CH 19-2 – Force by Magnetic Field on a Moving Charged Particle

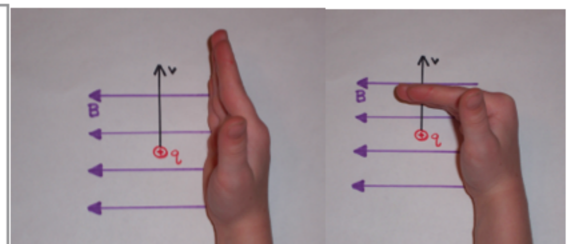
Important Ideas

- A magnetic field exerts a force on a moving charged particle, if the velocity of the particle is NOT parallel or antiparallel to the magnetic field. The magnitude of the magnetic force is

$$F_{mag} = |q|vBsin(\theta)$$

where θ is the angle between the velocity vector and the magnetic field vector. The direction of the magnetic force *on a positively charged particle* is given by the right-hand rule for magnetic force. If the particle's charge is negative, then the magnetic force is in the opposite direction. In this case, you can use your left hand.

Figure 19.7: To find the magnetic force on a charged particle moving in a magnetic field, point the fingers on your right hand in the direction of the velocity, as in the photo on the left. Orient your hand so you can curl your fingers into the magnetic field, as in the photo on the right. Keep your thumb perpendicular to your fingers, and your thumb points in the direction of the force experienced by a positive charge (out of the page, in this case). A negative charge experiences a force in the opposite direction. Photo courtesy of A. Duffy.



If the velocity is in the same direction as the magnetic field ($\theta = 0$) or if the velocity is opposite the magnetic field ($\theta = 180°$), then the magnetic force on the particle is zero.

- For a current-carrying wire, the force by a magnetic field on it is

$$F_{mag} = ILB\sin\theta$$

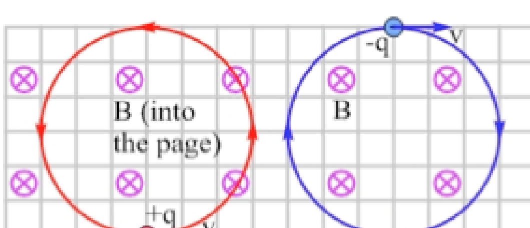
where θ is the angle between the direction of the current and the magnetic field. L is the length of the wire. The direction of the force is given by the right-hand rule for a positively charged particle moving in the direction of the current.

- If the initial velocity of a particle is perpendicular to the magnetic field, then $\theta = 90°$ and $F_{mag} = |q|vB$. The magnetic force will change the direction of the velocity, but not the speed. As a result, the particle will travel in uniform circular motion in a plane that is perpendicular to the magnetic field. The radius of the circular motion is

$$r = \frac{mv}{|q|B}$$

and the period of the circular motion is

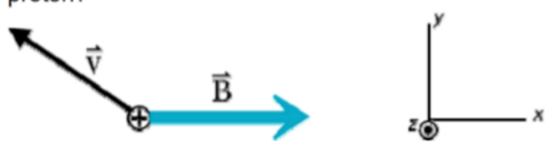
$$T = \frac{2\pi m}{|q|B}$$



Examples

1.

What is the direction of the magnetic force on the proton?	1) +x 2) –x 3) +y 4) –y 5) +z 6) –z 7) zero magnitude

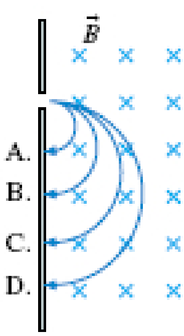


2.

An electron is traveling in the –y direction. At its location there is a magnetic field in the –z direction. What is the direction of the magnetic force on the electron?	1) +x 2) –x 3) +y 4) –y 5) +z 6) –z 7) zero magnitude

3. A magnetic field is in the $+y$ direction, and a proton travels in the $-y$ direction. In what direction is the force by the magnetic field on the proton?

