
5	5, 15
6	
7	
8	18
9	

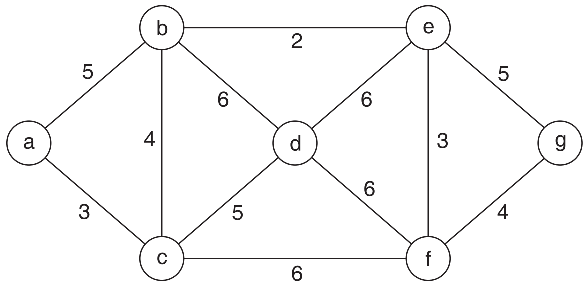
289. GATE (CS&IT) 2009, Q.37

What is the maximum height of any AVL-tree with 7 nodes? Assume that the height of a tree with a single node is 0.

(A) 2
(B) 3
(C) 4
(D) 5

290. GATE (CS&IT) 2009, Q.38

Consider the following graph:



Which one of the following is NOT the sequence of edges added to the minimum spanning tree using Kruskal's algorithm?

(A) (b, e) (e, f) (a, c) (b, c) (f, g) (c, d)
(B) (b, e) (e, f) (a, c) (f, g) (b, c) (c, d)
(C) (b, e) (a, c) (e, f) (b, c) (f, g) (c, d)
(D) (b, e) (e, f) (b, c) (a, c) (f, g) (c, d)

291. GATE (CS&IT) 2009, Q.39

In quick sort, for sorting n elements, the $(n/4)$th smallest element is selected as pivot using an $O(n)$ time algorithm. What is the worst case time complexity of the quick sort?

(A) $\theta(n)$
(B) $\theta(n \log n)$
(C) $\theta(n^2)$
(D) $\theta(n^2 \log n)$

292. GATE (CS&IT) 2009, Q.44

The following key values are inserted into a B+-tree in which order of the internal nodes is 3, and that of the leaf nodes is 2, in the sequence given below. The order of internal nodes is the maximum number of tree pointers in each node, and the order of leaf nodes is the maximum number of data items that can be stored in it. The B+-tree is initially empty.

10, 3, 6, 8, 4, 2, 1

The maximum number of times leaf nodes would get split up as a result of these insertions is

(A) 2
(B) 3
(C) 4
(D) 5

Statement for Linked Answer Questions 59 and 60:
Consider a binary max-heap implemented using an array.

293. GATE (CS&IT) 2009, Q.59

Which one of the following array represents a binary max-heap?

(A) {25, 12, 16, 13, 10, 8, 14}
(B) {25, 14, 13, 16, 10, 8, 12}
(C) {25, 14, 16, 13, 10, 8, 12}
(D) {25, 14, 12, 13, 10, 8, 16}

294. GATE (CS&IT) 2009, Q.60

What is the content of the array after two delete operations on the correct answer to the previous question?

(A) {14, 13, 12, 10, 8}
(B) {14, 12, 13, 8, 10}
(C) {14, 13, 8, 12, 10}
(D) {14, 13, 12, 8, 10}

295. GATE (CS&IT) 2010, Q.01

Let $G = (V, E)$ be a graph. Define $£(G) = \sum_d i_d \, x \, d$, where i_d is the number of vertices of degree d in G. If S and T are two different trees with $£(S) = £(T)$, then

(A) $|S| = 2|T|$
(B) $|S| = |T| - 1$
(C) $|S| = |T|$
(D) $|S| = |T| + 1$

296. GATE (CS&IT) 2010, Q.10

In a binary tree with n nodes, every node has an odd number of descendants. Every node is considered to be its own descendant. What is the number of nodes in the tree that have exactly one child?

(A) 0
(B) 1
(C) $(n - 1)/2$
(D) $n - 1$

297. GATE (CS&IT) 2010, Q.11

What does the following program print?

```
#include < stdio.h >
   void f (int *p, int *q) {
      p = q;
      *p = 2;
}
int main (){
f(&i , &j);
printf ("%d %d \ n", i, j);
return 0;
}
```

(A) 2 2
(B) 2 1
(C) 0 1
(D) 0 2

298. GATE (CS&IT) 2010, Q.13

Which data structure in a compiler is used for managing information about variables and their attributes?

