Physics 2145 Spring 2019 Test 3 (4 pages)

Name: Solution **April 24, 2019** **Total Score:** 120 **/120**

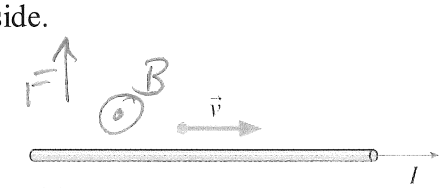
$\vec{F} = q\vec{E}$ $\Delta V = Ed$ electron $m_e = 9.11 \times 10^{-31}$ kg $e = 1.602 \times 10^{-19}$ C $\mu_0 = 4\pi\times10^{-7}$Tm/A

$F = qvB\sin\theta$ $F = ILB\sin\theta$ $B = \frac{\mu_0 I}{2\pi r}$ $B = \frac{\mu_0 I}{2R}$ $B = \frac{\mu_0 N I}{L}$ $\tau = IAB\sin\theta$

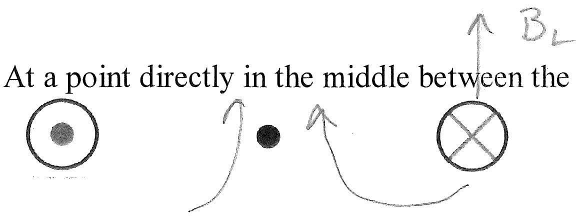
$\Phi = AB\cos\theta$ $\varepsilon = \left|\frac{\Delta\Phi}{\Delta t}\right|$ $V = IR$ $P = IV = \frac{V^2}{R} = I^2R$ $a_c = \frac{v^2}{R}$

A 1.(5)___ Which of the following statements is **TRUE**?
A) The net force on a current loop in a uniform magnetic field is zero.
B) The magnetic field of a solenoid depends on the soldenoid radius.
C) The net force on a current loop in a uniform magnetic field depends on the angle between the loop axis and the magnetic field.
D) The magnetic field of a solenoid is larger on the outside than on the inside.

A 2. (5) An electron is moving with velocity v parallel to a long wire which carries current I to the right. The force on the electron is
A) up (away from the wire) B) to the right
C) down (towards the wire) D) out of the page

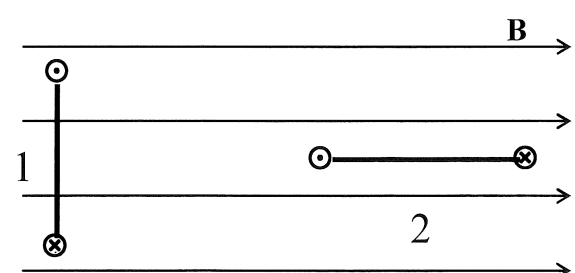


A 3. (5) Two wires carry equal and opposite currents as shown. At a point directly in the middle between the two wires, the net magnetic field is directed
A) up (towards top of page) B) left
C) down (towards bottom of page) D) the field is zero.



D 4. (5) For the wires in problem 3: The force the left wire exerts on the right wire is directed
A) towards the top of the page B) to the left C) towards the bottom of the page D) to the right

B 5. (5) The diagram shows a side view of two current loops in a uniform magnetic field. The loops are identical and carry the same current. Which statement is true about magnetic flux and torque?
A) Loop 1 has zero flux and loop 2 has maximum torque.
B) Loop 1 has maximum flux and loop 2 has maximum torque.
C) Loop 2 has maximum flux and loop 1 has zero torque.
D) Loop 2 has zero flux and loop 1 has maximum torque.



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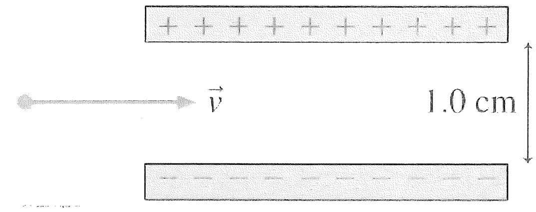
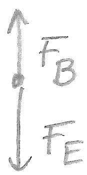
6. (20) A proton travels with speed 1.5×10^7 m/s between the two parallel charged plates shown in the figure. The plates are a distance 1.0cm apart and are charged to some potential difference. A magnetic field of magnitude 4×10^{-3} T is directed perpendicular to the ~~electron~~ proton's motion and perpendicular to the direction of the electric field.



