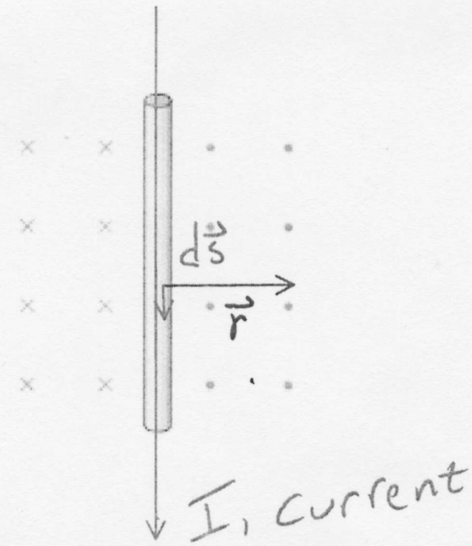
Q 33.5



Method ①: RHR: thumb along current, fingers curl in direction of $\vec{B}$

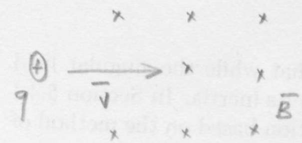
② Biot-Savart Law (where the above RHR is derived from!)

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{s} \times \hat{r}}{r^2}$$

RHR: $d\vec{s} \times \hat{r}$, out of page

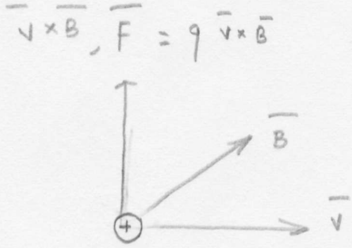
33.6

(a)

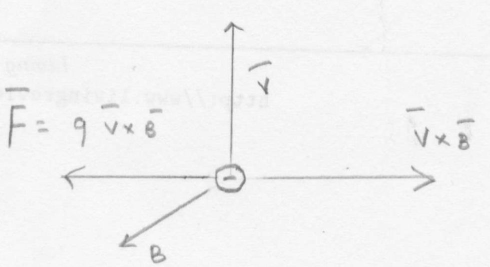


The initial direction of deflection should be along the direction of initial force. Now force on a charge q moving with velocity $\vec{v}$ in a magnetic field $\bar{B}$ is given by $\boxed{\bar{F} = q\, \bar{v} \times \bar{B}}$.

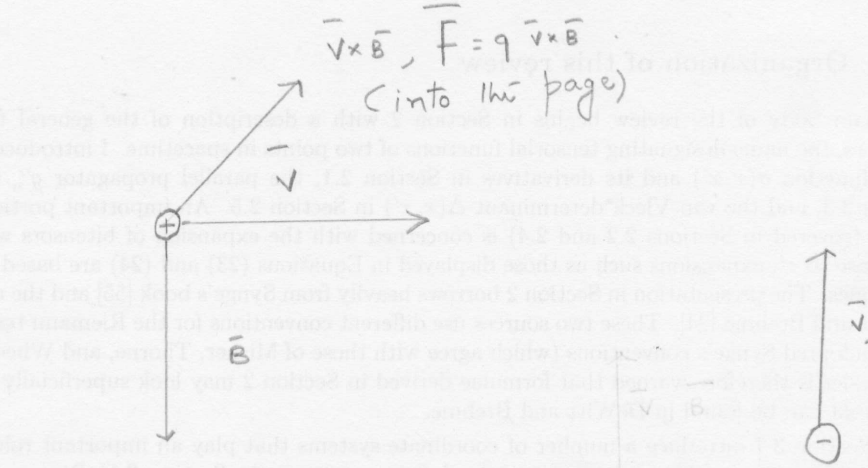
Here $q > 0$ (or positive). Hence, according to above formula $\bar{F}$ is in the direction of $\bar{v} \times \bar{B}$. Now velocity $\bar{v}$ points to the right and magnetic field $\bar{B}$ into the paper. Hence according to right hand rule $\bar{v} \times \bar{B}$ points upwards which is also the direction of initial force and hence deflection.



(b) In here velocity $\bar{v}$ is upwards, $\bar{B}$ points out of the page and also the charge q is negative. Hence the initial force will be opposite to the direction of $\bar{v} \times \bar{B}$ which, according to right hand rule, points to the right. Hence the force and consequently the deflection should be on the left.



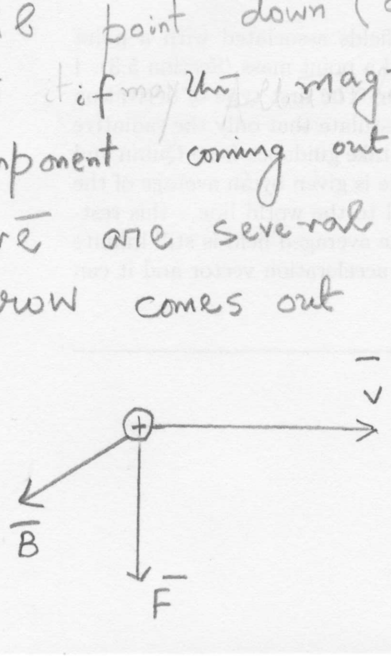
33.7 (a) $q > 0$ hence deflection is parallel to $\bar{v} \times \bar{B}$.

