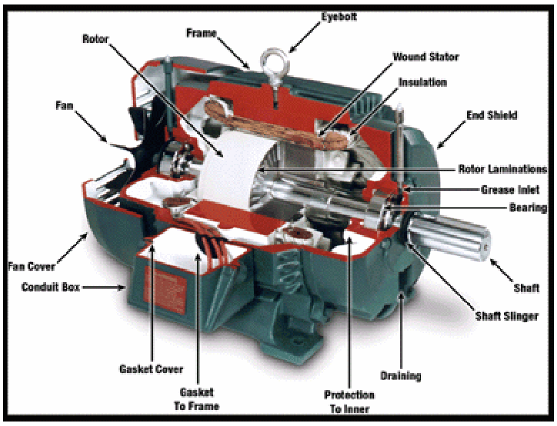
L13 - Motor Effect on a Point Charge



L13 - Motor Effect on a Point Charge:

$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$

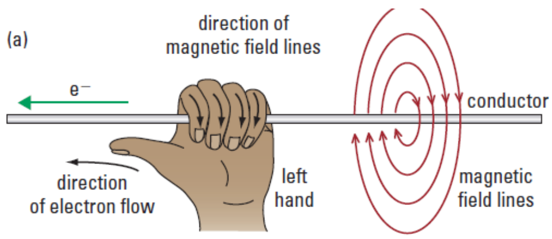
L14 - Motor Effect on a Wire:

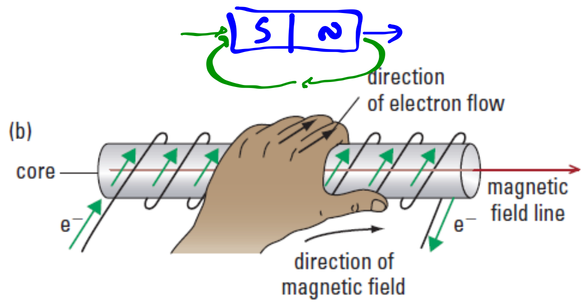
$$I = \frac{q}{t} \qquad \left|\vec{F}_{\mathrm{m}}\right| = Il_{\perp}\left|\vec{B}\right|$$

L15 - Motor Effect and Circular Motion:

$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right| \qquad \left|\vec{a}_{\mathrm{c}}\right| = \frac{v^2}{r} \qquad \left|\vec{v}_{\mathrm{c}}\right| = \frac{2\pi r}{T}$$

Review of Left-Hand Rules





Thumb: Direction of negative charge movement (straight line).

...Results In...

Fingers: Resulting magnetic field (curving).

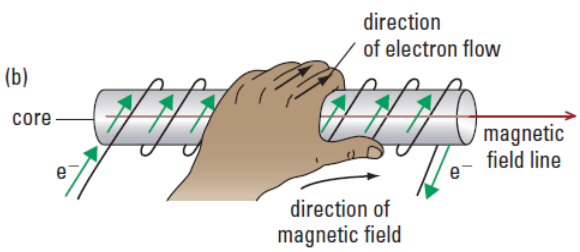
Fingers: Direction of negative charge movement (curving).

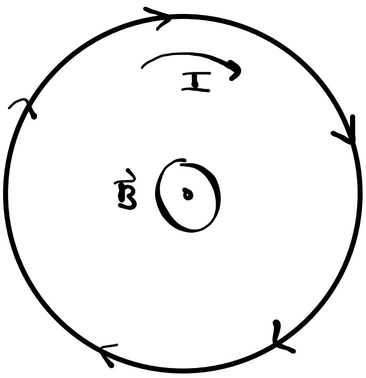
...Results In...

Thumb: Resulting magnetic field (straight line).