(A) Abstract Data Type
(B) Symbol Table
(C) Semantic Stack
(D) Parse Table

299. GATE (CS&IT) 2010, Q.18

Consider a B+-tree in which the maximum number of keys in a node is 5. What is the minimum number of keys in any non-root node?

(A) 1
(B) 2
(C) 3
(D) 4

300. GATE (CS&IT) 2010, Q.28

The degree sequence of a simple graph is the sequence of the degrees of the nodes in the graph in decreasing order. Which of the following sequences can not be the degree sequence of any graph?

I. 7, 6, 5, 4, 4, 3, 2, 1
II. 6, 6, 6, 6, 3, 3, 2, 2
III. 7, 6, 6, 4, 4, 3, 2, 2
IV. 8, 7, 7, 6, 4, 2, 1, 1

(A) I and II
(B) III and IV
(C) IV only
(D) II and IV

301. GATE (CS&IT) 2010, Q.35

What is the value printed by the following C program?

```
#include < stdio.h >
int f (int * a, int n)
{
      if (n <= 0)  return 0;
      else if(*a % 2 = = 0)   return * a + f(a + 1,n – 1);
      else return * a – f(a + 1, n – 1);
}
int main ( )
{
      int a[ ] = {12, 7,13,4,11, 6};
      printf("%d",  f(a,6));
      return 0;
}
```

(A) –9
(B) 5
(C) 15
(D) 19

302. GATE (CS&IT) 2010, Q.36

The following C function takes a simply-linked list as input argument. It modifies the list by moving the last element to the front of the list and returns the modified list. Some part of the code is left blank.

```
typedef struct node {
      int value;
      struct node *next;
}    Node;
Node *move_to_front (Node *head) {
         Node *p, *q;
         if ((head = = NULL  ||  (head -> next = = NULL)) return head;
         q = NULL; p = head;
         while ( p - > next ! = NULL) {
               q=P;
               p=p->next;
         }
         return head;
}
```

Choose the correct alternative to replace the blank line.

(A) q = NULL; p->next = head; head = p;
(B) q->next = NULL; head = p; p->next = head;
(C) head = p; p->next = q; q->next = NULL;
(D) q->next = NULL; p->next = head; head = p;

303. GATE (CS&IT) 2010, Q.50

Consider a complete undirected graph with vertex set {0, 1, 2, 3, 4}. Entry Wij in the matrix W below is the weight of the edge {i, j}.

$$W = \begin{matrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{matrix}$$

What is the minimum possible weight of a spanning tree T in this graph such that vertex 0 is a leaf node in the tree T?

(A) 7
(B) 8
(C) 9
(D) 10

304. GATE (CS&IT) 2010, Q.51

What is the minimum possible weight of a path *P* from vertex 1 to vertex 2 in this graph such that *P* contains at most 3 edges?

(A) 7
(B) 8
(C) 9
(D) 10

305. GATE (CS&IT) 2010, Q.52

A hash table of length 10 uses open addressing with hash function $h(k) = k$ mod 10, and linear probing. After inserting 6 values into an empty hash table, the table is as shown below

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

Which one of the following choices gives a possible order in which the key values could have been inserted in the table?

(A) 46, 42, 34, 52, 23, 33
(B) 34, 42, 23, 52, 33, 46
(C) 46, 34, 42, 23, 52, 33
(D) 42, 46, 33, 23, 34, 52

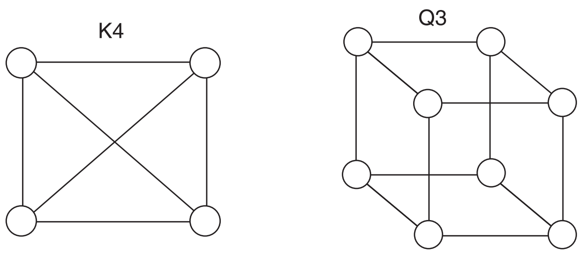
306. GATE (CS&IT) 2010, Q.53

How many different insertion sequences of the key values using the same hash function and linear probing will result in the hash table shown above?