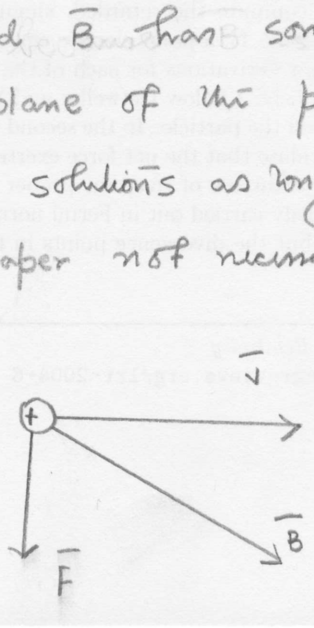


(b) Interestingly here $\bar{v} \times \bar{B} = 0$ [∵ $\bar{v}$ and $\bar{B}$ are parallel]

Hence $\bar{F} = q(\bar{v} \times \bar{B})$ is also zero and we don't have any deflection

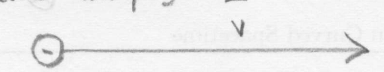
33.8 (a) Again as because $q > 0$, $\bar{F}$ is parallel to $\bar{v} \times \bar{B}$. Hence $\bar{B}$ should point such a way that right hand rule applied to $\bar{v} \times \bar{B}$ (with $\bar{v}$ pointing to the right) will make the thumb point down (along the direction of force. It'll be true if may the magnetic field $\bar{B}$ has some positive component coming out of the plane of the paper. [Yeah, there are several possible solutions as long as the $\bar{B}$ arrow comes out of the paper not necessarily perpendicularly].



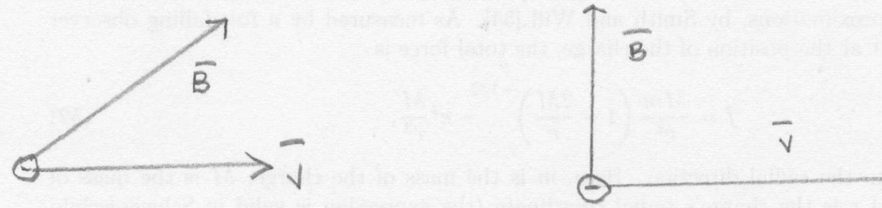


Both correct! (Cook up others)

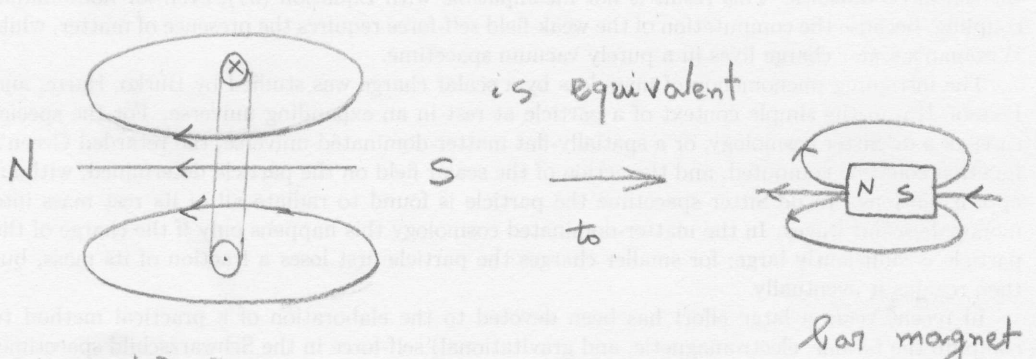
(b) $\bar{F}$ into the page



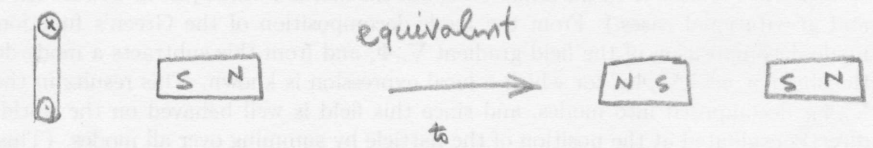
Following arguments in part (a) possible solutions [infinitely many] include



33.13



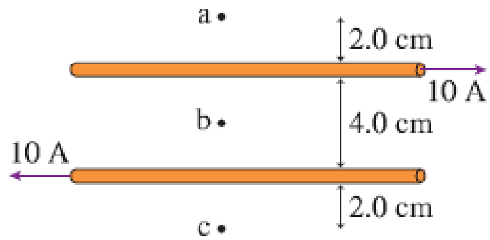
Hence



As because similar poles are nearer the two

Will repel each other

33.14



Let's start with point a. The magnetic field here due the presence of BOTH the wires will be the VECTOR sum of the magnetic fields produced by them INDIVIDUALLY [That's SUPERPOSITION PRINCIPLE]. Now, Magnetic field due to a current carrying STRAIGHT INFINITE wire is given by

$$\vec{B} = \frac{\mu_0 I}{2\pi d}$$

[refer Example 33.3 for derivation. Try deriving the same using Ampere's law[1]. It's much easier!]. Using the above formula we get

$$\vec{B}_{top} = \left(\frac{\mu_0 I}{2\pi d}, \text{ out of page}\right)$$

where d here is the distance of the point a from the top wire i.e. 2 cm = .02 m. Similarly, for the lower wire, we get

$$\vec{B}_{bottom} = \left(\frac{\mu_0 I}{2\pi d}, \text{ into page}\right)$$

where the term d = 6 cm now is the distance of the point a from the lower wire.
Now the two of them are oppositely directed and the latter one is less in magnitude [because its denominator is Larger due to Larger d]. Hence the NET field will be in the direction of the former i.e. OUT of the page. Its magnitude will simply be that of the former minus the latter giving us:

$$\Rightarrow B_{\text{at a}} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{2.0 \text{ cm}} - \frac{1}{(4.0+2.0) \text{ cm}}\right)$$

$$= \left(2\times10^{-7} \text{ T m/A}\right)(10 \text{ A})\left(\frac{1}{2.0\times10^{-2} \text{ m}} - \frac{1}{6.0\times10^{-2} \text{ m}}\right)$$

$$\Rightarrow \vec{B}_{\text{at a}} = \left(6.7\times10^{-5} \text{ T, out of page}\right)$$

