7.6 EXERCISES

Magnetic forces on charged particles

Ex 7.6.1. Find the direction of missing vector, either velocity, magnetic field, and magnetic force on the particle. Use a dot in a circle for pointing out of page and an $\times$ inside a circle for pointing in the page. (Some answers have infinite number of possible directions. In those cases describe the complete answer, and an example correct direction.)

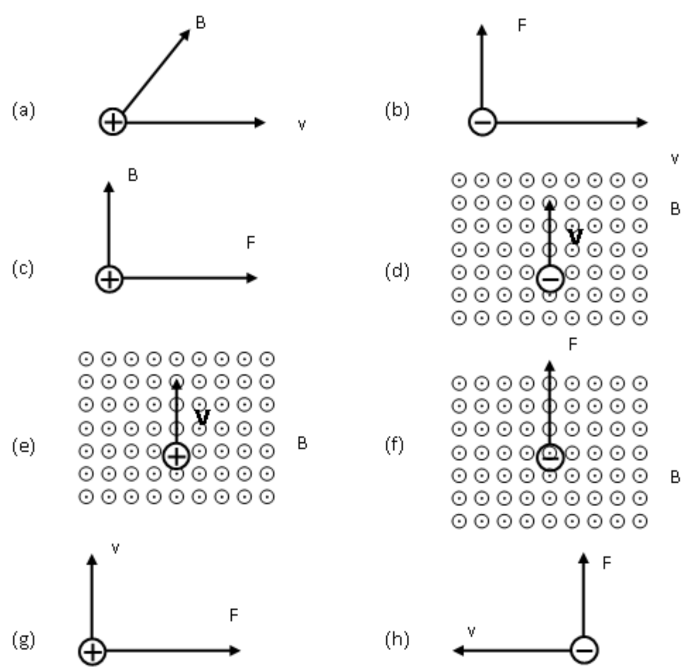

Figure 7.31: Exercise 7.6.1.

Ex 7.6.2. An electron of speed 5×10^6 m/s moves in a circle of radius 3 cm when subjected to a magnetic field perpendicular to its velocity. (a) Find the magnetic field. (b) Evaluate the cyclotron frequency. Ans: (a) Magnitude 9.5×10^{-4} T, (b) 1.7×10^8 rad/s.

Ex 7.6.3. In a region between north and south poles of a strong magnet there is a uniform magnetic field of 3 T pointed up. An alpha particle of charge $+2\ e$ and mass equal to the sum of two protons and two neutrons enters the region from east with a speed of 4×10^6 m/s. It makes a circular arc of 90-degrees before exiting. (a) Which direction does the alpha particle come out? (b) What is the radius of the circular arc? (c) What is the value of the cyclotron frequency? Ans: (b) 2.78 cm, (b) 1.44×10^8 rad/s.

Ex 7.6.4. A proton enters a uniform magnetic field region with a velocity of 6×10^5 m/s at an angle of 80-degrees with the direction of the magnetic field. Find the pitch of the helical path if the magnetic field is 2 T. Ans: 6.72 mm.

Ex 7.6.5. A Hall probe gives a reading of 1.5 μV for a current of 2 A when it is placed in a magnetic field of 1 T. What is the magnetic field in a region where the reading is 2 μV for 1.7 A of current? Ans: Magnitude 1.57 T.

Ex 7.6.6. Hall effect is to be used to find the nature of charge in a semiconductor sample. The probe is placed between the poles of a magnet so that magnetic field is pointed up. A current is passed through a rectangular sample placed horizontally. As current is passed through the sample in the east direction, the north side of the sample is found to be at a higher potential than the south side. Decide if the current carrier is positively or negatively charged. Ans: Negatively charged.

Ex 7.6.7. The density carrier is copper is 8.47×10^{28} electrons per cubic meter. What will be the Hall voltage reading from a probe made up of 3 $cm \times 2$ $cm \times 1$ cm ($L \times W \times T$) copper plate when a current of 1.5 A is passed through it in a magnetic field of 2.5 T perpendicular to the 3 $cm \times 2$ cm face. Ans: $4.65 \times 106{-}7$ V.

Ex 7.6.8. Hall effect is to be used to find the current carrier density in an unknown material. A Hall voltage 40 μV for 3 A current is observed in a 3 T magnetic field for a rectangular sample with length 2 cm, width 1.5 cm and height 0.4 cm. Determine the density of current carriers. Ans: 2.34×10^{28} electrons/m^3.

Force on Current Carrying Wires

Ex 7.6.9. A straight wire passed between two magnets as shown. Assume that there is no magnetic field outside the space between the poles, and it has uniform magnitude of B1 and B2 between the poles. Find the force on the wire when a current I passes through the wire.

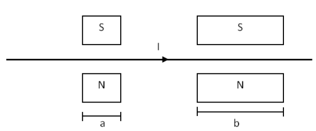

Figure 7.32: Exercise 7.6.9.

Ex 7.6.10. A 9-cm wire carrying a current of 5 A bends at 90°, with one leg being 6 cm and the other leg 3 cm. The wire is in a region of uniform magnetic field of 2.5 T perpendicular to the plane of the wire. Find the magnetic force on the wire. Ans: 0.84 N, directed 63.5° below the positive x-axis in the 4th quadrant where the x-axis is along 6 cm leg and the y-axis along 3 cm leg.

