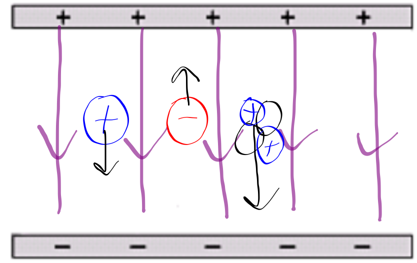
9. An electron, a proton, and an alpha particle are each released from rest midway between the two parallel plates shown.



a) Draw a vector to represent the electric force on each particle.

b) Draw a vector to represent the electric field at the location of each particle.

c) Compare the electric force on each particle.

$F_{e^-} = F_{p^+}$ $F_{\alpha^{++}} = 2F_{p^+}$

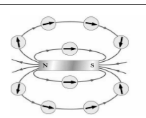
c) Describe and compare the motion of each particle.

$\vec{a}_{e^-} \sim 1000\,\vec{a}_{p^+}$ $a_{\alpha^{++}} = \frac{1}{2} a_{p^+}$

$\frac{2F}{4m}$

Magnetic Fields

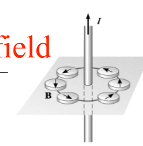
Magnetic Field around a Bar Magnet



Direction of magnetic field lines: the direction that the North pole of a small test compass would point if placed in the field (N to S)

What is the cause of magnetic fields? Moving electric charges

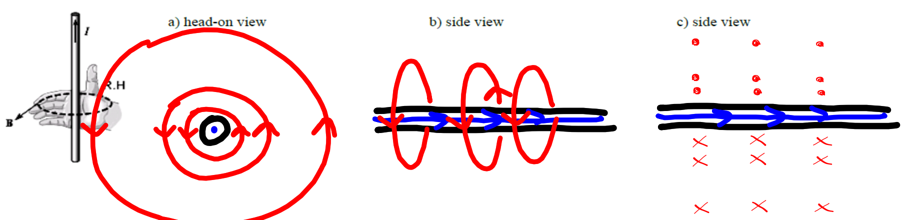
Therefore: current in a wire will produce a magnetic field



The Right Hand Rule for the Magnetic Field around a Wire

Thumb: direction of conventional current

Fingertips: direction of magnetic field – tangent to circle



$B \propto I$

$B \propto 1/r$

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

$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$F = k\frac{Qq}{r^2}$

$= \frac{1}{4\pi\varepsilon_0} Qq/r^2$

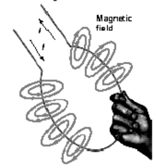
Alternate Right Hand Rule for Loops

Fingertips: direction of current

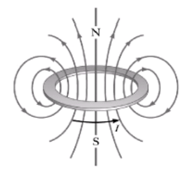
Thumb: points North

Note that a wire loop acts like a:

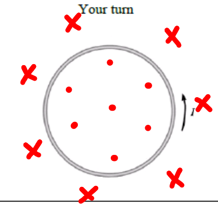
Component fields



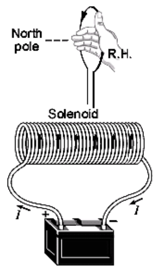
Resultant field

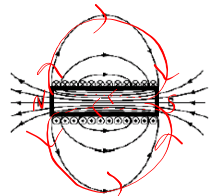


Your turn



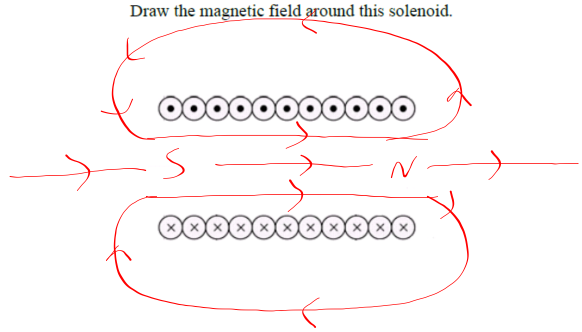
Solenoid: coil of wire – many loops





Note that a solenoid acts like a:

Draw the magnetic field around this solenoid.

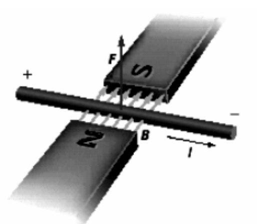


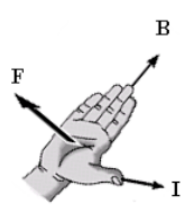
Magnetic Force on a Wire

If a wire with current flowing through it is placed in an external magnetic field, it will experience a force. Why?

