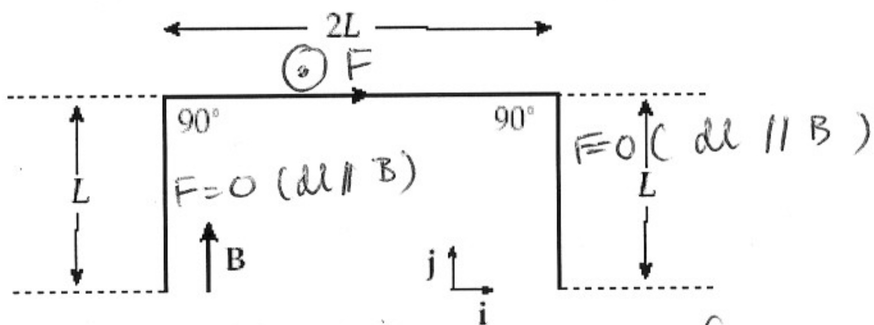
PHYS 232 Exam #2
04-01-05
50 minutes.

This quiz has 8 questions. Please show all your work. For multiple choice questions, circle the correct answer. If your chosen answer is not correct, you will get partial credit based on your work shown. You are allowed to have one hand-written, one-sided page of equations.

There are six short questions, each worth 7 points, in part I, and there are two long questions each worth 29 points in part II.

PART I

1. A straight wire is bent into the shape shown. Determine the net magnetic force on the wire when the current I travels in the direction shown in the magnetic field **B**.



a. $2IBL$ in the $-z$ direction
(b.) $2IBL$ in the $+z$ direction
c. $4IBL$ in the $+z$ direction
d. $4IBL$ in the $-z$ direction
e. zero

$F = I \cdot \int d\ell \times B$
$= I \cdot 2L \cdot B$ out of the pag[e] $(+\hat{z})$

2. A deuteron is accelerated from rest through a 10-kV potential difference and then moves perpendicularly to a uniform magnetic field with $B = 1.6$ T. What is the radius of the resulting circular path? (deuteron: $m = 3.3 \times 10^{-27}$ kg, $q = 1.6 \times 10^{-19}$ C)

a. 19 mm
b. 16 mm
(c.) 13 mm
d. 10 mm
e. 9.0 mm

$R = \frac{mv}{qB}$; $\frac{1}{2}mv^2 = KE = qV$

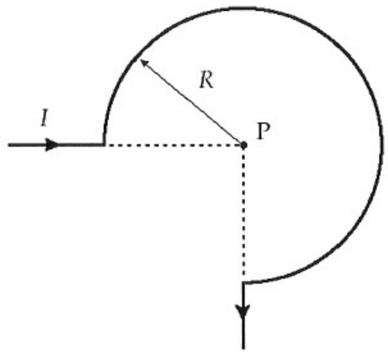
$v = \sqrt{\frac{2qV}{m}}$

$\therefore R = \frac{m}{qB} \cdot \sqrt{\frac{2qE}{m}}$

$= \frac{1}{B} \cdot \sqrt{\frac{2Em}{q}} = \frac{1}{1.6}\sqrt{\frac{2 \times 10^4 \times 3.3 \times 10^{-27}}{1.6 \times 10^{-19}}}$

$\simeq 1.3 \times 10^{-2}$ m $= 13$ mm

3. The segment of wire (total length = $6R$) is formed into the shape shown and carries a current I. What is the magnitude of the resulting magnetic field at the point P?



