Physics 2145 Spring 2023 Test 3 (4 pages)

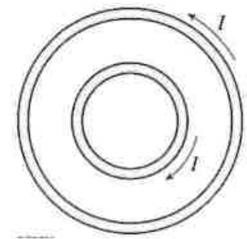
Name: Solution **April 20, 2023** **Total Score:** 120 **/120**

$\vec{F} = q\vec{E}$ $\quad \Delta V = Ed \quad$ electron $m_e = 9.11 \times 10^{-31}$ kg $\quad e = 1.602 \times 10^{-19}$ C

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

$\Phi = AB\cos\theta \quad \varepsilon = \left|\frac{\Delta\Phi}{\Delta t}\right| \quad V = IR \quad a_c = \frac{v^2}{R} \quad \mu_0 = 4\pi\times10^{-7}$ Tm/A

A 1. (5) One current **loop** is placed inside another current loop with twice the radius. Each loop carries the same current, but in opposite directions, as shown in the figure: the current in the big loop is counter-clockwise, the current in the small loop is clockwise. The magnetic field at the center is

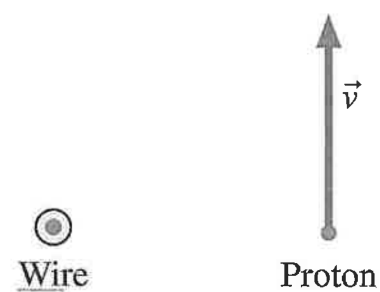


A) into the page B) zero C) out of the page D) clockwise

B 2. (5) A solenoid with radius *R* carries a current *I*. The magnetic field at a point inside the solenoid, a perpendicular distance *r* from the solenoid axis, depends on

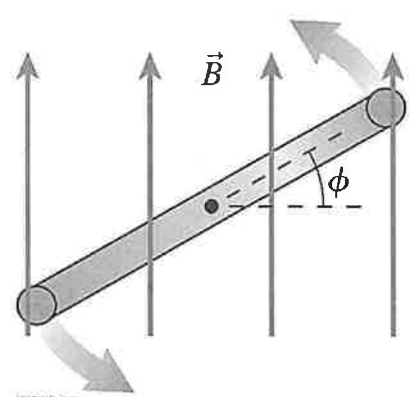
A) *I*, *R*, and *r* B) *I*, but not *R* or *r* C) *I* and *r*, but not *R* D) *I* and *R*, but not *r*

A 3. (5) A proton is moving with speed *v* close to a wire which is carrying a current directed out of the page, as shown in the figure. The force on the proton is
A) zero B) to the right C) into the page D) to the left



C 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 true?

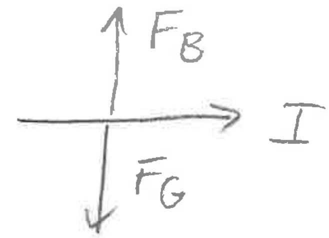
A) At angle Φ =0 the magnetic flux is zero and the torque is maximum.
B) At angle Φ =0 the magnetic flux is zero and the torque is zero.
C) At angle Φ =90° the magnetic flux is zero and the torque is maximum.
D) At angle Φ =90° the magnetic flux is maximum and the torque is zero.



20/20 points for this page

6. (15 pts) A horizontal wire of mass 1.0g and length 40cm is carrying a current of 4.0 A **to the right**. It is under the influence of a constant magnetic field so that the wire is levitating (i.e. the magnetic field prevents the wire from falling down.)

a) (5) What is the direction of the external magnetic **field**?



$\otimes$ into the page

b) (10) Calculate the magnetic field strength of this constant field.

$$F_B = F_G$$

$$ILB = mg$$

$$B = \frac{mg}{IL} = \frac{10^{-3}\,kg \cdot 9.8\,\frac{m}{s^2}}{4A \cdot 0.4m} = 6.1\,mT$$

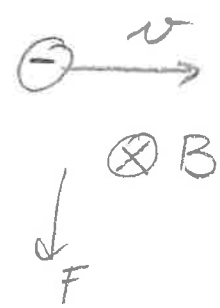
7) (15 pts) An electron with speed of $v = 2\times10^7$ m/s **moving to the right** enters a region of uniform magnetic field $B_1 = 1.5$ T **directed into of the page.**

a) (10)Derive a symbolic expression and calculate a numerical value for the radius of the orbit of the electrons.