Two magnetic fields – around wire and from external magnet – will either attract or repel

The Right Hand Rule for the Magnetic Force on a Current-Carrying Conductor in a Magnetic Field





Flat Hand: thumb and fingers at right angles

Fingers: external B field – north to south

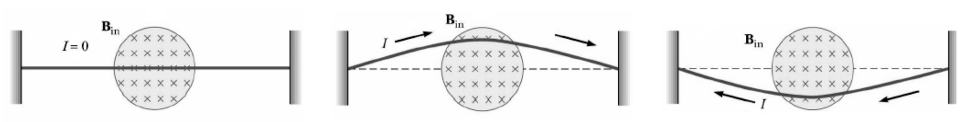
Thumb: current

Palm: force – "palm pushes"

Maximum force occurs when: current is perpendicular to B field

No force occurs when: current is parallel to B field

Use the right hand rule for forces to confirm the direction of the force in each case.



Magnitude of the magnetic force on a wire: $F = BIL \sin\theta$

Where θ is angle between current and B field

Magnetic field strength
Magnetic field intensity
Magnetic flux density

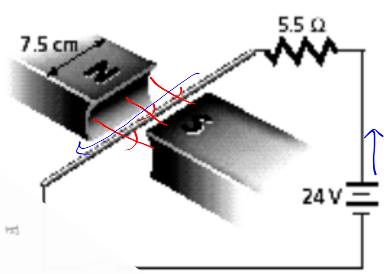
Units: $\left[\frac{N}{A \cdot m}\right] = [T]$

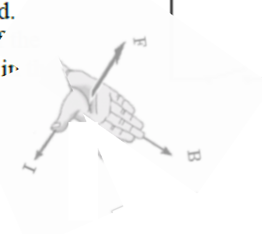
Definition of magnitude of magnetic field (#1):

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

The ratio of the magnetic force on a wire to the product of the current in the wire, the length of the wire and the sine of the angle between the current and the magnetic field

Find the magnitude and direction of the force on the wire segment confined to the gap between the two magnets as shown when the switch is closed. The strength of the magnetic field in the gap is 1.9 T



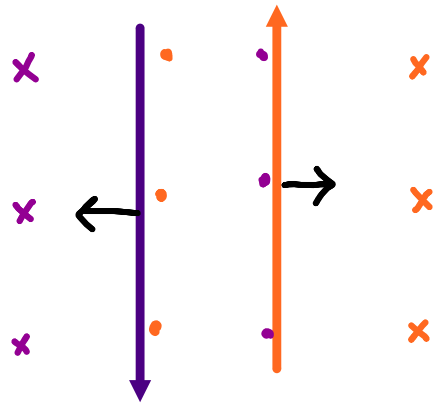


V/R

$$F = BIl$$

$$1.9T\left(\frac{24v}{5.5\Omega}\right).075m$$

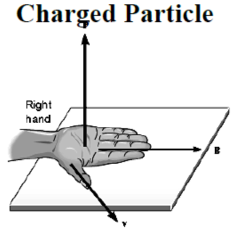
$= .6N$ up



Magnetic Force on a Moving Charged Particle

Why is there a magnetic force on a charged particle as it moves through a magnetic field? Moving charged particle creates its own magnetic field – two magnetic fields interact

Right Hand Rule: Magnetic Force on a Charged Particle



Flat Hand: thumb and fingers at right angles

Fingers: external B field – north to south

Right Hand: positive charge

Thumb: velocity

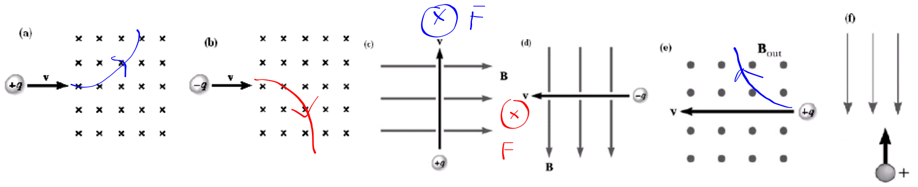
Left Hand: negative charge

Palm: force – "palm pushes"

Maximum force occurs when: velocity is perpendicular to B field

No force occurs when: velocity is parallel to B field

Find the direction of the magnetic force on each particle below as each enters the magnetic field shown.



Magnitude of the magnetic force on a moving charged particle:

F = qvB sin θ

Where θ is angle between v and B

Definition of magnitude of magnetic field (#2):

The ratio of the force on a charged particle moving in a magnetic field to the product of the particle's charge, velocity and sine of the angle between the direction of the magnetic field and velocity.

$B = \frac{F}{qv}$ → $\left[\frac{N}{C\ m/s}\right] = [T]$

A proton in a particle accelerator has a speed of 5.0×10^6 m/s. The proton encounters a magnetic field whose magnitude is 0.40T and whose direction makes an angle of $\theta = 30.0°$ with respect to the proton's velocity. Find the magnitude of the magnetic force on the proton and the proton's acceleration. How would these change if the particle was an electron?