P30.26 (a) $B_{\text{inner}} = \dfrac{\mu_0 NI}{2\pi r} = \dfrac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)(900)\left(14.0\times10^{3}\ \text{A}\right)}{2\pi(0.700\ \text{m})} = \boxed{3.60\ \text{T}}$

(b) $B_{\text{outer}} = \dfrac{\mu_0 NI}{2\pi r} = \dfrac{\left(2\times10^{-7}\ \text{T}\cdot\text{m/A}\right)(900)\left(14.0\times10^{3}\ \text{A}\right)}{1.30\ \text{m}} = \boxed{1.94\ \text{T}}$

P30.33 The field produced by the solenoid in its interior is given by

$$\mathbf{B} = \mu_0 nI\left(-\hat{\mathbf{i}}\right) = \left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(\frac{30.0}{10^{-2}\ \text{m}}\right)(15.0\ \text{A})\left(-\hat{\mathbf{i}}\right)$$

$$\mathbf{B} = -\left(5.65\times10^{-2}\ \text{T}\right)\hat{\mathbf{i}}$$ 

The force exerted on side *AB* of the square current loop is

$$\left(\mathbf{F}_B\right)_{AB} = I\mathbf{L}\times\mathbf{B} = (0.200\ \text{A})\left[\left(2.00\times10^{-2}\ \text{m}\right)\hat{\mathbf{j}}\times\left(5.65\times10^{-2}\ \text{T}\right)\left(-\hat{\mathbf{i}}\right)\right]$$

$$\left(\mathbf{F}_B\right)_{AB} = \left(2.26\times10^{-4}\ \text{N}\right)\hat{\mathbf{k}}$$ 

Similarly, each side of the square loop experiences a force, lying in the plane of the loop, of $\boxed{226\ \mu\text{N directed away from the center}}$. From the above result, it is seen that the net torque exerted on the square loop by the field of the solenoid should be zero. More formally, the magnetic dipole moment of the square loop is given by

$$\boldsymbol{\mu} = I\mathbf{A} = (0.200\ \text{A})\left(2.00\times10^{-2}\ \text{m}\right)^2\left(-\hat{\mathbf{i}}\right) = -80.0\ \mu\text{A}\cdot\text{m}^2\hat{\mathbf{i}}$$ 

The torque exerted on the loop is then $\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B} = \left(-80.0\ \mu\text{A}\cdot\text{m}^2\hat{\mathbf{i}}\right)\times\left(-5.65\times10^{-2}\ \text{T}\hat{\mathbf{i}}\right) = \boxed{0}$

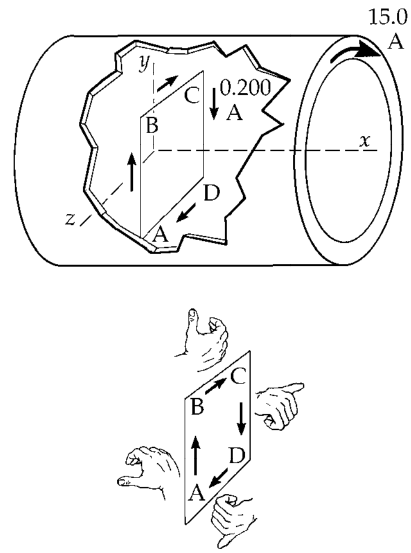

FIG. P30.33

P30.38 $\dfrac{d\Phi_E}{dt} = \dfrac{d}{dt}(EA) = \dfrac{dQ/dt}{\epsilon_0} = \dfrac{I}{\epsilon_0}$

(a) $\dfrac{dE}{dt} = \dfrac{I}{\epsilon_0 A} = \boxed{7.19\times10^{11}\ \text{V/m}\cdot\text{s}}$

(b) $\oint B\cdot ds = \epsilon_0\mu_0\dfrac{d\Phi_E}{dt}$ so $2\pi rB = \epsilon_0\mu_0\dfrac{d}{dt}\left[\dfrac{Q}{\epsilon_0 A}\cdot\pi r^2\right]$

$$B = \frac{\mu_0 Ir}{2A} = \frac{\mu_0(0.200)\left(5.00\times10^{-2}\right)}{2\pi(0.100)^2} = \boxed{2.00\times10^{-7}\ \text{T}}$$

P30.40 $B = \mu nI = \mu\left(\dfrac{N}{2\pi r}\right)I$ so $I = \dfrac{(2\pi r)B}{\mu N} = \dfrac{2\pi(0.100\ \text{m})(1.30\ \text{T})}{5\,000\left(4\pi\times10^{-7}\ \text{Wb/A}\cdot\text{m}\right)(470)} = \boxed{277\ \text{mA}}$

P30.51 We find the total number of turns: $B = \frac{\mu_0 NI}{\ell}$

$$N = \frac{B\ell}{\mu_0 I} = \frac{(0.030\,0\text{ T})(0.100\text{ m})\text{ A}}{(4\pi \times 10^{-7}\text{ T}\cdot\text{m})(1.00\text{ A})} = 2.39 \times 10^3$$

Each layer contains $\left(\frac{10.0\text{ cm}}{0.050\,0\text{ cm}}\right) = 200$ closely wound turns

so she needs $\left(\frac{2.39 \times 10^3}{200}\right) = \boxed{12\text{ layers}}$.