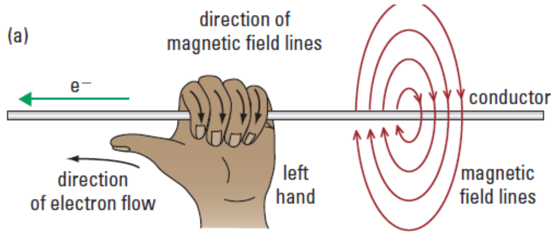
Left-Hand Rules - Actually just one rule

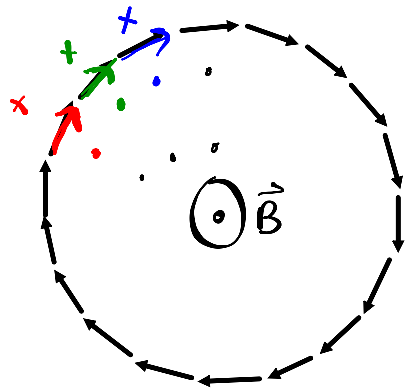
Loop of wire?

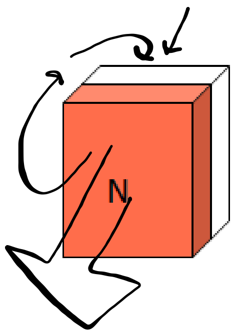


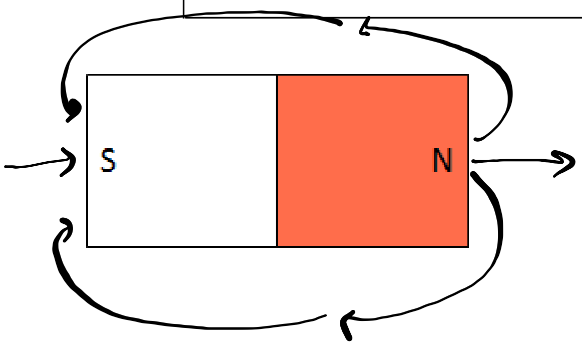


Lots of straight wires?

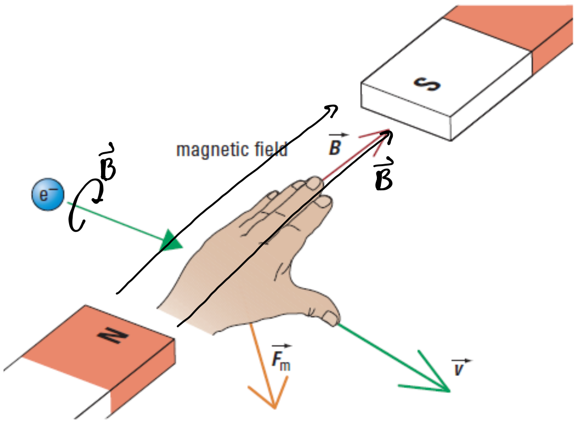








Motor Effect on a Point Charge



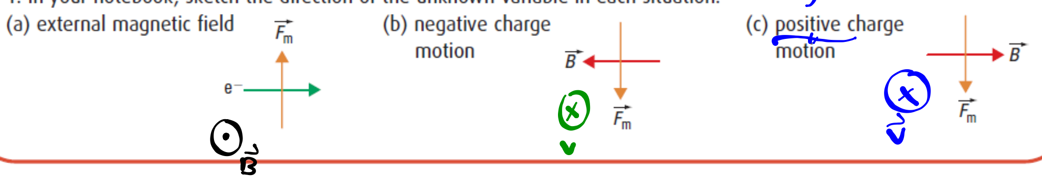
Thumb: Direction of motion ($\vec{v}$) (hitchhiking)

Fingers: Mag field ($\vec{B}$) (bumpy fingers)

Palm: Dir of force

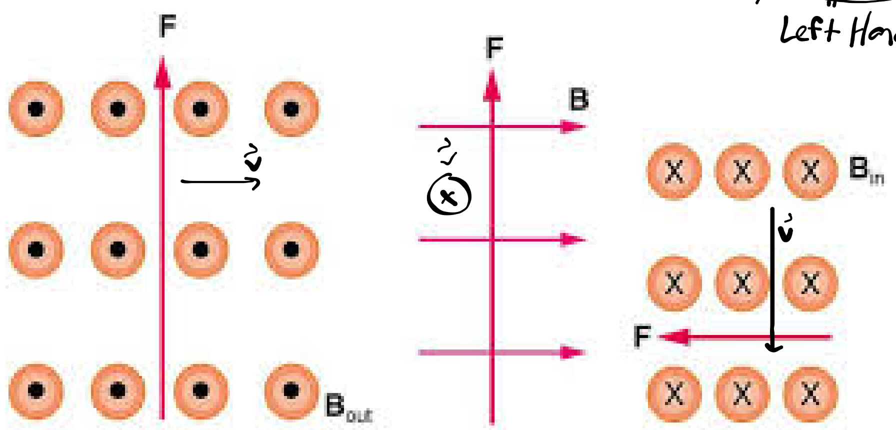
SKILLS PRACTICE Using the Left-hand Rule for Deflection

1. In your notebook, sketch the direction of the unknown variable in each situation. Right.



What is the Direction of Motion for the Negative Charge?

