5.16 For the circuit shown in Fig. P5.15, when $R = 11\ \Omega$, $L = 1$ H, and $C = 0.1$ F, then

$$\mathbf{H}_C(j\omega) = \frac{\mathbf{V}_C}{\mathbf{V}_1} = \frac{10}{10 + j\omega 11 + (j\omega)^2}$$
$$= \left(\frac{1}{1 + j\omega}\right)\left(\frac{10}{10 + j\omega}\right)$$

Thus $\mathbf{H}_C(j\omega)$ can be expressed as the product $\mathbf{H}_C(j\omega) = \mathbf{H}_1(j\omega)\mathbf{H}_2(j\omega)$, where $\mathbf{H}_1(j\omega) = 1/(1 + j\omega)$ and $\mathbf{H}_2(j\omega) = 10/(10 + j\omega)$. Use only the straight-line asymptotes to sketch the Bode plot—both the amplitude and phase responses—for $\mathbf{H}_C(j\omega)$ by adding the Bode plots for $\mathbf{H}_1(j\omega)$ and $\mathbf{H}_2(j\omega)$. What type of filter is this?

5.17 For the circuit shown in Fig. P5.15, when $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F, then

$$\mathbf{H}_C(j\omega) = \frac{\mathbf{V}_C}{\mathbf{V}_1} = \frac{1}{1 + j\omega 2 + (j\omega)^2}$$
$$= \left(\frac{1}{1 + j\omega}\right)\left(\frac{1}{1 + j\omega}\right)$$

Thus $\mathbf{H}_C(j\omega)$ can be expressed as the product $\mathbf{H}_C(j\omega) = \mathbf{H}_1(j\omega)\mathbf{H}_2(j\omega)$, where $\mathbf{H}_1(j\omega) = \mathbf{H}_2(j\omega) = 1/(1 + j\omega)$. Use only the straight-line asymptotes to sketch the Bode plot—both the amplitude and phase responses—for $\mathbf{H}_C(j\omega)$ by adding the Bode plots for $\mathbf{H}_1(j\omega)$ and $\mathbf{H}_2(j\omega)$. What type of filter is this?

5.18 For the circuit shown in Fig. P5.15, when $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F, then

$$\mathbf{H}_L(j\omega) = \frac{\mathbf{V}_L}{\mathbf{V}_1} = \frac{(j\omega)^2}{1 + j\omega 2 + (j\omega)^2}$$
$$= \left(\frac{j\omega}{1 + j\omega}\right)\left(\frac{j\omega}{1 + j\omega}\right)$$

Thus $\mathbf{H}_L(j\omega)$ can be expressed as the product $\mathbf{H}_L(j\omega) = \mathbf{H}_1(j\omega)\mathbf{H}_2(j\omega)$, where $\mathbf{H}_1(j\omega) = \mathbf{H}_2(j\omega) = j\omega/(1 + j\omega)$. Use only the straight-line asymptotes to sketch the Bode plot—both the amplitude and phase responses—for $\mathbf{H}_L(j\omega)$ by adding the Bode plots for $\mathbf{H}_1(j\omega)$ and $\mathbf{H}_2(j\omega)$. What type of filter is this?

5.19 For the circuit shown in Fig. P5.15, when $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F, then

$$\mathbf{H}_R(j\omega) = \frac{\mathbf{V}_R}{\mathbf{V}_1} = \frac{j\omega 2}{1 + j\omega 2 + (j\omega)^2}$$
$$= j\omega 2\left(\frac{1}{1 + j\omega}\right)\left(\frac{1}{1 + j\omega}\right)$$

Thus $\mathbf{H}_R(j\omega)$ can be expressed as the product $\mathbf{H}_R(j\omega) = \mathbf{H}_1(j\omega)\mathbf{H}_2(j\omega)\mathbf{H}_3(j\omega)$, where $\mathbf{H}_1(j\omega) = j\omega 2$ and $\mathbf{H}_2(j\omega) = \mathbf{H}_3(j\omega) = 1/(1 + j\omega)$. Use only the straight-line asymptotes to sketch the Bode plot—both the amplitude and phase responses—for $\mathbf{H}_R(j\omega)$ by adding the Bode plots for $\mathbf{H}_1(j\omega)$, $\mathbf{H}_2(j\omega)$, and $\mathbf{H}_3(j\omega)$. What type of filter is this?