a) (15) Derive a symbolic expression and calculate a numerical answer for the potential difference between the plates for which the ~~electrons~~ protons emerge undeflected.



$$q v B = q E$$

$$E = v B$$

$$\Delta V = E d \Rightarrow \boxed{\Delta V = v B d}$$

$$\Delta V = 1.5\times10^{7}\,\frac{m}{s}\cdot 4\times10^{-3}\,T\cdot 0.01\,m = 600\,V$$

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

Circle one: → ← ↑ ↓ ⊗ ⊙

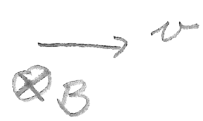
7. a) (15) Electrons with speed of $v = 1.5\times10^7$ m/s are **moving to the right** and then enter a region of uniform magnetic field $B_1 = 2$ T **directed into the page.**
Derive a symbolic expression and calculate a numerical value for the radius of the orbit of the electrons.

$$\Sigma F_x = m a_x$$

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

$$r = \frac{mv}{eB} = \frac{9.11\times10^{-31}\,kg\cdot 1.5\times10^{7}\,\frac{m}{s}}{1.6\times10^{-19}\,C\cdot 2T} = 4.3\times10^{-5}\,m$$

b) (5) What is the initial deflection of the electrons in part c?



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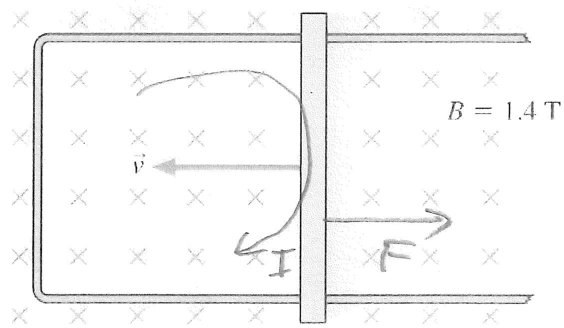
8. (30) The figure shows a 40 cm long metal rod pulled along two frictionless conducting rails at constant speed of 2 m/s. The rails have negligible resistance and rod has a resistance of 2 Ω.



a) (10) Calculate the current induced in the rod.

$$\mathcal{E} = \left|\frac{\Delta\phi}{\Delta t}\right| = \frac{\Delta(AB)}{\Delta t} = B\frac{\Delta x}{\Delta t}L = BvL$$

$$I = \frac{\mathcal{E}}{R} = \frac{BvL}{R}$$

$$I = \frac{1.4T \cdot 2\,m/s \cdot 0.4m}{2\Omega} = 0.56A$$

b) (5) What is the direction of the current? Circle the correct answer

clockwise   counter clockwise

c)(5) Calculate the force the magnetic field exerts on the rod.

$$F = ILB$$

$$F = 0.56A \cdot 0.4m \cdot 1.4T = 0.31N$$

d) (5) What is the direction of the force the magnetic field exerts on the rod?

Circle one: → ← ↑ ↓ ⊗ ⊙

e) (5) Calculate the power dissipated in the rod.

$$P = I^2R = (0.56A)^2 \cdot 2\Omega = 0.63W$$

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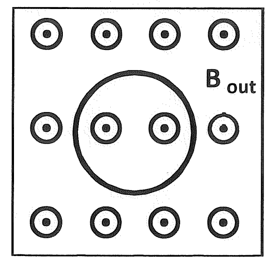
8. (25) A circular loop of 4 cm radius with a resistance of 2Ω is in a magnetic field that points out of the page, as shown in the figure. The magnitude of the magnetic field is increasing from 0T to 0.4T in one millisecond.



a) (5) What is the direction of the induced current?

Clockwise

b) (10) Calculcate the induced emf.

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \left|\frac{\Delta(AB)}{\Delta t}\right| = \frac{\pi r^2 \Delta B}{\Delta t}$$

$$\mathcal{E} = \frac{\pi(0.04m)^2 \cdot (0.4T - 0)}{10^{-3}s} = 2V$$

c) (5) Calculate the induced current.

$$I = \frac{\mathcal{E}}{R} = \frac{2V}{2\Omega} = 1A$$

d) (5) Calculate the magnitude of the **induced** magnetic field at the center of the loop.

$$B = \frac{\mu_0 I}{2R} = 4\pi \times 10^{-7} \frac{Tm}{A} \cdot \frac{1A}{2 \cdot 4 \times 10^{-2} m} = 1.57 \times 10^{-5} T$$

25 /25 points for this page