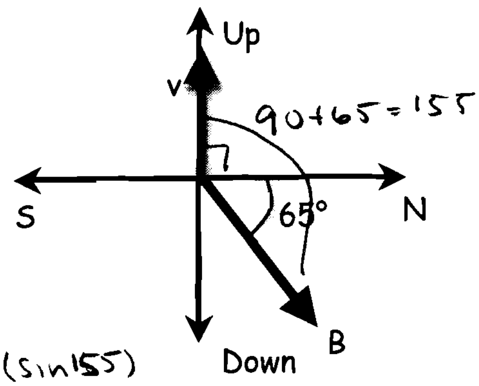
College Physics 104 Exam 2 Spring 2010

Name Key

Multiple Choice: (5pts each)

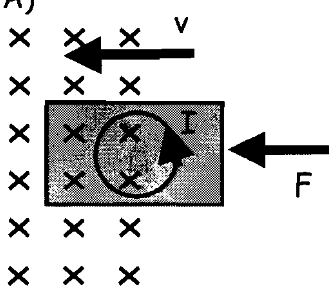
1. A proton is moving UP at a speed of 5.4x 10^6 m/s in a magnetic field of 2.2T pointed 65° below North as seen in the sketch. What is the magnitude and direction of the magnetic force?



a) 1.7×10^{-12} N up
b) 1.7×10^{-12} N East
c) 1.7×10^{-12} N West
d) 8.0×10^{-13} N down
e) 8.0×10^{-13} N East
f) 8.0×10^{-13} N West

$F = qvB\sin\theta$
$= (1.6\times10^{-19}\,C)(5.4\times10^{6}\,m/s)(2.2\,T)(\sin 155)$

2. A metal plate is moving to the left into a magnetic field pointing ~~out of~~ into the page. Which sketch shows the correct direction of the induced current in the metal and the direction of the force on the metal conductor?

A)


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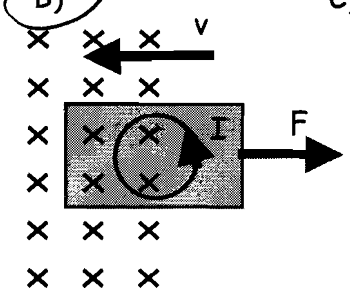

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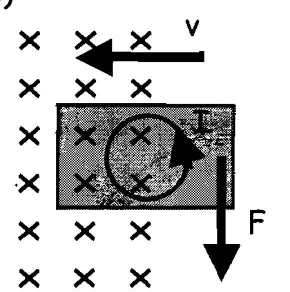
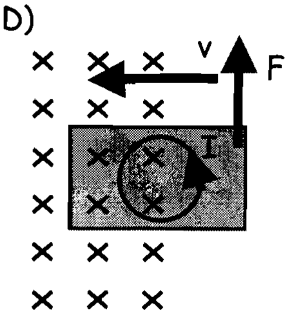


D)


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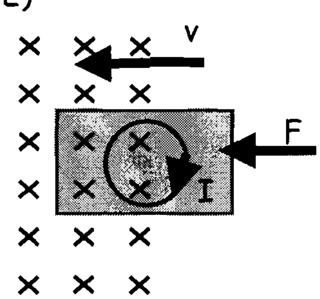

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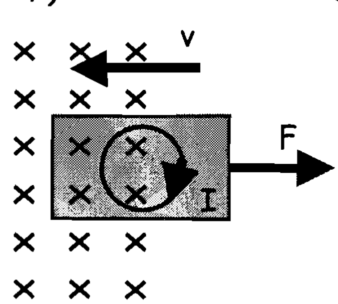
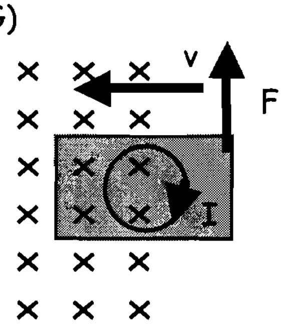


G)


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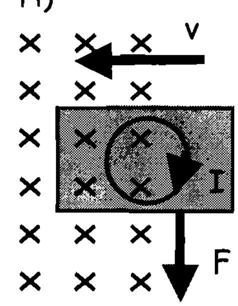

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Short Answer: (10 pts each)

1. 1)[10] In the diagram below, ions in the blood in an artery of width w flow to the left with a magnetic field out of the page.

a)[2] Sketch the paths of positive and negative ions.

b)[2] Sketch the electric field that results from the charge separation.

c)[2] Sketch how you would attach a voltmeter to measure the electric field

d)[4] If the magnetic field is 2.0T, the artery has a width of 0.30 cm and the blood flows at 0.45 m/s, what voltage would you measure across the artery?

