Chapter 15 Drill

The answers and explanations can be found in Chapter 17.

Section I: Multiple Choice

1. Which of the following statements is/are true?

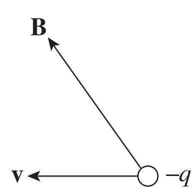
    I. Magnetic force can never do work on a charged particle.
    II. Magnetic force can never change the velocity of a charged particle.
    III. A charged particle will always experience a magnetic force if it moves through a magnetic field.

    (A) I only
    (B) I and II only
    (C) II and III only
    (D) III only
    (E) None of the above

2. The velocity of a particle of charge $+4.0 \times 10^{-9}$ C and mass 2×10^{-4} kg is perpendicular to a 0.1-tesla magnetic field. If the particle's speed is 3×10^{4} m/s, what is the acceleration of this particle due to the magnetic force?

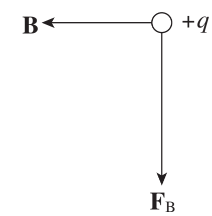
    (A) 0.0006 m/s^2
    (B) 0.006 m/s^2
    (C) 0.06 m/s^2
    (D) 0.6 m/s^2
    (E) None of the above

3. In the figure below, what is the direction of the magnetic force $\mathbf{F}_B$?

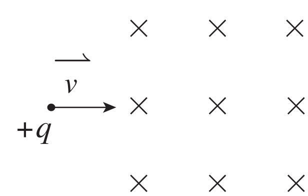


    (A) To the right
    (B) Downward, in the plane of the page
    (C) Upward, in the plane of the page
    (D) Out of the plane of the page
    (E) Into the plane of the page

4. In the figure below, what must be the direction of the particle's velocity, **v** ?



    (A) To the right
    (B) Downward, in the plane of the page
    (C) Upward, in the plane of the page
    (D) Out of the plane of the page
    (E) Into the plane of the page



5. A particle of charge $+q$ and mass m moving with speed v enters a uniform magnetic field directed into the plane of the page as shown above. Assuming the particle does not escape the magnetic field, what will be the radius of its motion? Will it move clockwise or counterclockwise?

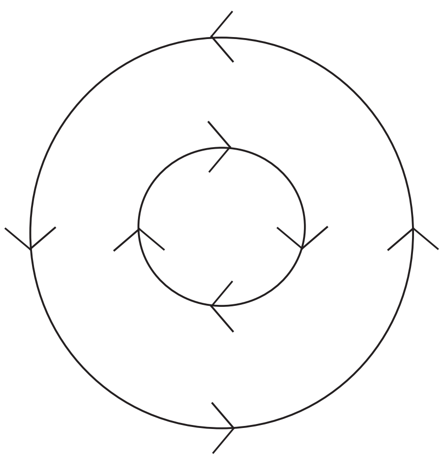
    (A) $mv^2/(qB)$, clockwise
    (B) $mv/(qB)$, clockwise
    (C) $mv/(qB)$, counterclockwise
    (D) $qB/(mv)$, clockwise
    (E) $qB/(mv)$, counterclockwise

6. A straight wire of length 2 m carries a 10-amp current. How strong is the magnetic field at a distance of 2 cm from the wire?

    (A) 1×10^{-6} T
    (B) 1×10^{-5} T
    (C) 2×10^{-5} T
    (D) 1×10^{-4} T
    (E) 2×10^{-4} T

7. Two long, straight wires are hanging parallel to each other and are 1 cm apart. The current in Wire 1 is 5 A, and the current in Wire 2 is 10 A in the same direction. Which of the following best describes the magnetic force per unit length felt by the wires?

(A) The force per unit length on Wire 1 is twice the force per unit length on Wire 2.
(B) The force per unit length on Wire 2 is twice the force per unit length on Wire 1.
(C) The force per unit length on Wire 1 is 0.0003 N/m, away from Wire 2.
(D) The force per unit length on Wire 1 is 0.001 N/m, toward Wire 2.
(E) The force per unit length on Wire 1 is 0.001 N/m, away from Wire 2.



