

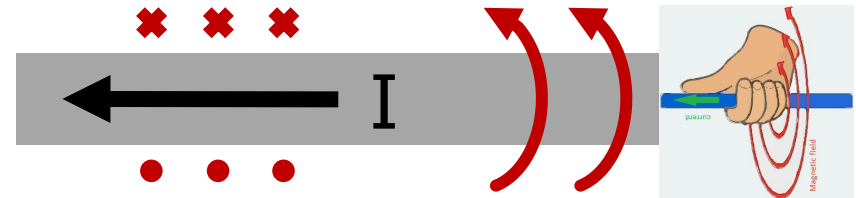
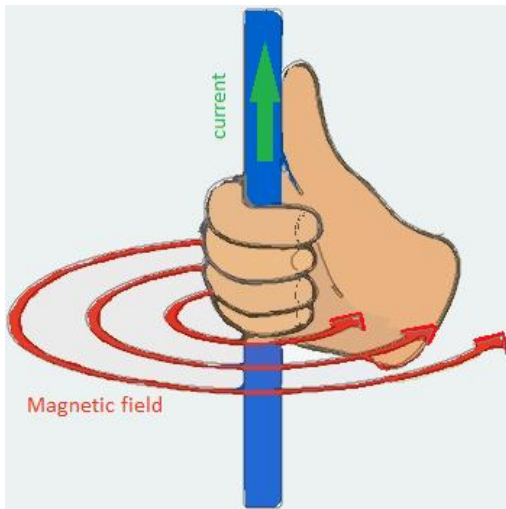
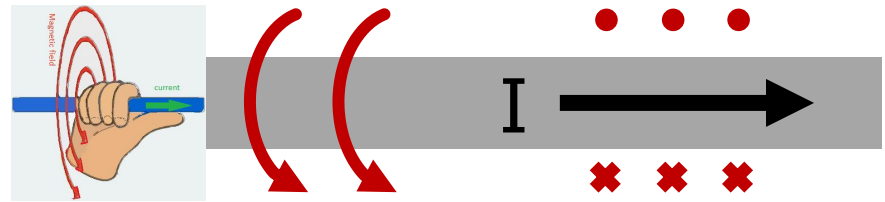
Electromagnetic Force

IB PHYSICS | FORCE FIELDS

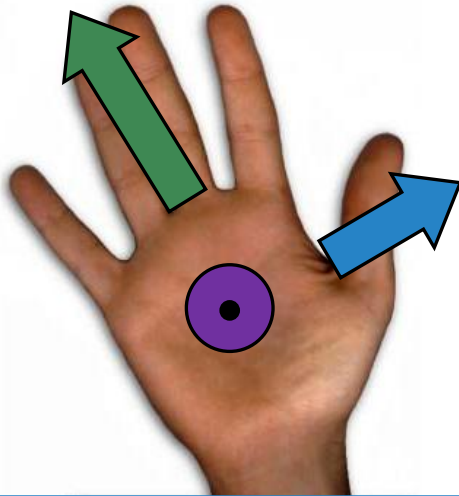
Remember the Right Hand Rule?

Thumb points in direction of the **current**

Fingers point in direction of the **field lines**



Right Hand Rule #2



Thumb points in direction of the **current**

Fingers point in direction of the **field lines**

Palm points in direction of the **force**

How do you represent a direction that's perpendicular to the paper?