$v = E/B$

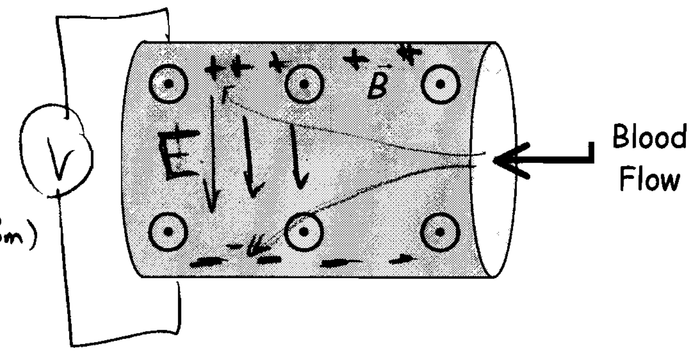
$v = \frac{\Delta V/d}{B}$

$\Delta V = vBd$

$= (0.45\,m/s)(2.0T)(0.003m)$

$= 2.7 \times 10^{-3}\,V$

or $= 2.7\,mV$



2. A 200 turn coil is laid on a hospital patient's chest to monitor whether or not they are breathing. The earth's magnetic field is 50 μT and it makes an angle of 28° with the plane of the coil. When the person breathes, the area of the loop increases by 3.9 x10^{-3} m^2. If it takes 1.8 s to inhale, what voltage is induced in the coil? (From Serway/Faughn/Vuille, College Physics, 7th edition)

$\mathcal{E}mF = -N\frac{\Delta\Phi}{\Delta t} = \frac{-N(\Phi_f - \Phi_i)}{\Delta t}$

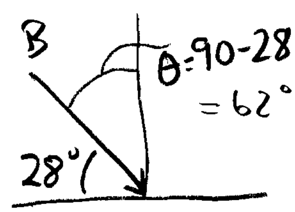
$N = 200$

$\Delta t = 1.8s$

$\Phi = BA\cos\theta$

$B\cos\theta = (50\times10^{-6}T)(\cos 62)$

$= 2.35\times10^{-5}\,T$



$\mathcal{E}mF = \left| -N\left(\frac{B\cos\theta\,\Delta A}{\Delta t}\right)\right| = \left|\frac{-200(2.35\times10^{-5}T)(3.9\times10^{-3}m^2)}{1.8s}\right|$

$= 1.02\times10^{-5}\,V$

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3. Below are two coils. Coil 1 is the source coil on the left and it is connected to a battery. Coil 2 is on the right and it is connected to a resistor.

a) When the switch in coil 1 is closed draw the direction of the current in the coil. Show the current on the loops on the coil.

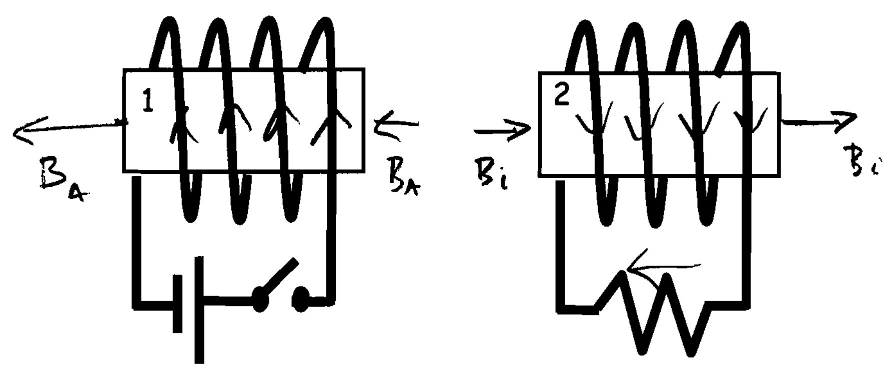
b) Draw arrows on each side of coil 1 showing the direction of the magnetic field.

c) As the switched is closed, what happens to the magnetic flux felt by coil 2?

Circle One: it decreases, it stays the same, it increases

d) Draw arrows on both sides of coil 2 showing the direction of the magnetic field induced in the coil.

e) As the switch is closed in coil 1, draw in the direction of the current in coil 2 on the loops and on the resistor.



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Problems: (20 pts each) Complete 3 of the following 4 problems. Write "OMIT" on the one you choose to skip.

8 1. At one instant an electron (e=-1.6×10^{-19}C) is moving at an angle of 30° above south at 6.3 $\times10^{5}$m/s in a uniform magnetic field of 5.2T directed due west.

a) On the coordinate system shown below, sketch the velocity vector AND the magnetic field vector AND the magnetic force vector. Be sure the label all the coordinate axes.

5 b) Find the magnitude of the magnetic force on the electron.