Following exactly the same procedure we get at points b[or 2] and c [or 3],

$$\vec{B}_{\text{at 2}} = \left(\frac{\mu_0 I}{2\pi d}, \text{ into page}\right) + \left(\frac{\mu_0 I}{2\pi d}, \text{ into page}\right) = \left(2.0\times10^{-4} \text{ T, into page}\right)$$

$$\vec{B}_{\text{at 3}} = \left(\frac{\mu_0 I}{2\pi d}, \text{ into page}\right) + \left(\frac{\mu_0 I}{2\pi d}, \text{ out of page}\right) = \left(6.7\times10^{-5} \text{ T, out of page}\right)$$

33.16

(a) Magnetic Dipole Moment of a current carrying loop is its AREA times CURRENT flowing through it where the direction is decided by the RIGHT HAND RULE [RHR]. For the given circular loop the diameter is given to be 2.0 mm or the radius is .002 m. The current is given to be 100 A. Hence,

$$\mu = \left(\pi R^2\right) I = \pi\left(1.0\times10^{-3}\ \mathrm{m}\right)^2 \left(100\ \mathrm{A}\right) = 3.1\times10^{-4}\ \mathrm{A\,m^2}$$

where the direction is along the perpendicular to the plane of the loop with the sense being determined by the direction of current [e.g. if you see the current to be Clockwise the direction is away from you etc.]

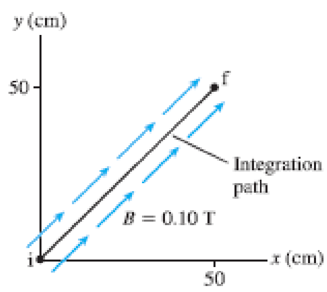
(b) The magnetic field due to a circular loop of current at a point on the axis of it z distance away from the center is given by

$$B_{\mathrm{ring}} = \frac{\mu_0}{2}\frac{IR^2}{\left(z^2+R^2\right)^{3/2}}$$

where the direction again is decided by the RHR [It is along the axis]. Here z = 5.0 cm = .050 m. Hence,

$$B_{\mathrm{ring}} = \frac{2\pi\left(10^{-7}\ \mathrm{T\,m/A}\right)\left(100\ \mathrm{A}\right)\left(1.0\times10^{-3}\ \mathrm{m}\right)^2}{\left[\left(0.050\ \mathrm{m}\right)^2+\left(0.0010\ \mathrm{m}\right)^2\right]^{3/2}} = 5.0\times10^{-7}\ \mathrm{T}$$

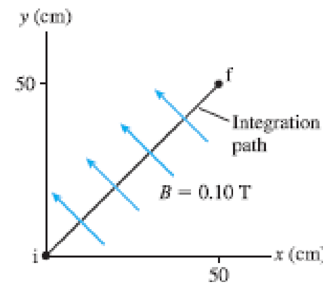
33.19



Solve: Because $\vec{B}$ is in the same direction as the integration path $\vec{s}$ from i to f, the dot product of $\vec{B}$ and $d\vec{s}$ is simply Bds. Hence the line integral

$$\int_i^f \vec{B}\cdot d\vec{s} = \int_i^f Bds = B\int_i^f ds = B\left(\sqrt{\left(0.50\ \mathrm{m}\right)^2+\left(0.50\ \mathrm{m}\right)^2}\right) = \left(0.10\ \mathrm{T}\right)\sqrt{2}\left(0.50\ \mathrm{m}\right) = 0.071\ \mathrm{T\,m}$$

33.20



Solve: The line integral of $\vec{B}$ between points i and f is

$$\int_{i}^{f} \vec{B} \cdot d\vec{s}$$

Because $\vec{B}$ is perpendicular to the integration path from i to f, the dot product is zero at all points and the line integral is zero.

33.23

Divide the line integral into three parts:

$$\int_{i}^{f} \vec{B} \cdot d\vec{s} = \int_{\text{left line}} \vec{B} \cdot d\vec{s} + \int_{\text{semicircle}} \vec{B} \cdot d\vec{s} + \int_{\text{right line}} \vec{B} \cdot d\vec{s}$$

Now, the magnetic field due to the wire is Perpendicular to the left and right line segments [Apply the right hand rule to find out the direction of magnetic field due to the current at the positions of left and right segment – on the left it points UP whereas on the right it's DOWN]. Hence the dot product of magnetic field and line elements are ZERO over there giving us ZERO contribution. All the contribution then comes form the semicircular region for which the magnetic field is along the circumference. The direction too matches as it goes form left to right. Hence on evaluation of the second integral we get,

$$\int_{i}^{f} \vec{B} \cdot d\vec{s} = 0 + BL + 0 = \frac{\mu_0 I}{2\pi d}(\pi d) = \frac{\mu_0 I}{2} = \frac{(4\pi \times 10^{-7}\ \text{T m/A})(2.0\ \text{A})}{2} = 1.26 \times 10^{-6}\ \text{T m}$$

where $L = \pi d$ is the length of the semicircle, which is half the circumference of a circle of radius d.