a. $\frac{3\mu_0 I}{8R}$

b. $\frac{3\mu_0 I}{2R}$

c. $\frac{3\mu_0 I}{4R}$

d. $\frac{3\mu_0 I}{2R}$

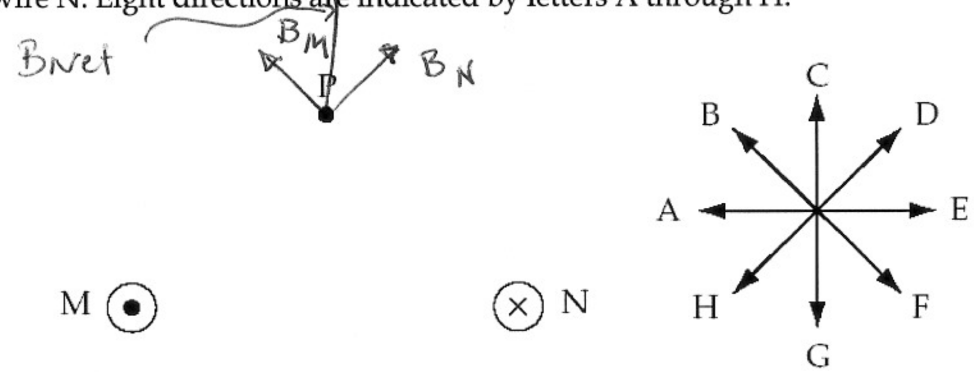
e. $\frac{3\mu_0 \pi I}{8R}$

B field at the center of a full circle ; $B = \frac{\mu_0 I}{2R}$

what we have is $\frac{3}{4}$ of a circle

$\Rightarrow B = \frac{3}{4} \frac{\mu_0 I}{2R} = \frac{3\mu_0 I}{8R}$

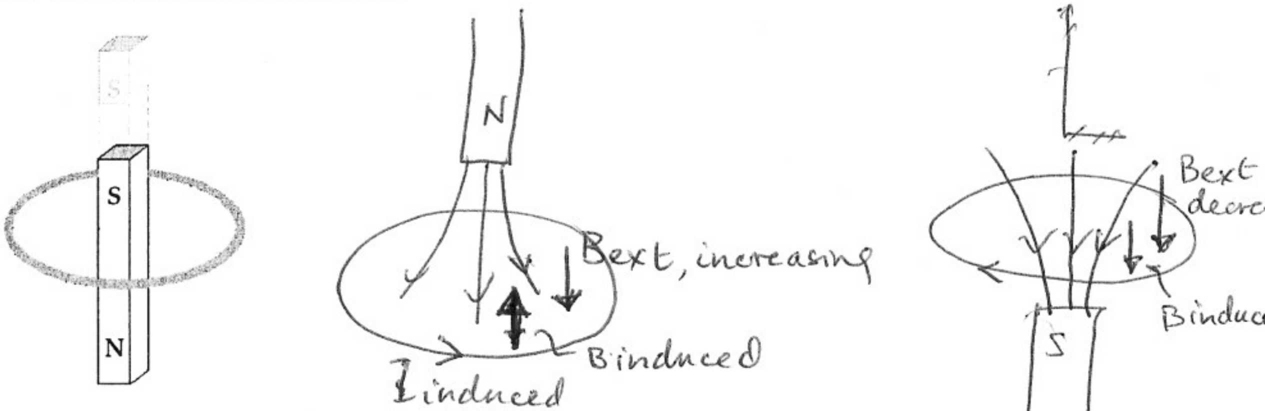
4. Equal currents of magnitude I travel out of the page in wire M and into the page in wire N. Eight directions are indicated by letters A through H.



The direction of the magnetic field at point P is

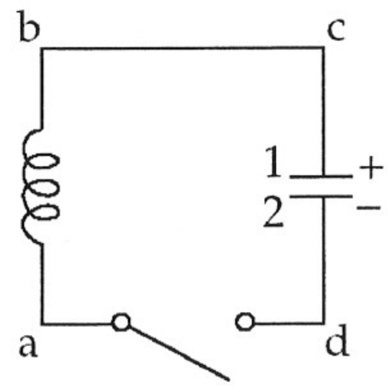
a. A.
b. B.
c. C.
d. D.
e. E.

5. A bar magnet is dropped from above and falls through the loop of wire shown below. The north pole of the bar magnet points downward towards the page as it falls. Which statement is correct?



a. The current in the loop always flows in a clockwise direction.
b. The current in the loop always flows in a counterclockwise direction.
c. The current in the loop flows first in a clockwise, then in a counterclockwise direction.
(d.) The current in the loop flows first in a counterclockwise, then in a clockwise direction.
e. No current flows in the loop because both ends of the magnet move through the loop.

6. A 10-μF capacitor in an LC circuit made entirely of superconducting materials ($R = 0\,\Omega$) is charged to 100 μC. Then a superconducting switch is closed. At $t = 0$ s, plate 1 is positively charged and plate 2 is negatively charged. At a later time, $V_{ab} = +10V$. At that time, V_{dc} is



at any time

$\Delta V_L + \Delta V_C = 0$

$\Rightarrow \Delta V_L = -\Delta V_C$

or $|\Delta V_L| = |\Delta V_C|$

$\Rightarrow |V_{dc}| = |\Delta V_{ab}|$

$= 10V$

a. 0 V.
b. 3.54 V.
c. 5.0 V.
d. 7.07 V.
(e.) 10 V.

