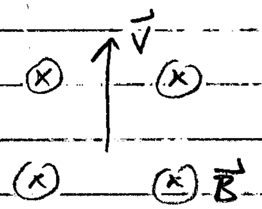
Physics 1B Solutions – Chap 19

Easy

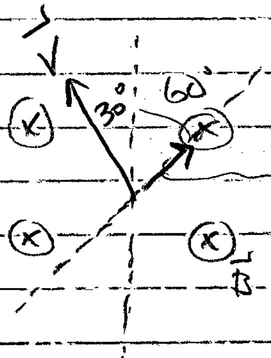
1 Take downward as into the page, and note that we are dealing with a negative particle:

(a)



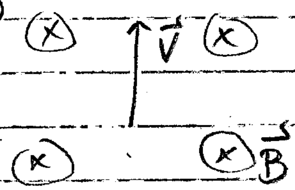
Using the right hand rule, start fingers pointing north along $\vec{V}$ and curl them downward into the page toward $\vec{B}$. Then your thumb points left, but since it is an electron, the force points opposite: $\boxed{\text{Force is right}}$

(b)

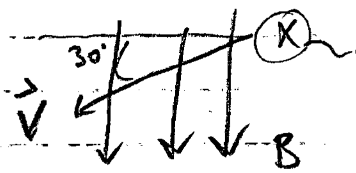


Force points $\boxed{60° \text{ east of north}}$ by again using the right hand rule.

(c)

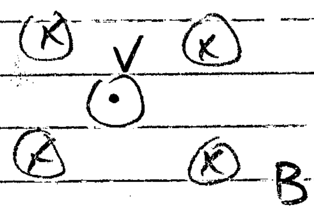


But 30° into page: examine a side view:



Using the RHR on the side view we find the force is into the page, which corresponds $\boxed{\text{to the right}}$ on the original picture. (again, remember it is a neg. charge)

(d)

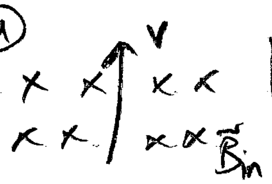


upward is out of page for the velocity; we cannot use the RHR here because the $\vec{V}$ and $\vec{B}$ vectors are parallel. Note the equation for force is $F = qvB \sin\theta$ and θ is 180° so $\boxed{F=0}$

Easy

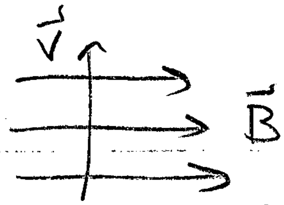
[2] Find force on proton for each picture; just use the RHR for each one. Point fingers along $\vec{V}$ & curl toward $\vec{B}$. Your Thumb points along Force.

(1a)



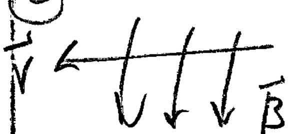
$\boxed{F = \leftarrow}$

(b)



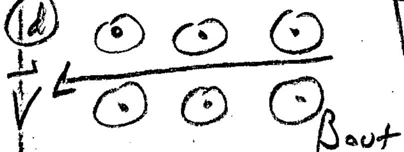
$\boxed{F = \otimes \text{ into page}}$

(c)



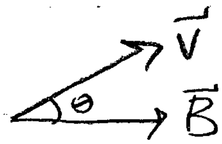
$\boxed{F = \odot \text{ out of page}}$

(d)



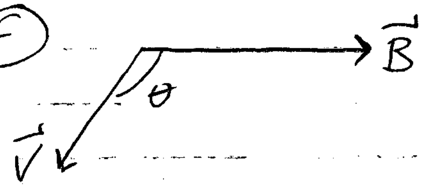
$\boxed{F = \text{upward} \uparrow}$

(1e)



$\boxed{F = \otimes \text{ in}}$

(f)



$\boxed{F = \odot \text{out}}$

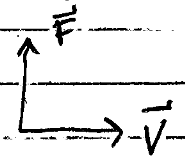
Note, for an electron, all 6 answers are the opposite because the electron has a negative charge.

(a) right $\rightarrow$
(b) out $\odot$
(c) in $\otimes$
(d) down $\downarrow$
(e) in $\odot$
(f) out $\otimes$

Easy

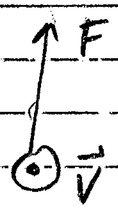
3 Given Force and velocity, find the $\vec{B}$ field.
→ A good strategy is to guess one of the two perpendicular vectors and check it. If you are wrong, choose the other.

