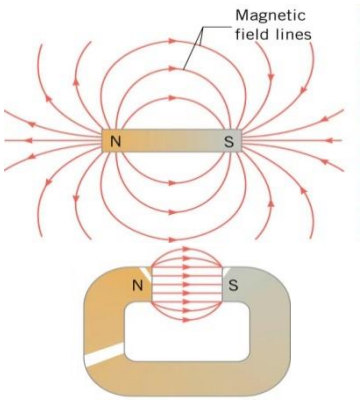
Physics 10-02 Magnetic Fields and Force on a Moving Charge Name: _____

Magnetic Fields



- Around a magnet is a magnetic _____ (B-field)
- At _____ point in _____ there is a magnetic _____
- Can be seen with a _____
- Unit is _____ (T)

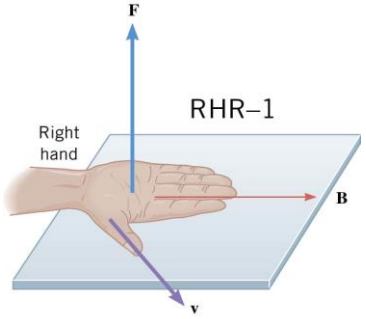
Magnetic Field Lines

- Magnetic fields can be _____ with field _____.
- Start at _____ pole and end at _____ pole
- The more lines in one area means _____ field

Force on a Moving Charge

- Since currents (moving charges) make _____, then other B-fields apply a _____ to _____ charges.
- For a moving charge to experience a _____
  - Charge must be _____
  - The _____ vector of the charge must have a _____ _____ to the _____
- $\vec{F} = qvB \sin\theta$
  - Where F = force, q = charge, v = speed of charge, B = magnetic field, θ = angle between v and B

Direction of force on positive moving charge



Right Hand Rule

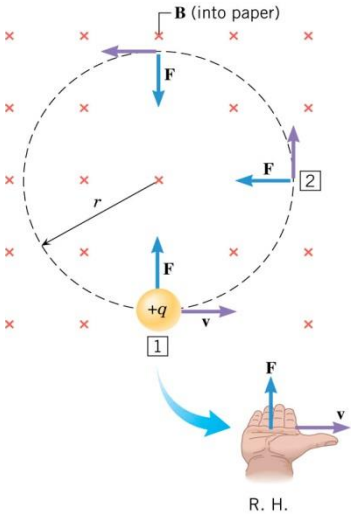
- Fingers point in direction of _____
- Thumb in direction of _____
- Palm faces direction of _____ on _____ charge
- Force will be _____ if v and B are parallel, so a moving charge will be unaffected

Motion of moving charged particle in uniform B-field

- _____
- $r = \frac{mv}{qB}$

A particle with a charge of -1.6×10^{-19} C and mass 9.11×10^{-31} kg moves along the positive x-axis from left to right. It enters a 3 T B-field is in the x-y plane and points at 45° above the positive x-axis.

What is the direction of the force on the particle?



After it has been in the B-field, the particle moves in a circle. If the radius of its path is 2×10^{-10} m, what is the speed of the particle?

What is the magnitude of the force on the particle?

Homework

1. Is the Earth's magnetic field parallel to the ground at all locations? If not, where is it parallel to the surface? Is its strength the same at all locations? If not, where is it greatest?
2. If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in that region is necessarily zero?
3. How can the motion of a charged particle be used to distinguish between a magnetic and an electric field?
4. What are the signs of the charges on the particles in Figure 1?
5. Which of the particles in Figure 2 has the greatest velocity, assuming they have identical charges and masses?
6. Which of the particles in Figure 2 has the greatest mass, assuming all have identical charges and velocities?

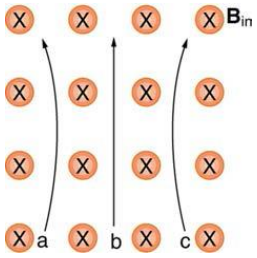


Figure 1

7. What is the direction of the magnetic force on a positive charge that moves as shown in each of the six cases shown in Figure 3? (OpenStax 22.1) **left, into, up, no, right, down**
8. Repeat Exercise 7 for a negative charge. (OpenStax 22.2) **right, out, down, no, left, up**
9. What is the direction of the velocity of a negative charge that experiences the magnetic force shown in each of the three cases in Figure 4, assuming it moves perpendicular to *B*? (OpenStax 22.3) **right, into, down**
10. Repeat Exercise 9 for a positive charge. (OpenStax 22.4) **left, out, up**
11. What is the direction of the magnetic field that produces the magnetic force on a positive charge as shown in each of the three cases in the Figure 5, assuming *B* is perpendicular to *v*? (OpenStax 22.5) **into, left, out**

