LINEAR CIRCUITS
ANALYSIS & SYNTHESIS

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A note to the reader

In this PDF file, you'll find hints and answers
to select end-chapter problems of the text
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Please send an email to the author:

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with your feedback as well as queries

Chapter 2

1. The battery releases energy; E = 1.5 $\times$ charge of an electron.

2. $v_{max} = 5\sqrt{5}$ V, and $i_{max} = 1/(40\sqrt{5})$ A

3. 48.4 kW

4. 0.2W, 20V

5. $v_s = 10.2$ V, and $r = 2\,\Omega$

6. $300\,\Omega$, 0.4833 ∓ 0.05 A

7. $6 \times 360 \times 9$ J, 6×360 C

8. Rs. 82.80

9. 101.25 J absorbed

10. releases

11. $Q = \int_{t_1}^{t_2} i(t)dt$, and $W = Q \int_{t_1}^{t_2} v(t)dt$

12. A current of 3A flows in the counterclockwise direction in the mesh.

13. A current of 3A flows in the clockwise direction in the mesh.

14. Element X absorbs 6W and the 2A source absorbs 4W.

15. The 5A source releases 25W, and the element X absorbs 15W.

16. The current source releases energy.

17. Working is similar to that of problem 2.16.

18. Assume that the internal resistance r is in Ω. Use the following equations:

$$
\begin{aligned}
i_s &= 11.965 + \frac{119.65}{r} \\
i_s &= 11.695 + 116.95\left(\frac{1}{r} + \frac{1}{1000}\right)
\end{aligned}
$$

19. You will get a pair of equations similar to those of problem 2.18.

20. The bulb is turned OFF if one of the two switches is in OFF position. If both the switches are either ON or OFF, then the bulb is turned ON.

Chapter 3

1. All are networks; (a) is not a circuit.

2. 4 nodes, 3 meshes, and 7 loops.

3. Problems 3.3 to 3.9 may be done quite trivially.

10. 1.5 $k\,\Omega$; 10 mW - (6 mW + 4 mW).

11. 12Ω; 1.25 - (0.75 + 0.5) W.

12. 0.2$k\,\Omega$

13. $\frac{1}{12}\,k\Omega$

14. Yes; the current source delivers.

15. E_1, E_3, and E_5 are active elements.

16. This problem does not require any hint.

17. The circuit is inconsitent; it does not obey KCR.

18. E_2: 4V with positive potential to the left, E_3: 6V with the positive potential to the right, and E_4: 4V with the positive potential to the right.

19.

$$[(30\|10)\ +\ (5\|5)]\ \|\,25\ +\ 20$$

20.

$$[(3\|18)\ +\ 10]\ \|\,6\,\|\,30$$

21. This problem does not require any hint.

22. The currents, in milli amperes, are as follows from left to right:

$$\frac{1}{3}, 1, \frac{4}{3}, \frac{8}{3}, \frac{16}{3}, \frac{14}{3}$$

23. Use series-parallel reductions.

24. $\frac{60}{21}\,\Omega$, $\frac{45}{21}\,\Omega$, $\frac{7}{5}\,\Omega$

25. This problem does not require any hint.

26. Follow the argument on ladder networks in the text.

27. Reduce this to a single series-parallel circuit.

28. The VCVS delivers power. Using nodal analysis you get the following equations:

$$\begin{aligned} 45\,v_1 - 37\,v_2 &= 0 \\ -169\,v_1 + 207\,v_2 &= 336 \end{aligned}$$

Using v_1 and v_2, we get $v_x = v_1 - v_2$, and $v_3 = v_1 - 6v_x$. It is now easy to compute the current through the VCVS.

Chapter 4

In this chapter, there are typographical errors in problems 8 and 26.