(a)



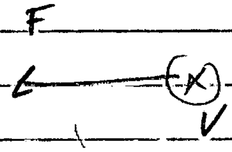
The $\vec{B}$ must point into the page or out of the page
Guess into page & check using the right hand rule.
(x)B → V yields force upward, as we want.
$\boxed{\text{Thus, B points (X) into page}}$

(b)

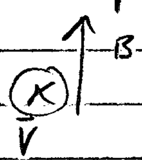


Guess $\vec{B}$ right (or left).
(·)$\vec{V}$ → B yield force ↑
$\boxed{\text{Thus B points right}}$

(c)



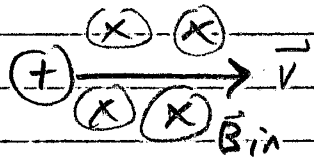
guess B up



yields force to the right which is opposite of what we want. Thus, $\boxed{\text{B points downward}}$

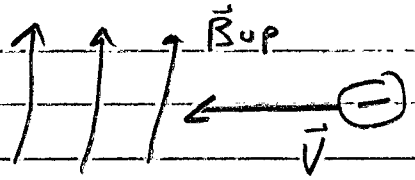
4 determining the direction of deflection is the same as determining the force for each one:

(a)



Force ↑ upward

(b)

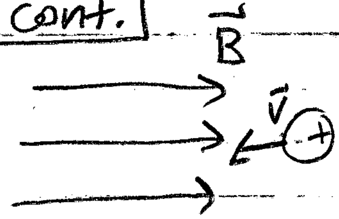


Force out of page (·)
(Note the neg charge)

Easy

4 - cont.

(c)

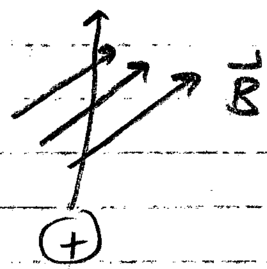


$F = qvB\sin\theta$

$F = 0$ b/c They are parallel

($\theta = 180°$, so $\sin\theta = 0$)

(d)

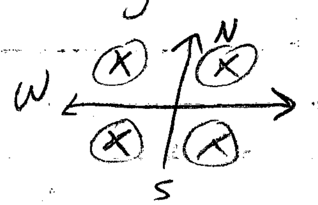


$F =$ (X) into page : Note, you still use the RHR even if it is not a 90° angle. Just point fingers along $\vec{v}$ (upward) and curl toward $\vec{B}$.

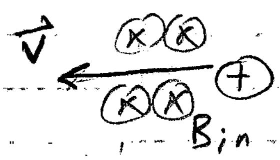
6 $B_{earth} = 50\,\mu T$ downward

proton moves west with $V = 6.2 \times 10^6\ m/s$

Force: direction: set up a diagram with directions labeled.



using The diagram we have



$\Rightarrow$ so force $= \downarrow =$ South

Force: magnitude: $F = qvB\sin\theta$

we have $\theta = 90°$ b/c west & down are perp.

$F = (+1.6 \times 10^{-19}\,C)(6.2 \times 10^6\,m/s)(50\,\mu T)(\sin 90°)$

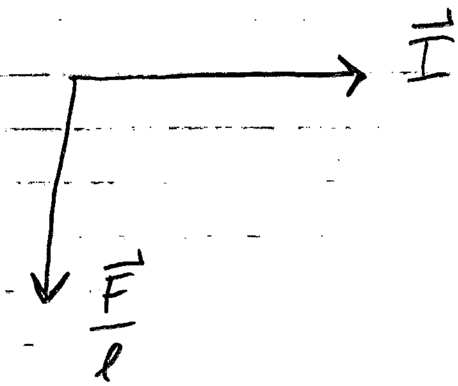
$\boxed{F = 4.96 \times 10^{-17}\,N,\ \text{South}}$

Easy

11 $I = 15\,A\ (+\hat{x})$ in perpendicular B field

$\frac{F}{\ell} = .12\,\frac{N}{m}\ (-\hat{y})$

draw a picture:



We know $F = I\ell B \sin\theta$

so $\frac{F}{\ell} = I B \sin\theta$

Since B is perpendicular, it must point into the page or out of the page. Guess and check with the right hand rule.