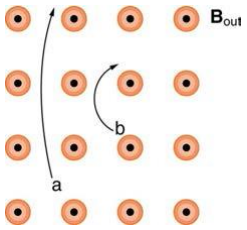


Figure 2

12. Repeat Exercise 11 for a negative charge. (OpenStax 22.6) **out, right, into**
13. What is the maximum force on an aluminum rod with a 0.100-μC charge that you pass between the poles of a 1.50-T permanent magnet at a speed of 5.00 m/s? In what direction is the force? (OpenStax 22.7) $\mathbf{7.50 \times 10^{-7}}$**N, ⊥**
14. (a) Aircraft sometimes acquire small static charges. Suppose a supersonic jet has a 0.500-μC charge and flies due west at a speed of 660 m/s over the Earth's south magnetic pole, where the 8.00×10^{-5}-T magnetic field points straight down. What are the direction and the magnitude of the magnetic force on the plane? (b) Discuss whether the value obtained in part (a) implies this is a significant or negligible effect. (OpenStax 22.8) $\mathbf{2.64 \times 10^{-8}}$ **N, south, negligible**
15. (a) A cosmic ray proton moving toward the Earth at 5.00×10^7 m/s experiences a magnetic force of 1.70×10^{-16} N. What is the strength of the magnetic field if there is a 45° angle between it and the proton's velocity? (b) Is the value obtained in part (a) consistent with the known strength of the Earth's magnetic field on its surface? Discuss. (OpenStax 22.9) $\mathbf{3.01 \times 10^{-5}}$ **T, yes**

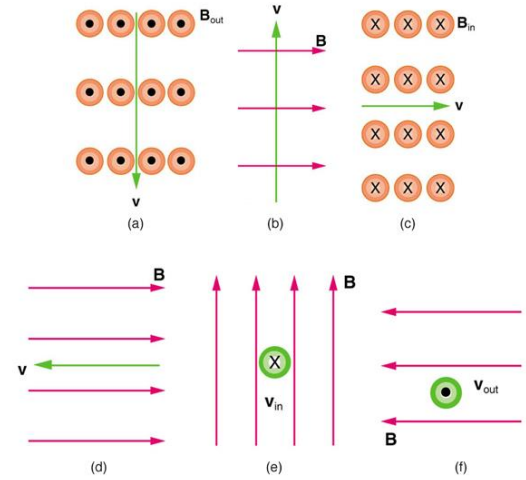


Figure 3

16. A cosmic ray electron moves at 7.50×10^6 m/s perpendicular to the Earth's magnetic field at an altitude where field strength is 1.00×10^{-5} T. What is the radius of the circular path the electron follows? (OpenStax 22.12) **4.27 m**
17. A proton moves at 7.50×10^7 m/s perpendicular to a magnetic field. The field causes the proton to travel in a circular path of radius 0.800 m. What is the field strength? (OpenStax 22.13) **0.979 T**

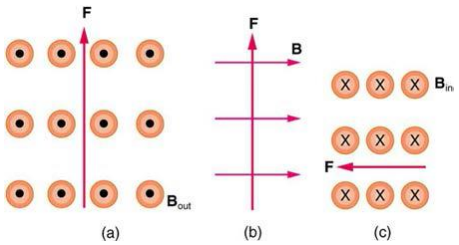


Figure 4

18. (a) Viewers of Star Trek hear of an antimatter drive on the Starship Enterprise. One possibility for such a futuristic energy source is to store antimatter charged particles in a vacuum chamber, circulating in a magnetic field, and then extract them as needed. Antimatter annihilates with normal matter, producing pure energy. What strength magnetic field is needed to hold antiprotons, moving at 5.00×10^7 m/s in a circular path 2.00 m in radius? Antiprotons have the same mass as protons but the opposite (negative) charge. (b) Is this field strength obtainable with today's technology or is it a futuristic possibility? (OpenStax 22.14) **0.261 T, yes**

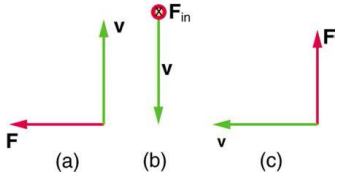


Figure 5

19. (a) An oxygen-16 ion with a mass of 2.66×10^{-26} kg travels at 5.00×10^6 m/s perpendicular to a 1.20-T magnetic field, which makes it move in a circular arc with a 0.231-m radius. What positive charge is on the ion? (b) What is the ratio of this charge to the charge of an electron? (c) Discuss why the ratio found in (b) should be an integer. (OpenStax 22.15) $\mathbf{4.80 \times 10^{-19}}$ **C, 3**