9.1 Consider the sinusoidal voltage

$$v(t) = 40\ \cos(100\pi t + 60^\circ)\ \text{V}.$$

a. What is the maximum amplitude of the voltage?
b. What is the frequency in hertz?
c. What is the frequency in radians per second?
d. What is the phase angle in radians?
e. What is the phase angle in degrees?
f. What is the period in milliseconds?
g. What is the first time after $t = 0$ that $v = -40$ V?
h. The sinusoidal function is shifted $10/3$ ms to the right along the time axis. What is the expression for $v(t)$?
i. What is the minimum number of milliseconds that the function must be shifted to the left if the expression for $v(t)$ is $40\ \sin\ 100\pi t$ V?

a) $\boxed{\text{Max amplitude: } 40V}$

b) $2\pi f = 100\pi \Rightarrow \boxed{f = 50\ Hz}$

c) $\boxed{\omega = 100\pi = 314.159\ rad/s}$

d) $60 \times \frac{\pi}{180} = \boxed{1.05\ rad = \theta}$

e) $\boxed{\theta = 60^\circ}$

f) $\boxed{T = \frac{1}{f} = 20ms}$

g) $\cos(\pi) = -1$

$100\pi t + \frac{\pi}{3} = \pi$

$\boxed{t = 6.67ms}$

h) $v = 40\cos\left[100\pi\left(t - \frac{0.01}{3}\right) + \frac{\pi}{3}\right]$

$\boxed{v = 40\cos[100\pi t]\ V}$

i) $100\pi(t - t_0) + \frac{\pi}{3} = 100\pi t + \left(\frac{3\pi}{2}\right)$

$100\pi t_0 = \frac{7\pi}{6}$

$\boxed{t_0 = 11.67ms}$

9.5 A sinusoidal voltage is zero at $t = (-2\pi/3)$ ms and increasing at a rate of $80,000$ V/s. The maximum amplitude of the voltage is 80 V.
a. What is the frequency of v in radians per second?
b. What is the expression for v?

$v(t) = 80\cos(\omega t + \theta)$

$\frac{dV}{dt} = -80\omega\sin(\omega t + \theta)$

$80\omega = 80000$

a) $\boxed{\omega = 1000\ rad/s}$

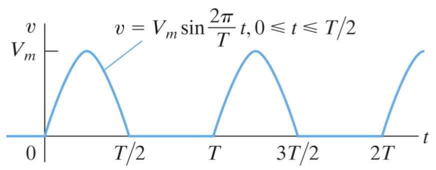
b) $f = \frac{\omega}{2\pi} = 159.16\ Hz$, $T = \frac{1}{159.16} = 6.28ms$

$\frac{-2\pi/3}{6.28} = -0.334 \qquad \theta = 120 - 90 = 30^\circ$

$\boxed{v(t) = 80\cos(1000t + 30^\circ)\ V}$

9.8 Find the rms value of the half-wave rectified sinusoidal voltage shown in Fig. P9.8.

Figure P9.8



$$\int_0^{T/2} V_m^2 \sin^2\left(\frac{2\pi}{T}t\right)dt = \frac{V_m^2}{2}\int_0^{T/2}\left(1 - \cos\frac{4\pi}{T}t\right)dt$$
$$= \frac{V_m^2}{2}\left(\frac{T}{2}\right)$$

$$V_{rms} = \sqrt{\frac{1}{T}\cdot\frac{V_m^2 T}{4}} \Rightarrow \boxed{V_{rms} = \frac{V_m}{2}}$$

9.13 A 400 Hz sinusoidal voltage with a maximum amplitude of 100 V at $t = 0$ is applied across the terminals of an inductor. The maximum amplitude of the steady-state current in the inductor is 20 A.

a. What is the frequency of the inductor current?
b. If the phase angle of the voltage is zero, what is the phase angle of the current?
c. What is the inductive reactance of the inductor?
d. What is the inductance of the inductor in millihenrys?
e. What is the impedance of the inductor?

a) $\boxed{400 \text{ Hz}}$

b) $I = \frac{100}{j\omega L} \angle 0^\circ = \frac{100}{\omega L} \angle -90^\circ$