(A) 10
(B) 20
(C) 30
(D) 40

307. GATE (CS&IT) 2011, Q.5

K4 and Q3 are graphs with the following structures



Which one of the following statements is TRUE in relation to these graphs?

(A) K4 is planar while Q3 is not
(B) Both K4 and Q3 are planar
(C) Q3 is planar while K4 is not
(D) Neither K4 not Q3 is planar

308. GATE (CS&IT) 2011, Q.10

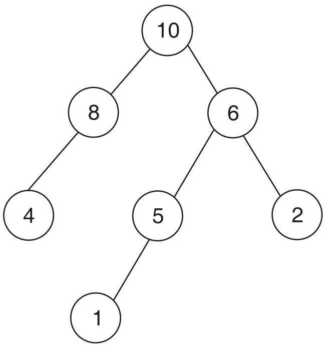
What does the following fragment of C-program print?
char c[ ] = "GATE2011";
char *p = c;
printf("%s", p+p[3] – p[1]) ;

(A) GATE2011
(B) E2011
(C) 2011
(D) 011

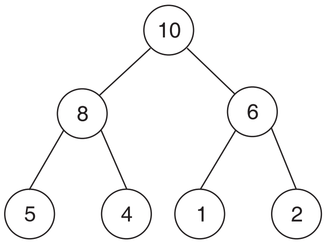
309. GATE (CS&IT) 2011, Q.11

A max-heap is a heap where the value of each parent is greater than or equal to the value of its children. Which of the following is a max-heap?

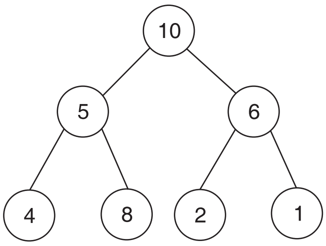
(A)



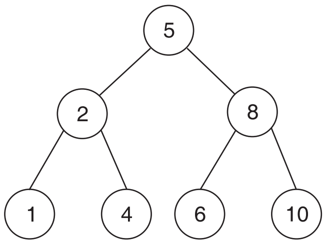
(B)



(C)



(D)



310. GATE (CS&IT) 2011, Q.16

If two fair coins are flipped and at least one of the outcomes is known to be a head, what is the probability that both outcomes are heads?

(A) 1/3 (B) 1/4
(C) 1/2 (D) 2/3

311. GATE (CS&IT) 2011, Q.26

Which of the given options provides the increasing order of asymptotic complexity of functions f1, f2, f3 and f4?

$f_1(n) = 2^n$; $f_2(n) = n^{3/2}$; $f_3(n) = n\log_2 n$; $f_4(n) = n^{\log_2 n}$

(A) f_3, f_2, f_4, f_1 (B) f_3, f_2, f_1, f_4
(C) f_2, f_3, f_1, f_4 (D) f_2, f_3, f_4, f_1

312. GATE (CS&IT) 2011, Q.27

Four matrices M_1, M_2, M_3 and M_4 are dimensions $p \times q$, $q \times r$, $r \times s$ and $s \times t$ respectively can be multiplied in several ways with different number of total scalar multiplications. For example When multiplied as $((M_1 \times M_2) \times (M_3 \times M_4))$ the total number of scalar multiplications is pqr+rst+prt. When multiplied as $(((M_1 \times M_2) \times M_3) \times M_4)$, the total number of scalar multiplications is pqr+prs+pst. If p=10, q=100, r=20, s=5 and t=80, then the minimum number of scalar multiplications needed is

(A) 248000 (B) 44000
(C) 19000 (D) 25000

313. GATE (CS&IT) 2010, Q.40

We are given a set of n distinct elements and an unlabeled binary tree with n nodes. In how many ways can we populate the tree with the given set so that it becomes a binary search tree?

