21.1 (a) $\Delta V_{max} = \sqrt{2}(\Delta V_{rms}) = \sqrt{2}(100\text{ V}) = \boxed{141\text{ V}}$

(b) $I_{rms} = \dfrac{\Delta V_{rms}}{R} = \dfrac{100\text{ V}}{5.00\ \Omega} = \boxed{20.0\text{ A}}$

(c) $I_{max} = \dfrac{\Delta V_{max}}{R} = \dfrac{141\text{ V}}{5.00\ \Omega} = \boxed{28.3\text{ A}}$ or $I_{max} = \sqrt{2}I_{rms} = \sqrt{2}(20.0\text{ A}) = \boxed{28.3\text{ A}}$

(d) $\mathcal{P}_{av} = I_{rms}^2 R = (20.0\text{ A})^2(5.00\ \Omega) = 2.00\times10^3\text{ W} = \boxed{2.00\text{ kW}}$

21.2 $\mathcal{P}_{av} = I_{rms}^2 R = \left(\dfrac{I_{max}}{\sqrt{2}}\right)^2 R = \dfrac{1}{2}\left[\dfrac{\Delta V_{max}}{R}\right]^2 R = \dfrac{(\Delta V_{max})^2}{2R}$, so $R = \dfrac{(\Delta V_{max})^2}{2\mathcal{P}_{av}}$

(a) If $\mathcal{P}_{av} = 75.0\text{ W}$, then $R = \dfrac{(170\text{ V})^2}{2(75.0\text{ W})} = \boxed{193\ \Omega}$

(b) If $\mathcal{P}_{av} = 100\text{ W}$, then $R = \dfrac{(170\text{ V})^2}{2(100\text{ W})} = \boxed{145\ \Omega}$

21.5 The total resistance (series connection) is $R_{eq} = R_1 + R_2 = 8.20\ \Omega + 10.4\ \Omega = 18.6\ \Omega$, so the current in the circuit is

$$I_{rms} = \frac{\Delta V_{rms}}{R_{eq}} = \frac{15.0\text{ V}}{18.6\ \Omega} = 0.806\text{ A}$$

The power to the speaker is then $\mathcal{P}_{av} = I_{rms}^2 R_{speaker} = (0.806\text{ A})^2(10.4\ \Omega) = \boxed{6.76\text{ W}}$

21.6 (a) $\Delta V_{max} = 150\text{ V}$, so $\Delta V_{rms} = \dfrac{\Delta V_{max}}{\sqrt{2}} = \dfrac{150\text{ V}}{\sqrt{2}} = \boxed{106\text{ V}}$

(b) $f = \dfrac{\omega}{2\pi} = \dfrac{377\text{ rad/s}}{2\pi} = \boxed{60.0\text{ Hz}}$

(c) At $t = (1/120)\text{ s}$, $v = (150\text{ V})\sin[(377\text{ rad/s})(1/120\text{ s})] = (150\text{ V})\sin(\pi\text{ rad}) = \boxed{0}$

(d) $I_{max} = \dfrac{\Delta V_{max}}{R} = \dfrac{150\text{ V}}{50.0\ \Omega} = \boxed{3.00\text{ A}}$

21.30 (a) $X_L = 2\pi fL = 2\pi(60.0\text{ Hz})(0.100\text{ H}) = 37.7\ \Omega$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(60.0\text{ Hz})\left(200\times10^{-6}\text{ F}\right)} = 13.3\ \Omega$$

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2} = \sqrt{(20.0\ \Omega)^2 + (37.7\ \Omega - 13.3\ \Omega)^2} = 31.6\ \Omega$$

$$\mathcal{P}_{av} = I_{rms}^2 R = \left(\frac{I_{max}}{\sqrt{2}}\right)^2 R = \frac{1}{2}\left(\frac{\Delta V_{max}}{Z}\right)^2 R = \frac{1}{2}\left(\frac{100\text{ V}}{31.6\ \Omega}\right)^2 (20.0\ \Omega) = \boxed{100\text{ W}}$$

$$\text{and } \textit{power factor} = \cos\phi = \frac{\mathcal{P}_{av}}{\Delta V_{rms} I_{rms}} = \frac{I_{rms}^2 R}{\Delta V_{rms} I_{rms}} = \left(\frac{I_{rms}}{\Delta V_{rms}}\right) R = \frac{R}{Z} = \frac{20.0\ \Omega}{31.6\ \Omega} = \boxed{0.633}$$

(b) The same calculations as shown in Part (a) above, with $f = 50.0\text{ Hz}$, give