Guess into page: $\underset{B}{\otimes} \longrightarrow I$ yields force upward,

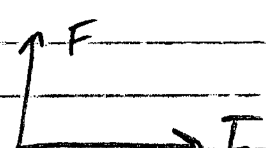
Thus B points opposite of our guess. $\boxed{B \text{ is } \odot \text{ out}}$

The magnitude is $\left(\frac{F}{\ell}\right)\frac{1}{I \sin\theta} = \boxed{B = .008\,T}$

(w/ $\theta = 90°$)

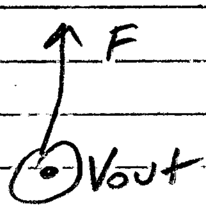
13 using $F = I\ell B \sin\theta$ & RHR we get the same answers as for question 3.

(a)



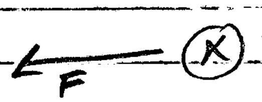
$\boxed{\text{B into page}}$

(b)



$\boxed{\text{B to the right}}$

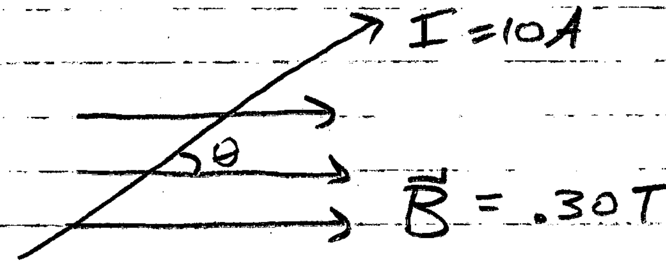
(c)



$\boxed{\text{B down}}$

Easy

15 $I = 10A$
$\theta = 30°$
$l = 5m$



$F = Il B \sin\theta$ → just plug in numbers
$\boxed{F = 7.5N}$

22 $I = 17mA$
$N = 1$ loop
Circumf = 2m
$B = .8T$

$\tau = NIAB\sin\theta$

θ is $90°$ because it is the angle between $\vec{B}$ and the normal to the loop.

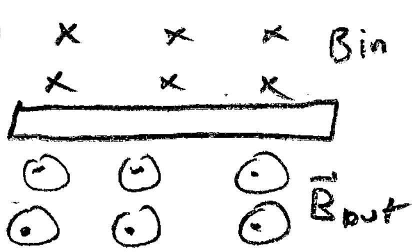
$\tau = (1)(17mA)A(.8T)(\sin 90°)$

Need Area: $A = \pi r^2$ and $2\pi r = C$
so $r = \frac{C}{2\pi}$ and $A = \pi\left(\frac{C}{2\pi}\right)^2 = \frac{C^2}{4\pi} = \frac{1m^2}{\pi}$

$\boxed{\tau = .0043\ Nm}$

34 For this RHR, your thumb is the current and your fingers curl along the B field

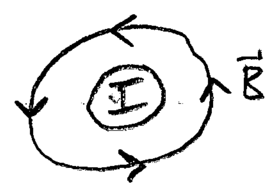
(a)



Thumb left gives the desired B field.

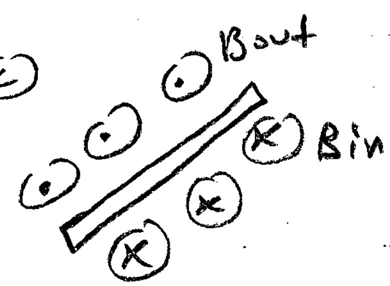
$\boxed{I \text{ points left}}$

(b)



Thumb out of page gives correct B field.

(c)



Thumb ↗ = I up and right gives answer for current.

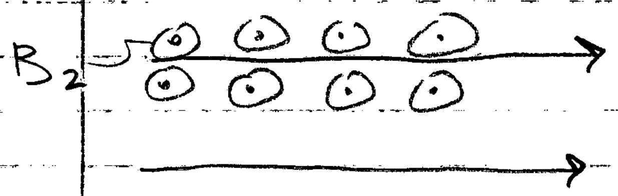
Easy

44 $I_1 = 10A$
$I_2 = 10A$
$d = 0.1m$

(a) current is same direction in both wires

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d} = \boxed{2.0 \times 10^{-4}\ N/m = \frac{F}{\ell}}$$

To see if they attract or repel we need a picture:



① draw the field at I_1 caused by $I_2 \Rightarrow \odot = B_2$

② Now consider the force on I_1 caused by B_2

$\odot \rightarrow I_1 \Rightarrow F$ is down
B_2

Thus, they are attracted.

