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) $e^{-3t}(\cos 4t - \sin 4t)u(t)$.

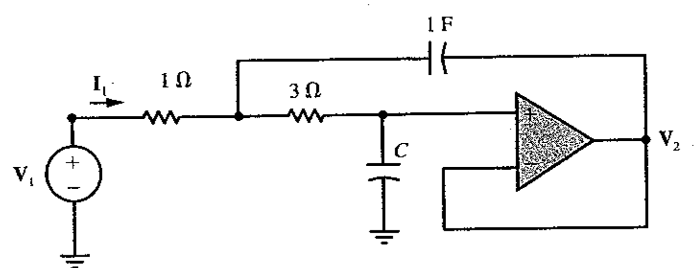

Fig. P5.49

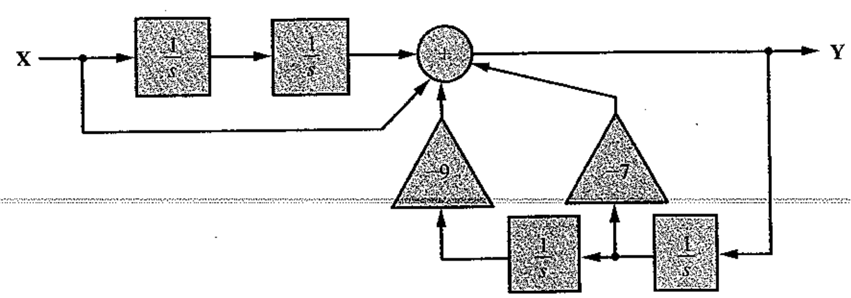

Fig. P5.53

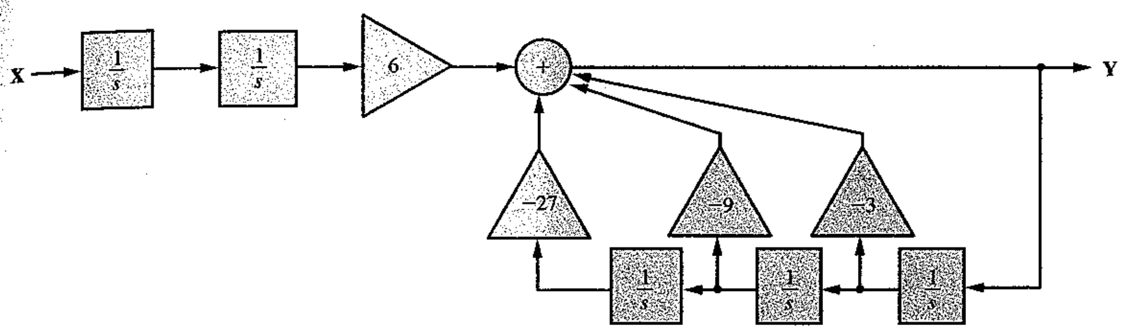

Fig. P5.54

5.60 Find the Laplace transform of (a) $\sin(\beta t - \phi)u(t)$, (b) $\cos(\beta t - \phi)u(t)$, (c) $e^{-\alpha t}\sin(\beta t - \phi)u(t)$, and (d) $e^{-\alpha t}\cos(\beta t - \phi)u(t)$.

5.61 Find the inverse Laplace transform of each of the following functions:

(a) $\dfrac{600}{s(s+10)(s+30)}$ (b) $\dfrac{60(s+4)}{s(s+2)(s+12)}$

5.62 Find the inverse Laplace transform of each of the following functions:

(a) $\dfrac{12s}{(s+3)(s^2+9)}$ (b) $\dfrac{4(s^2+1)}{s(s^2+4)}$

5.63 Find the inverse Laplace transform of each of the following functions:

(a) $\dfrac{(s+2)(s+3)}{s(s+1)^2}$ (b) $\dfrac{10s+80}{s^2+8s+20}$

5.64 Find the solution to the differential equation

$$\frac{d^2x(t)}{dt^2} + 7\frac{dx(t)}{dt} + 6x(t) = 36u(t)$$

subject to the initial conditions $dx(0)/dt = 0$ and $x(0) = -4$.