The inner diameter of the innermost layer is 10.0 mm. The outer diameter of the outermost layer is $10.0\text{ mm} + 2 \times 12 \times 0.500\text{ mm} = 22.0\text{ mm}$. The average diameter is 16.0 mm, so the total length of wire is

$$(2.39 \times 10^3)\pi(16.0 \times 10^{-3}\text{ m}) = \boxed{120\text{ m}}.$$

Chapter 31

P31.2 $$|\varepsilon| = \left|\frac{\Delta\Phi_B}{\Delta t}\right| = \frac{\Delta(\mathbf{B}\cdot\mathbf{A})}{\Delta t} = \frac{(2.50\text{ T} - 0.500\text{ T})(8.00 \times 10^{-4}\text{ m}^2)}{1.00\text{ s}}\left(\frac{1\text{ N}\cdot\text{s}}{1\text{ T}\cdot\text{C}\cdot\text{m}}\right)\left(\frac{1\text{ V}\cdot\text{C}}{1\text{ N}\cdot\text{m}}\right)$$

$|\varepsilon| = 1.60\text{ mV}$ and $I_{\text{loop}} = \frac{\varepsilon}{R} = \frac{1.60\text{ mV}}{2.00\ \Omega} = \boxed{0.800\text{ mA}}$

P31.9 (a) $$d\Phi_B = \mathbf{B}\cdot d\mathbf{A} = \frac{\mu_0 I}{2\pi x}L\,dx:\ \Phi_B = \int_h^{h+w}\frac{\mu_0 IL}{2\pi}\frac{dx}{x} = \boxed{\frac{\mu_0 IL}{2\pi}\ln\left(\frac{h+w}{h}\right)}$$

(b) $$\varepsilon = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left[\frac{\mu_0 IL}{2\pi}\ln\left(\frac{h+w}{h}\right)\right] = -\left[\frac{\mu_0 L}{2\pi}\ln\left(\frac{h+w}{h}\right)\right]\frac{dI}{dt}$$

$$\varepsilon = -\frac{(4\pi \times 10^{-7}\text{ T}\cdot\text{m/A})(1.00\text{ m})}{2\pi}\ln\left(\frac{1.00 + 10.0}{1.00}\right)(10.0\text{ A/s}) = \boxed{-4.80\ \mu\text{V}}$$

The long wire produces magnetic flux into the page through the rectangle, shown by the first hand in the figure to the right.

As the magnetic flux increases, the rectangle produces its own magnetic field out of the page, which it does by carrying $\boxed{\text{counterclockwise}}$ current (second hand in the figure).

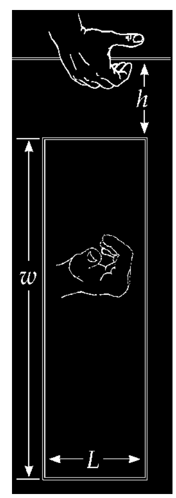

FIG. P31.9

P31.20 $I = \frac{\varepsilon}{R} = \frac{B\ell v}{R}$

$\boxed{v = 1.00\text{ m/s}}$

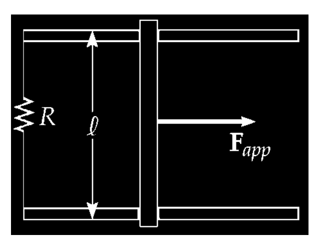

FIG. P31.20

P31.28 (a) $\mathbf{B}_{ext} = B_{ext}\hat{\mathbf{i}}$ and B_{ext} decreases; therefore, the induced field is $\mathbf{B}_0 = B_0\hat{\mathbf{i}}$ (to the right) and the current in the resistor is directed $\boxed{\text{to the right}}$.

(b) $\mathbf{B}_{ext} = B_{ext}\left(-\hat{\mathbf{i}}\right)$ increases; therefore, the induced field $\mathbf{B}_0 = B_0\left(+\hat{\mathbf{i}}\right)$ is to the right, and the current in the resistor is directed $\boxed{\text{to the right}}$.

(c) $\mathbf{B}_{ext} = B_{ext}\left(-\hat{\mathbf{k}}\right)$ into the paper and B_{ext} decreases; therefore, the induced field is $\mathbf{B}_0 = B_0\left(-\hat{\mathbf{k}}\right)$ into the paper, and the current in the resistor is directed $\boxed{\text{to the right}}$.

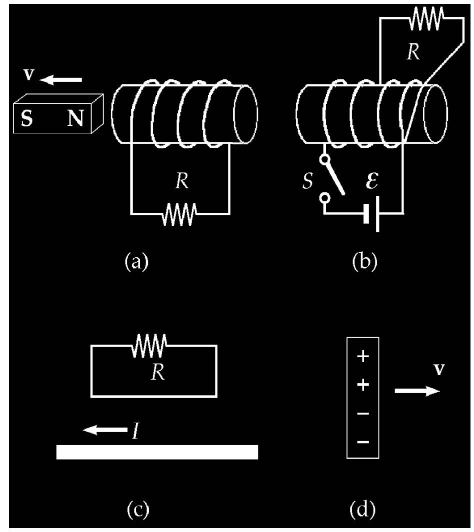

FIG. P31.28

(d) By the magnetic force law, $F_B = q(\mathbf{v}\times\mathbf{B})$. Therefore, a positive charge will move to the top of the bar if **B** is $\boxed{\text{into the paper}}$.

P31.58 $\varepsilon = B\ell v$ at a distance r from wire

$$|\varepsilon| = \left(\frac{\mu_0 I}{2\pi r}\right)\ell v$$

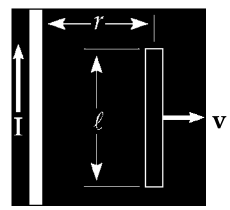

FIG. P31.58