47 $N = 1000$ turns
$\ell = .4m$
$B = 1 \times 10^{-4}\ T$
Find I

$$B = \mu_0 n I = \mu_0 \left(\frac{N}{\ell}\right) I \Rightarrow I = \frac{B}{\mu_0}\frac{\ell}{N}$$

plug in the numbers to obtain:

$$\boxed{I = .032\ A}$$

44b Force is the same but they repel instead of attract.

Medium

[8] e^- goes through $\Delta V = 2{,}400\ V$, Then enters a $1.7\ T$ B field.

(a) Find max magnetic force: $F = qVB\sin\theta$ will be max when V is max and θ is $90°$. (q and B are fixed.)

To get the velocity we use $\frac{1}{2}mv^2 = KE = -PE$ and $PE = q\Delta V = (-e)(2400V) \rightarrow KE = (+e)(2400V)$

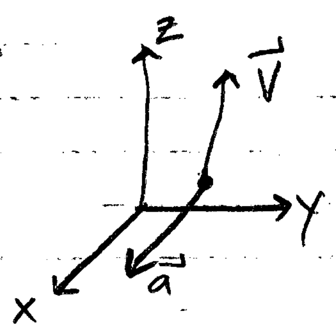
Thus $V = \sqrt{\frac{2[(+e)(2400V)]}{m_e}} = 2.9 \times 10^7\ m/s = \text{const.}$

Finally $F_B = qVB\sin 90° = \boxed{7.9 \times 10^{-12}\ N = F_{max}}$

(b) $F_{min} = (qVB\sin\theta)_{min}$; so if we set $\theta = 0°$

Then the force is 0. $\boxed{F_{min} = 0}$

[9]



$\vec{V} = 1\times10^7\ m/s\ (\hat{z})$ (proton)

$\vec{a} = 2\times10^{13}\ m/s^2\ (\hat{x}) = \frac{\vec{F}}{m}$

(1) $\vec{a}$ points in the same direction as the force, so using the RHR the B field must point along $(-\hat{y})$

For the magnitude we have: $F = qVB\sin 90° = ma$

so $B = \frac{ma}{qV} = \frac{(1.67\times10^{-27}\ kg)\ a}{(1.6\times10^{-19}\ C)\ V} = \boxed{.021\ T = B}$ $\boxed{-\hat{y}}$

Medium

24

$N = 100$

$A = lw = (.4m)(.3m) = .12 m$

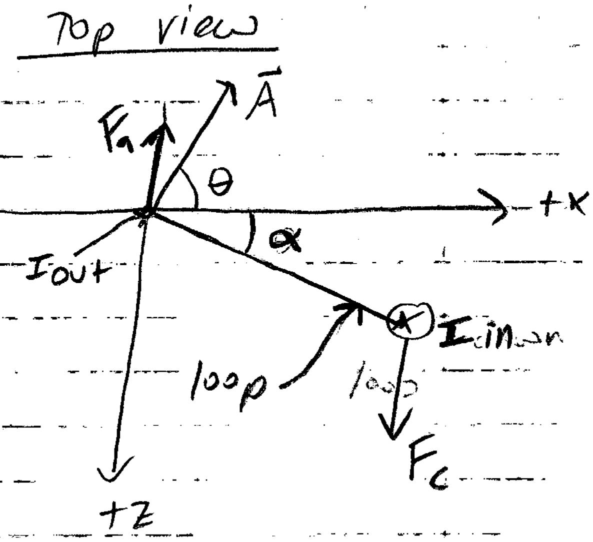
$B = .8T \ \hat{x}$

$I = 1.2A$

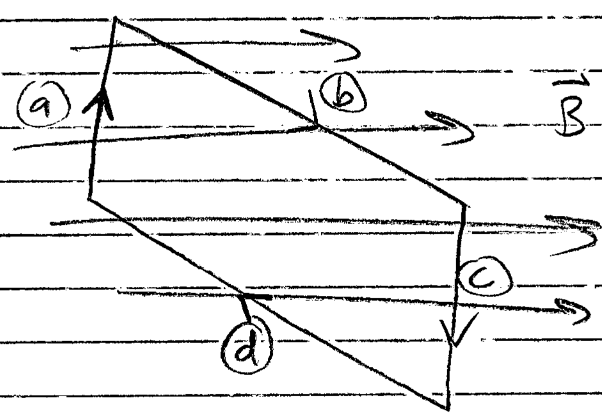
$\alpha = 30°$

$\theta = 60°$

$\tau = NIAB \sin\theta = \boxed{.10 \ Nm = \tau}$



To get direction of rotation, we examine forces on each side of the loop.



side	force
a	$-\hat{z}$
b	up $(+\hat{y})$
c	$+\hat{z}$
d	down $(-\hat{y})$

Thus, the loop will tend to rotate clockwise in the above diagram.