5.65 Find the solution to the differential equation

$$\frac{d^2x(t)}{dt^2} + 3\frac{dx(t)}{dt} + 2x(t) = 20\cos 2t\, u(t)$$

subject to the zero initial conditions $dx(0)/dt = x(0) = 0$.

5.66 For the series RC circuit shown in Fig. P5.66, suppose that $R = 5\ \Omega$ and $C = 0.1$ F. Find the step responses $v(t)$ and $i(t)$ when $v_s(t) = 20u(t)$ V.

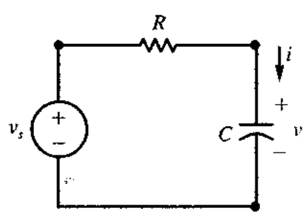

Fig. P5.66

5.67 For the series RC circuit shown in Fig. P5.66, suppose that $R = 2\ \Omega$ and $C = 2$ F. Find $v(t)$ and $i(t)$ when $v_s(t) = 12e^{-t/2}u(t)$ V.

5.68 For the series RC circuit shown in Fig. P5.66, suppose that $R = 2\ \Omega$ and $C = 2$ F. Find $v(t)$ and $i(t)$ when $v_s(t) = 12e^{-t/4}u(t)$ V.

5.69 For the series RL circuit shown in Fig. P5.69, suppose that $R = 5\ \Omega$ and $L = 5$ H. Find the step responses $i(t)$ and $v(t)$ when $v_s(t) = 20u(t)$ V.

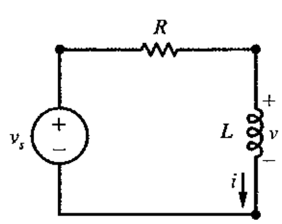

Fig. P5.69

5.70 For the series RL circuit shown in Fig. P5.69, suppose that $R = 2\ \Omega$ and $L = 2$ H. Find $i(t)$ and $v(t)$ when $v_s(t) = 12e^{-2t}u(t)$ V.

5.71 For the series RL circuit shown in Fig. P5.69, suppose that $R = 2\ \Omega$ and $L = 2$ H. Find $i(t)$ and $v(t)$ when $v_s(t) = 12e^{-t}u(t)$ V.

5.72 Find the step responses $v(t)$ and $i(t)$ for the circuit shown in Fig. P5.72 when $v_s(t) = 12u(t)$ V.

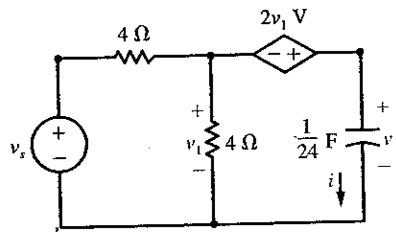

Fig. P5.72

5.73 For the circuit shown in Fig. P5.72, replace the capacitor with a 3-H inductor, and find the step responses $v(t)$ and $i(t)$ when $v_s(t) = 20u(t)$ V.

5.74 For the op-amp circuit shown in Fig. P5.3, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find the step response $v_2(t)$ when $v_1(t) = 3u(t)$ V.

5.75 For the op-amp circuit shown in Fig. P5.3, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find $v_2(t)$ when $v_1(t) = 3e^{-2t}u(t)$ V.

5.76 For the op-amp circuit shown in Fig. P5.3, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find $v_2(t)$ when $v_1(t) = 3e^{-4t}u(t)$ V.

5.77 For the op-amp circuit shown in Fig. P5.8, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find the step response $v_2(t)$ when $v_1(t) = 3u(t)$ V.

5.78 For the op-amp circuit shown in Fig. P5.8, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find $v_2(t)$ when $v_1(t) = 3e^{-2t}u(t)$ V.

5.79 For the op-amp circuit shown in Fig. P5.8, suppose that $R = 2\ \Omega$ and $C = \frac{1}{8}$ F. Find $v_2(t)$ when $v_1(t) = 3e^{-4t}u(t)$ V.

