***P5.23.** Reduce $5\cos(\omega t + 75°) - 3\cos(\omega t - 75°) + 4\sin(\omega t)$ to the form $V_m \cos(\omega t + \theta)$.

P5.23* We are given the expression

$$5\cos(\omega t + 75^\circ) - 3\cos(\omega t - 75^\circ) + 4\sin(\omega t)$$

Converting to phasors we obtain

$$5\angle 75^\circ - 3\angle -75^\circ + 4\angle -90^\circ =$$
$$1.2941 + j4.8296 - (0.7765 - j2.8978) - j4 =$$
$$0.5176 + j3.7274 = 3.763\angle 82.09^\circ$$

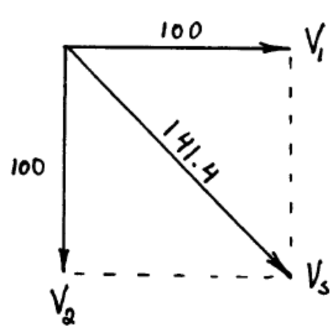
Thus, we have

$$5\cos(\omega t + 75^\circ) - 3\cos(\omega t - 75^\circ) + 4\sin(\omega t) =$$
$$3.763\cos(\omega t + 82.09^\circ)$$

***P5.24.** Suppose that $v_1(t) = 100\cos(\omega t)$ and $v_2(t) = 100\sin(\omega t)$. Use phasors to reduce the sum $v_s(t) = v_1(t) + v_2(t)$ to a single term of the form $V_m \cos(\omega t + \theta)$. Draw a phasor diagram, showing $\mathbf{V}_1, \mathbf{V}_2$, and $\mathbf{V}_s$. State the phase relationships between each pair of these phasors.

P5.24*

$$v_1(t) = 100\cos(\omega t)$$
$$v_2(t) = 100\sin(\omega t) = 100\cos(\omega t - 90^\circ)$$
$$\mathbf{V}_1 = 100\angle 0^\circ = 100$$
$$\mathbf{V}_2 = 100\angle -90^\circ = -j100$$
$$\mathbf{V}_s = \mathbf{V}_1 + \mathbf{V}_2 = 100 - j100 = 141.4\angle -45^\circ$$
$$v_s(t) = 141.4\cos(\omega t - 45^\circ)$$



$\mathbf{V}_2$ lags $\mathbf{V}_1$ by 90°

$\mathbf{V}_s$ lags $\mathbf{V}_1$ by 45°

$\mathbf{V}_s$ leads $\mathbf{V}_2$ by 45°

***P5.35.** A voltage $v_L(t) = 10\cos(2000\pi t)$ is applied to a 100-mH inductance. Find the complex impedance of the inductance. Find the phasor voltage and current, and construct a phasor diagram. Write the current as a function of time. Sketch the voltage and current to scale versus time. State the phase relationship between the current and voltage.

P5.35*

$$v_L(t) = 10\cos(2000\pi t)$$

$$\omega = 2000\pi$$

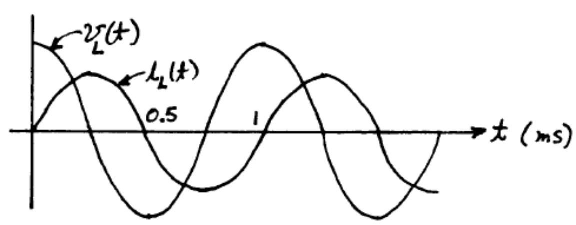
$$Z_L = j\omega L = j200\pi = 200\pi\angle 90^\circ$$

$$\mathbf{V}_L = 10\angle 0^\circ$$

$$\mathbf{I}_L = \mathbf{V}_L / Z_L = (1/20\pi)\angle -90^\circ$$

$$i_L(t) = (1/20\pi)\cos(2000\pi t - 90^\circ) = (1/20\pi)\sin(2000\pi t)$$

$i_L(t)$ lags $v_L(t)$ by 90°



***P5.37.** A voltage $v_C(t) = 10\cos(2000\pi t)$ is applied to a 10-μF capacitance. Find the complex impedance of the capacitance. Find the phasor voltage and current, and construct a phasor diagram. Write the current as a function of time. Sketch the voltage and current to scale versus time. State the phase relationship between the current and voltage.

P5.37*

$$v_C(t) = 10\cos(2000\pi t)$$

$$\omega = 2000\pi$$

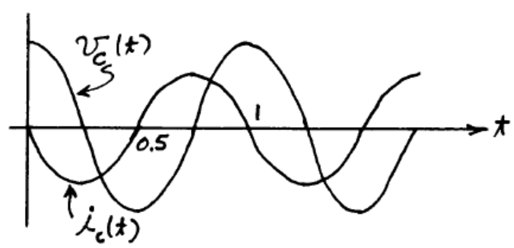
$$Z_C = \frac{-j}{\omega C} = -j15.92 = 15.92\angle -90^\circ\ \Omega$$

$$\mathbf{V}_C = 10\angle 0^\circ$$

$$\mathbf{I}_C = \mathbf{V}_C / Z_C = 0.6283\angle 90^\circ$$

$$i_C(t) = 0.6283\cos(2000\pi t + 90^\circ) = -0.6283\sin(2000\pi t)$$

$i_C(t)$ leads $v_C(t)$ by 90°



***P5.42.** Find the phasors for the current and for the voltages of the circuit shown in Figure P5.42. Construct a phasor diagram showing $\mathbf{V}_s$, $\mathbf{I}$, $\mathbf{V}_R$, and $\mathbf{V}_L$. What is the phase relationship between $\mathbf{V}_s$ and $\mathbf{I}$?

