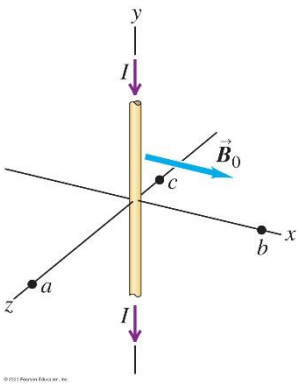
EP0605 Tutorial 7 – Magnetism

1. A long straight wire lies along the y-axis and carries a current $I = 8.00$ A in the $-y$-direction. In addition to the magnetic field due to the current in the wire, a uniform magnetic field $\vec{B}_0$ with magnitude 1.50×10^{-6} T is in the $+x$-direction. What is the total field (magnitude and direction) at the following points in the xz-plane:
(a) $x = 0$, $z = 1.00$ m,
(b) $x = 1.00$ m, $z = 0$,
(c) $x = 0$, $z = -0.250$ m?



2. A proton moves with a speed of 1.00×10^5 m/s through Earth's magnetic field, which has a value of 55.0 μT at a particular location. When the proton moves eastward, the magnetic force acting on it is directed straight upward and when it moves northward, no magnetic force acts on it.

   (a) What is the direction of the magnetic field?
   (b) What is the strength of the magnetic force when the proton moves eastward?
   (c) Calculate the gravitational force on the proton. Take g = 9.80 m/s^2.
   (d) Calculate the electric force on the proton if there were an electric field with magnitude E = 1.50×10^2 N/C. The mass of proton is 1.67×10^{-27} kg.

3. A particle with a charge of -1.24×10^{-8} C is moving with instantaneous velocity **v** = $(4.19 \times 10^4$ m/s) **i** + $(-3.85 \times 10^4$ m/s) **j**. What is the force exerted on this particle by a magnetic field

   (a) **B** = (1.40 T) **i** and
   (b) **B** = (1.40 T) **k?**

4. A particle with charge 7.80 μC is moving with velocity **v** = $(-3.80 \times 10^3$ m/s) **j**. The magnetic force on the particle is measured as **F** = $(7.60 \times 10^{-3}$ N) **i** − $(5.20 \times 10^{-3}$ N) **k**.

   (a) Calculate all the components of the magnetic field you can from this information.
   (b) Are there components of the magnetic field that are not determined by the measurement of the force? Explain.
   (c) Calculate the scalar product **B.F**. What is the angle between **B** and **F**?

5. A singly charged lithium ion has a mass 1.16×10^{-26} kg. It is accelerated through a potential difference of 220 V and then enters a magnetic field with magnitude 0.723 T perpendicular to the path of the ion. What is the radius of the ion's path in the magnetic field?

6. (a) What is the speed of a beam of electrons when the simultaneous influence of an electric field of 1.56×10^4 V/m and a magnetic field of 4.62×10^{-3} T with both fields normal to the beam and to each other, produces no deflection of the electrons?

   (b) When the electric field is removed, what is the radius of the electron orbit?

   (c) What is the period of the orbit?

   (d) In a diagram, show the relative orientation of the vectors **v, E** and **B**.

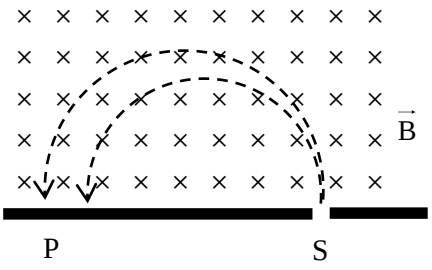
7. Singly ionized (one electron removed) atoms are accelerated and then passed through a velocity selector consisting of perpendicular electric and magnetic fields. The electric field is 155 V/m and the magnetic field is 0.0315 T. The ions next enter a uniform magnetic field of magnitude 0.0175 T that is oriented perpendicular to their velocity.

   (a) How fast are the ions moving when they emerge from the velocity selector?
   (b) If the radius of the path of the ions in the second magnetic field is 17.5 cm, what is their mass?

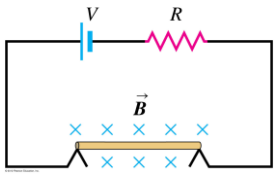
8. A wire carries a current of 22.0 A from west to east. Assume that at this location, the magnetic field of Earth is horizontal and directed from south to north and that it has a magnitude of 0.500×10^{-4} T.

   (a) Find the magnitude and direction of the magnetic force on a 36.0 m length of wire.
   (b) Calculate the gravitational force on the same length of wire if it is made of copper and has a cross sectional area of 2.50×10^{-6} m^2. The density of copper is 8.92×10^3 kg/m^3.

9. Two singly ionized atoms move out of a slit at point S as shown, and into a magnetic field of magnitude 0.100 T pointing into the page. Each has a speed of 1.00×10^6 m/s. The nucleus of the first atom contains one proton and has a mass of 1.67×10^{-27} kg, while the nucleus of the second atom contains a proton and a neutron and has a mass of 3.34×10^{-27} kg. Find their distance of separation when they strike a photographic plate at P.



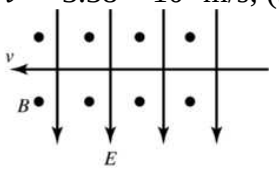
10. A thin 50.0-cm long metal bar with mass 750 g rests on (but not attached to) two metallic supports in a uniform magnetic field of 0.450 T as shown in the figure. A battery and a 25.0 Ω resistor in series are connected to the supports.



(a) What is the highest voltage the battery can have without breaking the circuit at the supports?
(b) The battery voltage has the maximum value calculated in part (a). If the resistor suddenly gets partially short-circuited, decreasing its resistance to 2.0 Ω, find the initial acceleration of the bar. (Hint: Use Ohm's Law to calculate voltage).

Answers

1. (a) $-0.1\ \mu$T $\hat{\imath}$; (b) 2.19 μT, 46.8° from x to z; (c) 7.9 μT $\hat{\imath}$
2. (a) North; (b) 8.80×10^{-19} N; (c) 1.64×10^{-26} N; (d) 2.40×10^{-17} N
3. (a) $(-6.68 \times 10^{-4}$ N) **k**; (b) $(6.68 \times 10^{-4}$ N) **i** + $(7.27 \times 10^{-4}$ N) **j**
4. (a) $B_x = -0.256$ T, $B_z = -0.175$ T; (b) B_y is not determined; (c) **B.F** = 0, angle is 90°
5. Radius = 7.81×10^{-3} m
6. (a) $v = 3.38 \times 10^{6}$ m/s; (b) $R = 4.17 \times 10^{-3}$ m; (c) 7.74×10^{-9} s



(d)

7. (a) $v = 4.92 \times 10^{3}$ m/s; (b) 9.96×10^{-26} kg
8. (a) 3.96×10^{-2} N; (b) 7.87 N
9. 0.210 m
10. (a) 817 V; (b) 113 m/s^2