5.80 For the series RLC circuit shown in Fig. P5.80, suppose that $R = \frac{1}{3}\ \Omega$, $L = \frac{1}{12}$ H, $C = 3$ F, and $v_s(t) = 0$ V. Find $v(t)$ and $i(t)$ when $i(0) = 4$ A and $v(0) = 0$ V.

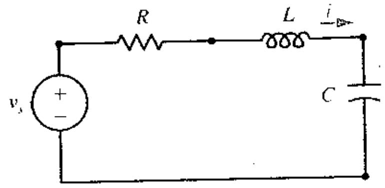

Fig. P5.80

5.81 For the series RLC circuit shown in Fig. P5.80, suppose that $R = \frac{1}{3}\ \Omega$, $L = \frac{1}{12}$ H, $C = \frac{3}{5}$ F, and $v_s(t) = 0$ V. Find $v(t)$ and $i(t)$ when $i(0) = 4$ A and $v(0) = 0$ V.

5.82 For the series RLC circuit shown in Fig. P5.80, suppose that $R = \frac{1}{3}\ \Omega$, $L = \frac{1}{12}$ H, $C = 4$ F, and $v_s(t) = 0$ V. Find $v(t)$ and $i(t)$ when $i(0) = 4$ A and $v(0) = 0$ V.

5.83 For the parallel RLC circuit shown in Fig. P5.83, suppose that $R = \frac{1}{2}\ \Omega$, $L = \frac{1}{4}$ H, $C = \frac{1}{2}$ F, and $i_s(t) = 0$ A. Find $v(t)$ and $i(t)$ when $i(0) = 6$ A and $v(0) = 0$ V.

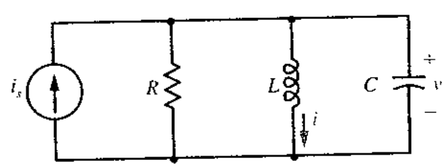

Fig. P5.83

5.84 For the parallel RLC circuit shown in Fig. P5.83, suppose that $R = \frac{1}{3}\ \Omega$, $L = \frac{1}{4}$ H, $C = \frac{1}{2}$ F, and $i_s(t) = 0$ A. Find $v(t)$ and $i(t)$ when $i(0) = 6$ A and $v(0) = 0$ V.

5.85 For the parallel RLC circuit shown in Fig. P5.83, suppose that $R = \frac{1}{3}\ \Omega$, $L = \frac{2}{9}$ H, $C = \frac{1}{2}$ F, and $i_s(t) = 0$ A. Find $v(t)$ and $i(t)$ when $i(0) = 6$ A and $v(0) = 0$ V.

5.86 For the series RLC circuit shown in Fig. P5.80, suppose that $R = 7\ \Omega$, $L = 1$ H, $C = 0.1$ F, and $v_s(t) = 0$ V. Find $i(t)$ and $v(t)$ when $v(0) = 12$ V and $i(0) = 0$ A.

5.87 For the series *RLC* circuit shown in Fig. P5.80, suppose that $R = 2\ \Omega$, $L = \frac{1}{4}$ H, $C = 0.2$ F, and $v_s(t) = 0$ V. Find $i(t)$ and $v(t)$ when $v(0) = 10$ V and $i(0) = 0$ A.

5.88 For the series *RLC* circuit shown in Fig. P5.80, suppose that $R = 2\ \Omega$, $L = 1$ H, $C = 1$ F, and $v_s(t) = 0$ V. Find $i(t)$ and $v(t)$ when $v(0) = 6$ V and $i(0) = 0$ A.

