HW 5 Solutions

33.2 $\Delta V_{rms} = \frac{170\text{ V}}{\sqrt{2}} = 120\text{ V}$

(a) $\mathcal{P} = \frac{(\Delta V_{rms})^2}{R} \to R = \frac{(120\text{ V})^2}{75.0\text{ W}} = \boxed{193\ \Omega}$

(b) $R = \frac{(120\text{ V})^2}{100\text{ W}} = \boxed{144\ \Omega}$

33.6 $\mathcal{P} = I_{rms}(\Delta V_{rms})$ and $\Delta V_{rms} = 120\text{ V}$ for each bulb (parallel circuit), so:

$I_1 = I_2 = \frac{\mathcal{P}_1}{\Delta V_{rms}} = \frac{150\text{ W}}{120\text{ V}} = \boxed{1.25\text{ A}}$, and $R_1 = \frac{\Delta V_{rms}}{I_1} = \frac{120\text{ V}}{1.25\text{ A}} = \boxed{96.0\ \Omega} = R_2$

$I_3 = \frac{\mathcal{P}_3}{\Delta V_{rms}} = \frac{100\text{ W}}{120\text{ V}} = \boxed{0.833\text{ A}}$, and $R_3 = \frac{\Delta V_{rms}}{I_3} = \frac{120\text{ V}}{0.833\text{ A}} = \boxed{144\ \Omega}$

33.9 (a) $X_L = \frac{\Delta V_{max}}{I_{max}} = \frac{100}{7.50} = 13.3\ \Omega$

$L = \frac{X_L}{\omega} = \frac{13.3}{2\pi(50.0)} = 0.0424\text{ H} = \boxed{42.4\text{ mH}}$

(b) $X_L = \frac{\Delta V_{max}}{I_{max}} = \frac{100}{2.50} = 40.0\ \Omega$

$\omega = \frac{X_L}{L} = \frac{40.0}{42.4 \times 10^{-3}} = \boxed{942\text{ rad/s}}$

33.16 $Q_{max} = C(\Delta V_{max}) = C\left[\sqrt{2}(\Delta V_{rms})\right] = \boxed{\sqrt{2}C(\Delta V_{rms})}$

33.18 $X_C = \frac{1}{\omega C} = \frac{1}{2\pi(60.0/\text{s})(1.00 \times 10^{-3}\text{ C/V})} = 2.65\ \Omega$

$v_C(t) = \Delta V_{max} \sin \omega t$, to be zero at $t = 0$

$i_C = \frac{\Delta V_{max}}{X_C} \sin(\omega t + \phi) = \frac{\sqrt{2}\,(120\text{ V})}{2.65\ \Omega} \sin\left[2\pi \frac{60\text{ s}^{-1}}{180\text{ s}^{-1}} + 90.0°\right] = (64.0\text{ A})\sin(120° + 90.0°) = \boxed{-32.0\text{ A}}$

33.20 $\omega L = \frac{1}{\omega C} \to \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(57.0 \times 10^{-6})(57.0 \times 10^{-6})}} = 1.75 \times 10^4\text{ rad/s}$

$f = \frac{\omega}{2\pi} = \boxed{2.79\text{ kHz}}$

33.24 $$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(60.0\text{ Hz})(20.0\times10^{-12}\text{ F})} = 1.33\times10^{8}\ \Omega$$

$$Z = \sqrt{(50.0\times10^{3}\ \Omega)^2 + (1.33\times10^{8}\ \Omega)^2} \approx 1.33\times10^{8}\ \Omega$$

$$I_{rms} = \frac{\Delta V_{rms}}{Z} = \frac{5000\text{ V}}{1.33\times10^{8}\ \Omega} = 3.77\times10^{-5}\text{ A}$$

$$(\Delta V_{rms})_{body} = I_{rms}R_{body} = (3.77\times10^{-5}\text{ A})(50.0\times10^{3}\ \Omega) = \boxed{1.88\text{ V}}$$