Into the paper

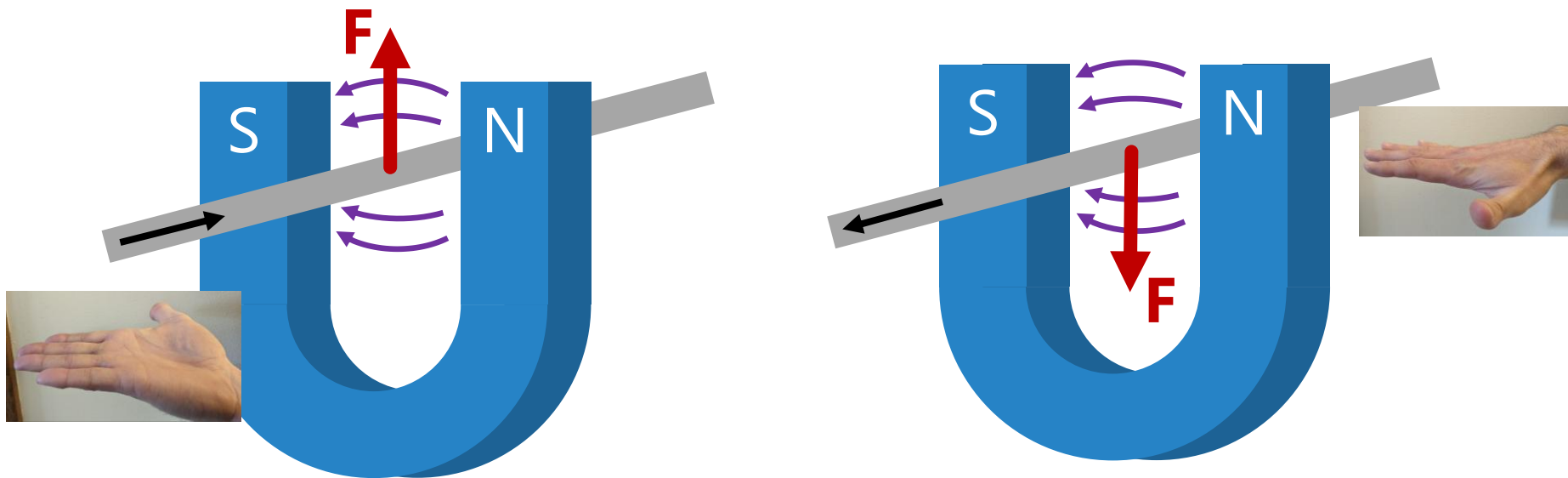


Out of the paper



Right Hand Rule #2

A current-carrying wire is placed in a magnetic field and the magnetic field exerts a force on the wire



Fields

Gravitational Field

$$g = \frac{F}{m} = \frac{[\text{N}]}{[\text{kg}]}$$

Magnetic Field

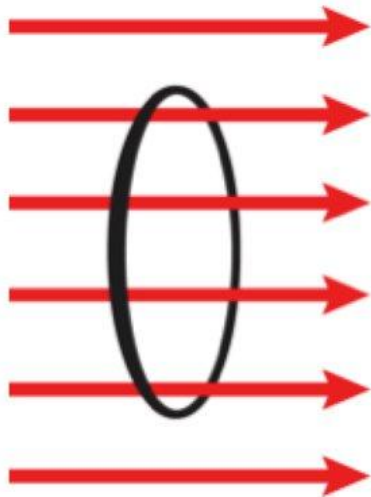
$$B = \frac{F}{I}$$

Electric Field

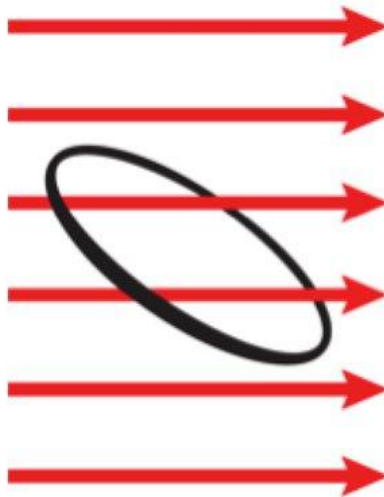
$$E = \frac{F}{q} = \frac{[\text{N}]}{[\text{C}]}$$

Magnetic Flux

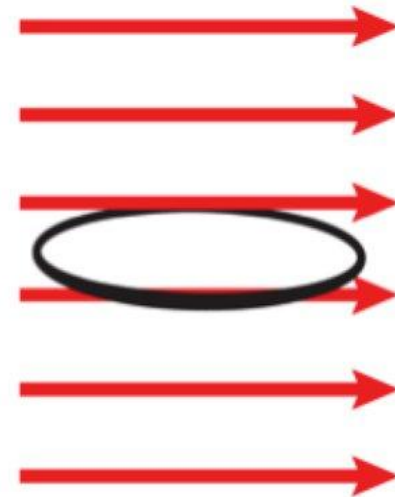
The magnetic field strength is sometimes referred to as magnetic flux and depends on how perpendicular the current is in relation to the field direction