5.20 Suppose that a filter has gain $|\mathbf{H}(j\omega)| = 16\omega/(\omega^2 + 4)$. (a) For what value of ω is the gain $|\mathbf{H}(j\omega)|$ maximum? (b) What is the maximum value M of the gain $|\mathbf{H}(j\omega)|$? (c) What are the half-power frequencies? (d) What is the bandwidth of the filter?

5.21 For the admittance shown in Fig. P5.21, suppose that $R = 1\ \Omega$, $L = 1$ H, and $C = \frac{1}{5}$ F. Find the resonance frequency.

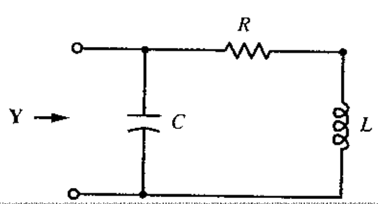

Fig. P5.21

5.22 Find a formula for the resonance frequency of the admittance shown in Fig. P5.21.

5.23 For the admittance shown in Fig. P5.23, suppose that $R = 1\ \Omega$, $L = 10$ H, and $C = 1$ F. Find the resonance frequency.

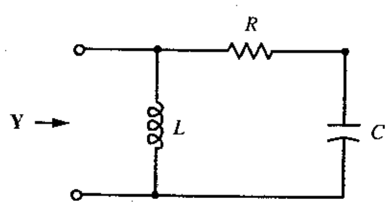

Fig. P5.23

5.24 Find a formula for the resonance frequency of the admittance shown in Fig. P5.23.

5.25 For the impedance shown in Fig. P5.25, suppose that $R = 1\ \Omega$, $L = 1$ H, and $C = 10$ F. Find the resonance frequency.

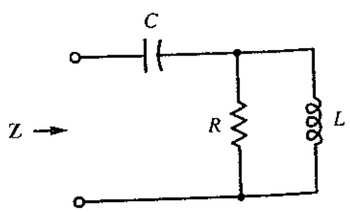

Fig. P5.25

5.26 Find a formula for the resonance frequency of the impedance shown in Fig. P5.25.

5.27 For the impedance shown in Fig. P5.27, suppose that $R = 1\ \Omega$, $L = \frac{1}{5}$ H, and $C = 1$ F. Find the resonance frequency.

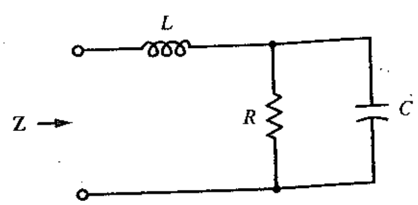

Fig. P5.27

5.28 Find a formula for the resonance frequency of the impedance shown in Fig. P5.27.

5.29 When $R = 6\ \Omega$, $L = 2$ H, and $C = \frac{1}{36}$ F, then the resonance frequency of the admittance shown in Fig. P5.21 is $\omega_r = 3$ rad/s. Apply a voltage source $v_1(t) = \cos 3t$ V to the admittance and calculate the following: (a) the energy stored by the inductor, (b) the energy stored by the capacitor, (c) the maximum total energy stored, (d) the power absorbed by the resistor, (e) the energy dissipated by the resistor in one period, and (f) the quality factor of the circuit.

5.30 When $R = 1\ \Omega$, $L = 1$ H, and $C = 2$ F, then the resonance frequency of the impedance shown in Fig. P5.25 is $\omega_r = 1$ rad/s. Apply a current source $i_1(t) = \cos t$ A to the impedance and calculate the following: (a) the energy stored by the inductor, (b) the energy stored by the capacitor, (c) the maximum total energy stored, (d) the power absorbed by the resistor, (e) the energy dissipated by the resistor in one period, and (f) the quality factor of the circuit.