$$\Sigma F_r = ma_r$$

$$|q| v B = m \frac{v^2}{r}$$

$$\boxed{r = \frac{mv}{eB}}$$



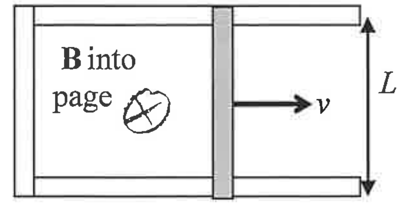
$$r = \frac{9\times10^{-31}\,kg \cdot 2\times10^{7}\,\frac{m}{s}}{1.6\times10^{-19}\,C \cdot 1.5T} = 7.5\times10^{-5}\,m$$

b)(5) What is the direction of the initial deflection of the electron? Circle the correct answer.

Up Down Left Right Into page Out of page

30/30 points for this page

8. (20) A conducting bar of length L= 20 cm moves on conducting rails at speed v= 10m/s to the right in a uniform magnetic field of magnitude B= 0.5T which is directed into the page.



a)(5) In which direction is the induced current?

Counter - clockwise

b) (10) Calculate the induced emf.

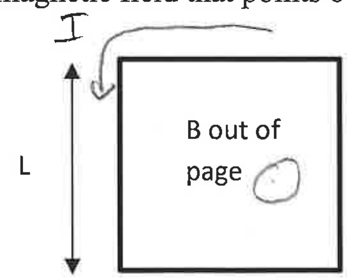
$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \frac{B\,\Delta A}{\Delta t} = BLv$$

$$\mathcal{E} = 0.5T \cdot 0.2m \cdot 10\,m/s = 1V$$

c) (5) What is the direction of the force the magnetic field exerts on the bar?

$\leftarrow$ to the left

9. (20) A square loop of side length L=5 cm has a resistance of 0.2 Ω. It is in a magnetic field that points **out** of the page. The induced current is I= 0.5 A in the **counterclockwise** direction.



a) (5) Calculate the induced emf.

$$\mathcal{E} = IR = 0.5A \cdot 0.2\Omega = 0.1V$$

b) (5) Is the magnetic field strength increasing or $\boxed{\text{decreasing?}}$

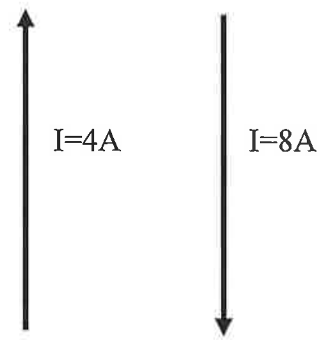
decreasing

c) (10) Find the change in magnetic field, ΔB, during a time of 5 ms.

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \frac{\Delta(BA)}{\Delta t} = A\frac{\Delta B}{\Delta t} = L^2\frac{\Delta B}{\Delta t}$$

$$\Delta B = \frac{\mathcal{E}\,\Delta t}{L^2} = \frac{0.1V \cdot 5\times10^{-3}s}{(0.05m)^2} = 0.2T$$

40 /40 points for this page



5. (30) Two parallel straight wires of length 50cm are 4mm apart. The left wire carries a current of 8.0A toward the top of the page. The right wire carries a current of 4.0 A toward the bottom of the page, as shown in the figure (not to scale).

a) (10) Calculate the magnitude of the magnetic field of the left wire at the location of the right wire.

$$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\cdot 10^{-7}\,\frac{Tm}{A}\cdot 4A}{2\pi\cdot 4\times 10^{-3}\,m} = 2\times 10^{-4}\,T$$

b) (5) What is the direction of the magnetic field of the left wire at the location of the right wire?

$\otimes$ into the page

c) (10) Calculate the magnitude of the force the left wire exerts on the right wire.

$$F = ILB\underbrace{\sin 90^\circ}_{1} = 8A\cdot 0.5m\cdot 2\times 10^{-4}\,T$$

$$F = 8\times 10^{-4}\,N$$

d) (5) What is the direction of the force the left wire exerts on the right wire?

$\longrightarrow$ to the right

30 /30 points for this page