Test 3
PHN 242

Dr. Weppner
April 2004 - Review 2006

NAME ______________ SCORE____

Remember to get full credit label answers with correct units, show all work, draw diagrams.

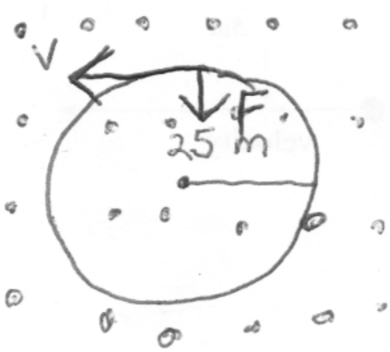
Useful constants and formulas: $\epsilon_0 = 8.85\times10^{-12}F/m$, $\frac{1}{4\pi\epsilon_0} = 8.99\times10^9 Nm^2/C^2$, $q_{electron} = -1.6\times10^{-19}C$, $mass_{electron} = 9.11\times10^{-31}kg$, $q_{proton} = +1.6\times10^{-19}C$, $mass_{proton} = 1.67\times10^{-27}kg$, $1ev = 1.6\times10^{-19}J$, $\mu_0 = 1.26\times10^{-6}H/m$, $B_{wire} = \frac{\mu_0 i}{2\pi r}$, $A_{circle} = \pi r^2$, $C_{circle} = 2\pi r$, $A_{triangle} = \frac{1}{2}bh$

1. [17 pts] We want to build an **electron** cyclotron (circular track) with a radius of 25.0m and a velocity of $2.0\times10^7 m/s$ (fast!).

(A) What is the magnitude of the $\vec{B}$ field needed to have this electron go around this circle (assume magnetic field is perpendicular to the velocity).

(B) Draw a possible version of this cyclotron. Give direction of magnetic field, electron velocity, and the force the electron feels.

left hand rule (electron!)



$$F = \frac{mv^2}{r} = qvB$$

$$\text{so } B = \frac{mv}{qr}$$

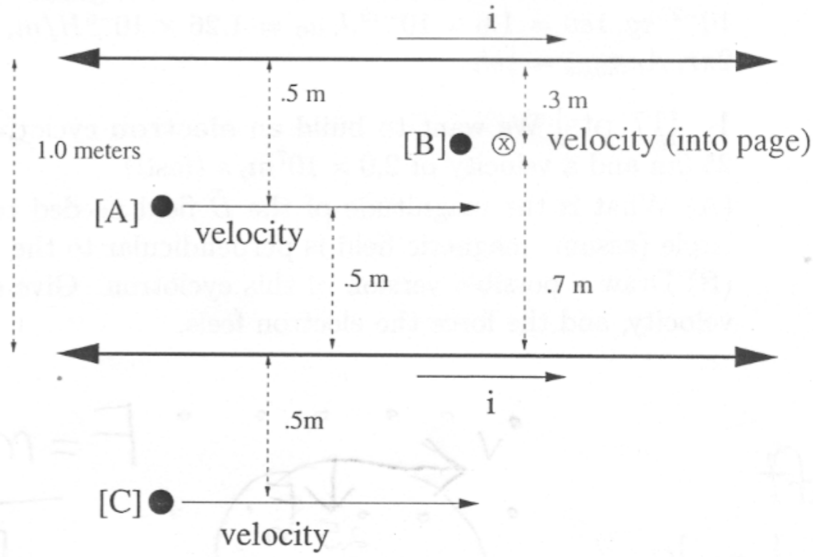
2. [20 pts] There are two wires 1 meter apart, both carrying 25 amps (see figure). A proton is traveling between the wires at a speed of $1.25 \times 10^7 m/s$. What is the force on the proton if moving in the direction of

(A) The velocity vector labeled A

(B) The velocity vector labeled B

(C) The velocity vector labeled C

HINT: Remember that each wire creates its own magnetic field which interacts with the proton.



