10. ***REASONING*** According to Equation 22.2, the magnetic flux Φ is the product of the magnitude B of the magnetic field, the area A of the surface, and the cosine of the angle ϕ between the direction of the magnetic field and the normal to the surface. The area of a circular surface is $A = \pi r^2$, where r is the radius.

SOLUTION The magnetic flux Φ through the surface is

$$\Phi = BA\cos\varphi = B\left(\pi r^2\right)\cos\varphi = (0.078\ \text{T})\,\pi\,(0.10\ \text{m})^2\cos 25^\circ = \boxed{2.2\times10^{-3}\ \text{Wb}}$$

11. ***REASONING AND SOLUTION***

a. According to Equation 22.2, we have $\Phi = BA \cos \phi$. If the wall faces north, then

$$\Phi = B_H A \cos 0.0° + B_V A \cos 90° = B_H A = (2.6 \times 10^{-5} \text{ T})(28 \text{ m}^2) = \boxed{7.3 \times 10^{-4} \text{ Wb}}$$

b. If the wall faces east, then

$$\Phi = B_H A \cos 90° + B_V A \cos 90° = \boxed{0 \text{ Wb}}$$

c. The normal to the floor is vertical, so

$$\Phi = B_H A \cos 90° + B_V A \cos 0.0° = B_V A = (4.2 \times 10^{-5} \text{ T})(112 \text{ m}^2) = \boxed{4.7 \times 10^{-3} \text{ Wb}}$$

18. ***REASONING*** The magnitude $|\xi|$ of the emf induced in the loop can be found using Faraday's law of electromagnetic induction:

$$|\xi| = \left| -N \frac{\Phi - \Phi_0}{t - t_0} \right| \tag{22.3}$$

where N is the number of turns, Φ and Φ_0 are, respectively, the final and initial fluxes, and $t - t_0$ is the elapsed time. The magnetic flux is given by $\Phi = BA\cos\phi$ (Equation 22.2), where B is the magnitude of the magnetic field, A is the area of the surface, and ϕ is the angle between the direction of the magnetic field and the normal to the surface.

SOLUTION Setting $N = 1$ since there is only one turn, noting that the final area is $A = 0\ \text{m}^2$ and the initial area is $A_0 = 0.20\ \text{m} \times 0.35\ \text{m}$, and noting that the angle ϕ between the magnetic field and the normal to the surface is 0°, we find that the magnitude of the emf induced in the coil is

$$|\xi| = \left| -N \frac{BA\cos\phi - BA_0\cos\phi}{t - t_0} \right|$$

$$= \left| -(1) \frac{(0.65\ \text{T})(0\ \text{m}^2)\cos 0° - (0.65\ \text{T})(0.20\ \text{m} \times 0.35\ \text{m})\cos 0°}{0.18\ \text{s}} \right| = \boxed{0.25\ \text{V}}$$

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19. **SSM** ***REASONING*** According to Equation 22.3, the average emf induced in a coil of N loops is $\xi = -N\Delta\Phi / \Delta t$.

SOLUTION For the circular coil in question, the flux through a single turn changes by

$$\Delta\Phi = BA\cos\ 45° - BA\cos\ 90° = BA\cos\ 45°$$

during the interval of $\Delta t = 0.010\text{ s}$. Therefore, for N turns, Faraday's law gives the magnitude of the emf as

$$|\xi| = \left| -N\frac{BA\cos\ 45°}{\Delta t} \right|$$

Since the loops are circular, the area A of each loop is equal to πr^2. Solving for B, we have

$$B = \frac{|\xi|\Delta t}{N\pi r^2 \cos\ 45°} = \frac{(0.065\text{ V})(0.010\text{ s})}{(950)\pi(0.060\text{ m})^2\cos 45°} = \boxed{8.6\times10^{-5}\text{ T}}$$

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20. ***REASONING*** According to Ohm's law (see Section 20.2), the resistance of the wire is equal to the emf divided by the current. The emf can be obtained from Faraday's law of electromagnetic induction.

SOLUTION The resistance R of the wire is

$$R = \frac{\xi}{I} \tag{20.2}$$

According to Faraday's law of electromagnetic induction, the induced emf is

$$\xi = -N\frac{\Delta\Phi}{\Delta t} = -N\left(\frac{\Phi - \Phi_0}{t - t_0}\right) \tag{22.3}$$

where N is the number of loops in the coil, Φ and Φ_0 are, respectively, the final and initial fluxes, and $t - t_0$ is the elapsed time. Substituting Equation 22.3 into Equation 20.2 yields

$$R = \frac{\xi}{I} = \frac{-N\left(\frac{\Phi - \Phi_0}{t - t_0}\right)}{I} = \frac{-(12)\left(\frac{4.0\text{ Wb} - 9.0\text{ Wb}}{0.050\text{ s}}\right)}{230\text{ A}} = \boxed{5.2\ \Omega}$$

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24. ***REASONING*** The energy dissipated in the resistance is given by Equation 6.10b as the power P dissipated multiplied by the time t, Energy = Pt. The power, according to Equation 20.6c, is the square of the induced emf ξ divided by the resistance R, $P = \xi^2/R$. The induced emf can be determined from Faraday's law of electromagnetic induction, Equation 22.3.