8. In the figure above, two concentric rings have current running through them in the directions shown. Assuming that both currents can be adjusted to any magnitude other than 0 (but always in the directions shown), where is it possible for the net magnetic field to be 0 ?

I. Inside the inner ring
II. Between the two rings
III. Outside the outer ring

(A) I only
(B) I and III only
(C) II only
(D) II and III only
(E) None of the above

9. How many windings must a solenoid of length 80 cm have in order to establish a magnetic field of strength 0.2 T inside the solenoid, if it carries a current of 20 amps?

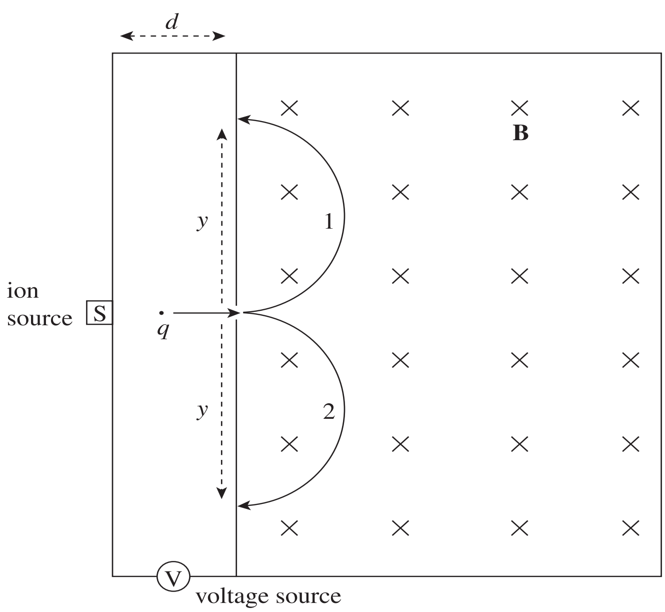
(A) 1,000
(B) 6,400
(C) 10,000
(D) 32,000
(E) 64,000

10. The value of $\oint \mathbf{B} \cdot d\mathbf{s}$ along a closed path in a magnetic field **B** is 6.28×10^{-6} T • m. What is the total current that passes through this closed path?

(A) 0.1 A
(B) 0.5 A
(C) 1 A
(D) 4 A
(E) 5 A

Section II: Free Response

1. The diagram below shows a simple mass spectrograph. It consists of a source of ions (charged atoms) that are accelerated (essentially from rest) by the voltage V and enter a region containing a uniform magnetic field, **B**. The polarity of V may be reversed so that both positively charged ions (cations) and negatively charged ions (anions) can be accelerated. Once the ions enter the magnetic field, they follow a semicircular path and strike the front wall of the spectrograph, on which photographic plates are constructed to record the impact.



(a) What is the acceleration of an ion of charge q just before it enters the magnetic field?

(b) Find the speed with which an ion of charge q enters the magnetic field.

(c) (i) Which semicircular path, 1 or 2, would a cation follow?

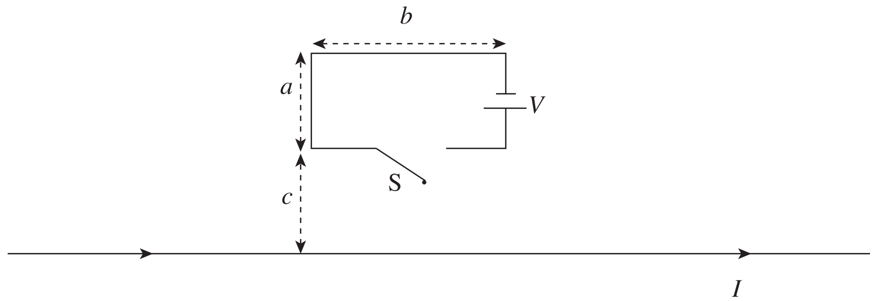
(ii) Which semicircular path, 1 or 2, would an anion follow?

(d) Determine the mass of a cation entering the apparatus in terms of y, q, B, and V.

(e) Once a cation of charge q enters the magnetic field, how long does it take to strike the photographic plate?

(f) What is the work done by the magnetic force in the spectrograph on a cation of charge q?

