PHY 1B(b) Chapter 19 Solutions

(6) From $F = qvB\sin\theta$,

$$F = (1.60\times10^{-19}\,C)(6.2\times10^{6}\,ms^{-1})(50.0\times10^{-6}\,T)\sin(90°)$$

$$F = \boxed{4.96\times10^{-17}\,N}$$

Using right hand rule (fingers point westward in direction of $\vec{v}$, so they move downward toward the direction of $\vec{B}$ as you close your hand, the thumb points southward. Thus, the direction of the force exerted on a proton (a positive charge) is **toward the south**.

(10) $F_1 = qvB\sin\theta$ (on single ion)

$$= (1.60\times10^{-19}\,C)(0.851\,m/s)(0.254\,T)\sin(51.0°)$$

$$= \boxed{2.69\times10^{-20}\,N}$$

Total number of ions,

$$N = \left(3.00\times10^{20}\,\frac{ions}{cm^3}\right)(100\,cm^3) = \boxed{3\times10^{22}}$$

Total force:

$$F = N\cdot F_1 = \boxed{806\,N}$$

16 a) $F = BIL\sin\theta = (0.60\times10^{-4}\,T)(15\,A)(10\,m)\sin(90^\circ)$

$= \boxed{9.0\times10^{-3}\,N}$

$\vec{F}$ is perpendicular to $\vec{B}$, $\vec{F}$ is 15° above the horizontal in the northward direction.

b) $F = BIL\sin\theta = (0.60\times10^{-4}\,T)(15\,A)(10\,m)(\sin 165^\circ)$

$= 2.3\times10^{-3}\,N$

direction is horizontal and west.

18 Magnetic force must be directed upward to counteract gravitational force.

$\Rightarrow \frac{|\vec{F}_m|}{L} = BI = \frac{mg}{L}$,

$I = \frac{(m/L)g}{B} = \frac{(0.40\,kg/m)(9.80\,m/s^2)}{3.60\,T} = \boxed{0.109\,A}$

From right hand rule, the current must be

$\boxed{\text{to the right}}$ (force upward and magnetic field out of page)

(24) Angle between field and perpendicular to plane of loop is $\theta = 90° - 30° = 60°$

$$\Rightarrow \tau = NBIA \sin 90° = 100(0.8\,T)(1.2\,A)[0.40\,m \cdot 0.30\,m] \cdot \sin 60° = \boxed{10\,N\text{-}m}$$

With the current in the $-y$ direction, the outside edge of the loop will experience a force directed out of the page ($+z$ direction). Thus, the loop will rotate $\boxed{\text{clockwise as viewed from above.}}$ (you can also think about which direction the loop will rotate based on the axis of the torque).

(27) $F_{\text{on proton}} = qvB\sin\theta = (+e)vB\sin(90°) = evB$

Force will supply a centripetal acceleration as proton follows a circular path.

$$\Rightarrow evB = \frac{mv^2}{r} \Rightarrow v = \frac{erB}{m}$$

time for one revolution:

$$T = \frac{2\pi r}{v} = \frac{2\pi r}{erB/m} = \frac{2\pi m}{eB}$$

with $T = 1\,\mu s$,

$$B = \frac{2\pi m}{eT} = \frac{2\pi(1.67\times10^{-27}\,kg)}{(1.6\times10^{-19}\,C)(1\times10^{-6}\,s)} = \boxed{6.56\times10^{-2}\,T}$$

(30) particles emerging from velocity selector is $v = \frac{E}{B}$

(since $F_m = F_e$ or $qvB = qE \Rightarrow v = E/B$)

magnetic force supplies centripetal acceleration,

$$qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} = \frac{m(E/B)}{qB} = \frac{mE}{qB^2}$$

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

$$= \boxed{0.150\text{mm}}$$

(31) From conservation of energy,

$$(KE+PE)_f = (KE+PE)_i,$$

$$\tfrac{1}{2}mv^2 + qV_f = 0 + qV_i$$

$$\Rightarrow v = \sqrt{\frac{2q(V_i - V_f)}{m}} = \sqrt{\frac{2q\Delta V}{m}} = \sqrt{\frac{2(1.60\times10^{-19}\text{C})(250\text{ V})}{2.5\times10^{-26}\text{ kg}}}$$

$$= \boxed{5.66\times10^4\text{ m/s}}$$

$$r = \frac{mv}{qB} = \frac{(2.5\times10^{-26}\text{ kg})(5.66\times10^4\text{ m/s})}{(1.6\times10^{-19}\text{C})(0.500\text{T})}$$

$$= 1.77\times10^{-2}\text{ m} = \boxed{1.77\text{ cm.}}$$

(33) Conservation of momentum:

$$m_p V_p + m_\alpha V_\alpha = m_\alpha V_0$$

Conservation of Kinetic Energy:

$$V_0 - 0 = -(V_\alpha - V_p) \implies V_p = V_\alpha + V_0.$$

Since $m_\alpha = 4m_p$,

$$m_p(V_\alpha + V_0) + (4m_p)V_\alpha = (4m_p)V_\alpha \implies V_\alpha = \frac{3V_0}{5}$$

$$V_p = \left(\frac{3V_0}{5}\right) + V_0 = \frac{8V_0}{5} \implies V_\alpha = \frac{3}{5}V_0 = \frac{3}{5}\left(\frac{5}{8}V_p\right) = \frac{3}{8}V_p$$

After collision, each particle follows a circular path in the horizontal plane.