1. Use the following linear system of equations:

$$\frac{1}{15}\begin{bmatrix} 8 & -3 & 0 & 0 \\ -3 & 7.5 & -3 & 0 \\ 0 & -3 & 6 & -3 \\ 0 & 0 & -3 & 4.5 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ -2 \\ 6 \end{bmatrix}$$

2. Use the following equations:

$$\frac{1}{60}\begin{bmatrix} 30 & -10 \\ -10 & 17 \end{bmatrix}\begin{bmatrix} v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} -16/3 \\ 5/24 \end{bmatrix}$$

3. The current through 4Ω resistor is 15.365 A from bottom to top.

4. Enumerating the nodes in the counterclockwise direction with v_1 at the apex,

$$v_1 = \frac{125}{7},\ v_2 = \frac{55}{7},\ v_3 = \frac{475}{7},\ \text{and } v_4 = -5 \ \text{V}$$

5. Mesh currents are already available; use mesh analysis.

6. $i_1 = -4$ A, $i_2 = 4$A, and $i_3 = 0$ A

7. You need to solve for only one mesh current.

8. There is a typographical error in this problem. The second voltage source at the extreme right should be 20V with the negative terminal at the top. There are several possible solutions satisfying

$$R_1 + R_2 = 2.5\,k\Omega$$

9. Use repeated source transformation followed by mesh analysis.

10. Obtain the mesh equations, and look at the mesh incidence matrix $\mathcal{M}$. You will notice that

$$v_1 + v_2 = v_3$$

with $v_1 \neq 0$, $v_2 \neq 0$, and $v_3 \neq 0$ will solve the problem since KVR has to be obeyed by the loop comprising the three voltage sources.

11. 14 mW

12. 1/450 mW

13. $21 \cdot v_4 = 10 \cdot i_A + 80 \cdot i_B$

14. The required number is ‘n’.

15. Assume i_A, i_B, and v_C arbitrarily and solve for α, β, and γ in the following:

$$\begin{bmatrix} i_A & i_B & 0 \\ i_A & 0 & v_C \\ 0 & i_B & v_C \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \\ \gamma \end{bmatrix} = \begin{bmatrix} 20 \\ -5 \\ 2 \end{bmatrix}$$

16. $R_{eq} = 14/3\,k\Omega$, $v_{OC} = 5/3$V

17. $R_{eq} = 0$

18. $R_{eq} = 800/13\,k\Omega$, $v_{OC} = 1160/13$V

19.

$$v_{50} = \frac{50}{50 + 800/13} \cdot v_{OC} \text{ V}, \quad P_{50} = v_{50}^2/50 \text{ W}$$

20. $R_L = 5/6\,k\Omega$

21. $r = 80\Omega = R_L$, $v_S = 200$V, and $P_{max} = 125$ W

22. Find R_{eq} as seen by R_L.

23. Use the following equations:

$$\begin{aligned} R_L &= 2R + [R \,\|\, (2R + R_s)] \\ R_s &= 2R + [R \,\|\, (2R + R_L)] \end{aligned}$$

24. Since $P \propto i^2$, take $i \propto \pm\sqrt{P}$. You get

$$k = -\frac{24}{11} \text{ or } -\frac{40}{13}$$

25. This problem may be solved triviallly.

26. There is a typographical error. The resistor above the controlled source should be **10 kΩ** instead of 10Ω. Each of the independent sources delivers 5/11 mW, and the controlled source absorbs 50/121 mW.

27. $i_x = 29$ A

28. Trivially, use a test voltage source v_{test} and compute the current it delivers.

29. Compute the equivalent resistance R_{eq} as seen by the port A-B; $R_L = R_{eq}$.

Chapter 5

In this chapter, there are typographical errors in problems 4 and 16.

1. $i_L(0^+) = 1$ A, $i_L(\infty) = 0$, and $\tau = 10$ milliseconds.

2. $i_L(0^+) = 5$ mA, $i_L(\infty) = 0$, and $\tau = 1/15$ microseconds. $y(0^+) = -150$V, and $y(\infty) = 0$.

3. $y(0^+) = i_L(0^+) = 5/6$ mA, $y(\infty) = 0$, and $\tau = 0.2$ microseconds.

4. There is a typographical error in the circuit. The controlled source is a CCVS with positive terminal at the top, and the proportionality constant is 8000 with the controlling variable i_s. $v_C(0^+) = 0$, and $v_C(\infty) = 4$V with the time constant $\tau = 6$ milliseconds.