33.24

For an IDEAL solenoid [which we assume to be the case] the magnetic field inside is given by

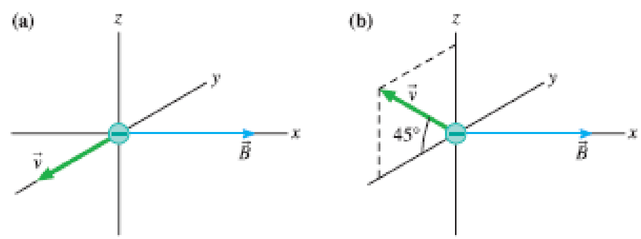
$$B_{\text{solenoid}} = \frac{\mu_0 N I}{l} = \mu_0 n I$$

where the solenoid has N turns and a length of l with the current I flowing through it. [The derivation can be had in **pg. 1015** of the text.]

Using $l = 0.15$ m and $N = 0.15\text{ m}/0.0010\text{ m} = 150$,

$$I = \frac{(3.0\times10^{-3}\text{ T})(0.15\text{ m})}{(4\pi)(10^{-7}\text{ T m/A})(150)} = 2.4\text{ A}$$

33.27



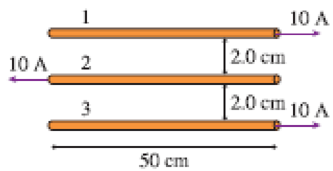
Solve: **(a)** The force is

$$\vec{F}_{\text{on q}} = q\vec{v}\times\vec{B} = (-1.60\times10^{-19}\text{ C})(-1.0\times10^{7}\hat{j}\text{ m/s})\times(0.50\hat{i}\text{ T}) = -8.0\times10^{-13}\hat{k}\text{ N}$$

(b) The force is

$$\vec{F}_{\text{on q}} = (-1.60\times10^{-19}\text{ C})(1.0\times10^{7}\text{ m/s})(-\cos45°\hat{j}+\sin45°\hat{k})\times(0.50\hat{i}\text{ T}) = 5.7\times10^{-13}(-\hat{j}-\hat{k})\text{ N}$$

33.36

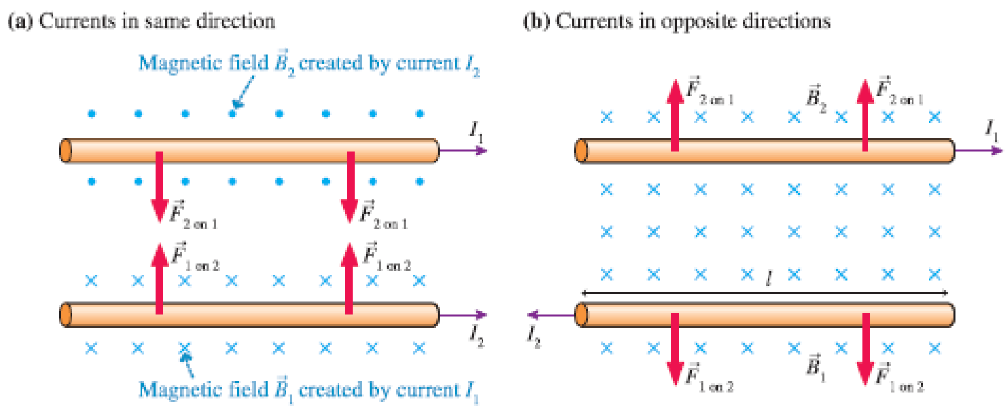


The force between two parallel current carrying wires is given by

$$F_{\text{parallel wires}} = I_1 l B_2 = I_1 l \frac{\mu_0 I_2}{2\pi d} = \frac{\mu_0 l I_1 I_2}{2\pi d}$$

(force between two parallel wires)

where the corresponding arrangement of the wires can be had in the following figure.



We see that they ATTRACT each other if the currents are in the SAME direction and REPEL OTHERWISE. So, for the given arrangement we get

$$F_{2\text{ on }1} = \frac{\mu_0 L I_1 I_2}{2\pi d} = \frac{\left(2\times10^{-7}\ \text{T m/A}\right)\left(0.50\ \text{m}\right)\left(10\ \text{A}\right)\left(10\ \text{A}\right)}{0.02\ \text{m}} = 5.0\times10^{-4}\ \text{N} = F_{2\text{ on }3} = F_{3\text{ on }2} = F_{1\text{ on }2}$$

$$F_{3\text{ on }1} = \frac{\mu_0 L I_1 I_3}{2\pi d} = \frac{\left(2\times10^{-7}\ \text{T m/A}\right)\left(0.50\ \text{m}\right)\left(10\ \text{A}\right)\left(10\ \text{A}\right)}{0.04\ \text{m}} = 2.5\times10^{-4}\ \text{N} = F_{1\text{ on }3}$$

[with proper directions.] Hence, we have,

$$\vec{F}_{\text{on }1} = \vec{F}_{2\text{ on }1} + \vec{F}_{3\text{ on }1} = \left(5.0\times10^{-4}\,\hat{j}\right)\ \text{N} + \left(-2.5\times10^{-4}\,\hat{j}\right)\ \text{N} = 2.5\times10^{-4}\,\hat{j}\,\text{N} = \left(2.5\times10^{-4}\,\text{N, up}\right)$$

$$\vec{F}_{\text{on }2} = \vec{F}_{1\text{ on }2} + \vec{F}_{3\text{ on }2} = \left(-5.0\times10^{-4}\,\hat{j}\right)\ \text{N} + \left(+5.0\times10^{-4}\,\hat{j}\right)\ \text{N} = \ 0\ \text{N}$$

$$\vec{F}_{\text{on }3} = \vec{F}_{1\text{ on }3} + \vec{F}_{2\text{ on }3} = \left(2.5\times10^{-4}\,\hat{j}\right)\ \text{N} + \left(-5.0\times10^{-4}\,\hat{j}\right)\ \text{N} = -2.5\times10^{-4}\,\hat{j}\ \text{N} = \left(2.5\times10^{-4}\,\text{N, down}\right)$$