$X_L = 31.4\ \Omega,\ X_C = 15.9\ \Omega,\ Z = 25.3\ \Omega,\ \mathcal{P}_{av} = \boxed{156\text{ W}}$ and *power factor* $= \boxed{0.790}$

21.33 The resonance frequency of the circuit should match the broadcast frequency of the station.

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ gives } L = \frac{1}{4\pi^2 f_0^2 C},$$

or
$$L = \frac{1}{4\pi^2\left(88.9\times10^6\text{ Hz}\right)^2\left(1.40\times10^{-12}\text{ F}\right)} = 2.29\times10^{-6}\text{ H} = \boxed{2.29\ \mu\text{H}}$$

21.34 (a) At resonance, $X_L = X_C$ so the impedance will be

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2} = \sqrt{R^2 + 0} = R = \boxed{15\ \Omega}$$

(b) When $X_L = X_C$, we have $2\pi fL = \dfrac{1}{2\pi fC}$ which yields

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(0.20\text{ H})\left(75\times10^{-6}\text{ F}\right)}} = \boxed{41\text{ Hz}}$$

(c) The current is a maximum $\boxed{\text{at resonance}}$ where the impedance has its minimum value of $Z = R$.

(d) At $f = 60\text{ Hz}$, $X_L = 2\pi(60\text{ Hz})(0.20\text{ H}) = 75\ \Omega$, $X_C = \dfrac{1}{2\pi(60\text{ Hz})\left(75\times10^{-6}\text{ F}\right)} = 35\ \Omega$,

and $Z = \sqrt{(15\ \Omega)^2 + (75\ \Omega - 35\ \Omega)^2} = 43\ \Omega$

Thus, $I_{\text{rms}} = \dfrac{\Delta V_{\text{rms}}}{Z} = \dfrac{\left(\Delta V_{\text{max}}/\sqrt{2}\right)}{Z} = \dfrac{150\text{ V}}{\sqrt{2}(43\ \Omega)} = \boxed{2.5\text{ A}}$

21.38 (a) $$\Delta V_{2,\text{ rms}} = \frac{N_2}{N_1}\left(\Delta V_{1,\text{ rms}}\right)$$

so $N_2 = N_1\left(\dfrac{\Delta V_{2,\text{ rms}}}{\Delta V_{1,\text{ rms}}}\right) = (240\text{ turns})\left(\dfrac{9.0\text{ V}}{120\text{ V}}\right) = \boxed{18\text{ turns}}$

(b) For an ideal transformer, $\left(\mathcal{P}_{\text{av}}\right)_{input} = \left(\mathcal{P}_{\text{av}}\right)_{ouput} = \left(\Delta V_{2,\text{ rms}}\right)I_{2,\text{ rms}}$

Thus, $\left(\mathcal{P}_{\text{av}}\right)_{input} = (9.0\text{ V})(0.400\text{ A}) = \boxed{3.6\text{ W}}$

21.42 $R_{line} = \left(4.50\times10^{-4}\ \Omega/\text{m}\right)\left(6.44\times10^{5}\ \text{m}\right) = 290\ \Omega$

(a) The power transmitted is $\left(\mathcal{P}_{\text{av}}\right)_{transmitted} = \left(\Delta V_{\text{rms}}\right)I_{\text{rms}}$

$$\text{so } I_{\text{rms}} = \frac{\left(\mathcal{P}_{\text{av}}\right)_{transmitted}}{\Delta V_{\text{rms}}} = \frac{5.00\times10^{6}\ \text{W}}{500\times10^{3}\ \text{V}} = 10.0\ \text{A}$$

$$\text{Thus, } \left(\mathcal{P}_{\text{av}}\right)_{loss} = I_{\text{rms}}^{2}R_{line} = \left(10.0\ \text{A}\right)^{2}\left(290\ \Omega\right) = 2.90\times10^{4}\ \text{W} = \boxed{29.0\ \text{kW}}$$

(b) The power input to the line is

$$\left(\mathcal{P}_{\text{av}}\right)_{input} = \left(\mathcal{P}_{\text{av}}\right)_{transmitted} + \left(\mathcal{P}_{\text{av}}\right)_{loss} = 5.00\times10^{6}\ \text{W} + 2.90\times10^{4}\ \text{W} = 5.03\times10^{6}\ \text{W}$$

and the fraction of input power lost during transmission is

$$fraction = \frac{\left(\mathcal{P}_{\text{av}}\right)_{loss}}{\left(\mathcal{P}_{\text{av}}\right)_{input}} = \frac{2.90\times10^{4}\ \text{W}}{5.03\times10^{6}\ \text{W}} = \boxed{0.005\,80\ \text{ or }\ 0.580\%}$$