31 Given

mass $= 2.5 \times 10^{-26}$ kg

charge $= +e = +1.6 \times 10^{-19}$ C

$\Delta V = 250V$

$B = .5T$

First we need the particles velocity

$$\frac{1}{2}mv^2 = KE = -PE = -q\Delta V \implies v = \left|\frac{-2q\Delta V}{m}\right|^{1/2}$$

Medium

31-cont

plug in numbers and get $V = 5.66 \times 10^{4}$ m/s

Now this goes into a B field ⊥ so $F = qVB \sin 90°$ and it goes along a circular path.
From mechanics (Physics 1A) you learned that a circular path has acceleration V^2/r so

$F_{circular} = \frac{mv^2}{r} = F_B = qVB$ → Now solve for r

$$\frac{mV^2}{r} = qVB \longrightarrow r = \frac{mV}{qB} = \boxed{.018 \text{ meters} = r}$$

32 $V = 3 \times 10^5$ m/s
$B = 0.6T$ (perpendicular)
Find Δr for ^{235}U and ^{238}U (single charged)

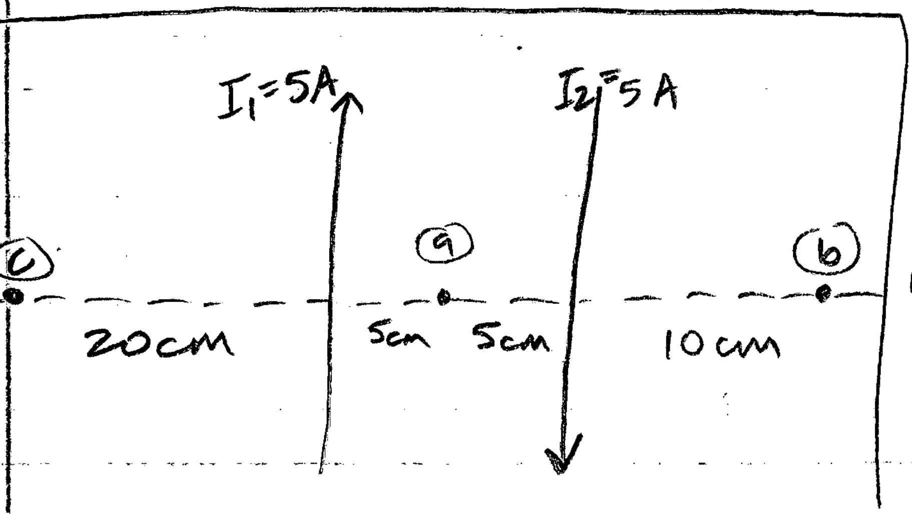
First calculate r for each and then subtract

$$r_{235} = \frac{M_{235} V}{(e)(B)} = \frac{(235)(1.67 \times 10^{-27})V}{eB} = 1.2264 \text{ m}$$

$$r_{238} = \text{''} = \frac{(238)(1.67 \times 10^{-27})V}{eB} = 1.2421 \text{ m}$$

$$\boxed{\Delta r = .0157 \text{ m}}$$

38



Since it asks for total distance between them it is the diff between diameters
$\Delta d = 2\Delta r$

$$\boxed{\Delta d = 3.14 \text{ cm}}$$

Medium

38-cont The field magnitude around a wire is given by $B = \mu_0 I / 2\pi r$ & the direction is found with the right hand rule #2.

(a) $B = B_1 + B_2 = \dfrac{\mu_0 (5A)}{2\pi(.05m)} \otimes_{in} + \dfrac{\mu_0 5A}{2\pi .05m} \otimes_{in}$

$$\boxed{B = 4 \times 10^{-5}\ T}$$

(b) $B = B_1 + B_2 = \dfrac{\mu_0 5A}{2\pi(.2m)} \otimes_{in} + \dfrac{\mu_0 5A}{2\pi(.1m)} \odot_{out}$

$$B = (5 \times 10^{-6} \otimes_{in} + 1 \times 10^{-5} \odot_{in})\,T$$

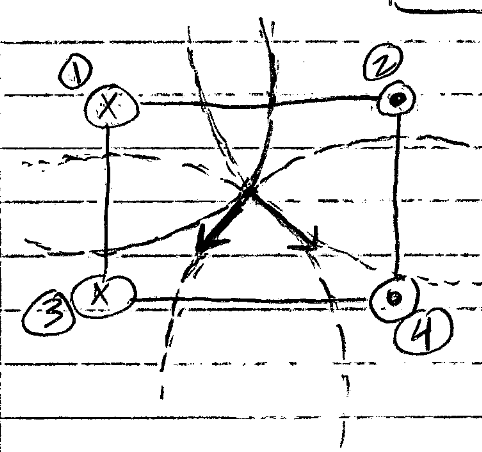
$$\boxed{B = 5 \times 10^{-6}\ T \odot_{in}}$$