5.31 Show that expressions for the half-power frequencies for the series *RLC* circuit given in Fig. 5.13*a* on p. 281 are:

$$\omega_1 = \frac{-R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$\omega_2 = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

5.32 For the series *RLC* circuit given in Fig. 5.13*a* on p. 281, suppose that $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F. Find (a) the resonance frequency, (b) the quality factor, (c) the bandwidth, and (d) the lower and upper half-power frequencies.

5.33 For the series *RLC* circuit given in Fig. 5.13*a* on p. 281, suppose that $R = 20\ \Omega$, $L = 10$ H, and $C = 0.001$ F. Find (a) the resonance frequency, (b) the quality factor, (c) the bandwidth, and (d) the lower and upper half-power frequencies.

5.34 For the series *RLC* circuit given in Fig. 5.13*a* on p. 281, suppose that $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F. (a) Find an expression for the gain $|\mathbf{H}_R(j\omega)| = |\mathbf{V}_R/\mathbf{V}_1|$. (b) For what value of ω is $|\mathbf{H}_R(j\omega)|$ maximum? (c) What are the half-power frequencies? (d) What is the bandwidth?

5.35 A 10-Ω resistor and a 2-H inductor are connected in series, and $\omega = 50$ rad/s. (a) What is the Q of this series connection? (b) What parallel *RL* connection has the same admittance as the series connection? (c) What is the Q of this parallel connection?

5.36 A 10-Ω resistor and a 2-H inductor are connected in parallel, and $\omega = 50$ rad/s. (a) What is the Q of this parallel connection? (b) What series *RL* connection has the same impedance as the parallel connection? (c) What is the Q of this series connection?

5.37 Consider the practical tank circuit shown in Fig. 5.17 on p. 285. Suppose that $R_s = 25\ \Omega$, $L =$

0.62 mH, and $C = 20$ pF. Approximate this admittance by a parallel RLC connection. What is the quality factor of this parallel connection?

5.38 Consider the practical tank circuit shown in Fig. 5.17 on p. 285. Suppose that $R_s = 50\ \Omega$, $L = 50$ mH, and $C = 0.005\ \mu$F. Approximate this admittance by a parallel RLC connection. What is the quality factor of this parallel connection?

5.39 An AM radio has a parallel RLC circuit for tuning in stations. Suppose that $R = 1.24\ \text{M}\Omega$, $L = 0.62$ mH, and $C = 20$ pF. (a) What is the resonance frequency in hertz? (b) What is the quality factor of the circuit? (c) What is the bandwidth in hertz? (d) If the current into the parallel connection due to a station at 1430 kHz is 5 μA rms, what is the resulting voltage at that frequency? (e) If the current into the parallel connection due to a station at 1450 kHz is 5 μA rms, what is the resulting voltage at that frequency?

5.40 For the series RLC circuit shown in Fig. P5.15, suppose that $R = \frac{5}{3}\ \Omega$, $L = 5$ H, $C = \frac{1}{25}$ F, and $v_1(t) = 20e^{-6t}\cos 3t$ V. Find (a) $v_R(t)$, (b) $v_L(t)$, and (c) $v_C(t)$.

5.41 For the series RLC circuit shown in Fig. P5.15, suppose that $R = 2\ \Omega$, $L = \frac{1}{2}$ H, $C = 2$ F, and $v_1(t) = 20e^{-6t}\cos 3t$ V. Find (a) $v_R(t)$, (b) $v_L(t)$, and (c) $v_C(t)$.

5.42 For the series RLC circuit shown in Fig. P5.15, suppose that $R = 2\ \Omega$, $L = 2$ H, $C = 2$ F, and $v_1(t) = 20e^{-6t}\cos 3t$ V. Find (a) $v_R(t)$, (b) $v_L(t)$, and (c) $v_C(t)$.

