19.34 Imagine grasping the conductor with the right hand so the fingers curl around the conductor in the direction of the magnetic field. The thumb then points along the conductor in the direction of the current. The results are

(a) $\boxed{\text{toward the left}}$ (b) $\boxed{\text{out of page}}$ (c) $\boxed{\text{lower left to upper right}}$

19.38 Assume that the wire on the right is wire 1 and that on the left is wire 2. Also, choose the positive direction for the magnetic field to be out of the page and negative into the page.

(a) At the point half way between the two wires,

$$B_{net} = -B_1 - B_2 = -\left[\frac{\mu_0 I_1}{2\pi r_1} + \frac{\mu_0 I_2}{2\pi r_2}\right] = -\frac{\mu_0}{2\pi r}(I_1 + I_2)$$

$$= -\frac{\left(4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}\right)}{2\pi\left(5.00\times 10^{-2}\ \text{m}\right)}(10.0\ \text{A}) = -4.00\times 10^{-5}\ \text{T}$$

or $B_{net} = \boxed{40.0\ \mu\text{T}\ \text{into the page}}$

(b) At point P_1, $\quad B_{net} = +B_1 - B_2 = \frac{\mu_0}{2\pi}\left[\frac{I_1}{r_1} - \frac{I_2}{r_2}\right]$

$$B_{net} = \frac{\left(4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}\right)}{2\pi}\left[\frac{5.00\ \text{A}}{0.100\ \text{m}} - \frac{5.00\ \text{A}}{0.200\ \text{m}}\right] = \boxed{5.00\ \mu\text{T}\ \text{out of page}}$$

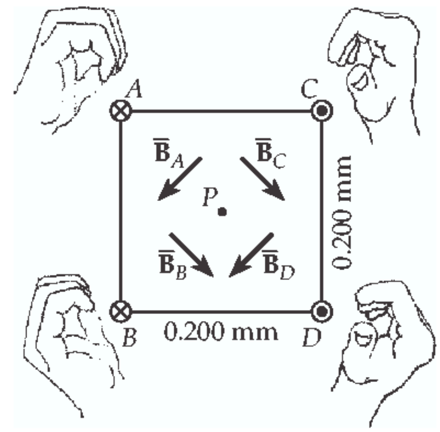
(c) At point P_2, $\quad B_{net} = -B_1 + B_2 = \frac{\mu_0}{2\pi}\left[-\frac{I_1}{r_1} + \frac{I_2}{r_2}\right]$

$$B_{net} = \frac{\left(4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}\right)}{2\pi}\left[-\frac{5.00\ \text{A}}{0.300\ \text{m}} + \frac{5.00\ \text{A}}{0.200\ \text{m}}\right]$$

$$= \boxed{1.67\ \mu\text{T}\ \text{out of page}}$$

19.39 The distance from each wire to point P is given by

$$r = \frac{1}{2}\sqrt{(0.200\text{ m})^2 + (0.200\text{ m})^2} = 0.141\text{ m}$$



At point P, the magnitude of the magnetic field produced by each of the wires is

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7}\text{ T}\cdot\text{m/A})(5.00\text{ A})}{2\pi(0.141\text{ m})} = 7.07\ \mu\text{T}$$

Carrying currents into the page, the field A produces at P is directed to the left and down at –135°, while B creates a field to the right and down at – 45°. Carrying currents toward you, C produces a field downward and to the right at – 45°, while D's contribution is downward and to the left. The horizontal components of these equal magnitude contributions cancel in pairs, while the vertical components all add. The total field is then

$$B_{net} = 4(7.07\ \mu\text{T})\sin 45.0° = \boxed{20.0\ \mu\text{T toward the bottom of the page}}$$

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).

19.4 Hold the right hand with the fingers in the direction of $\vec{v}$ so that as you close your hand, the fingers move toward the direction of $\vec{B}$. The thumb will point in the direction of the force (and hence the deflection) if the particle has a positive charge. The results are

(a) toward top of page   (b) out of the page, since the charge is negative.

(c) zero force   (d) into the page

19.9 $B=\dfrac{F}{qv}=\dfrac{ma}{qv}=\dfrac{\left(1.67\times10^{-27}\text{ kg}\right)\left(2.0\times10^{13}\text{ m/s}^2\right)}{\left(1.60\times10^{-19}\text{ C}\right)\left(1.0\times10^{7}\text{ m/s}\right)}=\boxed{0.021\text{ T}}$

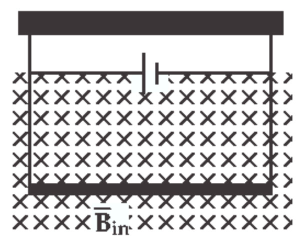
The right hand rule shows that $\vec{\mathbf{B}}$ must be in $\boxed{\text{the } -y \text{ direction}}$ to yield a force in the $+x$ direction when $\vec{\mathbf{v}}$ is in the $+z$ direction.

