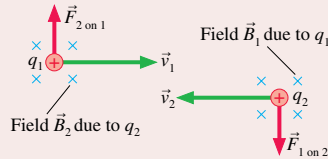


SUMMARY

The goal of Chapter 32 has been to learn how to calculate and use the magnetic field.

GENERAL PRINCIPLES

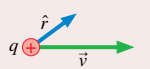
At its most fundamental level, **magnetism** is an interaction between moving charges. The magnetic field of one moving charge exerts a force on another moving charge.



Magnetic Fields

The Biot-Savart law

• A point charge, $\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$



• A short current element, $\vec{B} = \frac{\mu_0}{4\pi} \frac{I\Delta\vec{s} \times \hat{r}}{r^2}$

To find the magnetic field of a current

- Divide the wire into many short segments.
- Find the field of each segment Δs .
- Find \vec{B} by summing the fields of all Δs , usually as an integral.

An alternative method for fields with a high degree of symmetry is **Ampère's law**

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{through}}$$

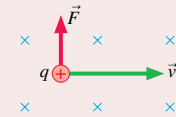
where I_{through} is the current through the area bounded by the integration path.

Magnetic Forces

The magnetic force on a moving charge is

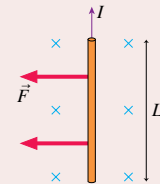
$$\vec{F} = q\vec{v} \times \vec{B}$$

The force is perpendicular to \vec{v} and \vec{B} .



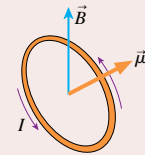
The magnetic force on a current-carrying wire perpendicular to a magnetic field is $F = ILB$.

$\vec{F} = \vec{0}$ for a charge or current moving parallel to \vec{B} .



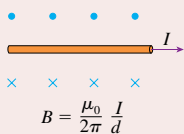
The magnetic torque on a magnetic dipole is

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

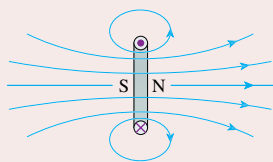


APPLICATIONS

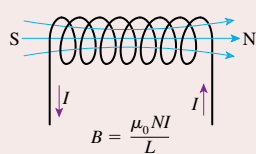
Wire



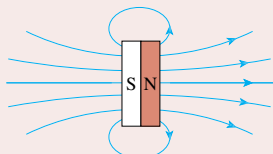
Loop



Solenoid



Flat magnet

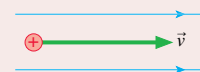


Right-hand rule

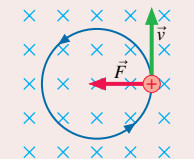
Point your right thumb in the direction of I . Your fingers curl in the direction of \vec{B} . For a dipole, \vec{B} emerges from the side that is the north pole.

Charged-particle motion

No force if \vec{v} is parallel to \vec{B} .



Circular motion at the cyclotron frequency $f_{\text{cyc}} = qB/2\pi m$ if \vec{v} is perpendicular to \vec{B} .



Parallel wires and current loops

Parallel currents attract. Opposite currents repel.