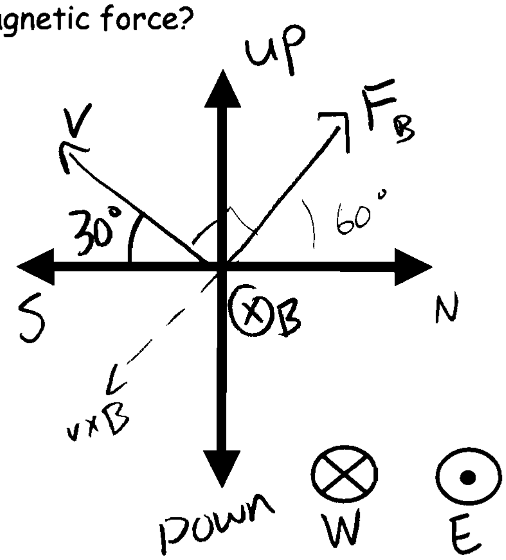
6 c) What would be the magnitude and direction of an electric field that would create an electric force to exactly balance the magnetic force?

N/S 1
u/D 1
E/W 1
v 2
B 1
F 2

b) $F = qvB\sin\theta$ $\theta = 90$

$= (1.6\times10^{-19}C)(6.3\times10^{5}m/s)(5.2T)$

$= 5.24\times10^{-13}N$

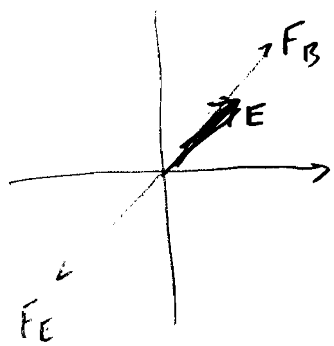


c) $F_E = F_B = qE$

$E = \frac{F_B}{q} = \frac{5.24\times10^{-13}N}{1.6\times10^{-19}C}$

$= 3.28\times10^{6}$ V/m

60 above N



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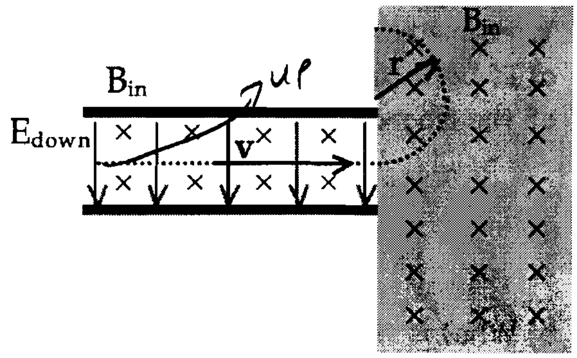
2. A mass spectrometer shown, consists of a velocity selector that allows particles of known charge and a certain velocity to enter into a region of magnetic field where they are deflected differing amounts depending on their charge and mass (all that manage to enter the magnetic field have the same velocity). The velocity selector is a region of crossed electric and magnetic fields that produce opposing forces on the moving charges.



5 **a)** For an electron (e^-) or a proton (p^+) moving through fields of $\vec{E} = 100\ \mathrm{V/m}$ down, and $\vec{B} = 0.50\ T$ into the page, what is the velocity of the particles that do not deflect in the fields (neglect gravity).

6 **b)** How far from the slit, and in which direction (up or down) must a detector be placed to detect the electron? ($m_e = 9.11 \times 10^{-31}$kg)

6 **c)** How far from the slit, and in which direction (up or down) must a detector be placed to detect the proton? ($m_p = 1.67 \times 10^{-27}$kg)

3 d) If a proton enters the velocity selector going too fast, what direction will it go? Put this in the sketch with a label.

a) $v = \frac{E}{B} = \frac{100\ \mathrm{V/m}}{0.5\,T} = 200\ \mathrm{m/s}$

b) $F_B = qvB = \frac{mv^2}{r}$ $\quad r = \frac{mv}{qB} = \frac{(9.11\times10^{-31}\,\mathrm{kg})(200\,\mathrm{m/s})}{(1.6\times10^{-19}\,C)(0.5\,T)}$

$= 2.2\times10^{-9}\,m$ DOWN

distance $= 2r = 4.4\times10^{-9}\,m$

c) $r = \frac{mv}{qB} = \frac{1.67\times10^{-27}\,\mathrm{kg}\ (200\,\mathrm{m/s})}{1.6\times10^{-19}\,C\ \ 0.5\,T} = 4.2\times10^{-6}\,m$

$d = 2r = 8.4\times10^{-6}\,m$ UP

d) UP

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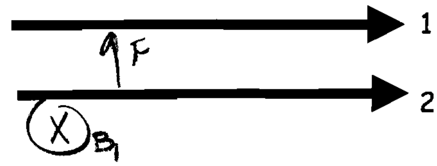
3. Two parallel wires each have a length of 2.2 m and are separated by 5.0 mm. Wire one has a current of 7.0A and wire 2 has a current of 3.5 A.