5. $y(t) = 35\, e^{-t/\tau}$ V, with $\tau = 20$ microseconds.

6. $\tau = 5$ seconds. Use nodal analysis for $t < 0$ and for $t \geq 0$ with the initial capacitor voltage.

7. Use a test voltage source v_{test} to compute the equivalent resistance as seen by the capacitor for $t \geq 0$.

8. This problem may also be solved using a v_{test} to compute the equivalent resistance, and then using nodal analysis.

9. Make necessary computations using nodal analysis for the following time intervals:

$$t < 2, \quad 2 \leq t < 3, \quad \text{and} \quad 3 \leq t \leq \infty$$

Alternatively, you may use the property of time-invariance.

10. First compute the common node potential for both the inductors. It turns out to be

$$v_L(t) \;=\; \frac{20}{3}\, e^{-t/\tau}$$

Use this inductor voltage to compute the current.

11. Use nodal analysis. Also use a test voltage source v_{test} to compute the R_{eq}.

12. Use nodal analysis. Remember that the series combination of two equal capacitances is just half of the individual capacitances.

13. This problem requires a careful computation of the initial conditions at the time of switching.

$$\begin{aligned} v_C(0^+) &= 2\ \text{V} \\ \tau_1 &= 12\ \text{millisec} \\ v_C^1(t) &= 6 \;-\; 4e^{-t/\tau_1} \\ \Rightarrow\; v_C(1^+\, millisec) &= 6 \;-\; 4e^{-1/12} \\ \tau_2 &= 10\ \text{millisec} \\ &\;\;\vdots \end{aligned}$$

14. The differential equation is

$$\frac{d^2}{dt^2}\, v_C(t) \;+\; 10^4\, \frac{d}{dt}\, v_C(t) \;+\; 5\times 10^8\, v_C(t) \;=\; -\;5\times 10^9$$

15. Neglect the initial conditions.

16. There is a typographical error in the circuit. Across the $50\,\Omega$ resistor, the voltage v_x is defined with the positive polarity at the bottom. You'll get the following differential equation:

$$\frac{d^2}{dt^2}\, y(t) \;+\; \frac{1}{300C}\, \frac{d}{dt}\, y(t) \;+\; \frac{1}{LC}\, y(t) \;=\; 0$$

17. Look at the differential equation for the above problem.

18. Apply nodal analysis and make use of the appropriate initial conditions.

19. This problem does not require any hint.

20. Observe that this is a parallel RLC circuit for $t \geq 0$.

21. Obtain the step response and use the time-invariance property.

22. Use nodal analysis.

23. This problem does not require any hint.

24. Solve for $i_L(t)$ using the following differential equation:

$$\frac{d^2}{dt^2} i_L(t) + \frac{R}{L} \frac{d}{dt} i_L(t) + \frac{1}{LC} i_L(t) = \frac{1}{LC}$$

with the initial conditions:

$$i_L(0^+) = 0 \text{ and } \frac{d}{dt} i_L(t)|_{t=0^+} = -20000$$

Then solve for $y(t)$ using:

$$y(t) = L\frac{d}{dt} i_L + R \cdot i_L$$

25. This problem does not require any hint.

26. This problem does not require any hint.

27. This problem does not require any hint.

28. This problem does not require any hint.

29. Use the following differential equation:

$$\ddot{y} + 3000\,\dot{y} + 5 \times 10^8\, y = 3 \times 10^9 \quad \forall\, t \geq 0$$

30. Use nodal analysis.

Chapter 6

1. The differential equation is

$$RC\,\frac{dv_C}{dt} \;+\; v_C \;=\; R\cdot i_S$$

2. $v_R \;=\; 2\angle 0^o \;-\; 2\sqrt{2}\angle -60^o$

3. (a) $1.064\,\Omega$

4. $\omega \;=\; 2000$, $j\omega L \;=\; j20$, and

$$i_R \;=\; \frac{j20}{10\,+\,j20}\,6\angle 0^o \quad \text{and} \quad v_R \;=\; 10\cdot i_R$$

5. With $\omega \;=\; 120\pi$, replace L and C with their respective reactances and use mesh analysis.

6. With the given ω, use appropriate reactances:

$$\mathcal{Z} \;=\; (j\omega L)\parallel\left(\frac{1}{j\omega C}\right)$$

7.