(c) $B = B_1 + B_2 = \dfrac{\mu_0 5A}{2\pi(.2m)} \odot_{out} + \dfrac{\mu_0 5A}{2\pi(.3m)} \otimes_{in}$

$$B = (5 \times 10^{-6} \odot_{out} + 3.33 \times 10^{-6} \otimes_{in})\,T$$

$$\boxed{B = 1.67 \times 10^{-6}\ T \odot_{out}}$$

39



Find B at center:

i) draw in $\vec{B}$ vectors for each current

B_1 and B_4 both point down left

B_2 and B_3 both point down right

ii) get magnitude and add vectors

$B = \dfrac{\mu_0 (5A)}{2\pi d}$ and $d = \sqrt{(.1m)^2 + (.1m)^2}$

$d = .141m$

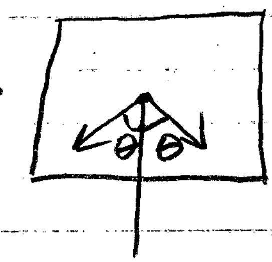
Medium

39-cont so B for each wire is $\frac{\mu_0\,5A}{2\pi\,.141\,m}$

$$B_{each} = 7.1\ \mu T$$

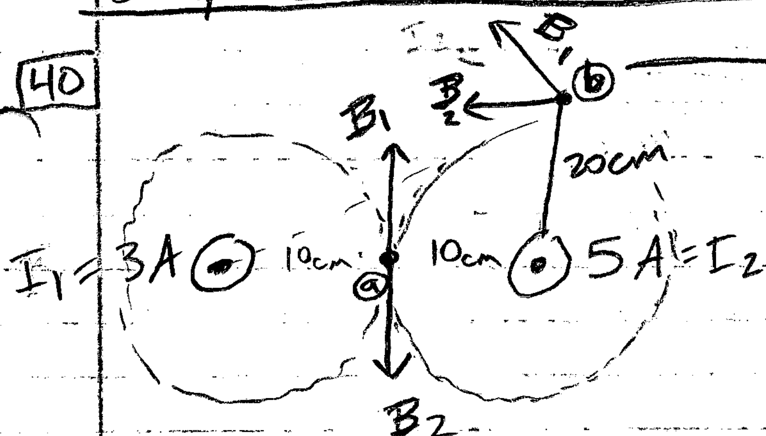
Since it is a square, the θ is 45°
all 4 point downward, so $B_{down} = 4\,B\cos 45°$

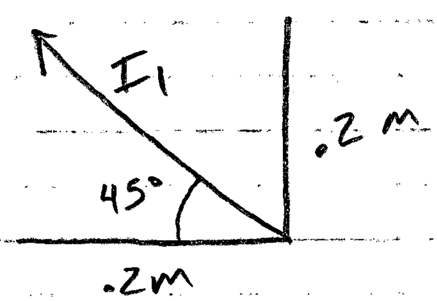
$$\boxed{B_{down} = 2\times10^{-5}\,T}$$



Since 2 point left & 2 point right and they have the same magnitude and angle, the left-right component cancels.

40





ⓐ $B = B_1 + B_2 = \frac{\mu_0 3A}{2\pi(.1m)} - \frac{\mu_0 5A}{2\pi(.1cm)} = \boxed{-4\mu T = B}$ (downward)

ⓑ must break I_1 into components.