5.89 For the circuit shown in Fig. P5.89, find $v_2(t)$ when $v_s(t) = 0$ V and $v_1(0) = v_2(0) = 6$ V.

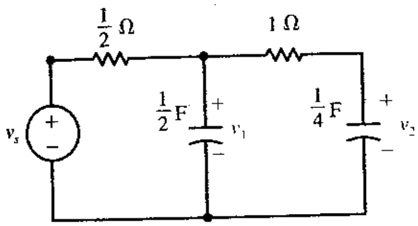

Fig. P5.89

5.90 For the circuit shown in Fig. P5.90, find $v(t)$ when $v_s(t) = 0$ V, $v(0) = 3$ V, and $i(0) = 3$ A.

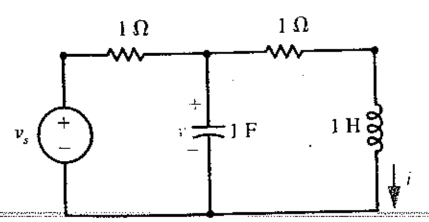

Fig. P5.90

5.91 For the circuit shown in Fig. P5.90, interchange the inductor and the capacitor. Find the capacitor voltage $v(t)$ and the inductor current $i(t)$ when $v_s(t) = 0$ V, $v(0) = 0$ V and $i(0) = 6$ A.

5.92 For the parallel *RLC* circuit shown in Fig. P5.83, suppose that $R = \frac{1}{2}\ \Omega$, $L = \frac{1}{5}$ H, and $C = \frac{1}{4}$ F. Find the step responses $v(t)$ and $i(t)$ when $i_s(t) = 2u(t)$ A.

5.93 For the parallel *RLC* circuit shown in Fig. P5.83, suppose that $R = 3\ \Omega$, $L = 3$ H, and $C = \frac{1}{12}$ F. Find the step responses $v(t)$ and $i(t)$ when $i_s(t) = 4u(t)$ A.

5.94 For the series *RLC* circuit shown in Fig. P5.80, suppose that $R = 7\ \Omega$, $L = 1$ H, and $C = 0.1$ F. Find the step responses $v(t)$ and $i(t)$ when $v_s(t) = 12u(t)$ V.

5.95 For the series *RLC* circuit shown in Fig. P5.80, suppose that $R = 2\ \Omega$, $L = 1$ H, and $C = 1$ F. Find the step responses $v(t)$ and $i(t)$ when $v_s(t) = 12u(t)$ V.

5.96 For the *RLC* circuit shown in Fig. P5.96, suppose that $R = \frac{1}{2}\ \Omega$, $L = \frac{1}{3}$ H, and $C = \frac{1}{4}$ F. Find the unit step responses $v(t)$ and $i(t)$ when $v_s(t) = u(t)$ V.

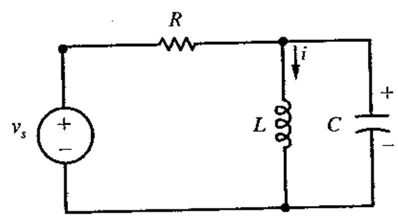

Fig. P5.96

5.97 For the *RLC* circuit shown in Fig. P5.96, suppose that $R = \frac{1}{2}\ \Omega$, $L = \frac{1}{4}$ H, and $C = \frac{1}{2}$ F. Find the unit step responses $v(t)$ and $i(t)$ when $v_s(t) = u(t)$ V.

5.98 For the circuit shown in Fig. P5.89, find the step response $v_2(t)$ when $v_s(t) = 9u(t)$ V.

5.99 For the circuit shown in Fig. P5.90, find the step response $v(t)$ when $v_s(t) = 6u(t)$ V.

5.100 For the op-amp circuit shown in Fig. P5.48, suppose that $C = \frac{1}{3}$ F. Find the step response $v_2(t)$ when $v_1(t) = 4u(t)$ V.

5.101 For the op-amp circuit shown in Fig. P5.48, suppose that $C = \frac{1}{8}$ F. Find the step response $v_2(t)$ when $v_1(t) = 8u(t)$ V.

5.102 For the op-amp circuit shown in Fig. P5.48, suppose that $C = \frac{1}{4}$ F. Find the step response $v_2(t)$ when $v_1(t) = 6u(t)$ V.

5.103 For the op-amp circuit shown in Fig. P5.49, suppose that $C = 1$ F. Find the step response $v_2(t)$ when $v_1(t) = 3u(t)$ V.

6.32 For the diode circuit shown in Fig. P6.32, D_1 and D_2 are silicon diodes having saturation currents of 5 nA and 10 nA, respectively, at 300 K. Given that both diodes are forward biased, find the value of R for which the current is 15 mA.