33.39

The Torque on a current carrying loop in a uniform magnetic field is given by

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

. Now the magnetic dipole moment [refer part (a) of 33.16] of the loop is given by the product of its area and current. Also, the dipole moment points in a direction that makes 30 degree with that of the magnetic field. Hence, we get,

$$\vec{\tau} = \vec{\mu} \times \vec{B} \Rightarrow \tau = \mu B \sin\theta = IAB\sin\theta = (0.500\ \text{A})(0.050\ \text{m} \times 0.050\ \text{m})(1.2\ \text{T})\sin 30° = 7.5 \times 10^{-4}\ \text{N m}$$

33.45

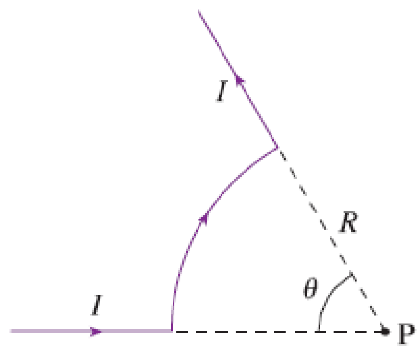
Solve: The magnetic field of a long wire carrying current I is

$$B_{\text{wire}} = \frac{\mu_0 I}{2\pi d}$$

We're interested in the magnetic field of the current right at the surface of the wire, where d = 1.5 mm. The maximum field is 0.10 T, so the maximum current is

$$I = \frac{(2\pi d) B_{\text{wire}}}{\mu_0} = \frac{2\pi (1.5 \times 10^{-3}\ \text{m})(0.10\ \text{T})}{4\pi \times 10^{-7}\ \text{T m/A}} = 750\ \text{A}$$

33.46



Solve: **(a)** The Biot-Savart law (Equation 33.6) for the magnetic field of a current segment $\Delta\vec{s}$ is

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{s}\times\hat{r}}{r^2}$$

where the unit vector $\hat{r}$ points from current segment Δs to the point, a distance r away, at which we want to evaluate the field. For the two linear segments of the wire, $\Delta\vec{s}$ is in the same direction as $\hat{r}$, so $\Delta\vec{s}\times\hat{r} = 0$. For the curved segment, $\Delta\vec{s}$ and $\hat{r}$ are always perpendicular, so $\Delta\vec{s}\times\hat{r} = \Delta s$. Thus

$$B = \frac{\mu_0}{4\pi}\frac{I\Delta s}{r^2}$$

Now we are ready to sum the magnetic field of all the segments at point P. For all segments on the arc, the distance to point P is $r = R$. The superposition of the fields is

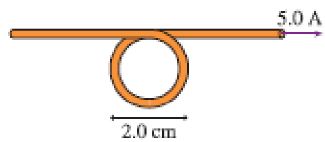
$$B = \frac{\mu_0}{4\pi}\frac{I}{R^2}\int_{\text{arc}} ds = \frac{\mu_0}{4\pi}\frac{IL}{R^2} = \frac{\mu_0 I\theta}{4\pi R}$$

where $L = R\theta$ is the length of the arc.
(b) Substituting $\theta = 2\pi$ in the above expression,

$$B_{\text{loop center}} = \frac{\mu_0 I 2\pi}{4\pi R} = \frac{\mu_0}{2}\frac{I}{R}$$

This is Equation 33.7, which is the magnetic field at the center of a 1-turn coil.

33.48



We know, the magnetic field due to an INFINITE straight wire at a distance R from it is given by

$$B_{\text{wire}} = \frac{\mu_0 I}{2\pi R}$$

and that the magnetic field due to a current carrying circular loop at the center of it is given by

$$B_{\text{loop center}} = \frac{\mu_0 I}{2R}$$

with the directions being given by RHR. In this case, both the fields point INTO the pane of the paper and hence we just need to add the two fields and get,

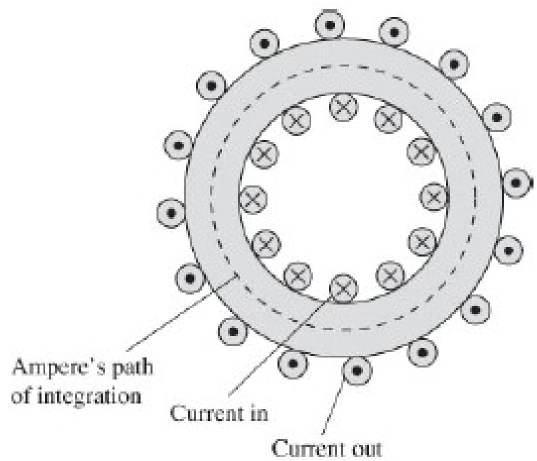
$$B_{\text{P}} = B_{\text{loop center}} + B_{\text{wire}} = \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{2\pi R}$$

$$= \frac{4\pi\left(10^{-7}\ \text{T m/A}\right)\left(5.0\ \text{A}\right)}{2\left(0.010\ \text{m}\right)} + \frac{4\pi\left(10^{-7}\ \text{T m/A}\right)\left(5.0\ \text{A}\right)}{2\pi\left(0.010\ \text{m}\right)} = 4.1\times10^{-4}\ \text{T}$$

33.54

Solve: **(a)** A long solenoid has a uniform magnetic field inside and it is roughly parallel to the axis. If we bend the solenoid to make it circular, we will have circular magnetic field lines around the inside of the toroid. However, as explained in part (c) the field is not uniform.