(A) 0 (B) 1

(C) n! (D) $\frac{1}{n+1} \cdot {}^{2n}C_n$

314. GATE (CS&IT) 2011, Q.45

A deck of 5 cards (each carrying a distinct number from 1 to 5) is shuffled thoroughly. Two cards are then removed one at a time from the deck. What is the probability that the two cards are selected with the number on the first card being one higher than the number on the second card?

(A) 1/5 (B) 4/25

(C) 1/4 (D) 2/5

Common Data Questions: 315 & 316

Consider the following recursive C function that takes two arguments

```
unsigned int foo (unsigned int n, unsigned int r) {
if (n > 0) return (n%r) foo ( n / r, r );
else return 0;
}
```

315. GATE (CS&IT) 2011, Q.48

What is the return value of the function `foo` when it is called as `foo (513, 2)`?

(A) 9 (B) 8

(C) 5 (D) 2

316. GATE (CS&IT) 2011, Q.49

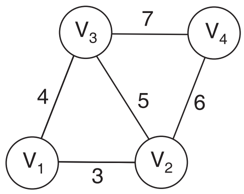
What is the return value of the function `foo` when it is called as `foo (345, 10)`?

(A) 345 (B) 12

(C) 5 (D) 3

Statement for Linked Answer Questions: 317 & 318

An undirected graph G(V, E) contains n (n > 2) nodes named $V_1, V_2, ..., V_n$. Two nodes V_i, V_j are connected if and only if $0 < |i - j| \leq 2$. Each edge (V_i, V_j) is assigned a weight i + j. A sample graph with n = 4 is shown below



317. GATE (CS&IT) 2011, Q.52

What will be the cost of the minimum spanning tree (MST) of such a graph with n nodes?

(A) $\frac{1}{12}(11n^2 - 5n)$ (B) $n^2 - n + 1$

(C) $6n - 11$ (D) $2n + 1$

318. GATE (CS&IT) 2011, Q.53

The length of the path from v5 to v6 in the MST of previous question with n = 10 is

(A) 11 (B) 25

(C) 31 (D) 41

319. GATE (CS&IT) 2012, Q.8

Let W(n) and A(n) denote respectively, the worst case and average case running time of an algorithm executed on an input of size n. Which of the following is **ALWAYS TRUE**?

(A) $A(n) = \Omega(W(n))$ (B) $A(n) = \Theta(W(n))$

(C) $A(n) = O(W(n))$ (D) $A(n) = o(W(n))$

320. GATE (CS&IT) 2012, Q.9

Let G be a simple undirected planar graph on 10 vertices with 15 edges. If G is a connected graph, then the number of **bounded** faces in any embedding of G on the plane is equal to

(A) 3 (B) 4

(C) 5 (D) 6

321. GATE (CS&IT) 2012, Q.10

The recurrence relation capturing the optimal execution time of the *Towers of Hanoi* problem with n discs is

(A) $T(n) = 2T(n - 2) + 2$ (B) $T(n) = 2T(n - 1) + n$

(C) $T(n) = 2T(n/2) + 1$ (D) $T(n) = 2T(n - 1) + 1$

322. GATE (CS&IT) 2012, Q.21

The worst case running time to search for an element in a balanced binary search tree with $n2^n$ elements is

(A) $\Theta(n \log n)$ (B) $\Theta(n2^n)$

(C) $\Theta(n)$ (D) $\Theta(\log n)$

323. GATE (CS&IT) 2012, Q.23

What will be the output of the following C program segment?

```
char   inChar  =  'A'  ;
switch  (inChar)  {
   case  'A'  :  printf  ("Choice  A\  n")  ;
```

```
case 'B' :
case 'C' : printf ("Choice B") ;
case 'D' :
case 'E' :
default : printf ("No Choice") ; }
```

(A) No Choice
(B) Choice A
(C) Choice A Choice B No Choice
(D) Program gives no output as it is erroneous

324. GATE (CS&IT) 2012, Q.27

The height of a tree is defined as the number of edges on the longest path in the tree. The function shown in the pseudo code below is invoked as height (root) to compute the height of a binary tree rooted at the tree pointer root.