33.30 $$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad \text{or} \quad (X_L - X_C) = \sqrt{Z^2 - R^2}$$

$$(X_L - X_C) = \sqrt{(75.0\ \Omega)^2 - (45.0\ \Omega)^2} = 60.0\ \Omega$$

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{60.0\ \Omega}{45.0\ \Omega}\right) = 53.1^\circ$$

$$I_{rms} = \frac{\Delta V_{rms}}{Z} = \frac{210\text{ V}}{75.0\ \Omega} = 2.80\text{ A}$$

$$\mathcal{P} = (\Delta V_{rms})I_{rms}\cos\phi = (210\text{ V})(2.80\text{ A})\cos(53.1^\circ) = \boxed{353\text{ W}}$$

33.38 $L = 20.0\text{ mH},\ C = 1.00\times10^{-7},\ R = 20.0\ \Omega,\ \Delta V_{max} = 100\text{ V}$

(a) The resonant frequency for a series $-RLC$ circuit is $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} = \boxed{3.56\text{ kHz}}$

(b) At resonance, $I_{max} = \frac{\Delta V_{max}}{R} = \boxed{5.00\text{ A}}$

(c) From Equation 33.36, $Q = \frac{\omega_0 L}{R} = \boxed{22.4}$

(d) $\Delta V_{L,max} = X_L I_{max} = \omega_0 L I_{max} = \boxed{2.24\text{ kV}}$

33.44 (a) $\left(\Delta V_{2,\,rms}\right) = \frac{N_2}{N_1}\left(\Delta V_{1,\,rms}\right)$ $\qquad N_2 = \frac{(2200)(80)}{110} = \boxed{1600\text{ windings}}$

(b) $I_{1,rms}\left(\Delta V_{1,rms}\right) = I_{2,rms}\left(\Delta V_{2,rms}\right)$ $\qquad I_{1,rms} = \frac{(1.50)(2200)}{110} = \boxed{30.0\text{ A}}$

(c) $0.950\, I_{1,rms}\left(\Delta V_{1,rms}\right) = I_{2,rms}\left(\Delta V_{2,rms}\right)$ $\qquad I_{1,rms} = \frac{(1.20)(2200)}{110(0.950)} = \boxed{25.3\text{ A}}$

33.48 For the filter circuit, $\frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} = \frac{X_C}{\sqrt{R^2 + X_C^2}}$

(a) At $f = 600 \text{ Hz}$,

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(600 \text{ Hz})(8.00 \times 10^{-9} \text{ F})} = 3.32 \times 10^4 \ \Omega$$

and

$$\frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} = \frac{3.32 \times 10^4 \ \Omega}{\sqrt{(90.0 \ \Omega)^2 + (3.32 \times 10^4 \ \Omega)^2}} \approx \boxed{1.00}$$

(b) At $f = 600 \text{ kHz}$,

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(600 \times 10^3 \text{ Hz})(8.00 \times 10^{-9} \text{ F})} = 33.2 \ \Omega$$

and

$$\frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} = \frac{33.2 \ \Omega}{\sqrt{(90.0 \ \Omega)^2 + (33.2 \ \Omega)^2}} = \boxed{0.346}$$

33.65 (a) From Equation 33.39, $\frac{N_1}{N_2} = \frac{\Delta V_1}{\Delta V_2}$

Let output impedance $Z_1 = \frac{\Delta V_1}{I_1}$ and the input impedance $Z_2 = \frac{\Delta V_2}{I_2}$

so that $\frac{N_1}{N_2} = \frac{Z_1 I_1}{Z_2 I_2}$ But from Eq. 33.40, $\frac{I_1}{I_2} = \frac{\Delta V_2}{\Delta V_1} = \frac{N_2}{N_1}$

So, combining with the previous result we have $\boxed{\frac{N_1}{N_2} = \sqrt{\frac{Z_1}{Z_2}}}$

(b) $\frac{N_1}{N_2} = \sqrt{\frac{Z_1}{Z_2}} = \sqrt{\frac{8000}{8.00}} = \boxed{31.6}$