Physics 2145 Spring 2022 Test 3 (4 pages)

Name: Solution **April 20, 2022** **Total Score:** 120 **/120**

$\vec{F} = q\vec{E}$ $\quad \Delta V = Ed$ $\quad$ electron $m_e = 9.11 \times 10^{-31}$ kg $\quad e = 1.602 \times 10^{-19}$ C $\quad \mu_0 = 4\pi\times10^{-7}$Tm/A

$F = qvB\sin\theta$ $\quad F = ILB\sin\theta$ $\quad B = \frac{\mu_o I}{2\pi r}$ $\quad B = \frac{\mu_o I}{2R}$ $\quad B = \frac{\mu_o N I}{L}$ $\quad \tau = IAB\sin\theta$

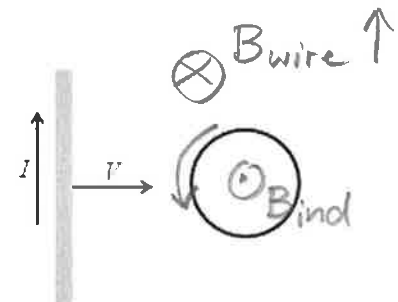
$\Phi = AB\cos\theta$ $\quad \varepsilon = \left|\frac{\Delta\Phi}{\Delta t}\right|$ $\quad V = IR$ $\quad P = IV = \frac{V^2}{R} = I^2R$ $\quad a_c = \frac{v^2}{R}$

C 1. (5) If you were to cut a small permanent bar magnet in half,
A) one piece would be a magnetic north pole and the other piece would be a south pole.
B) neither piece would be magnetic.
C) each piece would in itself be a smaller bar magnet with both north and south poles.
D) one half would have positive charge, the other would have negative charge.

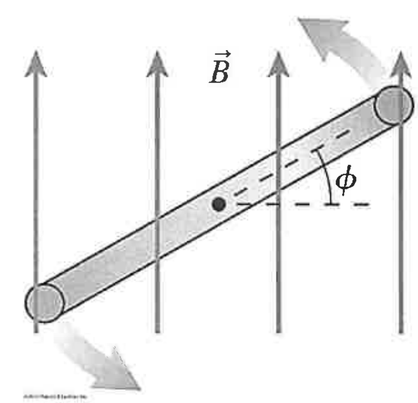
A 2.(5). A long solenoid of length L, N windings, and a certain radius carries a current. If the radius of the solenoid were doubled and all other quantities remained the same, the magnetic field magnitude would

A) remain the same B) double C) halve D) decrease by a factor of 4

D 3. (5) A wire carrying a constant current I is moved toward a conducting loop with speed V as shown. The direction of the induced current in the loop is
A) clockwise
B) out of the page
C) there is no induced current
D) counterclockwise



A 4. (5) A circular current loop rotates about an axle through its center. The figure shows a side view. The loop is in an external magnetic field that points towards the top of the page. Which of the following is **false**?
A) At angle Φ =0 the magnetic flux is zero and the torque is maximum.
B) At angle Φ =0 the magnetic flux is maximum and the torque is zero.
C) At angle Φ =90° the magnetic flux is zero and the torque is maximum.
D) The net force on the current loop is zero for any angle Φ.



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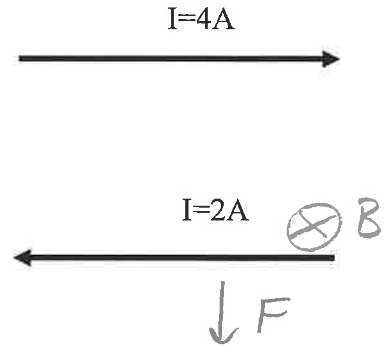
5. (30) Two parallel straight wires of length 40cm are 0.5cm apart. The upper wire carries a current of 4.0A to the right. The lower wire carries a current of 2.0 A to the left, as shown in the figure.



a) (10) Calculate the magnitude of the magnetic field of the upper wire at the location of the lower wire.

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

$$B = \frac{4\pi \times 10^{-7}\,\frac{Tm}{A} \cdot 4A}{2\pi \cdot (0.5 \times 10^{-2} m)} = 1.6 \times 10^{-4}\,T$$

b) (5) What is the direction of the magnetic field of the upper wire at the location of the lower wire?

$\otimes$ into the page

c) (10) Calculate the magnitude of the force the upper wire exerts on the lower wire.