2. A wire of diameter d and resistivity ρ is bent into a rectangular loop (of side lengths a and b) and fitted with a small battery that provides a voltage V. The loop is placed at a distance c from a very long, straight wire that carries a current I in the direction indicated in the diagram.



(Express all answers in terms of $a, b, c, d, \rho, V, I, m, B, x,$ and fundamental constants.)

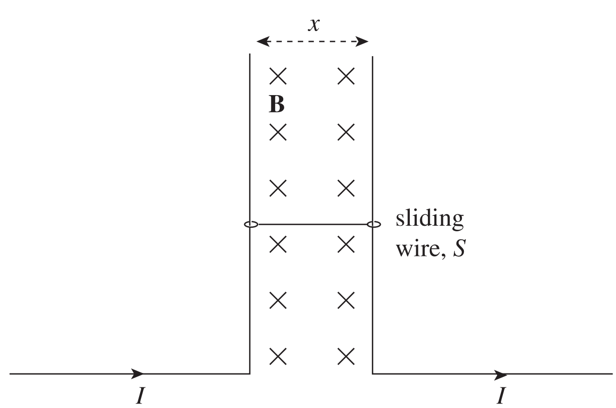
(a) When the switch S is closed, find the current in the rectangular loop.

(b) What is the magnetic force (magnitude and direction) exerted on the loop by the long, straight wire?

(c) The wire of the rectangular loop is then reshaped into a circle. What will be the radius of the circular loop?

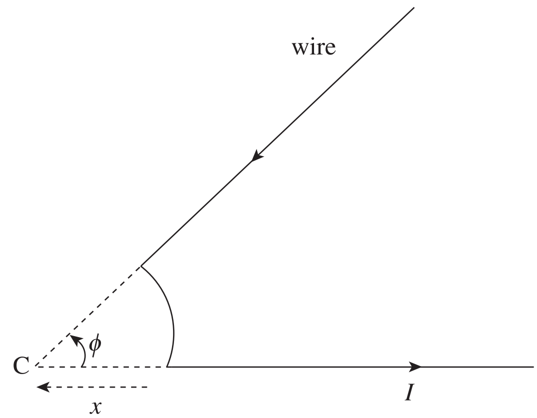
(d) If the loop constructed in part (c) were then threaded around the long, straight wire (so that the straight wire passed through the center of the circular loop), what would be the magnetic force on the loop now?

(e) In the following diagram, two fixed L-shaped wires, separated by a distance x, are connected by a wire that's free to slide vertically.



The mass of the sliding wire, S, is m. If the sliding wire S crosses a region that contains a uniform magnetic field **B**, how much current must be carried by the wire to keep S from sliding down (due to its weight)?

3. The figure below shows two long, straight wires connected by a circular arc of radius x that subtends a central angle ϕ. The current in the wire is I.



(a) Find the magnetic field (magnitude and direction) created at Point C. Write your answer in terms of x, ϕ, I, and fundamental constants.

(b) A particle of charge $+q$ is placed at Point C and released. Find the magnetic force on the particle.

(c) A second long, straight wire is set up perpendicular to the plane of the page through C, carrying the same current, I (directed out of the page), as the wire pictured in the diagram. Determine the magnetic force per unit length between the wires.

4. For a conducting rod that carries a current I, the current density is defined as the current per unit area: $J = I/A$.

Part 1. A homogeneous cylindrical rod of radius R carries a current whose current density, J, is uniform (constant); that is, J does not vary with the radial distance, r, from the center of the rod.

(a) Determine the total current, I, in the rod.

(b) Calculate the magnitude of the magnetic field for

(i) $r < R$

(ii) $r > R$, writing your answers in terms of r, R, I, and fundamental constants

Part 2. A nonhomogeneous cylindrical rod of radius R carries a current whose current density, J, varies with the radial distance, r, from the center of the rod according to the equation $J = \sigma r$, where σ is a constant.

(c) What are the units of σ ?

(d) Determine the total current, I, in the rod.

(e) Calculate the magnitude of the magnetic field for

(i) $r < R$

(ii) $r > R$, writing your answers in terms of r, R, and I