Ex 7.6.11. A 10-cm wire carrying a current of 5 amp bends at 30°, with one leg being 6-cm and the other leg 4 cm. The wire is in a region of uniform magnetic field of 2 T perpendicular to the plane of the wire. Find the magnetic force on the wire. Ans: Directed 49° below the positive x-axis in the 4th quadrant where the x-axis is along the 6-cm leg.

Ex 7.6.12. A straight wire of length 15 cm is carrying a current of 20 A. The wire is placed on a table where there is a magnetic field whose magnitude varies over the length of the wire, but the direction is always perpendicular to the table facing up. If wire is along the x-axis and the direction of the magnetic field is the y-axis, the y-component of the magnetic field is given by the following function of the coordinate x.

$$B_y(x) = \frac{16}{x} \quad \text{(in Tesla with } x \text{ in cm)}$$

The wire is placed from $x = 1$ cm to $x = 16$ cm. Find the magnetic force on the wire. Ans: Magnitude 8.9 N.

Ex 7.6.13. A straight wire of length L is carrying a current I. The wire is placed on a table where there is a magnetic field whose magnitude varies over the length of the wire, but the direction is always perpendicular to the table facing up. If wire is along the x-axis and the direction of the magnetic field is the positive y-axis, the y-component of the magnetic field is given by the following function of the coordinate x.

$$B_y(x) = \frac{a}{x} \quad \text{(in Tesla with } x \text{ in cm)}$$

The wire is placed from $x = x_1$ to $x = x_2$. Find the magnetic force on the wire. Ans: $Ia \ln (x_2/x_1)$.

Ex 7.6.14. A wire is bent into a quarter circle of radius 2 cm and placed between the poles of a magnet where there is a uniform magnetic field of 3.5 T perpendicular to the plane of the wire. Find force on the wire when there is 30 A current through it. Ans: 2.97 N, 45° from one end.

Ex 7.6.15. A wire is bent into a three-quarter of a circle of radius 1.5 cm and placed between the poles of a magnet where there is a uniform magnetic field of 4 T perpendicular to the plane of the wire. Find force on the wire when there is 10 A current through it. Ans: Magnitude 0.85 N.

Torque on Magnetic Dipoles

Ex 7.6.16. A triangular loop of wire in the shape of an equilateral triangle of side 3 cm carries a current of 10 A. Find the magnetic dipole moment. Ans: Magnitude 3.9×10^{-3} A.m^2.

Ex 7.6.17. Find the magnetic dipole moment of current I passing through two loops structures, the loops being circular with radius R.

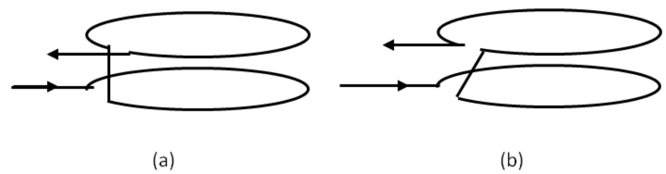

Figure 7.33: Exercise 7.6.17.

Ex 7.6.18. Find torques on the current loop in the following situations. Use B = 3 T , I = 10 A, and area of the loop 5 cm^2. Ans: Magnitudes: 0, 1.3×10^{-2} N.m, 1.4×10^{-2} N.m.

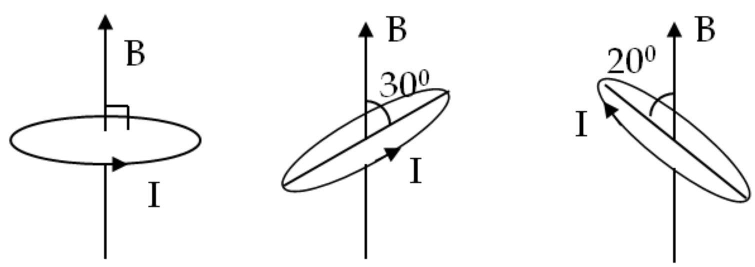

Figure 7.34: Exercise 7.6.18.

Ex 7.6.19. Two identical magnetic dipoles, of magnetic moment each, are attached to a light rod of length L pivoted in the middle. The rod is then placed in a magnetic field B perpendicular to the rod as shown in Figure. If the moment of inertia of the rods about the center is I_0, find the angular acceleration in each case.

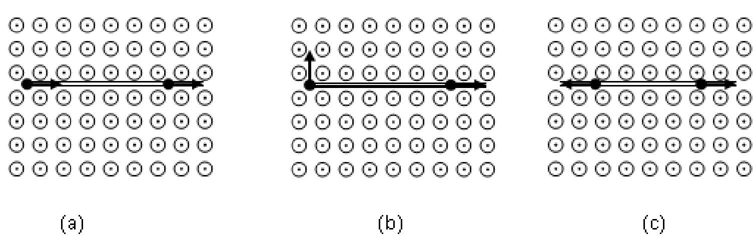

Figure 7.35: Exercise 7.6.19.