PART II

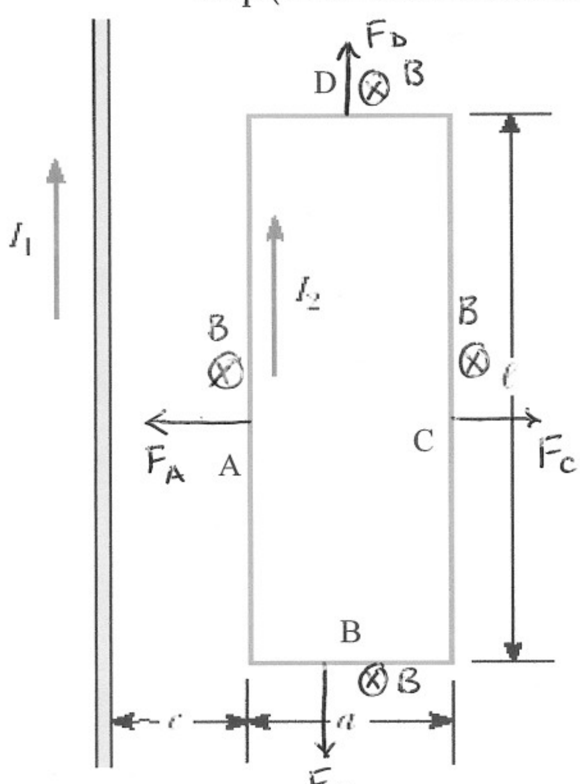
7. In the figure, the current in the long, straight wire is $I_1 = 1.00$ A, and the wire lies in the plane of the rectangular loop, which carries the current $I_2 = 2.0$ A. The dimensions are $c = 0.100$ m, $a = 0.150$ m, and $\ell = 0.50$ m.

   a. Indicate the direction of the magnetic field due to current I_1, at the locations of the four sides of the conducting loop (with arrows, arrow heads, or arrow backs) (7)

   b. Calculate the magnitude of the magnetic field due to I_1 at the sides A and C using Ampère's law. (7)

   c. Indicate the direction of the force due to I_1 exerted on each side of the loop (with arrows, arrow heads, or arrow backs) and calculate magnitude and direction of the net force exerted on the loop. (8)

   d. Now consider the situation where the loop is slowly turned around its long axis by 90°, so that sides A and C are equidistant from the long wire. Describe the forces, the net force and the torque on the loop (no calculations are necessary). (7)



(b) $B = \frac{\mu_0 I}{2\pi R}$

∴ at side (A) $B_A = \frac{\mu_0 I}{2\pi c}$

$= 2\times10^{-6}$

at side (C) $B_c = \frac{\mu_0 I}{2\pi(a+c)}$

$= 8\times10^{-7}$

(c) $|F_D| = |F_B|$, cancel each other

$F_A = I_2 \int d\vec{l} \times \vec{B}$

Since B is the same all along section A, and $B \perp dl$

$F_A = I_2 . l . B_A$ (to the left)

Problem #7 part c continued.

Similarly $F_c = I_2 l B_c$ (to the right)