$$\mathcal{Z} \;=\; \left(\frac{1}{j\omega C}\right) \;+\; (R\parallel j\omega L)$$

8. This problem does not require any hint.

9. Use $\omega \;=\; 1000$

10. Use $\omega \;=\; 10000$

11. Use complex numbers. You get the following LSE:

$$\begin{bmatrix} -j\,0.02 & +j\,0.02 \\ +j\,0.02 & 0.04\,+\,j0.08 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \;=\; \begin{bmatrix} 10\angle 30^o \\ 0 \end{bmatrix}$$

12. This problem does not require any hint.

13. Use nodal analysis.

14. This problem does not require any hint.

15. Use $v_S = 10$ and $i_S = -j50$.

16. This problem does not require any hint.

17. This problem does not require any hint.

18. $v_1 = 10\,j20$ V

19. Use mesh/nodal analysis.

20. This problem does not require any hint.

21. Use complex algebra and solve the following LSE:

$$\begin{aligned} \frac{v_{oc} - 10\angle 45^o}{j2} + \frac{v_{oc}}{-j10} &= 0 \\ \frac{10\angle 45^o}{5} + \frac{10\angle 45^o - v_{oc}}{j2} &= 0 \end{aligned}$$

22. This problem does not require any hint.

23. This problem does not require any hint.

24. Use $\omega = 10^4$ rad/sec, and replace L and C with their respective reactances.

25. Use mesh analysis.

26. Solve for v_{Th} and $\mathcal{Z}_{Th}$ in the following pair of equations:

$$\begin{aligned} \frac{1000}{\mathcal{Z}_{Th} + 1000} \cdot v_{Th} &= 2\angle -30^o \\ \frac{-j1000}{\mathcal{Z}_{Th} - j1000} \cdot v_{Th} &= 3\angle -135^o \end{aligned}$$

27. $R_1 \times R_2 \times C = L$

28. This problem does not require any hint.

29. Define

$$\mathcal{Z}_1 \triangleq \frac{R_1}{1 + j\omega R_1 C_1}$$

Use this $\mathcal{Z}_1$ in the following equation:

$$\frac{R_2}{R_2 + \mathcal{Z}_1} = \frac{R_L + j\omega L_L}{R_L + R_3 + j\omega L_L}$$

30. Define

$$\mathcal{Z}_1 \triangleq R_1 + \frac{1}{j\omega C_1}$$

and use this definition as in the above problem.

Chapter 7

1. It is easy to verify that for $\omega = 1$ rad/sec,

$$H(j\omega) = \frac{1 - j2}{13 - j2} \times \frac{2}{2 + j1}$$

2. Use complex algebra followed by voltage/current division rule.

3. Use nodal analysis and get the following pair of equations:

$$\begin{aligned} \frac{v_1 - v_S}{2} + \frac{v_1}{2/j\omega} + \frac{v_1 - v_R}{j\omega/2} &= 0 \\ \frac{v_R - v_1}{j\omega/2} + \frac{v_R}{5/j\omega} + \frac{v_R}{5} &= 0 \end{aligned}$$

4. Use mesh analysis.

5. Use mesh analysis.

6. Use mesh analysis.

7.

$$\begin{aligned} \mathcal{Z}_{series} &= 1000 + j\left(0.01\omega - \frac{10^9}{\omega}\right)\Omega \\ \mathcal{Y}_{parallel} &= \frac{1}{1000} + j\left(10^{-9}\omega - \frac{100}{\omega}\right)\Omega^{-1} \end{aligned}$$

8. $\omega = 0$ is the frequency when the magnitude is unity. For obtaining maximum magnitude and the frequency at which the magnitude attains maximum, use

$$\zeta = 0.2 \text{ and } \omega_n = 50$$

9. Rewrite the transfer function as:

$$H(j\omega) = \left(1 + \frac{j\omega}{10}\right) \cdot \frac{1}{\left(1 + \frac{j\omega}{100}\right)}$$