(b)



A top view of the toroid is shown. Current is into the page for the inside windings and out of the page for the outside windings. The closed Ampere's path of integration thus contains a current NI where I is the current flowing through the wire and N is the number of turns. Applied to the closed line path, the Ampere's law is

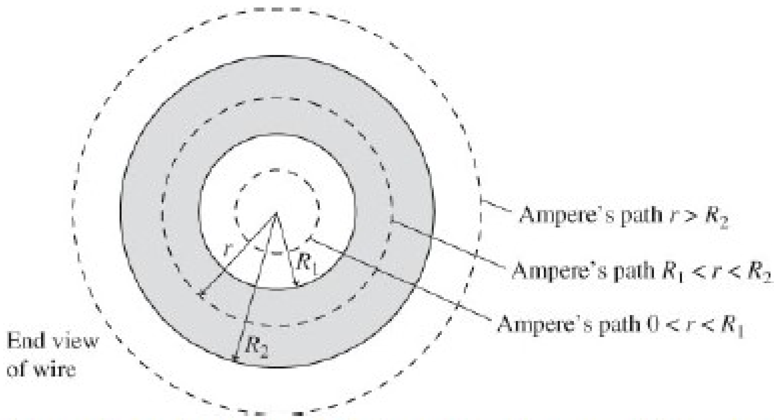
$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{through}} = \mu_0 NI$$

Because $\vec{B}$ and $d\vec{s}$ are along the same direction and B is the same along the line integral, the above simplifies to

$$B\oint ds = B2\pi r = \mu_0 NI \Rightarrow B = \frac{\mu_0 NI}{2\pi r}$$

(c) The magnetic field for a toroid depends inversely on r which is the distance from the center of the toroid. As r increases from the inside of the toroid to the outside, B_{toroid} decreases. Thus the field is not uniform.

33.55



Ampere's integration paths are shown in the figure for the regions 0 m $< r < R_1$, $R_1 < r < R_2$, and $R_2 < r$.

Solve: For the region 0 m $< r < R_1$, $\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{through}}$. Because the current inside the integration path is zero, $B = 0$ T. To find I_{through} in the region $R_1 < r < R_2$, we multiply the current density by the area inside the integration path that carries the current. Thus,

$$I_{\text{through}} = \frac{I}{\pi\left(R_2^2 - R_1^2\right)}\pi\left(r^2 - R_1^2\right)$$

where the current density is the first term. Because the magnetic field has the same magnitude at every point on the circular path of integration, Ampere's law simplifies to

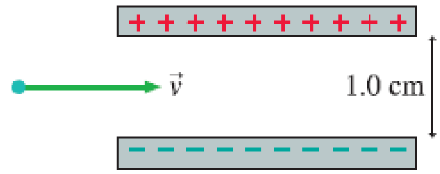
$$\oint \vec{B} \cdot d\vec{s} = B\int ds = B(2\pi r) = \mu_0 \frac{I\left(r^2 - R_1^2\right)}{\left(R_2^2 - R_1^2\right)} \Rightarrow B = \frac{\mu_0 I}{2\pi r}\left(\frac{r^2 - R_1^2}{R_2^2 - R_1^2}\right)$$

For the region $R_2 < r$, I_{through} is simply I because the loop encompasses the entire current. Thus,

$$\oint \vec{B} \cdot d\vec{s} = B\int ds = B2\pi r = \mu_0 I \Rightarrow B = \frac{\mu_0 I}{2\pi r}$$

Assess: The results obtained for the regions $r > R_2$ and $R_1 < r < R_2$ yield the same result at $r = R_2$. Also note that a hollow wire and a regular wire have the same magnetic field outside the wire.

33.58



Solve: The electric field is

$$\vec{E} = \left(\frac{200\text{ V}}{1\text{ cm}}, \text{down}\right) = (20{,}000\text{ V/m, down})$$

The force this field exerts on the electron is $\vec{F}_{elec} = q\vec{E} = -e\vec{E} = (3.2\times10^{-15}\text{ N, up})$. The electron will pass through without deflection *if* the magnetic field also exerts a force on the electron such that $\vec{F}_{net} = \vec{F}_{elec} + \vec{F}_{mag} = 0\text{ N}$. That is, $\vec{F}_{mag} =$ $(3.2\times10^{-15}$ N, 3.2×10^{-15} N, down). In this case, the electric and magnetic forces cancel each other. For a *negative* charge with $\vec{v}$ to the right to have $\vec{F}_{mag}$ down requires, from the right-hand rule, that $\vec{B}$ point *into* the page. The magnitude of the magnetic force on a moving charge is $F_{mag} = qvB$, so the needed field strength is

$$B = \frac{F_{mag}}{ev} = \frac{3.2\times10^{-15}\text{ N}}{(1.60\times10^{-19}\text{ C})(1.0\times10^{7}\text{ m/s})} = 2.0\times10^{-3}\text{ T} = 2.0\text{ mT}$$

Thus, the required magnetic field is $\vec{B}$ = (2.0 mT, into page).