5.43 For the series-parallel RLC circuit shown in Fig. P5.43, suppose that $R = \frac{5}{3}\ \Omega$, $L = 5$ H, $C = \frac{1}{25}$ F, and $v_1(t) = 20e^{-6t}\cos 3t$ V. Find (a) $v_R(t)$, (b) $v_L(t)$, and (c) $v_C(t)$.

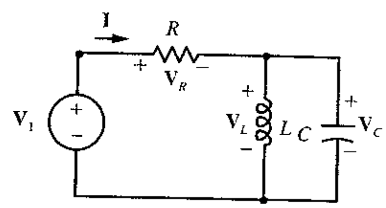

Fig. P5.43

5.44 For the series RLC circuit shown in Fig. P5.15, suppose that $R = \frac{5}{3}\ \Omega$, $L = 5$ H, and $C = \frac{1}{25}$ F. Draw a pole-zero plot for (a) $\mathbf{I}/\mathbf{V}_1$, (b) $\mathbf{V}_R/\mathbf{V}_1$, (c) $\mathbf{V}_L/\mathbf{V}_1$, and (d) $\mathbf{V}_C/\mathbf{V}_1$.

5.45 For the series RLC circuit shown in Fig. P5.15, suppose that $R = 2\ \Omega$, $L = \frac{1}{2}$ H, and $C = 2$ F. Draw a pole-zero plot for (a) $\mathbf{I}/\mathbf{V}_1$, (b) $\mathbf{V}_R/\mathbf{V}_1$, (c) $\mathbf{V}_L/\mathbf{V}_1$, and (d) $\mathbf{V}_C/\mathbf{V}_1$.

5.46 For the series RLC circuit shown in Fig. P5.15, suppose that $R = 2\ \Omega$, $L = 2$ H, and $C = 2$ F. Draw a pole-zero plot for (a) $\mathbf{I}/\mathbf{V}_1$, (b) $\mathbf{V}_R/\mathbf{V}_1$, (c) $\mathbf{V}_L/\mathbf{V}_1$, and (d) $\mathbf{V}_C/\mathbf{V}_1$.

5.47 For the series-parallel RLC circuit shown in Fig. P5.43, suppose that $R = \frac{5}{3}\ \Omega$, $L = 5$ H, and $C = \frac{1}{25}$ F. Draw a pole-zero plot for (a) $\mathbf{I}/\mathbf{V}_1$, (b) $\mathbf{V}_R/\mathbf{V}_1$, (c) $\mathbf{V}_L/\mathbf{V}_1$, and (d) $\mathbf{V}_C/\mathbf{V}_1$.

5.48 For the op-amp circuit shown in Fig. P5.48, draw the pole-zero plot of $\mathbf{H}(s) = \mathbf{V}_2/\mathbf{V}_1$ for the case that C is (a) 1 F, (b) $\frac{1}{4}$ F, and (c) $\frac{1}{16}$ F.

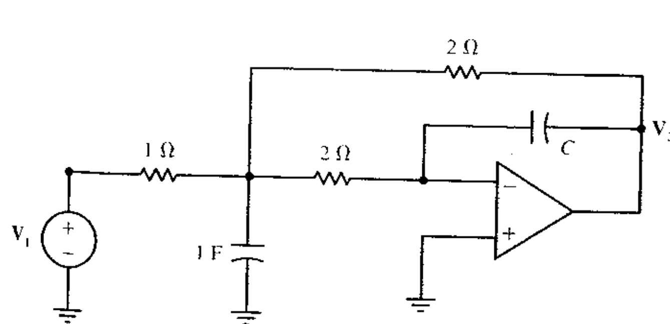

Fig. P5.48

5.49 For the op-amp circuit shown in Fig. P5.49, draw the pole-zero plot of $\mathbf{H}(s) = \mathbf{V}_2/\mathbf{V}_1$ for the case that C is (a) $\frac{1}{2}$ F, (b) 1 F, and (c) 2 F.