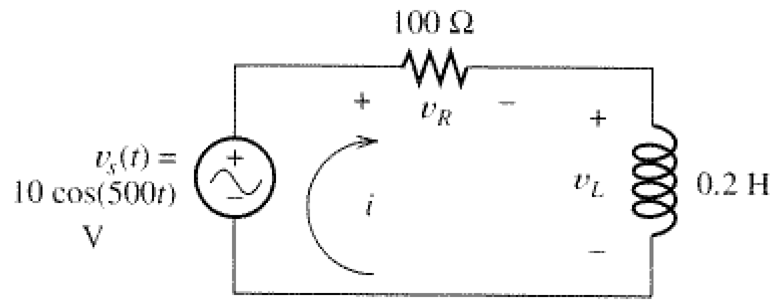


Figure P5.42

P5.42*

$$\mathbf{I} = \frac{\mathbf{V}_s}{R + j\omega L}$$

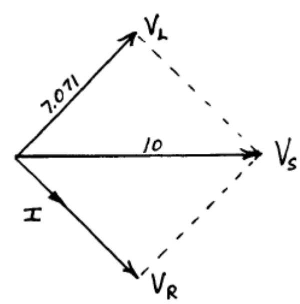
$$= \frac{10\angle 0^\circ}{100 + j100}$$

$$= 70.71\angle -45^\circ \text{ mA}$$

$$\mathbf{V}_R = R\mathbf{I} = 7.071\angle -45^\circ \text{ V}$$

$$\mathbf{V}_L = j\omega L\mathbf{I} = 7.071\angle 45^\circ \text{ V}$$

$\mathbf{I}$ lags $\mathbf{V}_s$ by 45°



***P5.44.** Find the phasors for the current and the voltages for the circuit shown in Figure P5.44. Construct a phasor diagram showing $\mathbf{V}_s$, $\mathbf{I}$, $\mathbf{V}_R$, and $\mathbf{V}_C$. What is the phase relationship between $\mathbf{V}_s$ and $\mathbf{I}$?

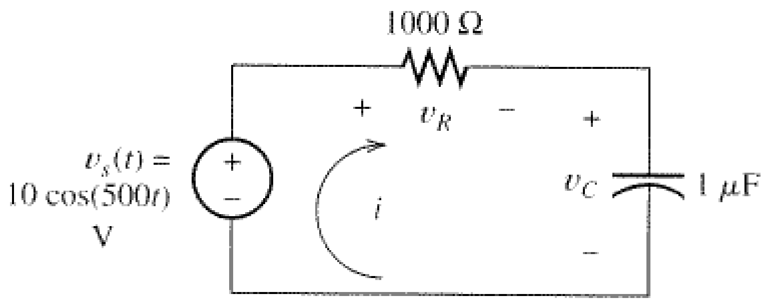


Figure P5.44

P5.44*

$$\mathbf{I} = \frac{\mathbf{V}_s}{R - j/\omega C}$$

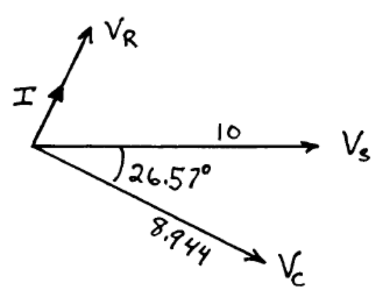
$$= \frac{10\angle 0^\circ}{1000 - j2000}$$

$$= 4.472\angle 63.43^\circ \text{ mA}$$

$$\mathbf{V}_R = R\mathbf{I} = 4.472\angle 63.43^\circ \text{ V}$$

$$\mathbf{V}_C = (-j/\omega C)\mathbf{I} = 8.944\angle -26.57^\circ \text{V}$$

$\mathbf{I}$ leads $\mathbf{V}_s$ by 63.43°



P5.47. Compute the complex impedance of the network shown in Figure P5.47 for $\omega = 500$. Repeat for $\omega = 1000$ and $\omega = 2000$. Give the answers in both polar and rectangular forms.

