PHYSICS 231 – TEST # 3

NAME:

STUDENT ID #:

USEFUL CONSTANTS

$$\epsilon_0 = 8.85 \times 10^{-12} C^2/(N \cdot m^2)$$

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

$$m_e = 9.1 \times 10^{-31} kg$$

$$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$$

USEFUL FORMULAS

Magnetic force

on point charge: $\vec{F} = q\vec{v} \times \vec{B}$
on wire: $\vec{F} = I \int d\vec{l} \times \vec{B}$
Magnetic flux through closed surface:

$$\Phi_B = \int \vec{B} \cdot d\vec{A} = 0$$

In a constant magnetic field a particle moves on circle of radius

$$R = \frac{mv}{|q|B}$$

Current loop:

force: $\vec{F} = \vec{0}$.
torque: $\vec{\tau} = \vec{\mu} \times \vec{B}$, $\vec{\mu} = I\vec{A}$.
energy: $U = -\vec{\mu} \cdot \vec{B}$.

Magnetic field

due to point charge:

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \vec{r}}{r^3}$$

due to wire (Biot-Savart law):

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l} \times \vec{r}}{r^3}$$

Ampère's law:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$$

outside infinite straight wire:

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

on axis of circular wire of radius a:

$$B_x = \frac{\mu_0 I a^2}{2(x^2 + a^2)^{3/2}}$$

at center of N circular loops:

$$B_x = \frac{\mu_0 N I}{2a}$$

inside solenoid: $B = \mu_0 n I$

Emf

in closed loop (Faraday's law):

$$\mathcal{E} = \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$

in moving loop: $\mathcal{E} = \oint (\vec{v} \times \vec{B}) \cdot d\vec{l}$
in uniform $\vec{B} \perp \vec{L} \perp \vec{v}$, $\mathcal{E} = vBL$

There are four (4) problems in this test. Make sure you answer all questions in each problem for full credit. Show as much of your work as possible to receive partial credit, in case you don't come up with the right answer. Good luck!

George Siopsis - 4/11/06

Problem 1

(a) A proton is being accelerated in a cyclotron. If the energy of the proton is doubled, by what factor does the radius of the circular path change?

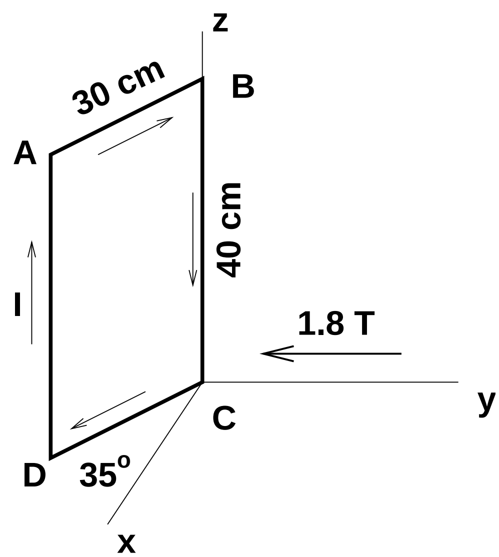
(b) A current was sent through a helical coil spring. The spring contracted, as though it had been compressed. Why?

Problem 2

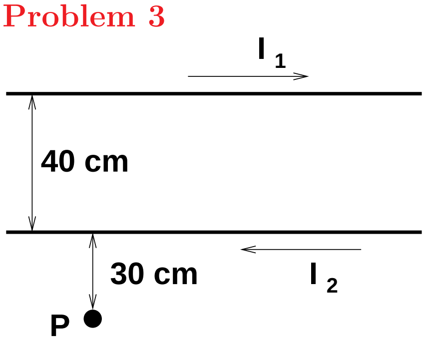
A 30 cm $\times$ 40 cm rectangular loop carries a current $I = 2.5$ A, as shown. Segment CD is in the xy-plane and forms a 35^o angle with the x-axis, as shown. The loop is inside a uniform external magnetic field of magnitude 1.8 T in the negative y-direction.

(a) Calculate the magnitude of the flux of the external magnetic field through the loop.

(b) Find the magnitude and direction of the force on segment BC due to the external magnetic field.



Problem 3



Two long straight wires are separated by 40 cm. The currents are $I_1 = 4$ A and $I_2 = 5$ A directed as shown.

(a) What is the magnitude and direction of the magnetic field at the point P which is a distance 30 cm below the lower wire?

(b) What is the magnitude and direction of the force on a 2.5 m long segment of the upper wire?

Problem 4

A uniform magnetic field of magnitude $B = 1.5$ T is directed into the plane of the paper in the region bounded by the dashed line, as shown. Outside this region the magnetic field is zero. A rectangular loop 20 cm $\times$ 60 cm and of resistance 3.5 Ω is being pulled into the magnetic field at a constant speed $v = 4.5$ m/s by an external force, as shown.

(a) Calculate the induced emf and current in the loop.

(b) Calculate the magnitude of the external force F_{ext} required to move the loop at constant speed.