(4) a) If both currents are traveling to the right, what is the magnitude and direction of the magnetic field of wire 1 at the location of wire 2?



$$B_1 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\,\mathrm{T\,m/A}\ \ 7\,\mathrm{A}}{2\pi\ (0.005\,\mathrm{m})}$$
$$= 2.8\times10^{-4}\,\mathrm{T}$$

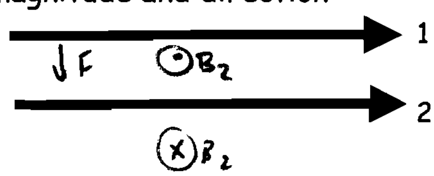
(4) b) What is the magnitude and direction of the magnetic force on wire 2 due to wire 1?

$$F = I_2 L B_1 \sin\theta$$
$$= (3.5\,\mathrm{A})(2.2\,\mathrm{m})(2.8\times10^{-4}\,\mathrm{T})$$
$$= 2.16\times10^{-3}\,\mathrm{N}$$

up $\uparrow$

F, I, B

(4) c) If both currents are traveling to the right, what is the magnitude and direction of the magnetic field of wire 2 at the location of wire 1?



$$B_2 = \frac{4\pi\times10^{-7}\,\mathrm{Tm/A}\ (3.5\,\mathrm{A})}{2\pi\ (0.005)} = \tfrac{1}{2} B_1$$
$$= 1.4\times10^{-4}\,\mathrm{T}$$

B

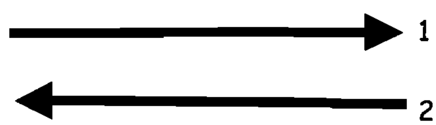
(4) d) What is the magnitude and direction of the magnetic force on wire 1 due to wire 2?

$$F = I_1 L B_2 \sin\theta$$
$$= (7.0\,\mathrm{A})(2.2\,\mathrm{m})(1.4\times10^{-4}\,\mathrm{T})$$
$$= 2.16\times10^{-3}\,\mathrm{N}$$

$\downarrow$ down

I, B, F

(4) e) Explain what happens to the directions of the magnetic field due to wire 2 and the magnetic force on wire 1 due to wire 2 if the direction of the current in wire 2 is to the left.



Switch directions

B_2: $\odot \longrightarrow \otimes$

F: $\downarrow \longrightarrow \uparrow$

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14

4. You are curious to find out how much current is flowing through the high voltage power lines. You construct a 1000 turn loop with a radius of 5.0 cm to help you. You measure a voltage of 80.0 mV when you hold your coil 10 meters below the HV power line. You know that the magnetic field due to the HV power line is changing direction every 1/60 of a second because the current is changing directions at that rate.

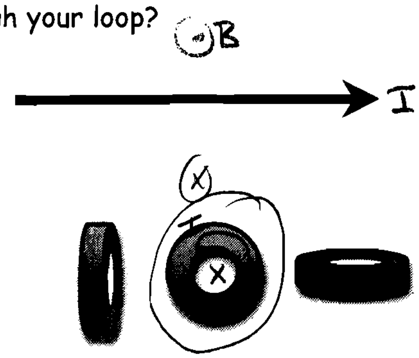
5 a) What is the maximum change in magnetic flux through your loop?

3 b) For the power line drawn on the right, circle the orientation of the coil that maximizes the magnetic flux through the loop.

5 c) What is the average magnetic field through your loop due to the current in the HV power line.

4 d) What is the current in the HV power line?

3 e) If the current in the HV line is decreasing while pointing to the right, sketch the direction of the current induced in your Loop.



$\Delta t = 1/60\ s$

$\mathcal{E}mF = 0.08V$

$N = 1000$

a) $|\mathcal{E}mF| = \left|-N \frac{\Delta \Phi}{\Delta t}\right|$

$$\Delta\Phi = \frac{\mathcal{E}mF\,\Delta t}{N} = \frac{(0.08V)(1/60\,s)}{1000} = 1.333\times10^{-6}\ Wb$$

c) $\Phi = B\ A\cos\theta$ $\quad \Delta\Phi = (B_f - B_i)A\cos\theta = 2B_{avg}A$

$$B_{avg} = \frac{\Delta\Phi}{2A} = \frac{1.333\times10^{-6}\,Wb}{2\pi(0.05m)^2} = 8.5\times10^{-5}\,T$$

d) $I = ?$ $\quad B = \frac{\mu_0 I}{2\pi r}$ $\quad I = \frac{B\,2\pi r}{\mu_0}$

$$I = \frac{(8.5\times10^{-5}T)(2\pi)(10m)}{4\pi\times10^{-7}\ Tm/A}$$

$= 4250\ A$

e) $\otimes$ BA decreasing $\rightarrow$ $\otimes B_i$ $\quad I \quad$ CW