(A) zero

$B_{TOT} = 0$

(B) zero

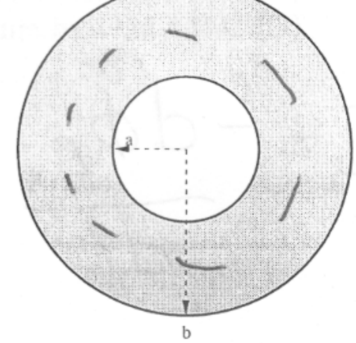
$B \parallel V$

C) $F = qvB$

$= qv(B_1 + B_2)$

$= qv\left(\frac{\mu_0 I}{2\pi(.5m)} + \frac{\mu_0 I}{(2\pi)(1.5m)}\right)$

3.[20 pts] The figure below shows a cross section of a hollow cylindrical conductor of inner radii a and outer radii b, carrying a uniformly distributed current i.
(A) Show that B(r) for the range $b < r < a$ is given by $B = \frac{\mu_0 i}{2\pi r}\frac{r^2-a^2}{b^2-a^2}$ (use Ampere's Law, show all work).
(B) Show that when $r = a$, this equation gives the magnetic field magnitude B for a long straight wire; and when r=b, it gives zero magnetic field.



$B 2\pi r = \mu_0 I_{enc}$

$I_{enc} = \frac{(r^2 - a^2)\pi}{(b^2 - a^2)\pi} \left(\frac{part}{whole}\right) i$

$= \frac{r^2 - a^2}{b^2 - a^2} i$

so $B = \frac{\mu_0 i}{2\pi r} \left(\frac{r^2 - a^2}{b^2 - a^2}\right)$

$r = a$ then $B = 0$ (no i enclosed)

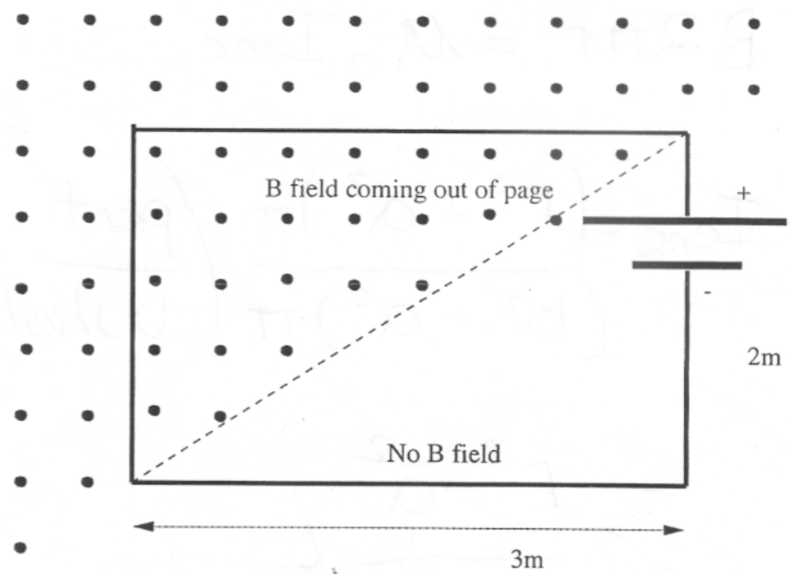
$r = b$ $B = \frac{\mu_0 i}{2\pi r}$ ✓ long straight wire

4.[15pts] A rectangular wire loop with a 2.00 m side and a 3.00 m side (see figure) is perpendicular to a uniform magnetic field, with only half the area of the loop in the field, as shown below. The loop contains a 12.0 V battery with no internal resistance. If the magnitude of the field varies with time according to $B = -.880t + .60$ (the magnetic field is decreasing over time) , with B in Tesla, t in seconds. Note that $\frac{dB}{dt} = -.880 Tesla/s$

(A) What is the induced emf in the circuit

(B) What is the direction of the induced emf?

(C) Is the induced current in the same direction as the current from the battery?



$\mathcal{E} = -\frac{d\phi_B}{dt}$

$= -A\frac{d}{dt}(B)$

$= \frac{(2.0m)(3.0m)}{2}(-.88 T/s) = 2.64V$

B) Compensate with more dots (field is decreasing)

dots would mean current CCW

C) Battery current is CCW also so $V_{Tot} = 14.64V$

5. [8 pts] Explain how pressurized steam created from burning coal, burning gas, and nuclear fuel can be transformed to electricity.

steam spins wheel (turbine) with magnets magnets spin by large coils which then carry induced currents

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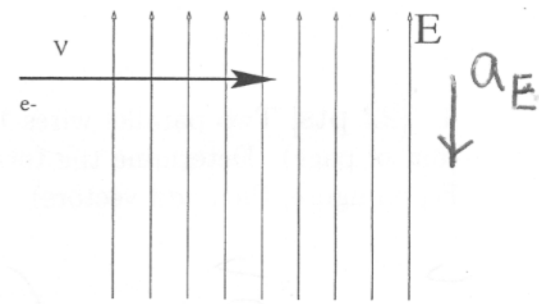
1. [15 pts] An electron enters a region of influence by an external E field as shown below. If we would like to keep the electron on the original straight line path we must add an external B field.