Max flux

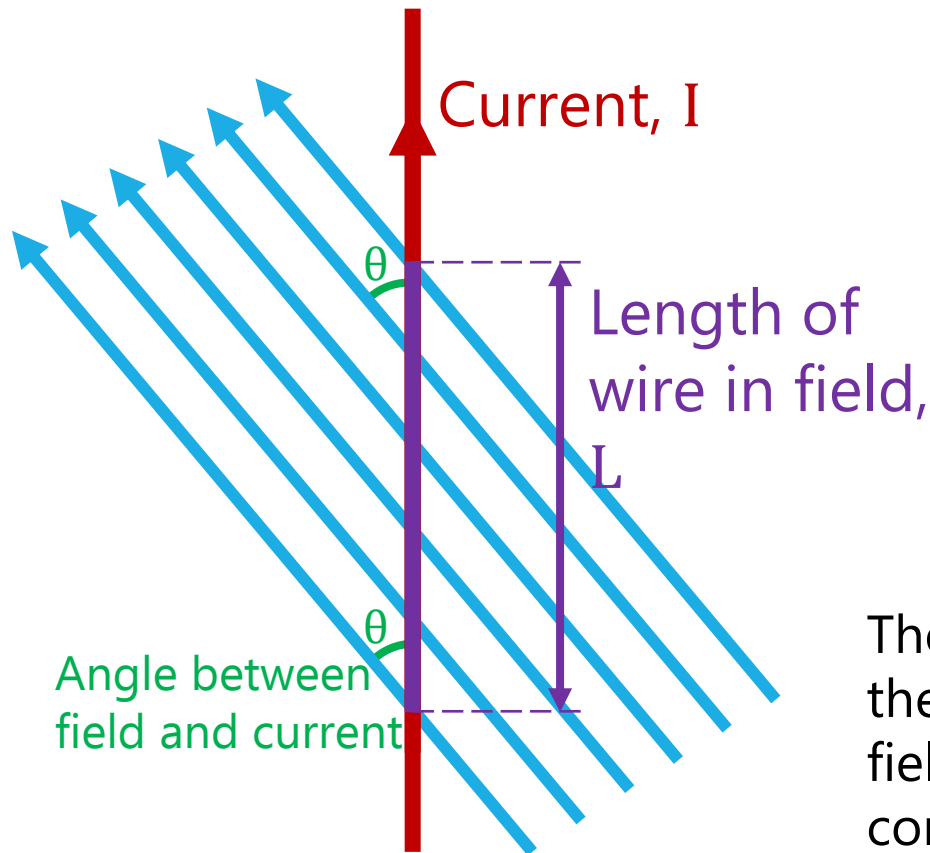


Less flux



No flux given.

Magnetic field Strength



$$B = \frac{F}{IL \sin \theta}$$

The force on the wire is proportional to the charge moving perpendicular to the field. Because of these the perpendicular component must be used in the calculation

Fields

$$B = \frac{F}{IL \sin\theta}$$

$$F = BIL \sin\theta$$

F	Magnetic force <i>Newtons [N]</i>
B	Magnetic field strength <i>Tesla [T]</i>
I	Current <i>Amperes [A]</i>

L	Length of conductor in uniform magnetic field
θ	Angle between magnetic field and current

IB Physics Data Booklet

D. Fields

Standard level and higher level	
D.1 Gravitational fields	$F = G \frac{m_1 m_2}{r^2}$ $g = \frac{F}{m} = G \frac{M}{r^2}$
D.2 Electric and magnetic fields	$F = k \frac{q_1 q_2}{r^2} \text{ where } k = \frac{1}{4\pi\epsilon_0}$ $E = \frac{F}{q}$ $E = \frac{V}{d}$
D.3 Motion in electromagnetic fields	$F = qvB \sin \theta$ $F = BIL \sin \theta$ $\frac{F}{L} = \mu_0 \frac{I_1 I_2}{2\pi r}$

Try This...