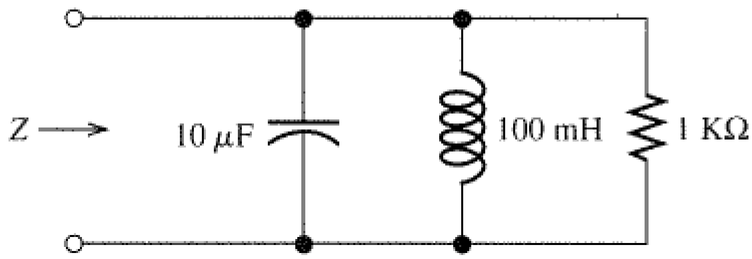


Figure P5.47

P5.47

$$Z = \frac{1}{1/Z_L + 1/Z_c} = \frac{1}{1/j\omega L + j\omega C + 1/R}$$

$$\omega = 500: \quad Z = \frac{1}{1/(j50) + j0.005 + 0.001}$$

$$= 4.425 + j66.37 = 66.52\angle 86.19^\circ\ \Omega$$

$$\omega = 1000: \ Z = 1000 + j0 = 1000\angle 0^\circ\ \Omega$$

$$\omega = 2000: \ Z = 4.425 - j66.37 = 66.52\angle -86.19^\circ\ \Omega$$

***P5.49.** Consider the circuit shown in Figure P5.49. Find the phasors $\mathbf{I}_s$, $\mathbf{V}$, $\mathbf{I}_R$, $\mathbf{I}_L$, and $\mathbf{I}_C$. Compare the peak value of $i_L(t)$ with the peak value of $i_s(t)$. Do you find the answer surprising? Explain.

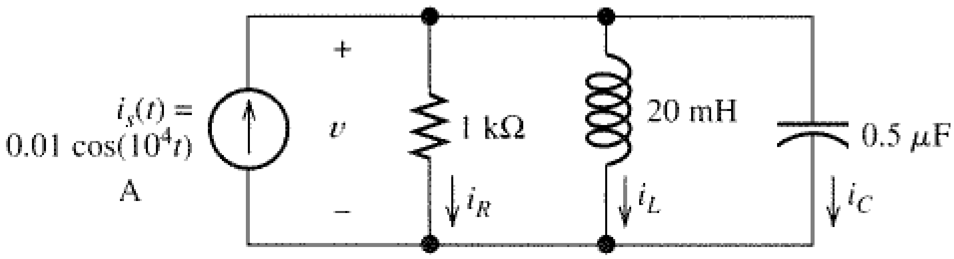


Figure P5.49

P5.49*

$$\mathbf{I}_s = 10\angle 0^\circ \text{ mA}$$

$$\mathbf{V} = \mathbf{I}_s \frac{1}{1/R + 1/j\omega L + j\omega C}$$

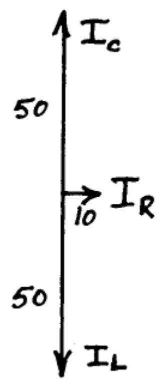
$$= 10^{-2} \frac{1}{1/1000 - j0.005 + j0.005}$$

$$= 10\angle 0^\circ \text{ V}$$

$$\mathbf{I}_R = \mathbf{V}/R = 10\angle 0^\circ \text{ mA}$$

$$\mathbf{I}_L = \mathbf{V}/j\omega L = 50\angle -90^\circ \text{ mA}$$

$$\mathbf{I}_C = \mathbf{V}(j\omega C) = 50\angle 90^\circ \text{ mA}$$



The peak value of $i_L(t)$ is five times larger than the source current! This is possible because current in the capacitance balances the current in the inductance (i.e., $\mathbf{I}_L + \mathbf{I}_C = 0$).

P5.57. Solve for the node voltage shown in Figure P5.57.

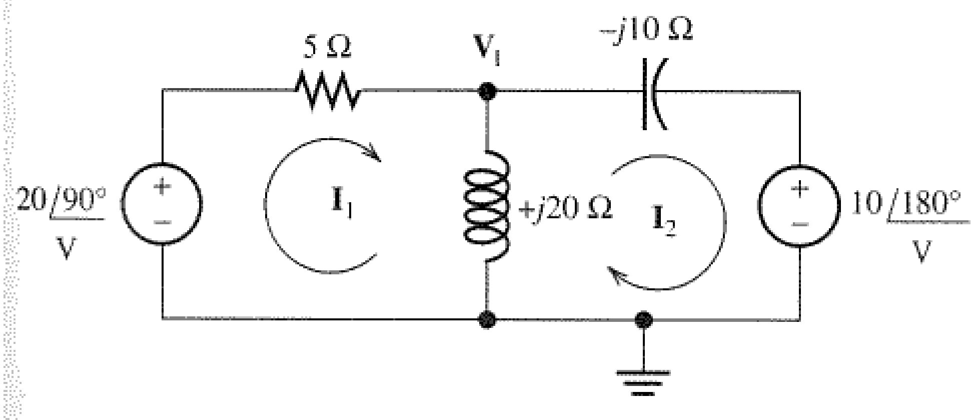


Figure P5.57

P5.57 The KCL equation is $\frac{\mathbf{V}_1 - j20}{5} + \frac{\mathbf{V}_1}{j20} + \frac{\mathbf{V}_1 + 10}{-j10} = 0$. Solving, we find $\mathbf{V}_1 = -12 + j16 = 20\angle 126.89^\circ$ V.