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6.5 Magnetic Force on moving charges

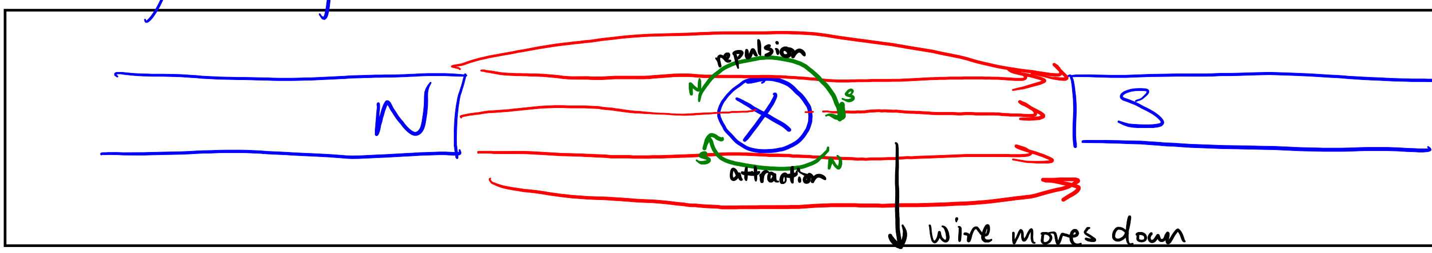
Let's see what happens when we put moving charges in magnetic fields.

What did you see when a current carrying wire was put between the poles of a magnet?

* write your observations ________________________________

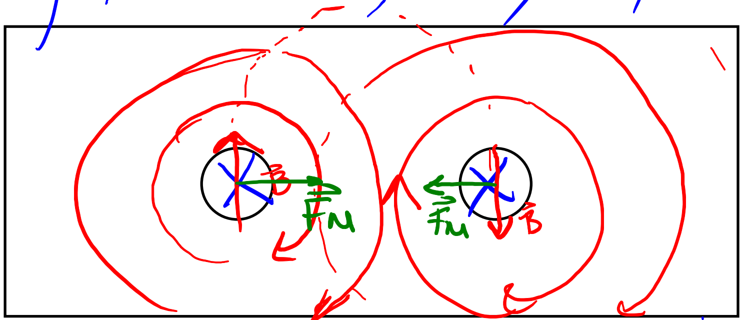
Why does this happen?

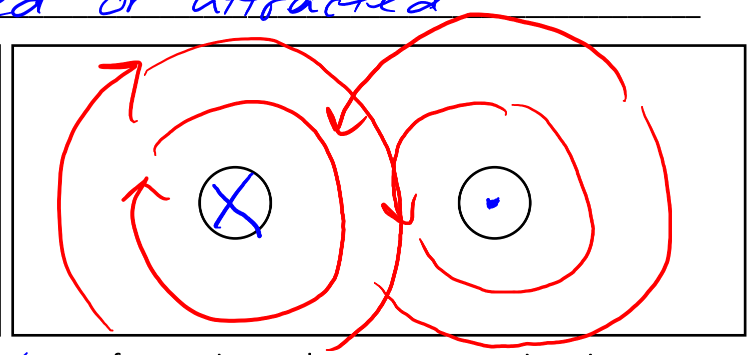
The magnetic field produced by the current carrying wire interacts with the external magnetic field, which produces a magnetic force that acts on the current carrying wire.



Notice how aligned fields repel and opposite fields attract.

What happens when we put 2 current carrying wires side by side? depending on the direction of the current, they repelled or attracted





To summarize the direction of the magnetic force acting on these current carrying wires, we use the **3rd Right Hand Rule:**

The magnitude of the magnetic force acting on a conductor in a magnetic field is:

$F_M = BIL\sin\theta$ (N) Where:

B = magnetic field (T) I = current (A)

L = length of wire (m) θ = angle between $\vec{I}$ and $\vec{B}$ (°)

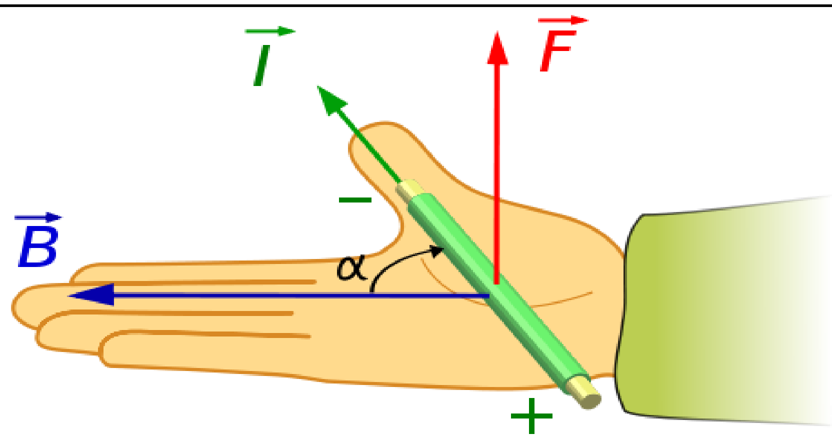
If the B field is perpendicular to the direction of the current, sin90 = 1, so F_M =

If B field is parallel to the direction of the current, sin0 = 0, so F_M =

Thumb: Direction of conventional current

Fingers: Direction of magnetic field

Palm facing: Direction of ~~magnetic field~~ force



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Since a current is moving charges, we can also find the magnetic force acting on a single charge.