10. Rewrite the transfer function as:

$$H(j\omega) = \frac{1}{(j\omega)^2} \cdot \left(1 + \frac{j\omega}{10}\right)^2 \cdot \frac{1}{\left(1 + \frac{j\omega}{10^4}\right)} \cdot 10^4$$

11. Rewrite the transfer function as:

$$H(j\omega) = (1 + j\omega) \cdot \frac{1}{\left(1 + \frac{j\omega}{10}\right)} \cdot \frac{1}{\left(1 + \frac{j\omega}{100}\right)}$$

12. There are two different second-order factors. Compute ζ and ω_n for each of the factors carefully.

13. Resonance.

14. $\omega = 1$ Mrad/sec.

15. Use standard formulae relating Q, half-power frequencies, and the bandwidth.

16. In this problem, $R_{eff} = 25 + R + 10\,\Omega$. Given L and $\omega_n = 1/\sqrt{LC}$, you may quickly compute C. Thereafter use standard formulae as in the above problem.

17. If you use source transformation, you would immediately get a parallel RLC circuit. Use standard formulae.

18. In this case, $R_{eff} = R \| R_s$.

19. This problem does not require any hint.

20. This problem does not require any hint.

21. Use the definition of Q in terms of energy dissipation.

22. Find the resonant frequency.

23. Find the resonant frequency.

Chapter 8

1. Use phasors to compute the required voltages and currents. Express them in the trigonometric form, with magnitude, frequency, and the phase angle. Obtain the $v(t) \cdot i(t)$ products.

2. Use mesh analysis.

3. Use mesh analysis.

4. Use mesh analysis.

5. Compute the Thévenin's equivalent.

6. Compute the Thévenin's equivalent.

7. Look at the magnitude part.

8. Recall that the frequency of $p(t)$ is twice that of $v(t)$. Accordingly, $\omega = 1000\pi$ rad/sec. Thereafter, use standard formulae.

9. Find the admittance $\mathcal{Y}_{eq}$ as seen by the source.

10. Use the relationship:

$$\frac{Q}{P} = \tan\phi = \frac{X}{R}$$

11. Follow example 8.6.

12. Follow example 8.6.

13. Use KVR and compute v_s and i_s. $\mathcal{S} = \mathcal{V} \cdot \mathcal{I}^*$.

14. Follow example 8.6.

15. This problem does not require any hint.

16. Use standard formulae.

17. Use star - delta transformation.

18. Use per-phase analysis.

19. Use per-phase analysis.

20. Use per-phase analysis.

21. Use per-phase analysis.

22. Use delta - star transformation at the load end. Perform per-phase analysis. On these results make appropriate line - phase transformations.

23. Use delta - star transformation at the load end. Perform per-phase analysis. On these results make appropriate line - phase transformations.

24. This problem does not require any hint.

25. Use standard formulae.

26. This problem does not require any hint.

27. Use per-phase analysis.

28. Use per-phase analysis.

29. Follow examples 8.17 and 8.18.

30. Use standard relationships and perform per-phase analysis.

Chapter 9

In this chapter, there are typographical errors in problems 1, 28, and 30.

1. There are a few typographical errors in this problem. Sub-problem numbers (i), (iii), (v), and (vii) are missing. In the sub-problem (vii), the phasor should be $\mathcal{I} = 10\angle 0^o$.

   (i) $s = 0$

   (ii) $s = -0.1$

   (iii) $s = -5 + j100$

   (iv) $s = j100$

   (v) $s = -5.1 + j8.6$, $10\angle 60^o = 10e^{-5.1t}\cos(8.6t + 60^o)$

   (vi) $10\angle -45^o = 10e^{-5.1t}\cos(8.6t - 45^o)$

   (vii) $10\angle 0^o = 10$ A, dc

   (viii) $10\cos(10^6 t)$

2.

$$\frac{1}{2} \cdot \frac{s\mathcal{V}_s(s)}{s^2 + 2.5s + 5}$$

3. The transfer function may be written as:

$$\frac{Y(s)}{U(s)} = \frac{s + 4}{s(s + 1)(s + 1 + 5)(s + 1 - j5)}$$

   Cross-multiply to get the required differential equation.