33.60

(a) A particle of charge q when injected in a region of uniform magnetic field with a velocity perpendicular to the field it goes on rotating in circle. The number of times it completes the circle in a second is given by the CYCLOTRON frequency [pg. 1020]

$$f_{cyc} = \frac{qB}{2\pi m}$$

where m is the mass of the particle. Solving for B and using the data given we get

$$B = \frac{2\pi fm}{e} = \frac{2\pi(2.4\times10^{9}\text{ Hz})(9.11\times10^{-31}\text{ kg})}{1.6\times10^{-19}\text{ C}} = 0.086\text{ T} = 86\text{ mT}$$

(b) If the velocity of the charge is v and the radius of the circle in which it moves be r then the cyclotron frequency f as defined above is given by f = 2 * pi * r / v => v = 2 pi r / f. Also the kinetic energy is given by the expression K = ½ m v^2, which on usage of the above formula gives K = ½ m * 4 pi^2 r^2 / f^2 which INCREASES with r. Hence MAX. Kinetic Energy will be had only when the radius of rotation is maximum i.e. r = 2.5 / 2 cm = 1.25 cm = .0125 m. So we get,

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}m(2\pi rf)^2 = \tfrac{1}{2}(9.11\times10^{-31}\text{ kg})\left[2\pi(0.0125\text{ m})(2.4\times10^{9}\text{ Hz})\right]^2 = 1.62\times10^{-14}\text{ J}$$

33.64. Model: Charged particles moving perpendicular to a uniform magnetic field undergo circular motion at constant speed.

Visualize: Please refer to Figure P33.64.

Solve: The potential difference causes an ion of mass m to accelerate from rest to a speed v. Upon entering the magnetic field, the ion follows a circular trajectory with cyclotron radius $r = mv/eB$. To be detected, an ion's trajectory must have radius $d = 2r = 8$ cm. This means the ion needs the speed

$$v = \frac{eBr}{m} = \frac{eBd}{2m}$$

This speed was acquired by accelerating from potential V to potential 0. We can use the conservation of energy equation to find the voltage that will accelerate the ion:

$$K_1 + U_1 = K_2 + U_2 \Rightarrow 0\ \text{J} + e\Delta V = \tfrac{1}{2}mv^2 + 0\ \text{J} \Rightarrow \Delta V = \frac{mv^2}{2e}$$

Using the above expression for v, the voltage that causes an ion to be detected is

$$\Delta V = \frac{mv^2}{2e} = \frac{m}{2e}\left(\frac{eBd}{2m}\right)^2 = \frac{eB^2d^2}{8m}$$

An ion's mass is the sum of the masses of the two atoms *minus* the mass of the missing electron. For example, the mass of N_2^+ is

$$m = m_N + m_N - m_{elec} = 2(14.0031\ \text{u})(1.661\times10^{-27}\ \text{kg/u}) - 9.11\times10^{-31}\ \text{kg} = 4.65174\times10^{-26}\ \text{kg}$$

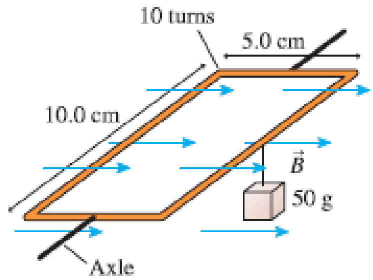
Note that we're given the atomic masses very accurately in Exercise 28. We need to retain this accuracy to tell the difference between N_2^+ and CO^+. The voltage for N_2^+ is

$$\Delta V = \frac{(1.6\times10^{-19}\ \text{C})(0.200\ \text{T})^2(0.08\ \text{m})^2}{8(4.65174\times10^{-26}\ \text{kg})} = 110.07\ \text{V}$$

Ion	Mass (kg)	Accelerating voltage (V)
N_2^+	4.65174×10^{-26}	110.07
O_2^+	5.31341×10^{-26}	96.36
CO^+	4.64986×10^{-26}	110.11

Assess: The difference between N_2^+ and CO^+ is not large but is easily detectable.

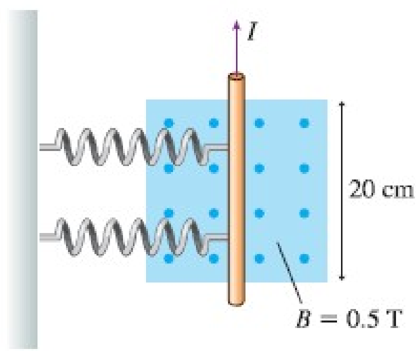
33.66



To prevent the loop from rotating we need to have the net torque on the loop about the axle to be zero. Now the weight induces a torque of T_1 = Force* Distance [form axle] = (m*g)*d = 50 g * 981 cm / s^2 * 2.5 cm = .05 kg * 9.81 m / s^2 * .025 m. Also the torque on a current carrying loop is given by the CROSS product of its Dipole Moment and magnetic field. So we get the Torque due to the Magnetic Field to be T_2 = N * I * Area * B * Sin 90^0 [as because the dipole moment of the loop is perpendicular to the magnetic field B and there are N = 10 loops over there]= 10 * 2.0 A* (.10 m* .050m) * B * 1 = 2.0 A* .05 m^2 * B. Equating T_1 and T_2 and Solving for B we get

B = .05 kg * 9.81 m / s^2 * .025 m / (2.0 A* .05 m^2) = .123 Tesla.