4. The figure below shows four particles moving to the right as they enter a region of uniform magnetic field, directed into the paper as noted. All particles move at the same speed and have the same charge. Which particle has the largest mass?

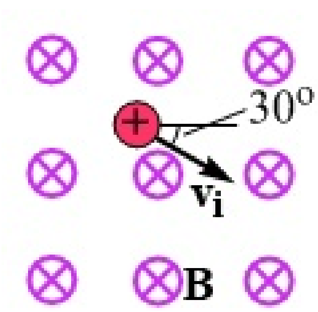


5. For the particles in the previous question, are they positively charged or negatively charged?

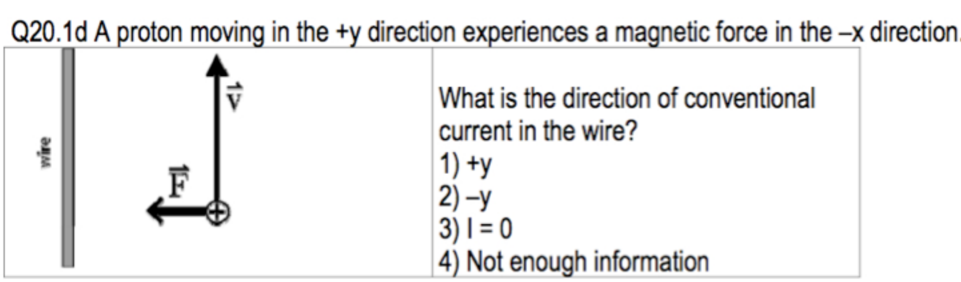
6. A He ion ($+1e$) enters a region of uniform magnetic field of magnitude 0.5 T at a velocity of 1×10^6 m/s perpendicular to the magnetic field. What will be the radius of its circular path?

7. In the previous question, what is the force by the magnetic field on the He ion?

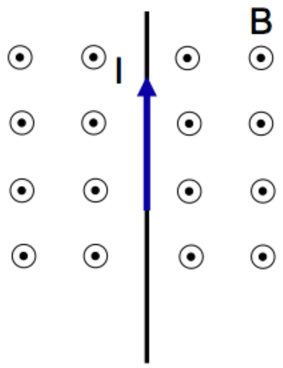
8. The particle in the figure below has a charge of 3.00×10^{-6} C and a speed of 2.60×10^3 m/s, and it is in a uniform magnetic field, directed into the page, of 2.00×10^{-2} T. As the figure shows, the initial velocity of the particle is directed at 30° below the positive x-direction, assuming the x-direction is toward the right. What is the magnitude of the magnetic force acting on the particle and what is its direction?



9.



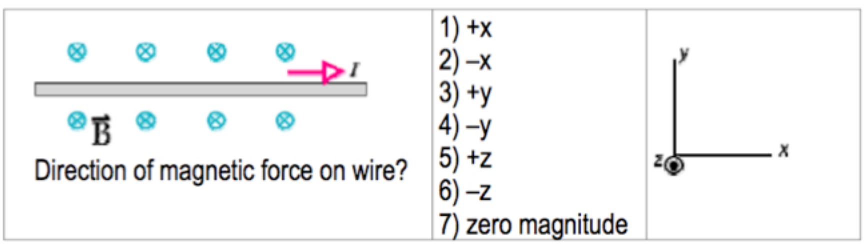
10.



What is the direction of the force of the magnetic field on the wire?

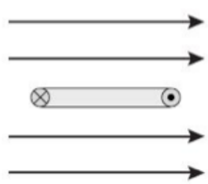
11. Suppose that the wire in the previous question has a length of 0.2 m and a current of 2 A. The magnetic field is 1×10^{-4} T. What is the force on the wire? If the mass of the wire is 2 g, what is the weight of the wire? Compare the magnetic force on the wire to the gravitational force.

12.



13.

A loop carrying a current as shown rests in a uniform magnetic field directed to the right. If the loop is free to rotate,



A. it will rotate clockwise.
B. it will not rotate.
C. it will rotate counterclockwise.