4. Similar to problem 9.3.

5. The transfer functions are

$$10\frac{(s + 1)(s + 6)}{s(s + 5)^2(s + 7)} \quad \text{and} \quad \frac{s(s^2 + 10s + 50)}{(s^2 + 4)(s^2 + 6s + 10)}$$

6.

$$\frac{10^6/5s}{100 + 0.01s + 10^6/5s} \cdot (10 + 0.01s)$$

7. Replace L and C with sL and $1/sC$ respectively, and use algebra.

8. $e^{-10^5 t}$ V

9.

$$\dot{v}_C = -10^4 v_C + 5 \times 10^3 v_i$$

10. Use mesh analysis.

11. Use mesh analysis.

12. Use mesh analysis.

13. Use the properties of Laplace transformation.

14. Express $f(t)$ as a sum of appropriate ramp functions.

15. $f(t) = 2e^{-t} - e^{-3t}$

16.

$$F(s) = 6 \cdot \frac{s^2 + 5}{(s + j1)(s - j1)(s + j2)(s - j2)}$$

17.

$$\underbrace{\frac{(s + 3)y(0) + \dot{y}(0)}{(s + 1)(s + 2)}}_{\text{natural response}} + \underbrace{\frac{2s/(s^2 + 4)}{(s + 1)(s + 2)}}_{\text{forced response}}$$

18. First obtain the ODE.

19. Unit step function is the integral of unit impulse function.

20. Assume that we are interested in $t \geq 0$. Both the sources are $5/s$, $R = 1\,k\Omega$, and $C = 10^6/s$.

21. $L = 0.001s$.

22. $v_S(s) = 10s/(s^2 + 10^{12})$. Use mesh analysis.

23. Use mesh analysis.

24. Use nodal analysis. $v_S(s) = 10/s^2$

25. Use the initial conditions with $v_S(s) = 1/s$.

26. This problem does not require any hint.

27. $v_S(t) = 10 - 5q(t)$. Use the initial conditions.

28. There is a typographical error in this problem. It should be read as $i_S = 2e^{-t}$ mA for $t \geq 0$. $i_S(s) = 2/(s + 1)$. Use initial conditions.

29. Similar to the above problem.

30. There is a typographical error in the figure. The output $v_0(t)$ should be across the $10\,k\Omega$ resistor at the extreme right. First obtain the transfer function $H(s)$. Express $v_S(t)$ in terms of its Laplace transform. Use the property that convolution in time is multiplication is s-domain.

Chapter 10

1. The series elements are $1 \mp j1\,\Omega$, and the shunt element is $1\,\Omega$.

2. This problem does not require any hint.

3. Use star - delta transformation.

4. Similar to problem 10.1.

5. This problem does not require any hint.

6. Take care of the VCVS while computing z_{21} and z_{22}. The matrix is

$$\begin{bmatrix} 3R & 2R \\ 2R(k + 1) & 2R(k + 1) \end{bmatrix}$$

7. Obtain the Y parameters, and then the Z parameters. Or, equivalently, use delta - star conversion.

8. From the standard definitions, identify appropriate parameters, and use the relationship among the parameters.

9. Follow the definitions.

10. Similar to problem 10.8.

11. Follow the definitions.

12. Follow the definitions.

13. Follow the definitions.

14. Follow the definitions. Also, use the relationship between h and T parameters.

15. Similar to problem 10.8.

16. Follow the definitions, and use the relationship among the parameters.

17. First obtain the elements of the network, and then proceed as per the instructions given in the problem.

18. Follow the equations given in section 10.4.1 on amplifiers.

19. Similar to problem 10.17.

20. Follow the definitions. Also, look at the circuit as an appropriate "interconnection" of two T-networks.

21. Follow the definitions. Also, look at the circuit as an appropriate "interconnection" of two T-networks.

22. See the network as a cascade connection.
23. Use T parameters on the cascade.
24. Obtain the network elements and proceed as per the instructions given in the problem.
25. $z_{11} = v_1/i_1$ with $i_2 = 0$.
26. $z_{11} = v_1/i_1$ with $i_2 = 0$, and $y_{11} = i_1/v_1$ with $v_2 = 0$.
27. Use a continued fraction similar to what you have done for the ladder networks in chapter 3.
28. This problem does not require any hint.
29. A simple series network!
30. Use a continued fraction.