$B_{1x} = -B_1\cos 45$ $\quad$ $B_{2x} = -B_2$

$B_{1y} = +B_1 \sin 45$ $\quad$ $B_{2y} = 0$

$B_1 = \frac{\mu_0 3A}{2\pi d}$ $\quad$ $B_2 = \frac{\mu_0 5A}{2\pi\,.2m}$

$d = \sqrt{(.2m)^2 + (.2m)^2} = .283m$

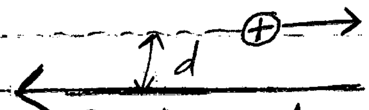
Medium

$\boxed{\text{40-cont}}$ $B_1 = 2.12\,\mu T \qquad B_2 = 5\,\mu T$

$B_{x\,TOT} = -6.5\,\mu T \;;\; B_{y\,TOT} = 1.5\,\mu T$

$$\boxed{B = (-6.5\hat{x} + 1.5\hat{y})\,\mu T}$$

$\boxed{42}$ We must balance the magnetic force with gravity.



$V = 2.3 \times 10^4\,m/s$

$I = 1.2\,\mu A \qquad F_B = qVB\sin\theta \qquad \theta = 90°$

$B = \frac{\mu_0 I}{2\pi r}$

$F_B = (+e)(V)\left(\frac{\mu_0 I}{2\pi d}\right) = F_{up} = mg$

b/c moving w/ constant distance from wire so force upward must balance force downward

$q = +e$

$V =$ given

solve for d

$eV\mu_0 I = (2\pi d)mg$

$\frac{eV\mu_0 I}{2\pi mg} = d = \frac{(1.6\times10^{-19})(2.3\times10^4)\,\mu_0(1.2\,\mu A)}{2\pi\,(1.67\times10^{-27}\,kg)(9.8)} = .054\,m$

$$\boxed{d = .054\,m}$$

$\boxed{45}$ Same concept as above: balance mag force & grav.

$\frac{F_B}{\ell} = \frac{F_g}{\ell} \Rightarrow \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{.08\,N}{1\,m} \leftarrow$ given this quantity as weight/length is F_g/ℓ

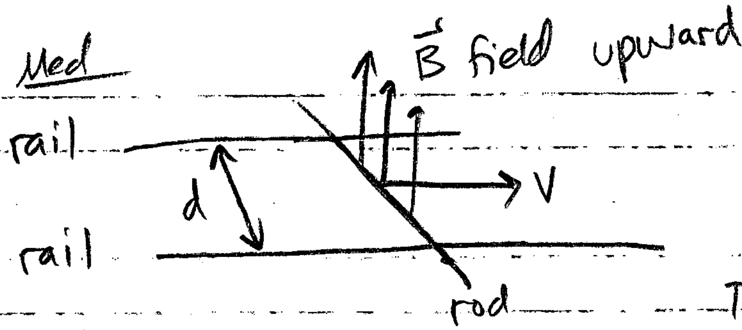
$d = \frac{\mu_0}{2\pi}\,\frac{I_1 I_2 (1m)}{(.08\,N)} = \boxed{.0045\,m = d}$

$I_1 = 30\,A$

$I_2 = 60\,A$

Med

54



rod mass = .2 kg
rod current = 10 A
d = .5 m
friction $\mu = .10$

To get constant velocity, we must balance forward magnetic force with backward friction force.

$F_B = I l B \sin\theta$

I = given
$l = .5\,m$
B = unknown
$\theta = 90°$

$F_F = \mu F_N = \mu m g$

$$I l B = \mu m g \rightarrow B = \frac{\mu m g}{I l} = \frac{(.1)(.2\,kg)(9.8)}{(10A)(.5m)} \rightarrow \boxed{B = .039\,T}$$

Hard

33 An elastic collision means conservation of energy and momentum, and the proton is initially at rest

Momentum

$$m_\alpha V_{\alpha i} = m_\alpha V_{\alpha f} + m_p V_{pf}$$

Energy

$$\cancel{\tfrac{1}{2}} m_\alpha V_{\alpha i}^2 = \cancel{\tfrac{1}{2}} m_\alpha V_{\alpha f}^2 + \cancel{\tfrac{1}{2}} m_p V_{pf}^2$$

$(m_\alpha = 4 m_p)$

$$V_{\alpha i} = V_{\alpha f} + \frac{1}{4} V_{pf} \qquad V_{\alpha i}^2 = V_{\alpha f}^2 + \frac{1}{4} V_{pf}^2$$

$$V_{\alpha i}^2 = \cancel{V_{\alpha f}^2} + 2\left(V_{\alpha f}\right)\left(\frac{1}{4} V_{pf}\right) + \frac{1}{16} V_{pf}^2 = \cancel{V_{\alpha f}^2} + \frac{1}{4} V_{pf}^2$$