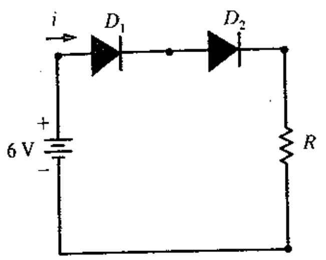

Fig. P6.32

6.33 A germanium diode has a saturation current of 20 μA at 300 K.
(a) Plot an i-v characteristic curve on a piece of graph paper.
(b) Suppose that this diode is used in the circuit given in Fig. 6.16a, on p. 368, where $v_1 = 1$ V and $R = 0.5\ \Omega$. Use the i-v curve obtained in part (a) to graphically determine i and v.

6.34 A germanium diode has a saturation current of 20 μA at 300 K. Suppose that this diode is used in the circuit given in Fig. 6.16a on p. 368, where $v_1 = 1$ V and $R = 0.5\ \Omega$. Use the numerical method described in Example 6.7 on p. 369 to find i and v. (Begin with $v = 0.2$ V.)

6.35 A silicon diode has a saturation current of 10 nA at 300 K.
(a) Plot an i-v characteristic curve on a piece of graph paper.
(b) Suppose that this diode is used in the circuit given in Fig. 6.16a, on p. 368, where $v_1 = 1$ V and $R = 100\ \Omega$. Use the i-v curve obtained in part (a) to determine graphically i and v.

6.36 A silicon diode has a saturation current of 10 nA at 300 K. Suppose that this diode is used in the circuit given in Fig. 6.16a, on p. 368, where $v_1 = 1$ V and $R = 100\ \Omega$. Use the numerical method described in Example 6.7 on p. 369 to find i and v. (Begin with $v = 0.5$ V.)

6.37 Given that the input voltage is $v_S = A \sin \omega t$ V, sketch the resulting output voltage v_o for the ideal-diode circuit shown in Fig. P6.37.

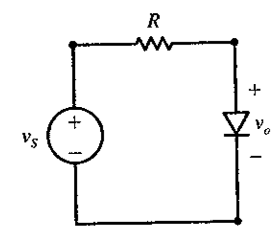

Fig. P6.37

6.38 The input voltage to the clipper circuit shown in Fig. P6.38 is $v_S = 12 \sin \omega t$ V. Determine the output voltage v_o and sketch this function.

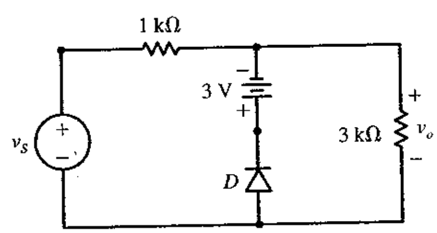

Fig. P6.38

6.39 For the ideal-diode circuit given in Fig. P6.38, reverse the polarity of the 3-V source. The input voltage to the resulting clipper circuit is $v_S = 12 \sin \omega t$ V. Determine the output voltage v_o and sketch this function.

6.40 The input voltage to the clipper circuit shown in Fig. P6.40 is $v_S = 6 \sin \omega t$ V. Determine the output voltage v_o and sketch this function.

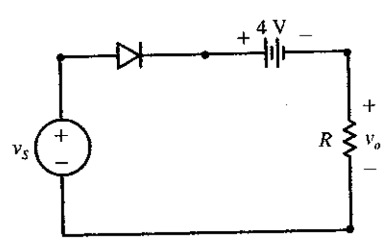

Fig. P6.40

6.41 The input voltage to the clipper circuit shown in Fig. P6.41 is $v_S = 12 \sin \omega t$ V. Determine the output voltage v_o and sketch this function.

