Section	Group	Name	Signature
Grade		Jacob Harkins	Jacob Harkins

After this activity you should know: • *Determine the magnetic force on a point charge moving in a magnetic field • Understand when a charge in a magnetic field will undergo circular motion, helical motion, or straight-line motion. •Be able to determine the radius of the orbit of a charge undergoing circular motion in a uniform magnetic field.*

1. A charge q moves with velocity $\vec{v}$ in a magnetic field $\vec{B}$. Write an expression for the magnetic force on the charge.

$F = q\vec{v}B \sin(\theta)$ $\quad\quad$ $F = q\vec{v} \times B$

2. The SI units for magnetic field is the tesla. Write a tesla in terms of coulombs, meters, kilograms, and seconds. Show work.

$$T = \frac{N}{C \cdot \frac{m}{s}} = \frac{Kg\, s^3}{C}$$

3. A point charge of 0.3 μC is moving in a uniform magnetic field 0.5 $T\ \hat{k}$. What is the magnetic force on the charge when the charge's velocity is $\vec{v} = (3\hat{\imath} - 4\hat{\jmath} + 2\hat{k})\ m/s$?

$$3\times10^{-7} \cdot \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -4 & 2 \\ 0 & \frac{1}{2} & 0 \end{vmatrix} = 3\times10^{-7}\langle -1, 0, \tfrac{3}{2} \rangle$$

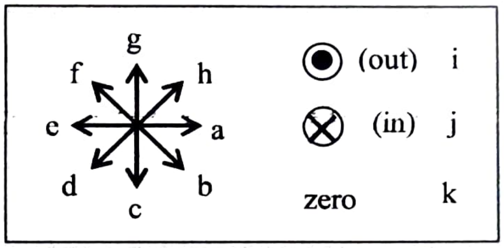
4. A positive point charge $+Q$ is moving to the left with speed v when an electromagnet is turned on generating a uniform magnetic field B to the right. $\theta = 180$ $\quad$ $\sin(\theta) = 0$

   a. What is the magnitude and direction of the magnetic force on the point charge at this point in time?

   0

   b. What will happen to the charge? Assume no other forces. Choose one.
   - The charge will continue moving in a straight line but will speed up.
   - The charge will continue moving in a straight line but will slow down.
   - The charge will continue moving in a straight line with the same speed.
   - The charge will move in a clockwise circle when viewed from above the page.
   - The charge will move in a counterclockwise circle when viewed from above the page.

5. The diagram shows a charge moving with velocity $\vec{v}$ in the magnetic field $\vec{B}$ directed as shown. Use the legend given to indicate the direction of the magnetic force on the charge if:



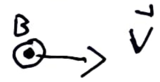
   a. The charge is positive:

   ~~B~~ f

   b. The charge is negative:

   ~~f~~ B

6. A positive point charge $+Q$ is moving to the right with speed v when an electromagnet is turned on generating a uniform magnetic field of magnitude B pointing out of the page.



   a. What is the direction and magnitude of the magnetic force at this time?

   Down

   b. What will happen to the charge? Assume no other forces.

   - The charge will continue moving in a straight line but will speed up.
   - The charge will continue moving in a straight line but will slow down.
   - The charge will continue moving in a straight line with the same speed.
   - The charge will move in a clockwise circle when viewed from above the page.
   - The charge will move in a counterclockwise circle when viewed from above the page.

7. A negative point charge $-Q$ with mass m initially moves with a speed v to the left in a uniform magnetic field of magnitude B which points out of the page.

   a. Determine the radius of the orbit in terms of Q, B, v and/or m. *Hint: think about what you know about uniform circular motion from Physics 211.*

$$-Q\vec{v}\times B = m\frac{v^2}{r}$$

$$r = \frac{mv^2}{-Q\vec{v}\times B}$$

$$= \frac{mv}{-QB\sin(\theta)}$$

   b. Determine the period of the orbit in terms of Q, B and m. *Hint: start by relating the period to the speed and the radius.*

$$T = \frac{2\pi r}{v} = \frac{2\pi m\cancel{v}}{-QB\sin(\theta)\cancel{v}} = \frac{2\pi m}{-QB\sin(\theta)}$$

The fact that the cyclotron frequency is independent of radius was the basis for early particle accelerators call cyclotrons.