$\boxed{\theta = -90^\circ}$

c) $\frac{100}{\omega L} = 20 \qquad \boxed{\omega L = 5\,\Omega}$

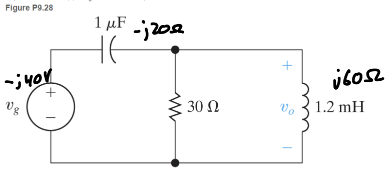
d) $L = \frac{5}{2f\pi} = \frac{5}{800\pi}$

$\boxed{L = 1.99 \text{ mH}}$

e) $\boxed{Z_L = j\omega L = j\,5\,\Omega}$

9.28 PSPICE MULTISIM The circuit in **Fig. P9.28** is operating in the sinusoidal steady state. Find the steady-state expression for $v_o(t)$ if $v_g = 40 \sin 50{,}000t$ V.

Figure P9.28



$V_g = 40\angle -90^\circ = -j40 \text{ V}$

$\frac{1}{j\omega C} = \frac{1}{j(10^{-6})(50\times10^3)} = -j20\,\Omega$

$j\omega L = j(50\times10^3)(1.2\times10^{-3}) = j60\,\Omega$

$Z_{e} = -j20 + 30 \| j60 = 24 - j8\,\Omega$

$I_g = \frac{-j40}{24-j8} = 0.5 - j1.5 \text{ A}$

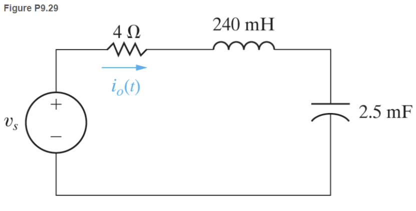
$V_o = \frac{30(j60)}{30+j60}(0.5 - j1.5) = 30 - j30$

$V_o = 42.43 \angle -45^\circ \text{ V}$

$\boxed{V_o(t) = 42.43 \cos(50000t - 45^\circ) \text{ V}}$

9.29 PSPICE MULTISIM Find the steady-state expression for $i_o(t)$ in the circuit in **Fig. P9.29** if $v_s = 100 \sin 50t$ mV.

Figure P9.29



$Z = 4 + j\omega L + \frac{1}{j\omega C}$

$= 4 + j\,50(0.24) - \frac{j}{50 \times 2.5\times10^{-3}}$

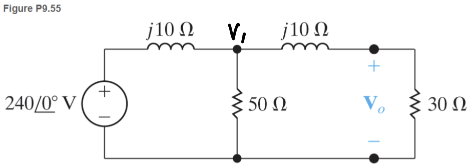
$= 5.66 \angle 45^\circ\,\Omega$

$I_o = \frac{V}{Z} = \frac{0.1\angle -90^\circ}{5.66\angle 45^\circ} = 17.67\angle -135^\circ \text{ mA}$

$\boxed{i_o(t) = 17.67 \cos(50t - 135^\circ) \text{ mA}}$

9.55 Use the node-voltage method to find $\mathbf{V}_o$ in the circuit in Fig. P9.55.

Figure P9.55



$$\frac{V_1 - 240}{j10} + \frac{V_1}{50} + \frac{V_1}{30+j10} = 0$$

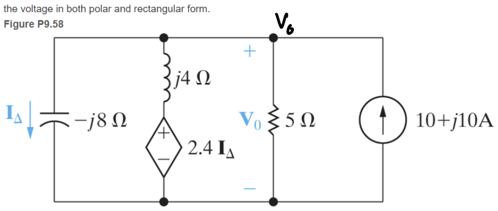
$$(V_1-240)(50)(30+j10) + V_1(j10)(30+j10) + V_1(50)(j10) = 0$$

$$V_1 = 198.63\angle -24.44^\circ \, V$$

$$\boxed{V_o = \frac{30}{30+j10} V_1 = 188.43\angle -42.88^\circ \, V}$$

9.58 Use the node-voltage method to find the phasor voltage $\mathbf{V}_0$ in the circuit shown in Fig. P9.58. Express the voltage in both polar and rectangular form.

