

(using F = qvB)

(No EM magnetic field here)

AP E&M Unit 5 - Worksheet 2

56 p/10

1. A uniform magnetic field of 3.5 mT, points upward. An electron has a kinetic energy of 6.2 MeV and enters this field moving North to South.

- (a) Determine the magnitude and direction of the magnetic force acting on the electron.

- (b) Find the acceleration of the electron through the field.

$$\frac{1}{2}mv^2 = 6.2 \times 10^6 \text{ J}$$

$$v = 1.48 \times 10^8 \text{ m/s}$$

$$F_B = qvB = (1.6 \times 10^{-19}) (1.48 \times 10^8) (3.5 \times 10^{-3})$$

$$F_B = 8.38 \times 10^{-14} \text{ N. East}$$

$$F = ma$$

$$a = \frac{8.38 \times 10^{-14}}{9.11 \times 10^{-31}} = 9.1816 \text{ m/s}^2$$

2. A proton, with kinetic energy of 1.7 MeV, is circulating in a magnetic field of magnitude 0.7 mT.

- (a) Determine the radius of the proton's path.

- (b) Determine the period of revolution.

$$qvB = mv^2/r$$

$$r = \frac{mv}{qB} = \frac{(1.67 \times 10^{-27})(1.8 \times 10^7)}{(1.6 \times 10^{-19})(0.7 \times 10^{-3})} = 2.68 \text{ fm}$$

$$\frac{1}{2}(0.67 \times 10^{-27})(v^2) = 0.726 \times 1.6 \times 10^{-9}$$

$$\sqrt{v} = 1.729 \text{ m/s}$$

$$r = \frac{2\pi r}{2\pi} = \frac{2\pi (1.67 \times 10^{-27})}{1.6 \times 10^{-19} (0.7 \times 10^{-3})}$$

$$T = 9.48 \times 10^{-3} \text{ s}$$

3. A proton has a velocity given by  $v = (2.6 \times 10^5 \text{ m/s})\hat{i} + (3 \times 10^5 \text{ m/s})\hat{j} - (1.4 \times 10^5 \text{ m/s})\hat{k}$  enters a magnetic field given by  $B = (0.05 \text{ T})\hat{i} - (0.23 \text{ T})\hat{j} + (0.075 \text{ T})\hat{k}$ . Find the magnitude and direction of the force on the proton.

$$E = 1.6 \times 10^{-19}$$

$$F = qv \times B$$

$$\begin{aligned} & (2.6 \times 10^5)(-0.23) - (3 \times 10^5)(0.075) \\ & - (1.4 \times 10^5)(0.05) = 1.235 \times 10^{-15} \text{ N} \end{aligned}$$

$$\begin{aligned} & 2.6 \times 10^5 \times 1.6 \times 10^{-19} \\ & \hat{i} - 0.23 \times 10^5 \times 1.6 \times 10^{-19} \hat{j} \\ & - 0.05 \times 10^5 \times 1.6 \times 10^{-19} \hat{k} \end{aligned}$$

$$\begin{aligned} & 4.24 \times 10^{-15} - 3.73 \times 10^{-15} \hat{j} \\ & - 1.3 \times 10^{-15} \hat{k} \end{aligned}$$

4. An electron is accelerated from rest by a potential difference of 200 V. It enters perpendicular to a magnetic field of magnitude 0.87 mT.

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- (a) Calculate the speed of the electron.

- (b) Calculate the radius of its path once it enters the magnetic field.

$$\begin{aligned} & qV = \frac{1}{2}mv^2 \\ & (1.6 \times 10^{-19})(200) = \frac{1}{2}(9.11 \times 10^{-31}) v^2 \\ & v = 2.65 \times 10^6 \text{ m/s} \end{aligned}$$

$$\begin{aligned} & qV = \frac{1}{2}mv^2 \\ & (1.6 \times 10^{-19})(200) = \frac{1}{2}(9.11 \times 10^{-31})(2.65 \times 10^6)^2 \\ & r = 0.55 \text{ m} \end{aligned}$$

$$(1.6 \times 10^{-19})(200) = \frac{1}{2}(9.11 \times 10^{-31})v^2$$

$$2.65 \times 10^6 = v$$

$$r = (9.11 \times 10^{-31})(2.65 \times 10^6)$$

$$r = 0.017 \text{ m}$$

5. A horizontal wire carries a current of 15 Amps. Find the magnitude and direction of the magnetic field which would allow the wire to "float". Assume the wire had a mass of approximately 25 grams and was 32 cm long.