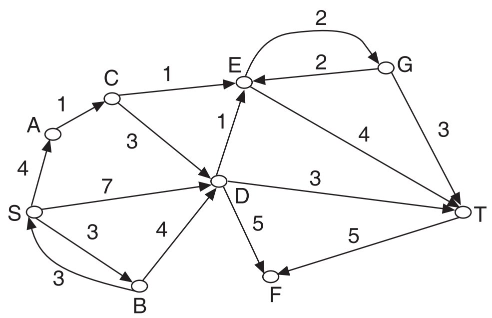
```
int height (treeptr n)
{ if (n == NULL) return -1;
  if (n → left == NULL)
    if (n → right == NULL) return 0;
    else return B1;                    // Box 1
else { h1 = height (n → left);
    if ((n → right == NULL)return (1+h1);
    else {h2 = height (n → right);
            return B2;               // Box 2
            }
        }
}
```

The appropriate expressions for the two boxes B1 and B2 are

(A) B1: (1 + height(n → right))
B2: (1 + max(h1, h2))
(B) B1: (height(n → right))
B2: (1 + max(h1, h2))
(C) B1: height(n → right)
B2: max(h1, h2)
(D) B1: (1 + height(n → right))
B2: max(h1, h2))

325. GATE (CS&IT) 2012, Q.33

Consider the directed graph shown in the figure below. There are multiple shortest paths between vertices S and T. Which one will be reported by Dijkstra's shortest path algorithm? Assume that, in any iteration, the shortest path to a vertex v is updated only when a strictly shortest path to v is discovered.



(A) SDT
(B) SBDT
(C) SACDT
(D) SACET

326. GATE (CS&IT) 2012, Q.34

A list of n strings, each of length n, is sorted into lexicographic order using the merge-sort algorithm. The worst case running time of this computation is

(A) O(n log n)
(B) $O(n^2 \log n)$
(C) $O(n^2 + \log n)$
(D) $O(n^2)$

327. GATE (CS&IT) 2012, Q.35

Let G be a complete undirected graph on 6 vertices. If vertices of G are labeled, then the number of distinct cycles of length 4 in G is equal to

(A) 15
(B) 30
(C) 90
(D) 360

328. GATE (CS&IT) 2012, Q.38

Suppose a circular queue of capacity (n – 1) elements is implemented with an array of n elements. Assume that the insertion and deletion operations are carried out using REAR and FRONT as array index variables, respectively. Initially, REAR = FRONT = 0. The conditions to detect *queue full* and *queue empty* are

(A) *full*: (REAR + 1) mod n = = FRONT
empty: REAR == FRONT
(B) *full*: (REAR + 1) mod n = = FRONT
empty: (FRONT + 1) mod n = REAR
(C) *full*: REAR = = FRONT
empty: (REAR + 1) mod n== FRONT
(D) *full*: (FRONT + 1) mod n = = REAR
empty: REAR == FRONT

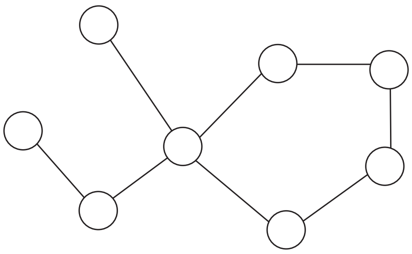
329. GATE (CS&IT) 2012, Q.44

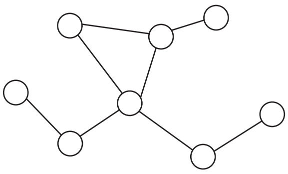
Let G be a weighed graph will edge weights greater than one and G′ be the graph constructed by squaring the weights of edges in G. Let T and T′ be the minimum spanning tress of G and G′ respectively, with total weights t and t′. Which of the following statements is **TRUE**?