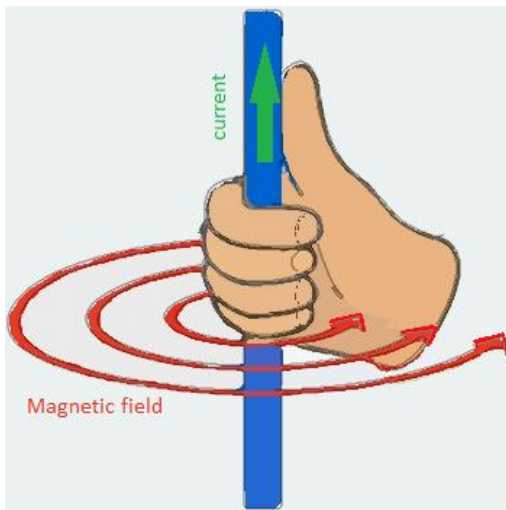
A current of 3.8 A in a long wire experiences a force of 5.7×10^{-3} N when it flows through a magnetic field of strength 25 mT. If the length of wire in the field is 10 cm, what is the angle between the field and current?

$$F = BIL \sin\theta$$

Strength of Field around Wire

$$B = \frac{\mu_0 I}{2\pi r}$$

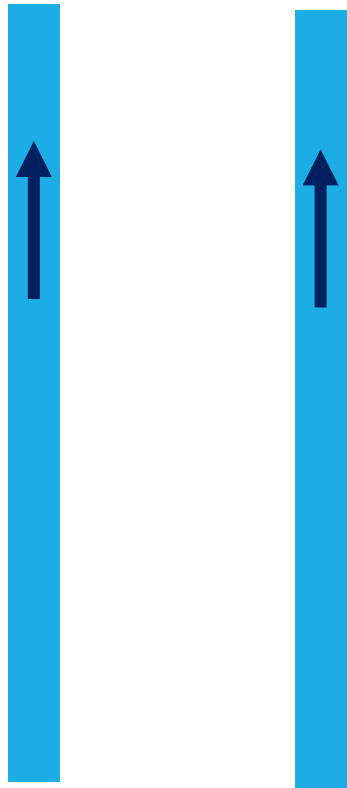
The **strength of the magnetic field** around a current carrying wire depends on the **current**, **distance from the wire**, and the **permeability of free space**



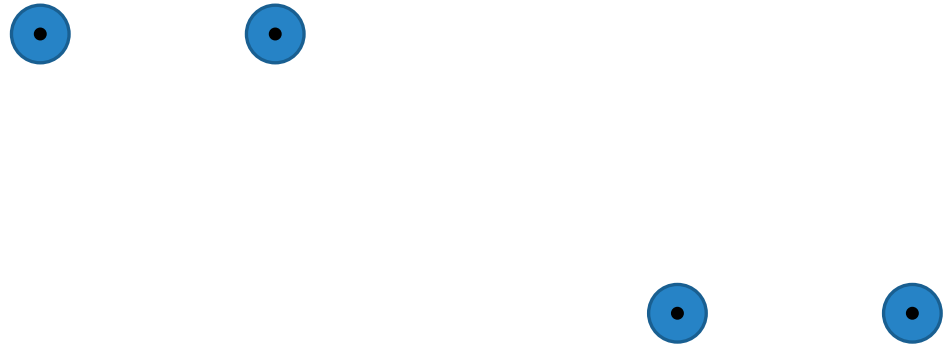
Fundamental constants

Quantity	Symbol	Approximate value
Acceleration of free fall	g	9.8 m s^{-2} (Earth's surface)
Gravitational constant	G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Avogadro constant	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$
Permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Permeability of free space	μ_0	$4\pi \times 10^{-7} \text{ T m A}^{-1}$

Definition of the Ampere



Consider two parallel wires, with current in the same direction. Do they attract or repel??