$$q_p V_p B = m_p \frac{V_p^2}{R} \quad \text{or} \quad R = \frac{m_p V_p}{q_p B} = \frac{m_p V_p}{eB}$$

and $$q_\alpha V_\alpha B = m_\alpha \frac{V_\alpha^2}{r} \implies r = \frac{m_\alpha V_\alpha}{q_\alpha B} = \frac{(4m_p)(3V_p/8)}{(2e)B}$$

$$= \boxed{\frac{3}{4}R}$$

(37) $B = \dfrac{\mu_0 I}{2\pi r}$,

$$r = \frac{\mu_0 I}{2\pi B} = \frac{(4\pi \times 10^{-7}\ T\cdot m/A)(20A)}{2\pi(1.7\times 10^{-3}T)} = 2.4\times 10^{-3} m$$

$$= \boxed{2.4\ mm}$$

(39) ~~Distance~~ Distance from each wire to point P

is given by $r = \frac{1}{2}\sqrt{(0.200m)^2 + (0.200m)^2} = 0.141\,m$

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

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

~~Field A~~ Field that A produces at P is directed to the left and down at $-135°$, while B creates a field to the right and down at $-45°$. C produces a field downward and to the right at $-45°$, while D's contribution ~~is~~ is downward and to the left.

$B_{net} = 4(7.07\ \mu T)(\sin 45°) = 20.0\ \mu T$ toward bottom of page.

(42) Proton moves w/ constant velocity $\Rightarrow F_{net} = 0$.

~~###~~ $\Rightarrow F_{mag} = F_{grav}$ and $B = \mu_0 I / 2\pi d$.

$$\Rightarrow \frac{qv\mu_0 I}{2\pi d} = mg \quad \text{or} \quad d = \frac{qv\mu_0 I}{2\pi mg}$$

$$d = \frac{(1.60\times10^{-19}C)(2.3\times10^{4}\,m/s)(4\pi\times10^{-7}\,T\cdot m/A)(1.20\times10^{-6}A)}{2\pi(1.67\times10^{-27}\,kg)(9.8\,m/s^2)}$$

$$\Rightarrow d = 5.40\times10^{-2}\,m = \boxed{5.40\ cm.}$$

(43) a) According to $B = \frac{\mu_0 I}{2\pi r}$, field will be $\frac{1}{10}B_0$ is distance is increased by factor of 10.

$$\Rightarrow r' = 10r = 10(0.400\,m) = \boxed{4.00\ m.}$$

b) Since currents are in opposite directions,

$$B_{net} = B_1 - B_2$$

$$\text{or } B_{net} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = \frac{(4\pi\times10^{-7}\,T\cdot m/A)(2A)}{2\pi}\left(\frac{1}{.3985m} - \frac{1}{.4015\,m}\right)$$

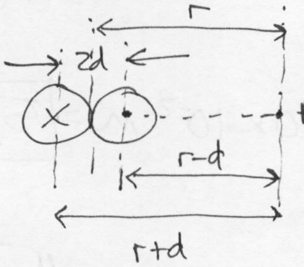
$$= 7.50\times10^{-9}\,T = \boxed{7.50\ nT}$$

43 c) Call r the distance from cord center to point P and $2d = 3.00$ mm the distance between centers of the conductors

$$B_{net} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{r-d} - \frac{1}{r+d}\right) = \frac{\mu_0 I}{2\pi}\left(\frac{2d}{r^2-d^2}\right)$$

$$\Rightarrow 7.50\times10^{-10}\,\text{T} = \frac{(4\pi\times10^{-7}\,\text{T}\cdot\text{m/A})(2\,\text{A})}{2\pi}\left(\frac{3\times10^{-3}\,\text{m}}{r^2-2.25\times10^{-6}\,\text{m}^2}\right)$$

$$\Rightarrow \boxed{r = 1.26\text{ m.}}$$



d) The cable creates $\boxed{\text{zero}}$ field according to Ampere's Law since $\boxed{I_{enc} = 0}$

45 ~~F_{mag}~~ $F_{mag} = F_{grav}$.

$$\Rightarrow \frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d} = 0.080\text{ N/m}$$

$$\Rightarrow d = \frac{\mu_0 I_1 I_2}{2\pi(0.080\text{ N/m})} = \frac{(4\pi\times10^{-7}\,\text{T}\cdot\text{m/A})(60\,\text{A})(30\,\text{A})}{2\pi(0.08\text{ N/m})}$$

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

48 a) From $R = \frac{\rho L}{A}$,

$$L = \frac{RA}{\rho} = \frac{(5\ \Omega)(\pi(0.5\times10^{-3}\,m)^2/4)}{1.7\times10^{-8}\ \Omega\cdot m} = 57.7\ m.$$

Total number of turns on the solenoid (the number of times this length will go around a 1.00 cm. radius cylinder) is

$$N = \frac{L}{2\pi r} = \frac{57.7\,m}{2\pi(1\times10^{-2}m)} = \boxed{919}$$

b) From $B = \mu_0 n I$,

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

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

50 Magnetic force supplies the centripetal acceleration, so $qvB = \frac{mv^2}{r}$

$$\Rightarrow B = \frac{mv}{qr} = \frac{(9.11\times10^{-31}\,kg)(1\times10^{4}\,m/s)}{(1.6\times10^{-19}\,C)(2\times10^{-2}\,m)} = \boxed{2.8\ \mu T}$$

$\longrightarrow$

50 b) From $B = \mu_0 n I$,

$$I = \frac{B}{\mu_0 n} = \frac{2.847 \times 10^{-6}\,T}{(4\pi \times 10^{-7}\,T \cdot m/A)(25\,turns/cm)(100\,cm/1m)}$$

$$= 9.1 \times 10^{-4}\,A = \boxed{0.91\,mA}$$