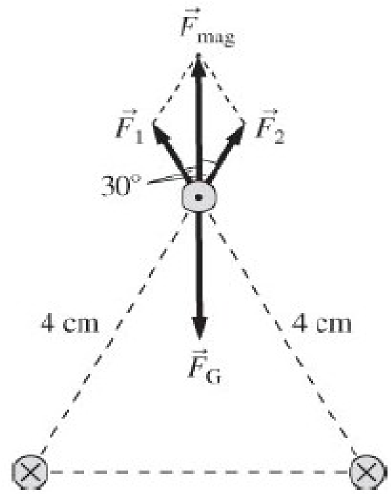
33.67



The figure shows a wire in a magnetic field that is directed out of the page. The magnetic force on the wire is therefore to the right and will stretch the springs.

Now on stretching each of the springs will exert a force of K*x where K = spring constant and x = stretching. As because we have TWO of them we'll be having a force TWICE as much i.e. F_S = 2* K * x = 2 * 10 N/m * .010 m = .2 N. This force must balance the force on the wire due to the current and the magnetic field which is F_M = I* L * B* Sin 90^0 = I * .2 m * 0.5 T = .1 I T-m.
For Equilibrium we need $F_S = F_M$ or, .2 N = .1 I T-m => I = 2 A.

33.70



Solve: Each lower wire exerts a repulsive force on the upper wire because the currents are in opposite directions. The currents are of equal magnitude and the distances are equal, so $F_1 = F_2$. Consider segments of the wires of length L. Then the forces are

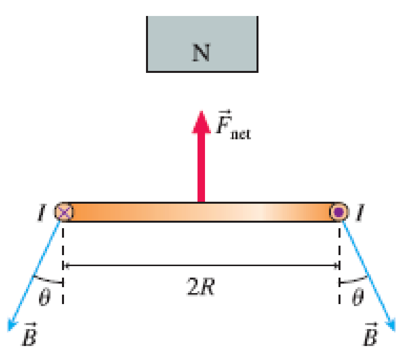
$$F_1 = F_2 = \frac{\mu_0 L I^2}{2\pi d}$$

The horizontal components of these two forces cancel, so the net magnetic force is upward and of magnitude

$$F_{mag} = 2F_1 \cos 30° = \frac{\mu_0 L I^2 \cos 30°}{\pi d}$$

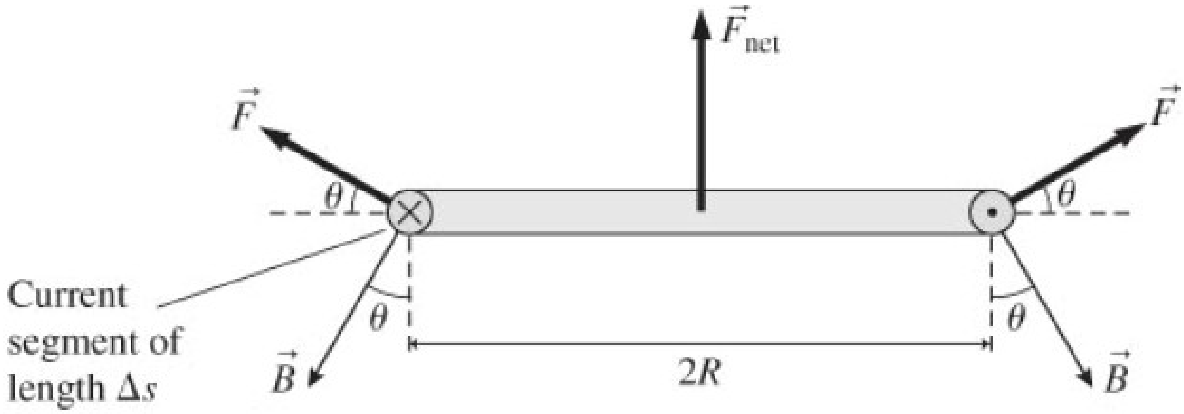
In equilibrium, this force must exactly balance the downward weight of the wire. The wire's linear mass density is $\mu = 0.050$ kg/m, so the mass of this segment is $m = \mu L$ and its weight is $w = mg = \mu L g$. Equating these gives

$$\frac{\mu_0 L I^2 \cos 30°}{\pi d} = \mu L g \Rightarrow I = \sqrt{\frac{\mu g \pi d}{\mu_0 \cos 30°}} = \sqrt{\frac{(0.050 \text{ kg/m})(9.8 \text{ m/s}^2)\pi(0.040 \text{ m})}{(4\pi \times 10^{-7} \text{ T m/A})\cos 30°}} = 238 \text{ A}$$



33.76

The NET FORCE on a current carrying LOOP is zero ONLY in UNIFORM magnetic field. If the Field is NOT so then there will be some NON-Zero NET force acting on the loop. The following example illustrates that.



Solve: **(a)** Consider a small segment of the loop of length Δs. The magnetic force on this segment is perpendicular both to the current and to the magnetic field. The figure shows two segments on opposite sides of the loop. The horizontal components of the forces cancel but the vertical components combine to give a force toward the bar magnet. The net force is the sum of the vertical components of the force on all segments around the loop. For a segment of length Δs, the magnetic force is $F = IB\Delta s$ and the vertical component is $F_y = (IB\Delta s)\sin\theta$. Thus the net force on the current loop is

$$F_{net} = \sum F_y = \sum (IB\Delta s)\sin\theta = IB\sin\theta \sum \Delta s$$

We could take $\sin\theta$ outside the summation because θ is the same for all segments. The sum of all the Δs is simply the circumference $2\pi R$ of the loop, so

$$F_{net} = 2\pi RIB\sin\theta$$

(b) The net force is

$$F_{net} = 2\pi(0.020\ \text{m})(\sin 20°)(0.50\ \text{A})(200 \times 10^{-3}\ \text{T}) = 4.3 \times 10^{-3}\ \text{N}$$