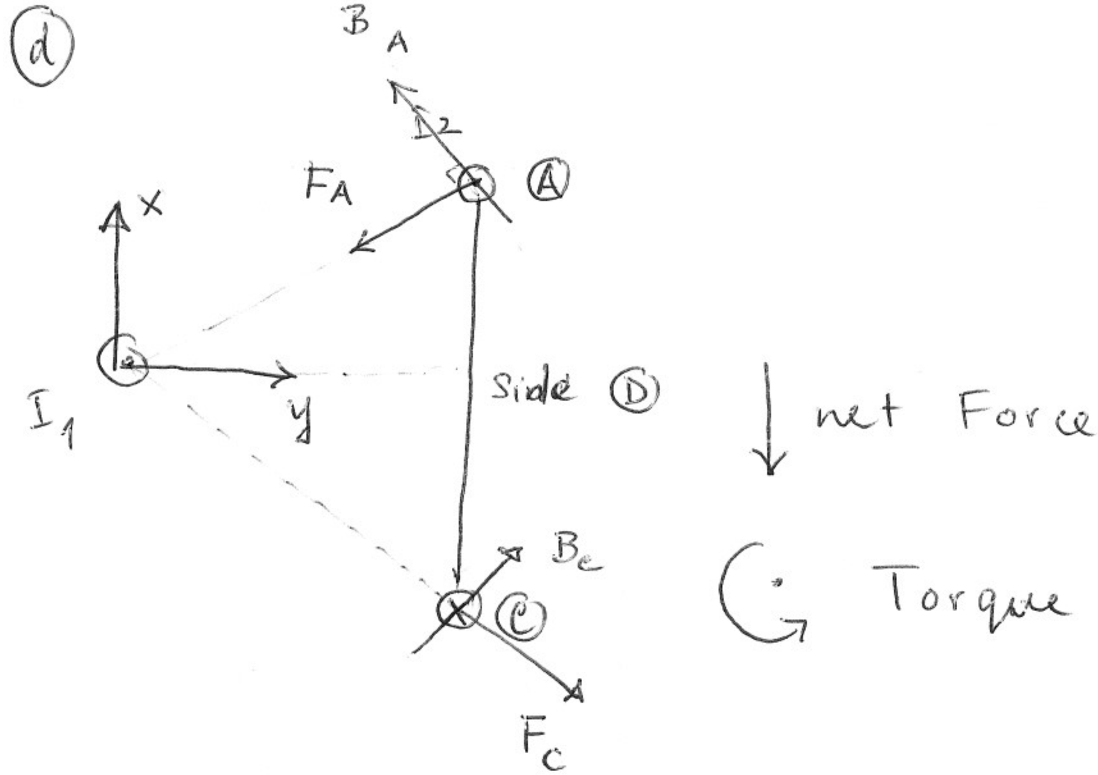
$\therefore$ Net force on the loop

$F = F_A - F_c = I_2 l (B_A - B_c)$

$= 2 \times 0.5 \times 1.2 \times 10^{-6}$

$= 1.2 \times 10^{-6}$ N to the left.

(d)



The two y componets of the forces cancell.

But the two x components add.

$\Rightarrow$ Net force in the $-x$ direction.

A torque in the ccw direction.

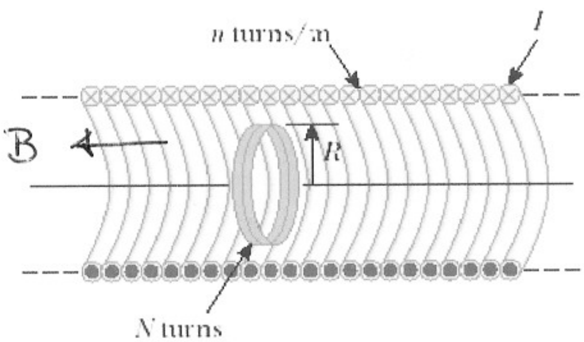
8. A long solenoid has 5000 turns per meter and has a radius of 10.0 cm. It carries a current given by $I=(1.0 + 100t)$A , where t is time measured in seconds. Inside the solenoid and coaxial with it is a coil that has a radius of 6.00 cm and consists of a total of 250 turns of fine wire.

(7) a. Calculate the magnetic field inside the solenoid at t=0.

(8) b. Calculate the emf induced in the coil by the changing current.

(7) c. As indicated in the figure, the current in the solenoid flows in the clockwise direction, what is the direction of the current induced in the coil (CW or CCW)? Explain how you arrived at your answer.

(7) d. The maximum current is reached in 2 seconds, after that the current in the solenoid decreases as given by $I=(I_{max} - 100t)$A; the direction of this current is still clockwise. What is the direction of the current induced in the coil now (CW or CCW)? Explain how you arrived at your answer.



(a) $B = \mu_0 n I(t)$

at t=0

$B = 4\pi \times 10^{-7} \times 5000 \times 1$ T

$\simeq 6.3 \times 10^{-3}$ T $= 6.3$ mT to the left

(b) $\mathcal{E}mf = -N \dfrac{d\phi_B}{dt}$

$\phi_B = \int \vec{B} \cdot d\vec{A}$;

over the surface of the coil

Since $B \parallel d\vec{A}$, B is uniform

$\phi_B = B \cdot A_{coil} = 10^{-3} \times 6.3\,(1 + 100t) \cdot \pi (.06)^2$

$\qquad = \left(6.3(1 + 100t) \cdot \pi (0.06)^2\right) \times 10^{-3}$

$\therefore |\mathcal{E}mf| = 250 \cdot \dfrac{d}{dt}\left(6.3(1+100t) \cdot \pi (0.06)^2\right) \times 10^{-3}$

$= 250 \times 6.3 \times 100 \times \pi \times (0.06)^2 \times 10^{-3} = 1.78$ V

Problem #8 continued.

(c) Magnetic flux through the coil is to the left increasing. Need to induce flux to the right (Lenz) ⇒ Induced current

CCW.

(d) Magnetic flux is to the left But decreasing. ⇒ Need induced flux to the left (Lenz) ⇒ Induced current

CW.