Chapter 11

In this chapter, there is a typographical error in problem 10.

1. Simple linear equations. $a_4 = +1$, $a_2 = -1$, and $a_0 = +1$.
2. Graphical calculation.
3. Graphical calculation.
4. Verify as instructed in the problem.
5. This problem does not require any hint.
6. Make the circuit as per the directions given in the problem and apply nodal analysis.
7. $Y(s) = N(s)/D(s)$ with $deg[N(s)] > deg[D(s)] + 1$.

8. α is a negative real number.

9. Assume arbitrary functions, and verify the properties.

10. There is a typographical error in part (d) of this problem. In the numerator the second term should be $6s^2$. Look at the zero-pole location.

11. Follow the hint given at the end of the problem, and solve for the constants using the given data.

12. Use the properties of pr functions.

13. Locate the zeros and the poles in terms of the coefficients of the polynomials.

14. Obtain the driving point impedance of the given network and compare it with

$$\frac{(s + 2)(s + 4)}{(s + 1)(s + 3)}$$

15. This problem does not require any hint. For Foster II form, remember to expand $Y(s)/s$ as a sum of partial fractions.

16. Similar to problem 11.15.

17. Expand $Z(s)$ as a continued fraction. Remember not to expand $1/Z(s)$!

18. Use Cauer forms. Put the continued fraction and examine the resulting $Z(s)$.

19. The driving point impedance is

$$z_{11}(s) = \frac{75}{3} \frac{(s + 2)(s + 4)}{(s + 1)(s + 3)}$$

20. This problem does not require any hint.

21. Obtain the impedance function and examine the numerator and denominator polynomials.

22. This problem does not require any hint.

23. This problem does not require any hint.

24. This problem does not require any hint.

25. Obtain $Z(s)$ and use this to synthesize Foster and Cauer forms.

26. Make a Cauer network, obtain its driving point function, and study the numerator and denominator polynomials.

27. Instructions are given in the problem itself.

28. Look at the hint for problem 11.26.

29. Use scaling. Choose, for instance, the network with lower values of inductances.

30. Use scaling.

Chapter 12

1. Use nodal analysis with the Op - Amp rule: $v_n = v_p$.

2. Similar to problem 12.1.

3. Similar to problem 12.1.

4. Similar to problem 12.1.

5. Similar to problem 12.1.

6. Similar to problem 12.1.

7. Similar to problem 12.1.

8. Obtain the transfer function $H(s)$ and use Laplace transformation.

10. Use Laplace transformation.

12. Use Laplace transformation, and take care of the initial condition.

14. Use transient analysis. cf. Chapter 5.

15. Use Laplace transformation and the property of time-invariance.

16. Use transient analysis.

19. Obtain $Z_i(s)$ and put it in the form of $s \cdot (.)$.

20. Use phasors and replace C with its reactance.

22. A band pass filter should have an initial attenuation, followed by a mid-band gain, and then followed by an attenuation at higher frequencies.

23. Obtain the ordinary differential equation using nodal analysis.

25. Use s-domain analysis.

26. Use transient analysis.

27. Use transient analysis.

28. Use phasors.

29. Use phasors.

30. Use s-domain analysis.

Chapter 13

1. Use standard formulae.

2. Use standard formulae.

3. Use standard formulae.

4. Use standard formulae.

5. Use standard formulae.

6. Use standard formulae. Notice the exponential while performing integration.

8. Use Parseval's formula.

11. Obtain the transfer function using phasors and use the properties of linearity and time-invariance.

12. Similar to problem 13.11.

14. Similar to problem 13.11.

15. Similar to problem 13.11.

18. Use Parseval's theorem.

19. Similar to problem 13.11.

20. Obtain the transfer function of the network, and use the properties of Fourier transform; particularly regarding convolution.

21. Obtain the transfer function of the network: $sRC/(sRC + 1)$.

22. Use Parseval's theorem.

24. Use phasors.