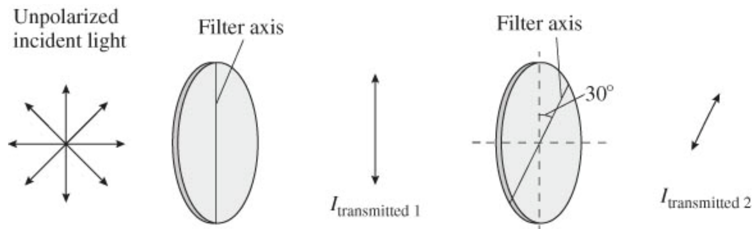
35.10. $I_d > I_c = I_e > I_b > I_a$. The intensity passing through a polarizer is $I_0 \cos^2 \theta$. Polarizer d is aligned with the incident wave $(\theta = 0)$ while $\theta = 90°$ for polarizer a. Polarizers c and e are at the same angle θ from the vertical.

35.27. Model: Use Malus's law for polarized light.

Visualize:



Solve: For unpolarized light, the electric field vector varies randomly through all possible values of θ. Because the *average* value of $\cos^2\theta$ is $\frac{1}{2}$, the intensity transmitted by a polarizing filter is $I_{\text{transmitted}} = \frac{1}{2}I_0$. On the other hand, for polarized light $I_{\text{transmitted}} = I_0 \cos^2\theta$. Therefore,

$$I_{\text{transmitted 2}} = I_{\text{transmitted 1}} \cos^2\theta = \tfrac{1}{2}I_0 \cos^2\theta = \tfrac{1}{2}\left(350 \text{ W/m}^2\right)\cos^2 30° = 131 \text{ W/m}^2$$

Assess: Note that any particular *wave* has a clear polarization. It is only in a "sea" of waves that the resultant wave has no polarization.

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

(b) 4.0 A. Use $I_R = \dfrac{V_R}{R} = \dfrac{\varepsilon_0}{R}$.

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

36.3. **(a)** 4.0 A. Use $I_c = \omega C \varepsilon_0$ for all parts of this question.

(b) 4.0 A

(c) 4.0 A

36.5. **(a)** $I_L = 1.0$ A. Use $I_L = \dfrac{V_L}{X_L} = \dfrac{\varepsilon_0}{\omega L}$ for all parts of this question.

(b) $I_L = 4.0$ A

(c) $I_L = 1.0$ A

36.6. **(a)** 1000 Hz. Use $\omega_0 = \dfrac{1}{\sqrt{LC}}$. Resistance does not matter.

(b) $\dfrac{1}{\sqrt{2}}$ 1000 Hz = 707 Hz

(c) $\dfrac{1}{\sqrt{2}}$ 1000 Hz = 707 Hz

(d) 1000 Hz. Peak emf does not matter.

36.8. The current lags the emf. The phase angle $\phi > 0$ and $X_L > X_C$.

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,

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

36.9. Visualize: Figure EX36.7 shows a simple one-capacitor circuit.

Solve: **(a)** From Equation 36.11,

$$I_C = \frac{V_C}{X_C} = \frac{V_C}{1/\omega C} = \omega C V_C = 2\pi f C V_C \Rightarrow f = \frac{50\times10^{-3}\ \text{A}}{2\pi(5.0\ \text{V})(20\times10^{-9}\ \text{F})} = 80\ \text{kHz}$$

(b) The AC current through a capacitor *leads* the capacitor voltage by 90° or $\pi/2$ rad. For a simple one-capacitor circuit $i_C = I_C\cos\left(\omega t + \frac{1}{2}\pi\right)$. For $i_C = I_C$, $\left(\omega t + \frac{1}{2}\pi\right)$ *must* be equal to $2n\pi$, where n = 1, 2, ... This means

$$\omega t = \frac{3\pi}{2}, \frac{7\pi}{2}, \frac{11\pi}{2}, \ \ldots$$

At these values of ωt, $v_C = V_C\cos(\omega t) = 0$ V. That is, i_C is maximum when $v_C = 0$ V.

36.11. Solve: **(a)** From Equation 36.11,

$$I_c = \frac{V_c}{X_c} = \frac{V_c}{1/\omega C} = \omega C V_c = 2\pi f C V_c$$

$$\Rightarrow C = \frac{I_c}{2\pi f V_c} = \frac{\left(330\times10^{-6}\ \text{A}\right)}{2\pi\left(250\times10^{3}\ \text{Hz}\right)\left(2.2\ \text{V}\right)} = 9.5\times10^{-11}\ \text{C} = 95\ \text{pC}$$

(b) Doubling the frequency will halve the capacitive reactance X_c, doubling the current, so I_c = 2 (330 μA) = 660 μA.