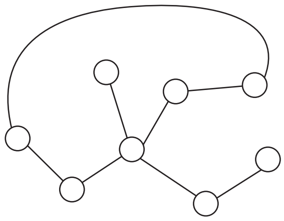
(A) T′ = T with total weight $t' = t^2$
(B) T′ = T with total weight $t' < t^2$
(C) T′ ≠ T but total weight $t' = t^2$
(D) None of these

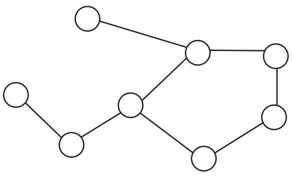
330. GATE (CS&IT) 2012, Q.46

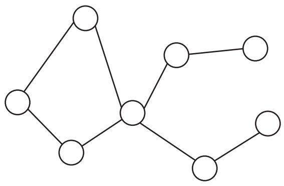
Which of the following graphs is isomorphic to



(A) 

(B) 

(C) 

(D) 

Common Data for Questions 331 and 332:
Consider the following C code segment:

```
int a, b, c = 0;
void prtFun(void);
main ( )
{
   static int a = 1;        /* Line 1 */
   prt Fun( );
   a += 1;
   prtFun( );
   printf(“\n %d %d”, a, b);
}
```

```
   void prtFun(void)
{
   static int a = 2;          /* Line 2 */
   int b = 1;
   a += ++b;
   printf("\n %d %d", a, b);
}
```

331. GATE (CS&IT) 2012, Q.50

What output will be generated by the given code segment?

(A) 3 1
4 1
4 2

(B) 4 2
6 1
6 1

(C) 4 2
6 2
2 0

(D) 3 1
5 2
5 2

332. GATE (CS&IT) 2012, Q.51

What output will be generated by the given code segment if:
Line 1 is replaced by **`auto int a = 1;`**
Line 2 is replace by **`register int a = 2;`**

(A) 3 1
4 1
4 2

(B) 4 2
6 1
6 1

(C) 4 2
6 2
2 0

(D) 4 2
4 2
2 0

333. GATE (CS&IT) 2013, Q.6

Which one of the following is the tightest upper bound that represents the number of swaps required to sort *n* numbers using selection sort?

(A) O(log n) (B) O(n)
(C) O(n log n) (D) $O(n^2)$

334. GATE (CS&IT) 2013, Q.7

Which one of the following is the tightest upper bound that represents the time complexity of inserting an object into a binary search tree of n nodes?

(A) O(1) (B) O(log n)
(C) O(n) (D) O(n log n)

335. GATE (CS&IT) 2013, Q.19

What is the time complexity of Bellman-Ford single-source shortest path algorithm on a complete graph of n vertices?

(A) $\Theta(n^2)$ (B) $\Theta(n^2 \log n)$
(C) $\Theta(n^3)$ (D) $\Theta(n^3 \log n)$

336. GATE (CS&IT) 2013, Q.24

Consider an undirected random graph of eight vertices. The probability that there is an edge between a pair of vertices is 1/2. What is the expected number of unordered cycles of length three?

(A) 1/8 (B) 1
(C) 7 (D) 8

337. GATE (CS&IT) 2013, Q.25

Which of the following statements is/are **TRUE** for undirected graphs?
P: Number of odd degree vertices is even.
Q: Sum of degrees of all vertices is even.

(A) P only (B) Q only
(C) Both P and Q (D) Neither P nor Q

338. GATE (CS&IT) 2013, Q.26

The line graph L(G) of a simple graph G is defined as follows:

- There is exactly one vertex `v(e)` in L(G) for each edge e in G.
- For any two edges `e` and `e'` in G, L(G) has an edge between `v(e)` and `v(e')`, if and only if `e` and `e'` are incident with the same vertex in G.