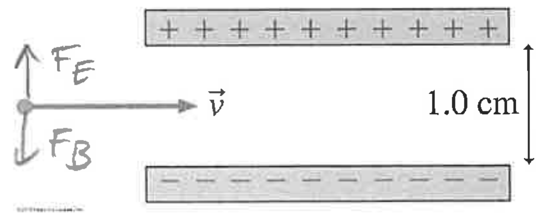
$$F = ILB = 2A \cdot 0.4m \cdot 1.6 \times 10^{-4}\,T = 1.28 \times 10^{-4}\,N$$

d) (5) What is the direction of the force the upper wire exerts on the lower wire?

$\downarrow$

30/30 points for this page

6. (15) An electron travels with speed 2×10^7 m/s between the two parallel charged plates shown in the figure. The plates are a distance 1.0cm apart and are charged to some potential difference. A magnetic field of magnitude 3 mT is directed perpendicular to the electron's motion and perpendicular to the direction of the electric field.



a) (10) Derive a symbolic expression and calculate a numerical answer for the potential difference between the plates for which the electron emerges undeflected.

$$F_E = F_B$$
$$|q|E = |q|vB$$
$$E = vB$$
$$\Delta V = Ed$$
$$\frac{\Delta V}{d} = vB$$
$$\boxed{\Delta V = vBd}$$
$$\Delta V = 2\times10^{+7}\,\tfrac{m}{s}\cdot 3\times10^{-3}\,T\cdot 10^{-2}\,m$$
$$\boxed{\Delta V = 600\,V}$$

b) (5) What is the direction of the magnetic field that allows the electron to pass undeflected?

Circle one: → ← ↑ ↓ ⊗ ⊙

7. (15) ~~An ion~~ particle with charge +e and speed of $v = 1.5\times10^5$ m/s is **moving to the left.** It enters a region of uniform magnetic field $B_1 = 2$ T directed **out of the page** which causes it to move in a circle of radius $2\text{x}10^{-6}$ m

a) (10) Derive a symbolic expression and calculate a numerical value for the mass of the ion.

$$\Sigma F_x = ma_x$$
$$q\cancel{v}B = m\frac{v^{\cancel{2}}}{r}$$
$$\boxed{m = \frac{qBr}{v} = \frac{eBr}{v}}$$

$\overleftarrow{v}$

⊙ B

$$m = \frac{1.6\times10^{-19}\,C\cdot 2T\cdot 2\times10^{-6}\,m}{1.5\times10^{5}\,m/s}$$
$$m = 4.3\times10^{-30}\,kg$$

b) (5) What is the initial deflection of the ion in part a?

Circle one: → ← ↑ ↓ ⊗ ⊙

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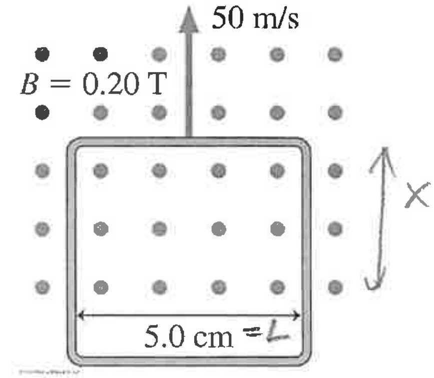
8. (20) The loop in the figure is being pushed into a 0.20 T magnetic field at 50m/s.



a)(5) What is the direction of the induced current? Circle the correct answer.

Clockwise   Counter- clockwise

b) (15) Calculate the induced emf. Begin with Faraday's law and show all work.

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \frac{\Delta(AB\cos 0^\circ)}{\Delta t} = B\frac{\Delta A}{\Delta t}$$

$$\mathcal{E} = B\frac{\Delta(Lx)}{\Delta t} = BL\frac{\Delta x}{\Delta t} = BLv$$

$$\mathcal{E} = 0.2T \cdot 5\times10^{-2}m \cdot 50\frac{m}{s} = 0.5\,V$$

9.(20) A circular loop of 10cm diameter with a resistance of 0.1Ω is in a magnetic field that points **out of the page**. The induced current is counterclockwise and has a magnitude of 40mA.

a) (5) Calculate the induced emf.

$$\mathcal{E} = IR = 40\times10^{-3}A \cdot 0.1\Omega = 4\,mV$$

B

I_{ind}

B_{ind} ⊙

a) (5) Is the magnetic field increasing or decreasing?

b) (10) Find the rate of change of the magnetic field, ΔB/ Δt.

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \left|\frac{\Delta(AB\cos 0)}{\Delta t}\right| = A\left|\frac{\Delta B}{\Delta t}\right|$$

$$\frac{\Delta B}{\Delta t} = -\frac{\mathcal{E}}{A} = -\frac{4mV}{\pi(0.05m)^2} = -0.51\,\frac{T}{s}$$

40 /40 points for this page