***One ampere is defined as the current that would cause a force of 2×10^{-7} N per meter between two long parallel conductors separated by 1 m in a vacuum*

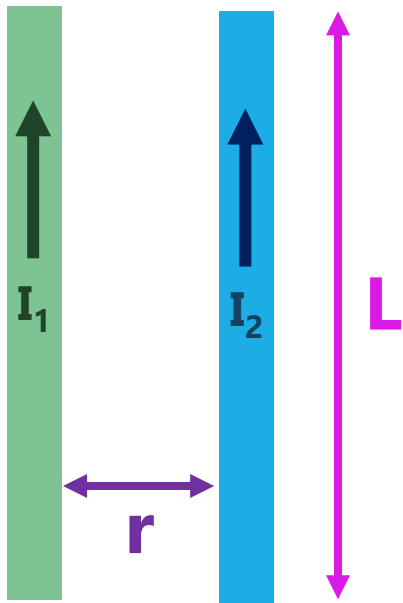
Definition of the Ampere

$$B = \frac{\mu_0 I}{2\pi r}$$

$$F = BIL \sin\theta$$

$$F = \frac{\mu_0 I_1}{2\pi r} I_2 L$$

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$



IB Physics Data Booklet

D. Fields

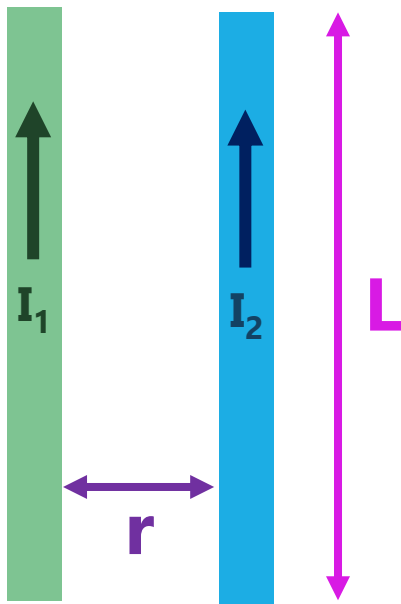
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Try This