Which of the following statements is/are **TRUE**?
(P) The line graph of a cycle is a cycle.
(Q) The line graph of a clique is a clique.
(R) The line graph of a planar graph is planar.
(S) The line graph of a tree is a tree.

(A) P only (B) P and R only
(C) R only (D) P, Q and S only

339. GATE (CS&IT) 2013, Q.30

The number of elements that can be sorted in $\Theta(\log n)$ time using heap sort is

(A) $\Theta(1)$

(B) $\Theta(\sqrt{\log n})$

(C) $\Theta\left(\frac{\log n}{\log \log n}\right)$

(D) $\Theta(\log n)$

340. GATE (CS&IT) 2013, Q.31

Consider the following function:

```
int unknown(int n)
{
    int i, j, k=0;
    for (i=n/2; i<=n; i++)
      for (j=2; j<=n; j=j*2)
        k = k + n/2;
      return (k);
}
```

The return value of the function is

(A) $\Theta(n^2)$

(B) $\Theta(n^2 \log n)$

(C) $\Theta(n^3)$

(D) $\Theta(n^3 \log n)$

341. GATE (CS&IT) 2013, Q.42

What is the return value of `f(p,p)`, if the value of `p` is initialized to 5 before the call? Note that the first parameter is passed by reference, whereas the second parameter is passed by value.

```
int f (int &x, int c) {
    c = c - 1;
    if (c==0) return 1;
    x = x + 1;
    return f(x,c) * x;
}
```

(A) 3024

(B) 6561

(C) 55440

(D) 161051

342. GATE (CS&IT) 2013, Q.43

The preorder traversal sequence of a binary search tree is 30, 20, 10, 15, 25, 23, 39, 35, and 42. Which one of the following is the postorder traversal sequence of the same tree?

(A) 10, 20, 15, 23, 25, 35, 42, 39, 30
(B) 15, 10, 25, 23, 20, 42, 35, 39, 30
(C) 15, 20, 10, 23, 25, 42, 35, 39, 30
(D) 15, 10, 23, 25, 20, 35, 42, 39, 30

343. GATE (CS&IT) 2013, Q.44

Consider the following operation along with `Enqueue` and `Dequeue` operations on queues, where k is a global parameter.

```
MultiDequeue(Q){
m = k
while(Q is not empty) and (m > 0) {
Dequeue(Q)
m = m - 1
}
}
```

What is the worst case time complexity of a sequence of *n* queue operations on an initially empty queue?

(A) $\Theta(n)$ (B) $\Theta(n + k)$

(C) $\Theta(nk)$ (D) $\Theta(n^2)$

Common Data for Questions 344 and 345:

The procedure given below is required to find and replace certain characters inside an input character string supplied in array `A`. The characters to be replaced are supplied in array `oldc`, while their respective replacement characters are supplied in array `newc`. Array `A` has a fixed length of five characters, while arrays `oldc` and `newc` contain three characters each. However, the procedure is flawed.

```
void find_and_replace (char *A, char *oldc, char *newc) {
for (int i=0; i<5; i++)
for (int j=0; j<3; j++)
if (A[i] == oldc[j]) A[i] = newc[j];
}
```

The procedure is tested with the following four test cases.

(1) `oldc = "abc", newc = "dab"`
(2) `oldc = "cde", newc = "bcd"`
(3) `oldc = "bca", newc = "cda"`
(4)/ `oldc = "abc", newc = "bac"`

346. GATE (CS&IT) 2013, Q.50

The tester now tests the program on all input strings of length five consisting of characters `'a'`, `'b'`, `'c'`, `'d'` and `'e'` with duplicates allowed. If the tester carries out this testing with the four test cases given above, how many test cases will be able to capture the flaw?

(A) Only one (B) Only two

(C) Only three (D) All four

347. GATE (CS&IT) 2013, Q.51

If array `A` is made to hold the string `"abcde"`, which of the above four test cases will be successful in exposing the flaw in this procedure?

(A) None (B) 2 only

(C) 3 and 4 only (D) 4 only