The magnitude of the magnetic force acting on a charged particle in a magnetic field is:

$F_M =$ $qvB\sin\theta$ (N)

Where:

B = magnetic field (T)

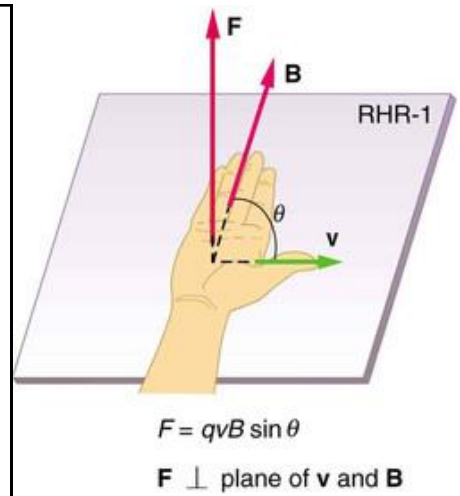
v = velocity (m/s)

q = charge (C)

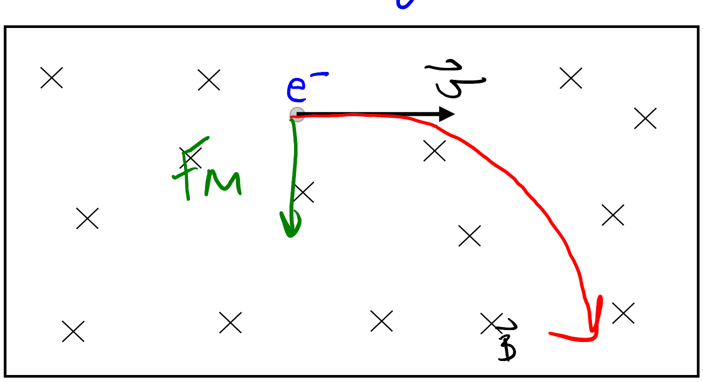
θ = angle between $\vec{B}$ and $\vec{v}$ (°)

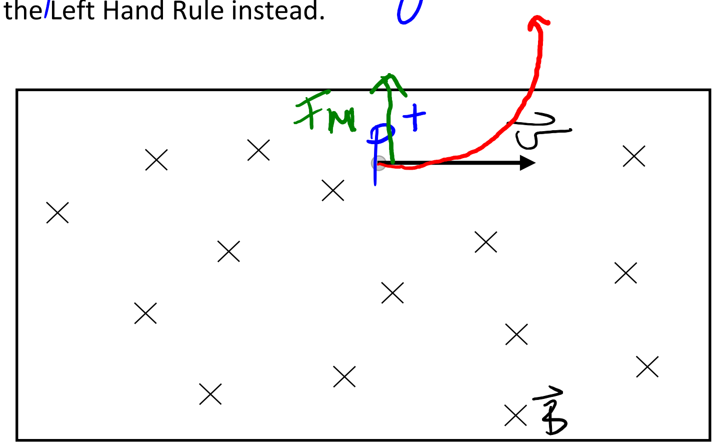
If the B field is perpendicular to the charge's velocity, sin90 = 1, so $F_M =$ qvB

If B field is parallel to the charge's velocity, sin0 = 0, so $F_M =$ 0



Careful! The Right Hand Rule for moving charges is only for positive charges. For negative charges, you can use the Left Hand Rule instead.

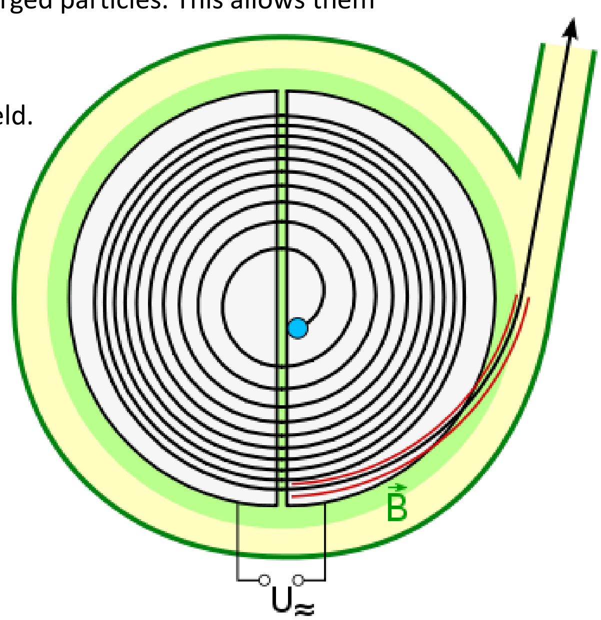




What happens when the velocity of a moving object is perpendicular to the force acting on it? You get circular motion where $F_M = F_{net}$ towards the center of the circle

$c = 3.0 \times 10^8 \, m/s$

Ex. 1: Circular particle accelerators use magnetic fields to bend beams of charged particles. This allows them reach phenomenal speeds in relatively small spaces. The cyclotron at UBC's TRIUMF contains the largest of its kind in the world. It accelerates a beam of hydrogen anions (H^-) to 75% the speed of light and uses a 0.42 T magnetic field. Note that at these speeds the relativistic mass of a hydrogen anion is 2.524×10^{-27} kg. (ANS: 8.5m)



What is the outer radius of the cyclotron?

$F_{net} = \frac{mv^2}{r}$ $\quad F_M = q\vec{v}\vec{B}$

$F_{net} = F_M$ $\quad r = ?$

$\frac{mv^2}{r} = qvB$

HW: Worksheet 6.5 #1, 3, 4, 6, 11, 12, 14, 24, 26