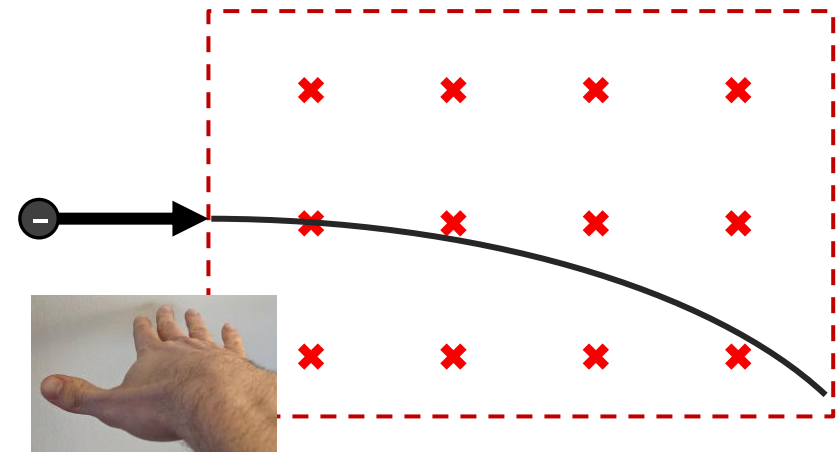
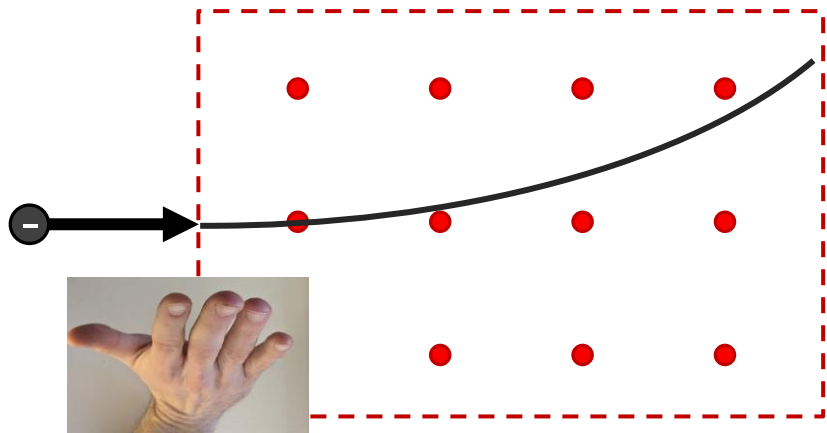
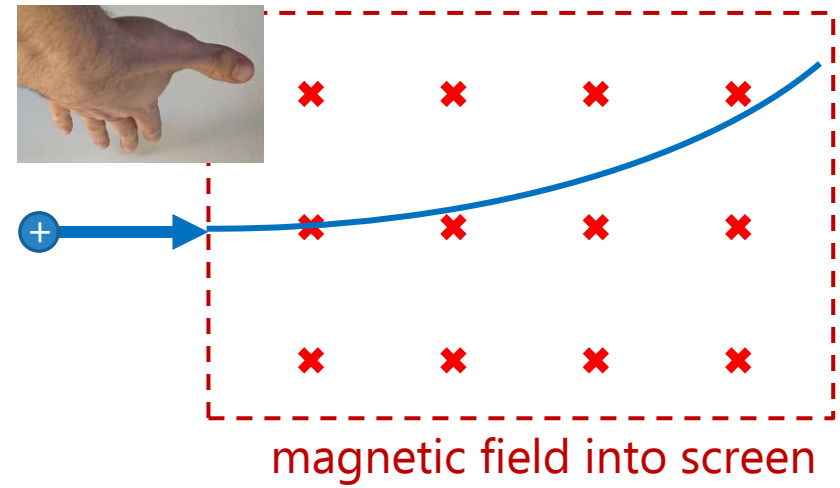
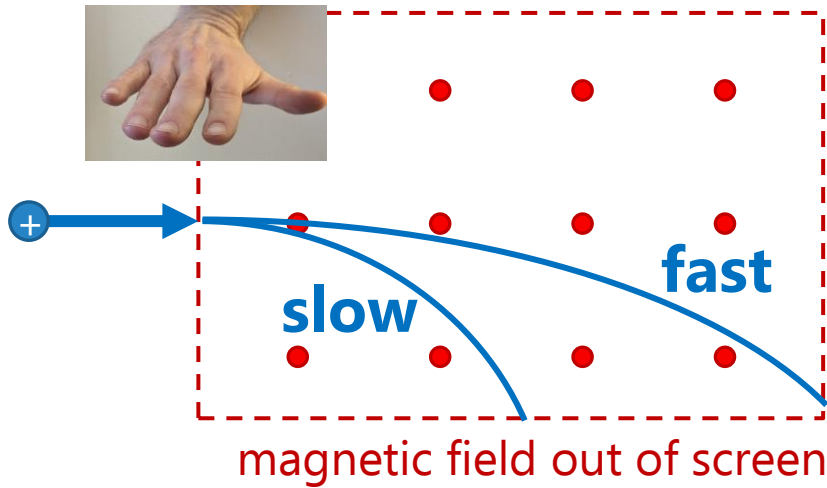
$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

Two parallel wires have currents of 8.0 A and 3.0 A respectively. What is the separation distance if the 0.2-meter-long wires are experiencing an inward force of attraction of 1.5×10^{-5} N?



Particles Moving Across Fields

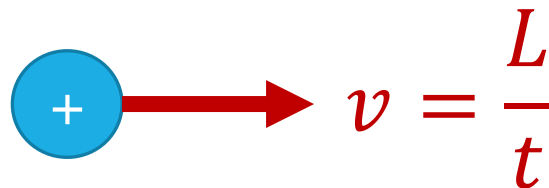


Force on a Charged Particle

When there is a magnetic force on a current carrying wire, the force is really on the moving charges inside of the conductor.

Single charged particles can also experience a magnetic force when moving through a magnetic field...

$$F = BIL \sin\theta$$



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Try This...

What is the magnetic force acting on a proton ($+1.6 \times 10^{-19}$ C) moving at an angle of 32° across a magnetic field of 5.3×10^{-3} T at a speed of 3.4×10^5 m s $^{-1}$?

$$F = qvB \sin\theta$$

Lesson Takeaways

- I can calculate electromagnetic force on a current carrying wire in a magnetic field
- I can describe the force between two parallel current carrying wires
- I can use the right-hand rule to predict the direction of force on a moving charge
- I can calculate the force on a charged particle in a magnetic field