SOLUTION Expressing the energy consumed as Energy = Pt, and substituting in $P = \xi^2/R$, we find

$$\text{Energy} = Pt = \frac{\xi^2 t}{R}$$

The induced emf is given by Faraday's law as $\xi = -N(\Delta\Phi/\Delta t)$, and the resistance R is equal to the resistance per unit length (3.3×10^{-2} Ω/m) times the length of the circumference of the loop, $2\pi r$. Thus, the energy dissipated is

$$\text{Energy} = \frac{\left(-N\dfrac{\Delta\Phi}{\Delta t}\right)^2 t}{\left(3.3\times10^{-2}\ \Omega/\text{m}\right)2\pi r} = \frac{\left[-N\left(\dfrac{\Phi-\Phi_0}{t-t_0}\right)\right]^2 t}{\left(3.3\times10^{-2}\ \Omega/\text{m}\right)2\pi r}$$

$$= \frac{\left[-N\left(\dfrac{BA\cos\phi - B_0A\cos\phi}{t-t_0}\right)\right]^2 t}{\left(3.3\times10^{-2}\ \Omega/\text{m}\right)2\pi r} = \frac{\left[-NA\cos\phi\left(\dfrac{B-B_0}{t-t_0}\right)\right]^2 t}{\left(3.3\times10^{-2}\ \Omega/\text{m}\right)2\pi r}$$

$$= \frac{\left[-(1)\pi(0.12\ \text{m})^2(\cos 0°)\left(\dfrac{0.60\ \text{T}-0\ \text{T}}{0.45\ \text{s}-0\ \text{s}}\right)\right]^2(0.45\ \text{s})}{\left(3.3\times10^{-2}\ \Omega/\text{m}\right)2\pi(0.12\ \text{m})} = \boxed{6.6\times10^{-2}\ \text{J}}$$

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35. **SSM** ***REASONING*** We can use the information given in the problem statement to determine the area of the coil A. Since it is square, the length of one side is $\ell = \sqrt{A}$.

SOLUTION According to Equation 22.4, the maximum emf ξ_0 induced in the coil is $\xi_0 = NAB\omega$. Therefore, the length of one side of the coil is

$$\ell = \sqrt{A} = \sqrt{\frac{\xi_0}{NB\omega}} = \sqrt{\frac{75.0\text{ V}}{(248)(0.170\text{ T})(79.1\text{ rad/s})}} = \boxed{0.150\text{ m}}$$

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37. ***REASONING AND SOLUTION*** If the generators have the same peak emf, number of turns and angular frequency, then $NB_1A_1\sin \omega t = NB_2A_2 \sin \omega t$, so that $B_1A_1 = B_2A_2$. Thus,

$$B_2 = B_1\left(\frac{A_1}{A_2}\right) = (0.10\ \text{T})\left(\frac{0.045\ \text{m}^2}{0.015\ \text{m}^2}\right) = \boxed{0.30\ \text{T}}$$

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55. ***REASONING*** The air filter is connected to the secondary, so that the power used by the air filter is the power provided by the secondary. However, the power provided by the secondary comes from the primary, so the power used by the air filter is also the power delivered by the wall socket to the primary. This power is $\overline{P} = I_P V_P$ (Equation 20.15a), where I_P is the current in the primary and V_P is the voltage provided by the socket, which we know. Although we do not have a value for I_P, we do have a value for I_S, which is the current in the secondary. We will take advantage of the fact that I_P and I_S are related according to $\frac{I_S}{I_P} = \frac{N_P}{N_S}$ (Equation 22.13).

SOLUTION The power used by the filter is

$$\overline{P} = I_P V_P$$

Solving Equation 22.13 for I_P shows that $I_P = I_S\left(\frac{N_S}{N_P}\right)$. Substituting this result into the expression for the power gives

$$\overline{P} = I_P V_P = I_S\left(\frac{N_S}{N_P}\right)V_P = \left(1.7\times10^{-3}\text{ A}\right)\left(\frac{50}{1}\right)(120\text{ V}) = \boxed{1.0\times10^{1}\text{ W}}$$

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59. **SSM** ***REASONING*** The power used to heat the wires is given by Equation 20.6b: $P = I^2 R$. Before we can use this equation, however, we must determine the total resistance R of the wire and the current that flows through the wire.

SOLUTION

a. The total resistance of one of the wires is equal to the resistance per unit length multiplied by the length of the wire. Thus, we have

$$(5.0\times10^{-2}\ \Omega/\text{km})(7.0\ \text{km}) = 0.35\ \Omega$$

and the total resistance of the transmission line is twice this value or 0.70 Ω. According to Equation 20.6a ($P = IV$), the current flowing into the town is

$$I = \frac{P}{V} = \frac{1.2\times10^{6}\ \text{W}}{1200\ \text{V}} = 1.0\times10^{3}\ \text{A}$$

Thus, the power used to heat the wire is

$$P = I^2 R = \left(1.0\times10^{3}\ \text{A}\right)^2 (0.70\ \Omega) = \boxed{7.0\times10^{5}\ \text{W}}$$

b. According to the transformer equation (Equation 22.12), the stepped-up voltage is

$$V_\text{s} = V_\text{p}\left(\frac{N_\text{s}}{N_\text{p}}\right) = (1200\ \text{V})\left(\frac{100}{1}\right) = 1.2\times10^{5}\ \text{V}$$

According to Equation 20.6a ($P = IV$), the current in the wires is

$$I = \frac{P}{V} = \frac{1.2\times10^{6}\ \text{W}}{1.2\times10^{5}\ \text{V}} = 1.0\times10^{1}\ \text{A}$$

The power used to heat the wires is now

$$P = I^2 R = \left(1.0\times10^{1}\ \text{A}\right)^2 (0.70\ \Omega) = \boxed{7.0\times10^{1}\ \text{W}}$$