19.12 Hold the right hand with the fingers in the direction of the current so, as you close the hand, the fingers move toward the direction of the magnetic field. The thumb then points in the direction of the force. The results are

(a) $\boxed{\text{to the left}}$ (b) $\boxed{\text{into the page}}$ (c) $\boxed{\text{out of the page}}$

(d) $\boxed{\text{toward top of page}}$ (e) $\boxed{\text{into the page}}$ (f) $\boxed{\text{out of the page}}$

19.18 To have zero tension in the wires, the magnetic force per unit length must be directed upward and equal to the weight per unit length of the conductor. Thus,



$$\frac{\left|\vec{\mathbf{F}}_m\right|}{L}=BI=\frac{mg}{L}\text{, or}$$

$$I=\frac{(m/L)g}{B}=\frac{\left(0.040\text{ kg/m}\right)\left(9.80\text{ m/s}^2\right)}{3.60\text{ T}}=\boxed{0.109\text{ A}}$$

From the right hand rule, the current must be $\boxed{\text{to the right}}$ if the force is to be upward when the magnetic field is into the page.

19.24 Note that the angle between the field and the perpendicular to the plane of the loop is $\theta=90.0°-30.0°=60.0°$. Then, the magnitude of the torque is

$$\tau=NBIA\sin\theta=100\left(0.80\text{ T}\right)\left(1.2\text{ A}\right)\left[\left(0.40\text{ m}\right)\left(0.30\text{ m}\right)\right]\sin 60.0°=\boxed{10\text{ N}\cdot\text{m}}$$

With current in the $-y$ direction, the outside edge of the loop will experience a force directed out of the page ($+z$ direction) according to the right hand rule. Thus, the loop will rotate $\boxed{\text{clockwise as viewed from above}}$.

19.31 From conservation of energy, $(KE+PE)_f = (KE+PE)_i$, we find that $\frac{1}{2}mv^2 + qV_f = 0 + qV_i$, or the speed of the particle is

$$v = \sqrt{\frac{2q(V_i - V_f)}{m}} = \sqrt{\frac{2q(\Delta V)}{m}} = \sqrt{\frac{2(1.60\times10^{-19}\text{ C})(250\text{ V})}{2.50\times10^{-26}\text{ kg}}} = 5.66\times10^{4}\text{ m/s}$$

The magnetic force supplies the centripetal acceleration giving $qvB = \frac{mv^2}{r}$

$$\text{or} \qquad r = \frac{mv}{qB} = \frac{(2.50\times10^{-26}\text{ kg})(5.66\times10^{4}\text{ m/s})}{(1.60\times10^{-19}\text{ C})(0.500\text{ T})} = 1.77\times10^{-2}\text{ m} = \boxed{1.77\text{ cm}}$$

19.46 The magnetic forces exerted on the top and bottom segments of the rectangular loop are equal in magnitude and opposite in direction. Thus, these forces cancel, and we only need consider the sum of the forces exerted on the right and left sides of the loop. Choosing to the left (toward the long, straight wire) as the positive direction, the sum of these two forces is

$$F_{net} = +\frac{\mu_0 I_1 I_2 \ell}{2\pi c} - \frac{\mu_0 I_1 I_2 \ell}{2\pi(c+a)} = \frac{\mu_0 I_1 I_2 \ell}{2\pi}\left(\frac{1}{c} - \frac{1}{c+a}\right)$$

$$\text{or } F_{net} = \frac{(4\pi\times10^{-7}\text{ T}\cdot\text{m/A})(5.00\text{ A})(10.0\text{ A})(0.450\text{ m})}{2\pi}\left(\frac{1}{0.100\text{ m}} - \frac{1}{0.250\text{ m}}\right)$$

$$= +2.70\times10^{-5}\text{ N} = \boxed{2.70\times10^{-5}\text{ N to the left}}$$

19.47 The magnetic field inside a long solenoid is $B = \mu_0 n I = \mu_0\left(\frac{N}{L}\right)I$. Thus, the required current is

$$I = \frac{BL}{\mu_0 N} = \frac{(1.00\times10^{-4}\text{ T})(0.400\text{ m})}{(4\pi\times10^{-7}\text{ T}\cdot\text{m/A})(1000)} = 3.18\times10^{-2}\text{ A} = \boxed{31.8\text{ mA}}$$