$$ALB = mg$$

$$B = \frac{(2.3 \times 10^{-3})(9.1 \times 10^3)}{(1.9)(32 \times 10^{-2})}$$

$$B = 0.017 \text{ T}$$

6. A flat horizontal rectangular loop of wire (xy plane) is positioned in a  $B$  field of magnitude 0.1T and pointing in the z-direction. If the rectangle, ABCD, has a current of 2.5 Amps moving in alphabetical order, determine the magnitude and direction of the force on each segment of the wire.

$$E \propto AB \quad F = qvB \quad v \ll c \quad (2.5)(1.2)(1.1) \quad F = 0.075N$$

$$AB = 20\text{cm} \quad BC = 30\text{cm}$$



7. The Bohr model depicts the hydrogen atom as an electron circulating around a proton in an orbit with radius of 0.0529 nm at a speed of  $2.2 \times 10^6$  m/s. Determine the orbital magnetic dipole moment of the electron (called the Bohr magneton).

$$r = 0.0529\text{nm} \quad v = 2.2 \times 10^6 \text{m/s} \quad M = NIA = (1) \left( \frac{e}{2\pi r} \right) (1.1 \times 10^{-2})$$

$$\mu = \frac{qvr}{2} = \frac{evr}{2\pi r} = \frac{ev}{2\pi} \quad \mu = \frac{evr}{2} = (1.6 \times 10^{-19})(2.2 \times 10^6)(0.0529 \times 10^{-9})$$

8. A current carrying, square loop, ABCD is hinged on side AB. The loop is of side 25cm and is wound 35 times. It carries a current of 0.45 Amps and is set up in a magnetic field of 0.92 T at a 20 degree angle with side AD. Calculate the torque acting on the loop about AB.



$$N = 35 \quad T = M \times B = MB \sin \theta$$

$$A = MSA$$

$$M = NIA$$

$$(35)(0.45)(0.25)^2$$

$$M = 0.984$$

$$(1.97)(0.92) \sin 20^\circ$$

$$T = 1.851 \text{ N.m}$$

9. A rectangular coil of 3.5 cm in length and 1.4 cm wide is made to have 200 turns. It is into a magnetic field of magnitude 0.41 T, with the normal vector perpendicular to the field. If it carries 0.56 mA of current,
- What is the magnitude of the magnetic dipole moment.
  - What is the torque created?
  - If the magnetic dipole moment is lined up with the external magnetic field, how much work is required to turn the coil end to end?

$$A = (3.5 \times 10^{-2})(1.4 \times 10^{-2}) = 4.9 \times 10^{-4}$$

$$N = 200$$

$$B = 0.41\text{T}$$

$$I = 0.56\text{mA}$$

$$a) M = NIA$$

$$(200)(0.56 \times 10^{-3})(4.9 \times 10^{-4})$$

$$M = 5.52 \times 10^{-7}\text{ Am}^2$$

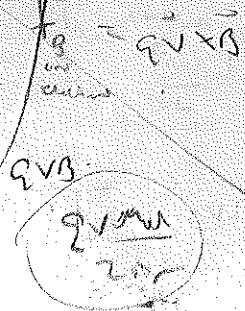
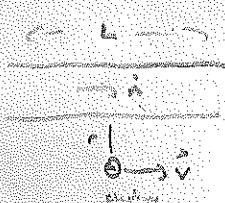
$$b) T = M \times B = (5.52 \times 10^{-7})(0.41) = 2.265 \times 10^{-7}\text{ N.m}$$

$$-MB \cos 180^\circ = (-MB \cos 0^\circ)$$

$$U = 2MB - 2(5.52 \times 10^{-7})(0.41)$$

$$= 4.512 \times 10^{-7}$$

10. A current carrying wire of length L and current  $i$  is set up carrying a current from west to east. If an electron, charge  $q$  and moving with velocity  $v$  from west to east is placed a distance  $r$  from this wire, derive an expression for the force on the charge from the magnetic field of the wire in terms of  $q$ ,  $v$ ,  $i$ ,  $L$  and  $F_{\text{wire}}$ .



$$\text{Need } B = \frac{\mu_0 i}{2\pi r}$$

$$F = qv \times B$$

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