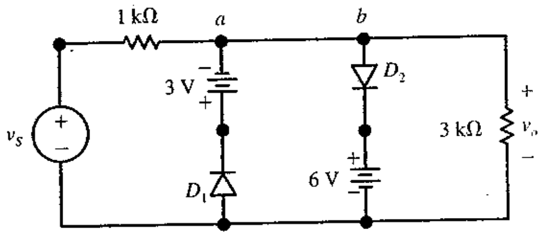

Fig. P6.41

6.42 For the ideal-diode circuit given in Fig. P6.41, reverse the polarity of the 3-V source. The input voltage to the resulting clipper circuit is $v_S = 12 \sin \omega t$ V. Determine the output voltage v_o and sketch this function.

6.43 For the ideal-diode circuit given in Fig. P6.41, remove the short circuit between points a and b, and replace it with a 2-kΩ resistor. Find the range of values of v_S for which (a) D_1 and D_2 are OFF; (b) D_1 is ON and D_2 is OFF; and (c) D_1 is OFF and D_2 is ON. Is it possible for both D_1 and D_2 to be ON?

6.44 The ideal-diode circuit shown in Fig. P6.44 is known as a **full-wave** (or **bridge**) **rectifier circuit.** Determine which diodes are ON and which are OFF when (a) $v_S > 0$ V, and (b) $v_S < 0$ V. Sketch the output voltage v_o for the case that the input voltage is $v_S = A \sin \omega t$ V.

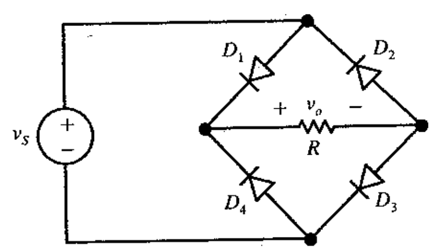

Fig. P6.44

6.45 The ideal-diode circuit shown in Fig. P6.45 is also an example of a full-wave rectifier. Determine which diodes are ON and which are OFF when (a) $v_S > 0$ V, and (b) $v_S < 0$ V. Sketch the output voltage v_o when the input voltage is $v_S = A \sin \omega t$ V.

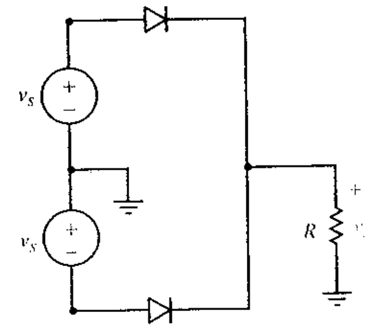

Fig. P6.45

6.46 When a diode is used in a rectifier circuit, the maximum reverse-bias voltage across that diode is known as the **peak inverse voltage** (PIV) of the diode. (Of course, the PIV must be less than the breakdown voltage of the diode.) If $v_S = A \sin \omega t$ V, find the PIV of the diodes in the rectifier circuit given in (a) Fig. 6.20, on p. 373, (b) Fig. P6.44, and (c) Fig. P6.45.

6.47 For the ideal-diode circuit given in Fig. 6.28 on p. 377, let $R_f = 1$ kΩ and $R = 9$ kΩ. Find the output voltage v_o when the input voltages are (a) $v_1 = v_2 = 0$ V; (b) $v_1 = 0$ V, $v_2 = 10$ V; (c) $v_1 = v_2 = 10$ V.

6.48 For the ideal-diode circuit given in Fig. 6.31, on p. 380, let $R_f = 1$ kΩ, $R = 9$ kΩ, and $V_H = 10$ V. Find the output voltage v_o when the input voltages are (a) $v_1 = v_2 = 0$ V; (b) $v_1 = 0$ V, $v_2 = 10$ V; (c) $v_1 = v_2 = 10$ V.

6.49 A silicon diode with a saturation current of 5 nA at 300 K has a forward-bias voltage of 0.7 V. (a) Find the dc resistance of the diode. (b) Find the ac resistance of the diode. (c) Find the dc resistance of the diode for 310 K. (d) Find the ac resistance of the diode for 310 K.

6.50 A germanium diode with a saturation current of 10 μA at 300 K has a forward-bias voltage of 0.3 V. (a) Find the dc resistance of the diode. (b) Find the ac resistance of the diode. (c) Find the dc resistance of the diode for 310 K. (d) Find the ac resistance of the diode for 310 K.