Chapter 28: Sources of Magnetic Field

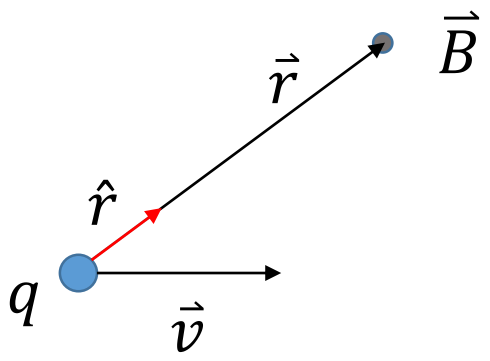
- Electric Current Generates Magnetic Field

- Ampere’s Law

Electric Current Generates Magnetic Field

Magnetic field generated from a moving charge

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$$



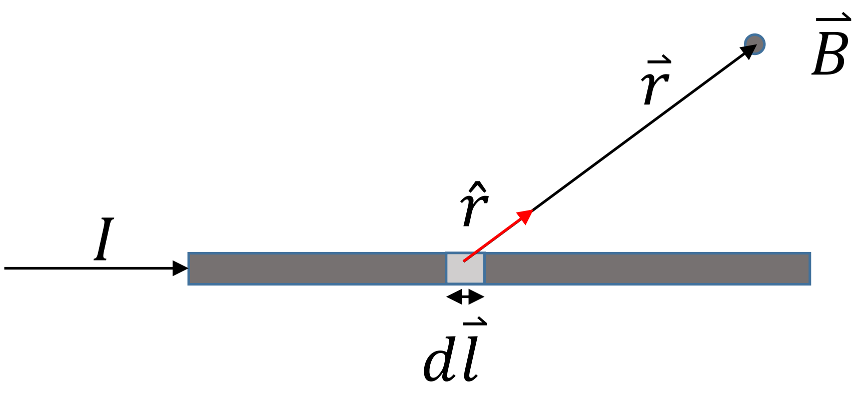
Example 1

A negative charge $q_1 = -3.60 \times 10^{-6} C$ is located at the origin and has velocity $\vec{v}_1 = (7.50 \times 10^4\ m/s)\hat{\imath} + (-4.90 \times 10^4\ m/s)\hat{\jmath}$. At this instant what are the magnitude and direction of the magnetic force produced by this charge on another positive charge $q_2 = 3.60 \times 10^{-6} C$ with velocity $\vec{v}_2 = (2.50 \times 10^4\ m/s)\hat{\imath} + (4.90 \times 10^4\ m/s)\hat{\jmath}$ located at the point $(x, y, z) = (0.200, -0.300, 0)m$?

Electric Current Generates Magnetic Field

Magnetic field generated from a section of current (a group of moving charges)

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \hat{r}}{r^2}$$



Electric Current Generates Magnetic Field

Magnetic field produced by an infinite long current-carrying wire.

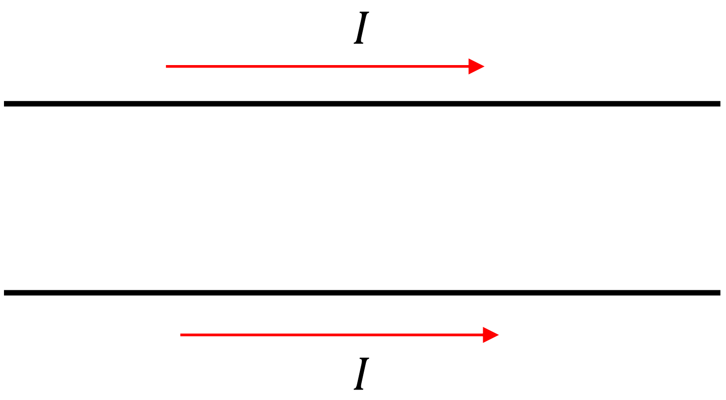
$$\vec{B} = \frac{\mu_0 I}{2\pi r}(\widehat{rhr})$$

Magnetic field produced by a circular current-carrying loop. (with radius *a*, at a distance *x* away from the center of the loop along the axis)

$$\vec{B} = \frac{\mu_0 I a^2}{2(x^2 + a^2)^{3/2}}\hat{n}$$

Quiz

Two straight long current-carrying wires are placed next to each other in parallel. What directions of the forces do the two wires feel?



A. Attract each other
B. Repel each other
C. No force
D. The top wire experiences a force go into the screen; while the bottom wire experiences a force go out of the screen
E. The top wire experiences a force go out of the screen; while the bottom wire experiences a force go into the screen

What is the magnitude of the force?

Ampere's Law

$$\oint_C \vec{B} \cdot d\vec{l} = \mu_0 I_{encl}$$

For a closed "loop"

How to use it?

1. Choose a closed loop containing the point where you want to know the magnetic field.
2. The choice of the loop better to have all the segments of the loop are either (a) perpendicular to the magnetic field; or (b) parallel to the magnetic field.
3. Do the integration
4. Find all enclosed current in the loop.

Ampere’s Law

Try it!

(1) Long straight current-carrying wire
(2) Current-carrying solenoid
(3) Current-carrying toroidal solenoid