E field will cause Electron to accelerate down so a_B or (F_B) must be up



(A) In which direction must this external B field point (draw on figure). Give justification for choice. out of page (left hand rule) force must be up

(B) If the electric force on the electron is equal to and opposite the magnetic force, than what must $\frac{E}{B}$ be equal to? Show work.

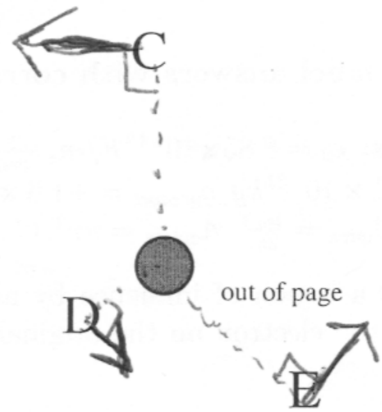
$qvB = qE$ so $\frac{E}{B} = v$ velocity!

2. [15pts] Protons in Fermi Lab in Illinois are magnetically steered clockwise around a 2km loop at a speed of $3.0\times10^8 m/s$ (around the world eight times a second!). What is the size and direction of the magnetic field needed to provide this steering. Draw a picture.

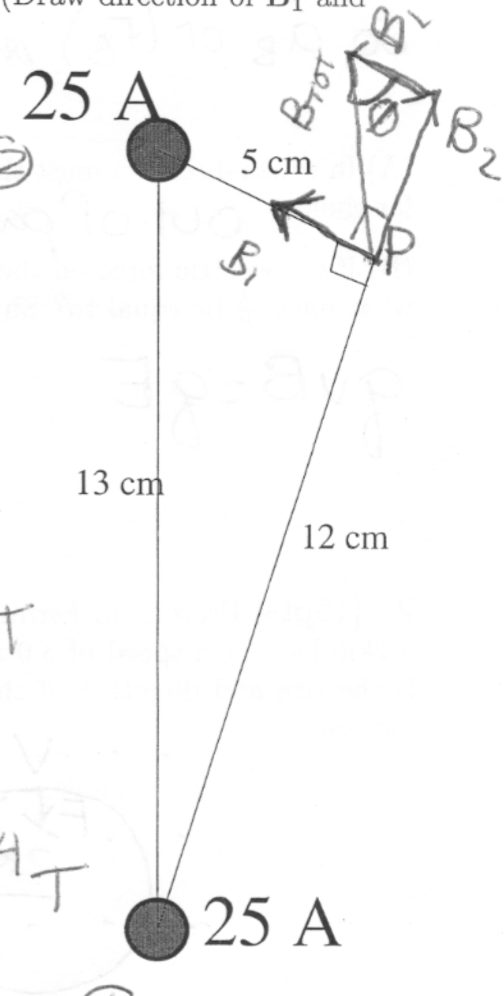
$\frac{mv^2}{r} = qvB$

so $B = \frac{mv}{qr}$

3. [12 pts] In the figure below a long straight wire carries current out of the page toward the viewer. Indicate, with appropriate arrows, the direction of **B** at points C, D, and E.



4. [22 pts] Two parallel wires 13.0cm apart carry 25 A currents in the same direction (out of page). Determine the total magnetic field at point P (Draw direction of $\mathbf{B_1}$ and $\mathbf{B_2}$ on figure, then add vectors).



$\vec{B}_1 + \vec{B}_2$ (they are ⊥)

$$B_1 = \frac{\mu_0 (25A)}{2\pi(.12cm)} = 4.17 \times 10^{-5} T$$

$$B_2 = \frac{\mu_0 (25A)}{2\pi(.05cm)} = 1.0 \times 10^{-4} T$$

$$B_{TOT} = \sqrt{B_1^2 + B_2^2} = 1.2 \times 10^{-4} T$$

$$\theta = \tan^{-1} \frac{1 \times 10^{-4} T}{.417 \times 10^{-4} T}$$

$$= 67°$$