$$\frac{1}{2} V_{\alpha f} \cancel{V_{pf}} = \left(\frac{1}{4} - \frac{1}{16}\right) V_{pf}^{\cancel{2}} \Rightarrow \frac{1}{2} V_{\alpha f} = \frac{3}{16} V_{pf}$$

$$\boxed{V_{\alpha f} = \frac{3}{8} V_{pf}}$$

Using the cyclotron formula for radius

$$r = \frac{mV}{qB}$$

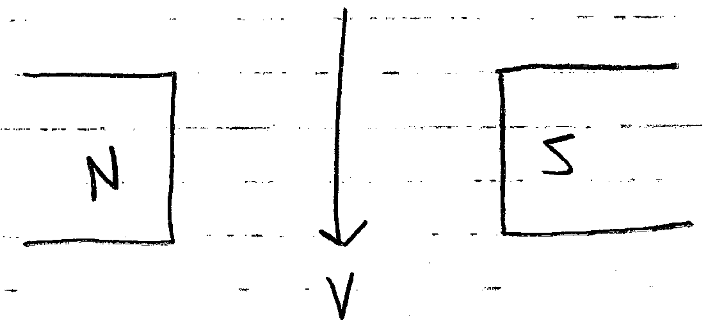
$$\left.\begin{array}{l} m_\alpha = 4 m_p \\ q_\alpha = 2 q_p \end{array}\right\} \text{given}$$

$$R_\alpha = \frac{m_\alpha V_\alpha}{q_\alpha B} = \frac{(4 m_p)\left(\frac{3}{8} V_p\right)}{(2 q_p) B} = \left(\frac{4 \cdot \frac{3}{8}}{2}\right) \underbrace{\frac{m_p V_p}{q_p B}}_{R_{proton} = R} = \left(\frac{3}{4}\right) R$$

$$\boxed{\text{Thus } R_\alpha = \frac{3}{4} R}$$

Hard

57 Top view



positive charges in this B field will flow out of the page (electrode A in book pic) and negative charges will flow into the page. This charge separation sets up an electric field that balances the $\vec{B}$ field. (E point into page)

At equilibrium the net force on the ions must equal zero

$$F_{net} = 0 = \underset{(out)}{F_B} - \underset{(in)}{F_E} = qvB - qE = 0$$

Thus $v = \dfrac{E}{B}$ but

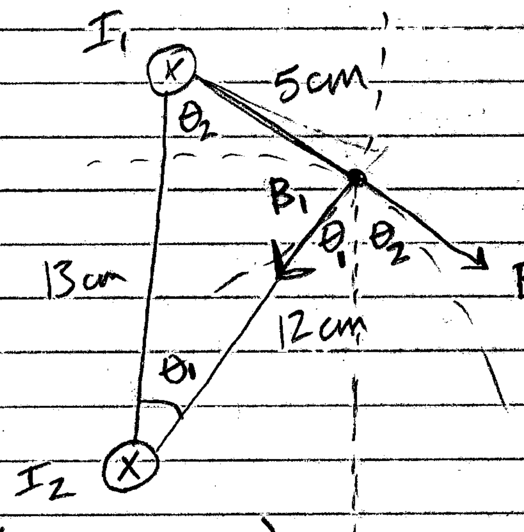
recall that $E = \dfrac{\Delta V}{\Delta d}$, so $v = \dfrac{\Delta V}{\Delta d\, B}$

$$v = \frac{160\,\mu V}{(3\,mm)(.04\,T)} = \boxed{v = 1.33\ m/s}$$

(b) (+) charges move to point A and (−) charges move to point B, Thus either (+) or (−) charges both make point A at a higher voltage than point B.

Hard

61



$(I_1 = I_2 = 3A)$

First get magnitude and angles

$\theta_1 = \tan^{-1} \frac{5}{12} = \theta_1 = 22.6°$

$\theta_2 = 90 - \theta_1 = \theta_2 = 67.4°$

$B_1 = \frac{\mu_0 I_1}{2\pi(.05m)} = B_1 = 12\mu T$

$B_2 = \frac{\mu_0 I_2}{2\pi(.12m)} = B_2 = 5\mu T$

Next break into x & y components

$B_1x = -B_1 \sin\theta_1 = -4.61\mu T$
$B_2x = +B_2 \sin\theta_2 = +4.61\mu T$ } $B_x = 0$

$B_1y = -B_1 \cos\theta_1 = -11.08\mu T$
$B_2y = -B_2 \cos\theta_2 = -1.92\mu T$ } $B_y = -13\mu T$

$\boxed{B_{TOT} = -13\mu T \text{ downward}}$