SOLUTION'S CHAPTER 19

12. The shock of the blow shakes the domains out of alignment.

19.2 (a) For a positively charged particle, the direction of the force is that predicted by the right hand rule. These are:

(a′) in plane of page and to left

(b′) into the page

(c′) out of the page

(d′) in plane of page and toward the top

(e′) into the page

(f′) out of the page

(b) For a negatively charged particle, the direction of the force is exactly opposite what the right hand rule predicts for positive charges. Thus, the answers for part (b) are reversed from those given in part (a).

19.13 Hold the right hand with the thumb in the direction of the current and the fingers in the direction of the magnetic field. The palm then faces the direction of the force. The results are

(a) to the left

(b) into the page

(c) out of the page

(d) toward top of page

(e) into the page

(f) out of the page

19.19 For the wire to move upward at constant speed, the net force acting on it must be zero. Thus, $BIL\sin\theta = mg$, and for minimum field $\theta = 90°$. The minimum field is

$$B = \frac{mg}{IL} = \frac{(0.015\text{ kg})(9.80\text{ m/s}^2)}{(5.0\text{ A})(0.15\text{ m})} = \boxed{0.20\text{ T}}$$

For the magnetic force to be directed upward when the current is toward the left, **B** must be directed out of the page.

19.23 The area is $A = \pi ab = \pi(0.200\text{ m})(0.150\text{ m}) = 0.0942\text{ m}^2$. Since the field is parallel to the plane of the loop, $\theta = 90.0°$ and the magnitude of the torque is

$$\tau = NBIA\sin\theta$$

$$= 8(2.00\times10^{-4}\text{ T})(6.00\text{ A})(0.0942\text{ m}^2)\sin 90.0° = \boxed{9.05\times10^{-4}\text{ N}\cdot\text{m}}$$

The torque is directed to make the left-hand side of the loop move toward you and the right-hand side move away.

19.26 The resistance of the loop is

$$R = \frac{\rho L}{A} = \frac{\left(1.70\times10^{-8}\ \Omega\cdot\text{m}\right)(8.00\ \text{m})}{1.00\times10^{-4}\ \text{m}^2} = 1.36\times10^{-3}\ \Omega,$$

and the current in the loop is $I = \frac{\Delta V}{R} = \frac{0.100\ \text{V}}{1.36\times10^{-3}\ \Omega} = 73.5\ \text{A}$

The magnetic field exerts torque $\tau = NBIA\sin\theta$ on the loop, and this is a maximum when $\sin\theta = 1$. Thus,

$$\tau_{max} = NBIA = (1)(0.400\ \text{T})(73.5\ \text{A})(2.00\ \text{m})^2 = \boxed{118\ \text{N}\cdot\text{m}}$$

19.30 The speed of the particles emerging from the velocity selector is $v = E/B$ (see Problem 29). In the deflection chamber, the magnetic force supplies the centripetal acceleration, so $qvB = \frac{mv^2}{r}$, or $r = \frac{mv}{qB} = \frac{m(E/B)}{qB} = \frac{mE}{qB^2}$.

Using the given data, the radius of the path is found to be

$$r = \frac{\left(2.18\times10^{-26}\ \text{kg}\right)(950\ \text{V/m})}{\left(1.60\times10^{-19}\ \text{C}\right)(0.930\ \text{T})^2} = 1.50\times10^{-4}\ \text{m} = \boxed{0.150\ \text{mm}}$$

19.35 Treat the lightning bolt as a long, straight conductor. Then, the magnetic field is

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(1.00\times10^{4}\ \text{A}\right)}{2\pi(100\ \text{m})} = 2.00\times10^{-5}\ \text{T} = \boxed{20.0\ \mu\text{T}}$$

19.41 Call the wire along the x axis wire 1 and the other wire 2. Also, choose the positive direction for the magnetic fields at point P to be out of the page.

At point P, $B_{net} = +B_1 - B_2 = \frac{\mu_0 I_1}{2\pi r_1} - \frac{\mu_0 I_2}{2\pi r_2} = \frac{\mu_0}{2\pi}\left(\frac{I_1}{r_1} - \frac{I_2}{r_2}\right)$,

or $$B_{net} = \frac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)}{2\pi}\left(\frac{7.00\ \text{A}}{3.00\ \text{m}} - \frac{6.00\ \text{A}}{4.00\ \text{m}}\right) = +1.67\times10^{-7}\ \text{T}$$

$$B_{net} = \boxed{0.167\ \mu\text{T out of the page}}$$

19.45 In order for the system to be in equilibrium, the repulsive magnetic force per unit length on the top wire must equal the weight per unit length of this wire.

Thus, $\frac{F}{L}=\frac{\mu_0 I_1 I_2}{2\pi d}=0.080\ \text{N/m}$, and the distance between the wires will be

$$d=\frac{\mu_0 I_1 I_2}{2\pi(0.080\ \text{N/m})}=\frac{(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A})(60.0\ \text{A})(30.0\ \text{A})}{2\pi(0.080\ \text{N/m})}$$

$$=4.5\times10^{-3}\ \text{m}=\boxed{4.5\ \text{mm}}$$

19.48 (a) From $R=\rho L/A$, the required length of wire to be used is

$$L=\frac{R\cdot A}{\rho}=\frac{(5.00\ \Omega)\left[\pi(0.500\times10^{-3}\ \text{m})^2/4\right]}{1.70\times10^{-8}\ \Omega\cdot\text{m}}=57.7\ \text{m}$$

The total number of turns on the solenoid (i.e., the number of times this length of wire will go around a 1.00 cm radius cylinder) is

$$N=\frac{L}{2\pi r}=\frac{57.7\ \text{m}}{2\pi(1.00\times10^{-2}\ \text{m})}=\boxed{919}$$

(b) From $B=\mu_0 nI$, the number of turns per unit length on the solenoid is

$$n=\frac{B}{\mu_0 I}=\frac{4.00\times10^{-2}\ \text{T}}{(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A})(4.00\ \text{A})}=7.96\times10^{3}\ \text{turns/m}$$

Thus, the required length of the solenoid is

$$\frac{N}{n}=\frac{919\ \text{turns}}{7.96\times10^{3}\ \text{turns/m}}=0.115\ \text{m}=\boxed{11.5\ \text{cm}}$$