HW # 6 Solutions

Conceptual Questions

36.1. **(a)** a: –100 V b: +60 V c: +80 V. The emf is the x-component of the counterclockwise rotating vectors.
(b) a: Decreasing b: Decreasing c: Increasing

36.2. **(a)** 1.0 A. Use $I_R = \dfrac{V_R}{R}$.

(b) 4.0 A. Use $I_R = \dfrac{V_R}{R} = \dfrac{\mathcal{E}_0}{R}$.

(c) 2.0 A. I_R is not dependent on the frequency.

36.3. **(a)** 4.0 A. Use $I_c = \omega C \mathcal{E}_0$ for all parts of this question.
(b) 4.0 A
(c) 4.0 A

Exercises and Problems

36.1. **Model:** A phasor is a vector that rotates counterclockwise around the origin at angular frequency ω.
Solve: **(a)** Referring to the phasor in Figure EX36.1, the phase angle is

$$\omega t = 180^\circ + 30^\circ = 210^\circ \times \frac{\pi \text{ rad}}{180^\circ} = 3.665 \text{ rad} \Rightarrow \omega = \frac{3.665 \text{ rad}}{15 \times 10^{-3} \text{ s}} = 2.4 \times 10^2 \text{ rad/s}$$

(b) The instantaneous value of the emf is

$$\mathcal{E} = \mathcal{E}_0 \cos\omega t = (12 \text{ V})\cos(3.665 \text{ rad}) = -10.4 \text{ V}$$

Assess: Be careful to change your calculator to the radian mode to work with the trigonometric functions.

36.2. Model: A phasor is a vector that rotates counterclockwise around the origin at angular frequency ω.
Solve: **(a)** Referring to the phasor in Figure EX36.2, the phase angle is

$$\omega t = 135° = 135° \times \frac{\pi \text{ rad}}{180°} = \frac{3\pi}{4} \text{ rad} \Rightarrow \omega = \frac{3\pi/4}{2.0 \text{ ms}} = 1178 \text{ rad/s}$$

(b) From Figure EX36.2,

$$\mathcal{E} = \mathcal{E}_0 \cos\omega t \Rightarrow \mathcal{E}_0 = \frac{\mathcal{E}}{\cos\omega t} = \frac{50 \text{ V}}{\cos(3\pi/4 \text{ rad})} = -71 \text{ V}$$

36.5. Visualize: Please refer to Figure EX36.4 for an AC resistor circuit.
Solve: **(a)** For a circuit with a single resistor, the peak current is

$$I_R = \frac{\mathcal{E}_0}{R} = \frac{10 \text{ V}}{200 \,\Omega} = 0.050 \text{ A} = 50 \text{ mA}$$

36.6. Model: Current and voltage phasors are vectors that rotate counterclockwise around the origin at angular frequency ω.
Visualize: Please refer to Figure EX36.6.
Solve: **(a)** The frequency is

$$f = \frac{\omega}{2\pi} = \frac{1}{T} = \frac{1}{0.04 \text{ s}} = 25 \text{ Hz}$$

(b) From the figure we note that $V_R = 10$ V and $I_R = 0.50$ A. Using Ohm's law,

$$R = \frac{V_R}{I_R} = \frac{10 \text{ V}}{0.50 \text{ A}} = 20 \,\Omega$$

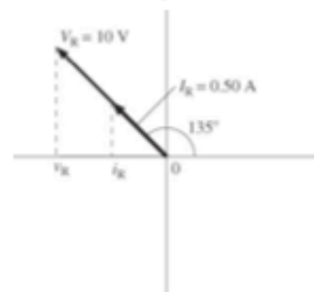
(c) The voltage and current are

$$v_R = V_R \cos\omega t = (10 \text{ V})\cos[2\pi(25 \text{ Hz})t] \qquad i_R = I_R \cos\omega t = (0.50 \text{ A})\cos[2\pi(25 \text{ Hz})t]$$

For both the voltage and the current at $t = 15$ ms, the phase angle is

$$\omega t = 2\pi(25 \text{ Hz})(15 \text{ ms}) = 2\pi(0.375) \text{ rad} = 135°$$

That is, the current and voltage phasors will make an angle of 135° with the starting $t = 0$ s position.



Assess: Ohm's law applies to both the instantaneous *and* peak currents and voltages. For a resistor, the current and voltage are in phase.

36.8. Solve: **(a)** For a simple one-capacitor circuit,

$$I_C = \frac{V_C}{X_C} = \frac{V_C}{1/\omega C} = \omega C V_C$$

When the frequency is doubled, the new current is

$$I_C' = \omega' C V_C = (2\omega) C V_C = 2(\omega C V_C) = 2I_C = 20 \text{ mA}$$

(b) Likewise, when the voltage is doubled, the current doubles to 20 mA.
(c) When the frequency is halved and the emf is doubled, the current remains the same at 10 mA.

36.10. Solve: From Equation 36.11,

$$I_C = \frac{V_C}{X_C} = \frac{V_C}{1/\omega C} = \omega C V_C \Rightarrow C = \frac{I_C}{\omega V_C} = \frac{65 \times 10^{-3} \text{ A}}{2\pi(15{,}000 \text{ Hz})\left[\sqrt{2}(6.0 \text{ V})\right]} = 81 \times 10^{-9} \text{ F} = 81 \text{ nF}$$