5.50 For the series-parallel RLC circuit given in Fig. P5.43, consider the capacitor to be the load. Find the Thévenin equivalent of the voltage source, resistor, and inductor combination. Use this Thévenin-equivalent circuit to determine the voltage $v_C(t)$ across the load for the case that $v_1(t) = 20e^{-6t}\cos 3t$ V.

5.51 Use integrators, adders, and scalers to simulate the transfer function

$$\mathbf{H}(s) = \frac{4s}{(s^2 + 2s + 3)}$$

5.52 Use integrators, adders, and scalers to simulate the transfer function

$$\mathbf{H}(s) = \frac{(s^2 + 2)}{(s^2 + 3s + 4)}$$

5.53 Find the transfer function $\mathbf{H}(s) = \mathbf{Y}/\mathbf{X}$ of the system shown in Fig. P5.53.

5.54 Find the transfer function $\mathbf{H}(s) = \mathbf{Y}/\mathbf{X}$ of the system shown in Fig. P5.54.

5.55 For the feedback system shown in Fig. 5.35 on p. 304, find the transfer function $\mathbf{Y}/\mathbf{X}$ when $\mathbf{G}(s) = (s + 1)/(s + 2)$ and $\mathbf{H}(s) = 1/(s + 3)$.

5.56 For the feedback system shown in Fig. 5.35 on p. 304, suppose that $\mathbf{G}(s) = (s + 1)/(s + 2)$. Determine $\mathbf{H}(s)$ such that the resulting transfer function is $\mathbf{Y}/\mathbf{X} = (s + 1)(s + 5)/(s + 3)^2$.

5.57 For the feedback system given in Fig. 5.35 on p. 304, suppose that $\mathbf{H}(s) = (s + 1)/(s + 2)$. Determine $\mathbf{G}(s)$ such that the resulting transfer function is $\mathbf{Y}/\mathbf{X} = (s + 2)^2/(s + 1)(s + 4)$.

5.58 For the feedback system given in Fig. 5.35 on p. 304, suppose that $\mathbf{G}(s) = 4s(s + 1)/(s + 2)^2$ and $\mathbf{H}(s) = 1/(s + 1)$. At what frequency will the system oscillate?

5.59 Find the Laplace transform of (a) $(2e^{-8t} - e^{-2t})u(t)$, (b) $(6 + 2e^{-6t} - 12e^{-t})u(t)$, (c) $(2 + 3t)e^{-2t}u(t)$, and (d) $e^{-3t}(\cos 4t - \sin 4t)u(t)$.

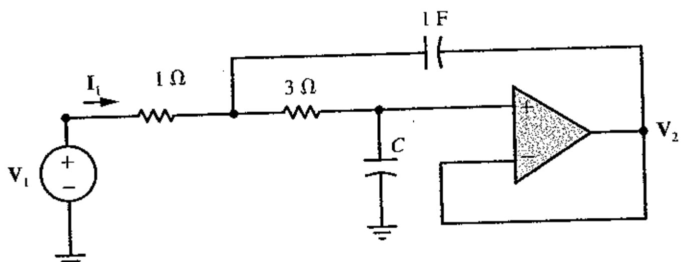

Fig. P5.49

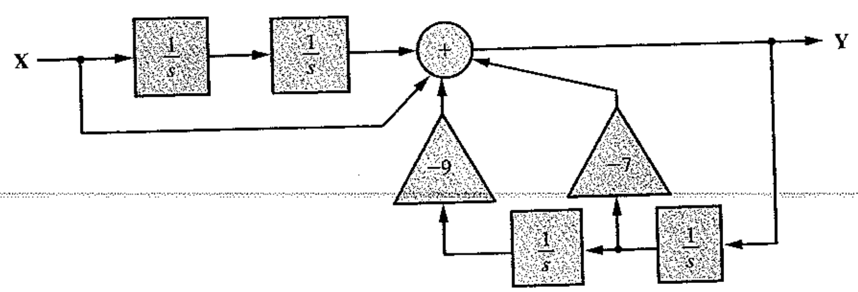

Fig. P5.53