36.12. Model: The current and voltage of a resistor are in phase, but the capacitor current leads the capacitor voltage by 90°.

Solve: For an RC circuit, the peak voltages are related through Equation 36.12. We have

$$\mathcal{E}_0^2 = V_R^2 + V_C^2 \Rightarrow V_R = \sqrt{\mathcal{E}_0^2 - V_C^2} = \sqrt{(10.0\text{ V})^2 - (6.0\text{ V})^2} = 8.0\text{ V}$$

36.22. Model: The AC current through an inductor lags the inductor voltage by 90°.
Solve: **(a)** From Equation 36.21,

$$I_L = 330\,\mu\text{A} = \frac{V_L}{X_L} = \frac{V_L}{2\pi fL}$$

$$\Rightarrow L = \frac{2.2\text{ V}}{2\pi\left(45\times10^{6}\text{ Hz}\right)\left(330\times10^{-6}\text{ A}\right)} = 2.4\times10^{-5}\text{ H} = 24\ \mu\text{H}$$

(b) Doubling the frequency will double the inductive reactance and halve the current, so

$$I_L = \frac{330\,\mu\text{A}}{2} = 165\,\mu\text{A}$$

36.23. Solve: (a) When the resistance is doubled, the resonance frequency stays the same because f is independent of R. Hence, $f = 200$ kHz.
(b) From Equation 36.30,

$$f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$

When the capacitor value is doubled,

$$f' = \frac{1}{2\pi}\frac{1}{\sqrt{L(2C)}} = \frac{f}{\sqrt{2}} = \frac{200 \text{ kHz}}{\sqrt{2}} = 141 \text{ kHz}$$

36.25. Model: At the resonance frequency, the current in a series RLC circuit is a maximum. The resistor does not affect the resonance frequency.

Solve: From Equation 36.30,

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \Rightarrow C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\pi^2 (1000 \text{ Hz})^2 (20 \times 10^{-3} \text{ H})} = 1.27 \times 10^{-6} \text{ F} = 1.27\ \mu\text{F}$$

36.35. Solve: **(a)** From Equation 36.14,

$$V_{\mathrm{R}} = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + \left(\omega_{\mathrm{cap}} C\right)^{-2}}} = \frac{\mathcal{E}_0}{2} \Rightarrow R^2 + \frac{1}{\omega_{\mathrm{res}}^2 C^2} = 4R^2 \Rightarrow \omega_{\mathrm{res}} = \frac{1}{\sqrt{3}RC}$$

(b) At this frequency,

$$V_{\mathrm{C}} = IX_{\mathrm{C}} = \frac{V_{\mathrm{R}}}{R}\left(\frac{1}{\omega_{\mathrm{res}} C}\right) = \frac{\left(\mathcal{E}_0/2\right)}{R}\left(\sqrt{3}RC\right)\frac{1}{C} = \frac{\sqrt{3}}{2}\mathcal{E}_0$$

(c) The crossover frequency is

$$\omega_{\mathrm{c}} = \frac{1}{RC} = 6280 \text{ rad/s} \Rightarrow \omega_{\mathrm{res}} = \omega_{\mathrm{c}}\big/\sqrt{3} = 3630 \text{ rad/s}$$

36.39. Visualize: Please refer to Figure 36.13.

Solve: For an RC filter, $I = \mathcal{E}_0 \big/ \sqrt{R^2 + X_C^2}$ and

$$V_R = IR = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + (1/\omega C)^2}} \qquad V_C = IX_C = \frac{\mathcal{E}_0 X_C}{\sqrt{R^2 + (1/\omega C)^2}}$$

At the crossover frequency $\omega = \omega_c = 1/RC$ and thus $1/\omega_c C = R$. Hence,

$$V_R = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + R^2}} = \frac{\mathcal{E}_0}{\sqrt{2}} \qquad V_C = \frac{\mathcal{E}_0 (1/\omega C)}{\sqrt{R^2 + (1/\omega C)^2}} = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + R^2}} = \frac{\mathcal{E}_0}{\sqrt{2}}$$