**Practice Problems**

**P5.16, P5.23, P5.25, P5.34, P5.38**
**P5.42, P5.50, P5.52, P5.53, P5.63**

**P5.16** The limits on the integral don't matter as long as they cover one period

$$V_{rms} = \sqrt{\frac{1}{T}\int_{-T/2}^{T/2} v^2(t)dt} = \sqrt{20\int_{-0.025}^{0.025}[4\cos(20\pi t)]^2 dt} = \sqrt{20\int_{-0.025}^{0.025}[8+8\cos(40\pi t)]dt}$$

$$V_{rms} = \sqrt{\left(160t + \frac{160}{40\pi}\sin(40\pi t)\right)\Bigg|_{t=-0.025}^{t=0.025}} = \sqrt{8} = 2\sqrt{2}\ \text{V}$$

**P5.23***

$$\omega = 2\pi f = 400\pi$$

$$v_1(t) = 10\cos(400\pi t + 30^\circ)$$
$$v_2(t) = 5\cos(400\pi t + 150^\circ)$$
$$v_3(t) = 10\cos(400\pi t + 90^\circ)$$

$v_1(t)$ lags $v_2(t)$ by $120^\circ$
$v_1(t)$ lags $v_3(t)$ by $60^\circ$
$v_2(t)$ leads $v_3(t)$ by $60^\circ$

**P5.25** $V_m = 15\ \text{V} \qquad T = 20\ \text{ms}$

$$f = \frac{1}{T} = 50\ \text{Hz} \qquad \omega = 2\pi f = 100\pi\ \text{rad/s}$$

$$\theta = -360^\circ \frac{t_{max}}{T} = 72^\circ$$

$$v(t) = 15\cos(100\pi t + 72^\circ)\ \text{V}$$

$$\mathbf{V} = 15\angle 72^\circ\ \text{V}$$

$$V_{rms} = \frac{15}{\sqrt{2}} = 10.61\ \text{V}$$

**P5.34** (a) Notice that the current is a sine rather than a cosine.

$\mathbf{V} = 100\angle 30^\circ \quad \mathbf{I} = 2.5\angle -60^\circ \quad Z = \dfrac{\mathbf{V}}{\mathbf{I}} = 40\angle 90^\circ = j40$

Because $Z$ is pure imaginary and positive, the element is an inductance.

$\omega = 200 \qquad L = \dfrac{|Z|}{\omega} = 200 \text{ mH}$

(b) Notice that the voltage is a sine rather than a cosine.

$\mathbf{V} = 100\angle -60^\circ \quad \mathbf{I} = 4\angle 30^\circ \quad Z = \dfrac{\mathbf{V}}{\mathbf{I}} = 25\angle -90^\circ = -j25$

Because $Z$ is pure imaginary and negative, the element is a capacitance.

$\omega = 200 \qquad C = \dfrac{1}{|Z|\omega} = 200\ \mu\text{F}$

(c) $\mathbf{V} = 100\angle 30^\circ \quad \mathbf{I} = 5\angle 30^\circ \quad Z = \dfrac{\mathbf{V}}{\mathbf{I}} = 20\angle 0^\circ = 20 + j0$

Because $Z$ is pure real, the element is a resistance of 20 Ω.

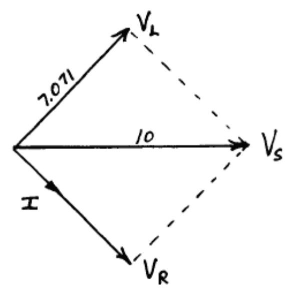
**P5.38***

$$\mathbf{I} = \frac{\mathbf{V}_s}{R + j\omega L} = \frac{10\angle 0^\circ}{100 + j100} = 70.71\angle -45^\circ \text{ mA}$$

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

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

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




**P5.42***

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

$\omega = 500: \quad Z = j50 + 50 - j200$
$\qquad\qquad = 50 - j150\ \Omega = 158.1\angle -71.57^\circ$

$\omega = 1000: \quad Z = j100 + 50 - j100$
$\qquad\qquad = 50\ \Omega = 50\angle 0^\circ$

$\omega = 2000: \quad Z = j200 + 50 - j50$
$\qquad\qquad = 50 + j150\ \Omega = 158.1\angle 71.57^\circ$

**P5.50** The KCL equation is $\frac{\mathbf{V}_1 - j20}{5} + \frac{\mathbf{V}_1}{5 + j5} + 3 = 0$. Solving, we find $\mathbf{V}_1 = -13 + j9 = 15.81\angle 145.30^\circ$ V.

**P5.52** (a) The impedance is given by $Z = j\omega(0.02) - j/(\omega 50 \times 10^{-6})$ which is infinite for zero frequency and for infinite frequency. Thus, the combination is equivalent to an open circuit for zero frequency and for infinite frequency.

Setting the impedance equal to zero, we solve to find $\omega = 1000$. Thus, the combination is equivalent to a short circuit for $f = 1000/2\pi = 159.2$ Hz.

(b) The impedance is given by $Z = \frac{1}{j\omega(50 \times 10^{-6}) - j/(0.02\omega)}$ which is infinite when the denominator is zero. This occurs for $\omega = 1000$. Thus, the parallel combination is equivalent to an open circuit for $f = 1000/2\pi = 159.2$ Hz.

The impedance is zero for zero frequency and for infinite frequency. Thus, the parallel combination is equivalent to a short circuit for zero frequency and for infinite frequency.

**P5.53** The KCL equation is $\frac{\mathbf{V}_1 - j20}{10} + \frac{\mathbf{V}_1}{j10} + \frac{\mathbf{V}_1 - 10}{-j5} = 0$. Solving, we find $\mathbf{V}_1 = 20 + j20 = 28.28\angle 45^\circ$ V.

**P5.63*** $\mathbf{I} = \frac{1000\sqrt{2}\angle 0^\circ}{100} + \frac{1000\sqrt{2}\angle 0^\circ}{-j265.3} = 14.14 + j5.331 = 15.11\angle 20.66^\circ$

$P = V_{rms} I_{rms} \cos\theta = 10$ kW

$Q = V_{rms} I_{rms} \sin\theta = -3.770$ kVAR

Apparent power $= V_{rms} I_{rms} = 10.68$ kVA

Power factor $= \cos(20.66^\circ) = 0.9357 = 93.57\%$ leading