Figure P9.58



$$\frac{V_o}{-j8} + \frac{V_o - 2.4I_\Delta}{j4} + \frac{V_o}{5} - (10+j10) = 0$$

$$\frac{V_o}{-j8} + \frac{V_o - 2.4\left(\frac{V_o}{-j8}\right)}{j4} + \frac{V_o}{5} = 10+j10$$

$$\frac{V_o}{-j8} + \frac{V_o - 0.3jV_o}{j4} + \frac{V_o}{5} = 10+j10$$

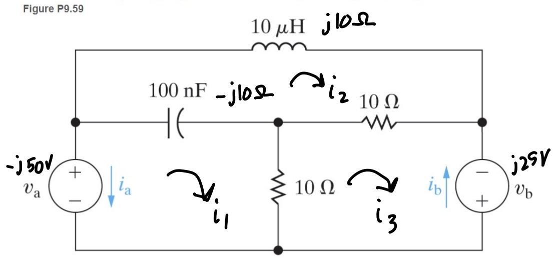
$$V_o\left[-\frac{1}{j8} + \frac{1}{j4} - \frac{j0.3}{j4} + \frac{1}{5}\right] = 10+j10$$

$$V_o = \frac{10+j10}{0.125-0.125j} = 80j\,V$$

$$\boxed{V_o = 80\angle 90^\circ \, V}$$

9.59 PSPICE MULTISIM Use the mesh-current method to find the steady-state expression for the branch currents i_a and i_b in the circuit seen in Fig.P9.59 if $v_a = 50 \sin 10^6 t\, V$ and $v_b = 25 \cos(10^6 t + 90^\circ) V$.

Figure P9.59



$$V_a = 50\angle -90^\circ = -j50\,V$$

$$V_b = 25\angle 90 = j25\,V$$

$$\frac{1}{j\omega C} = \frac{-j}{(10^6)(0.1\times10^{-6})} = -j10\,\Omega$$

$$j\omega L = j\,10^6(10\times10^{-6}) = j10\,\Omega$$

① $j10 i_1 + 10 i_2 - 10 i_3 = 0$

② $(10-j10) i_1 + j10 i_2 - 10 i_3 = -j50$

③ $-10 i_1 - 10 i_2 + 20 i_3 = j25$

Solving for $i_1 + i_3$

$i_1 = 0.5 - j1.5\,A \quad i_3 = -1 + j0.5\,A$

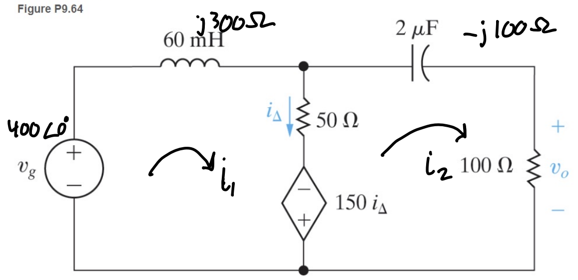
$i_a = -i_1 = -0.5 + j1.5 = 1.58\angle 108.43^\circ$

$i_b = -i_3 = 1 - j0.5 = 1.12\angle -26.57^\circ$

$$\boxed{\begin{aligned} i_a &= 1.58 \cos(10^6 t + 108.43^\circ) A \\ i_b &= 1.12 \cos(10^6 t - 26.57^\circ) A \end{aligned}}$$

9.64 PSPICE MULTISIM Use the mesh-current method to find the steady-state expression for v_o in the circuit seen in Fig. P9.64 if v_g equals $400 \cos 5000t$ V.

Figure P9.64



$$-400 + (50 + j300)i_1 - 50 i_2 - 150(i_1 - i_2) = 0$$

$$(150 - j100) i_2 - 50 i_1 + 150(i_1 - i_2) = 0$$

<u>Solving</u>

$$i_1 = -0.8 + 1.6A \quad , \quad i_2 = -1.6 + j0.8A$$

$$V_0 = 100 i_2 = -160 + j80 = 178.89\angle 153.43°$$

$$\boxed{V_0 = 178.89 \cos(5000t + 153.43°)\,V}$$