Left Hand



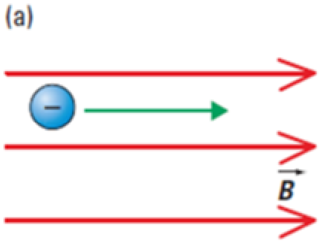
(a) (b) (c)

Motor Effect - Magnitude of Magnetic Force

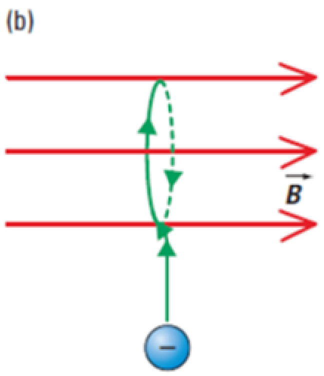
$$\left|\vec{F}_{\text{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$

Motor Effect - Complicated (Pt 1)

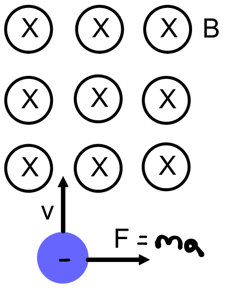
A magnetic field deflects a moving charged particle that is moving ***perpendicular*** to it.

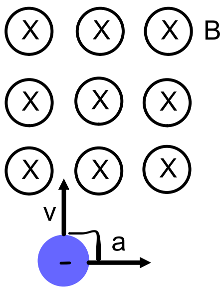


No perpendicular component. Therefore no force.



From a different view.



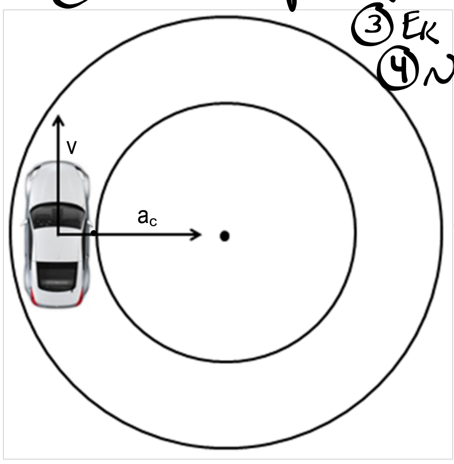


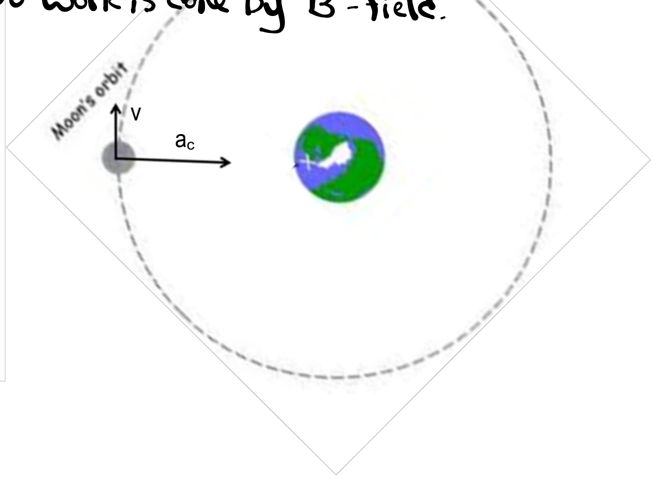
What happens when velocity and acceleration (due to Force) are perpendicular?

Answer:

Circular Motion!!!

1. Acceleration (change in direction)
2. Constant speed (uniform circ. mot)
3. Ek stays same
4. No work is done by $\vec{B}$-field.



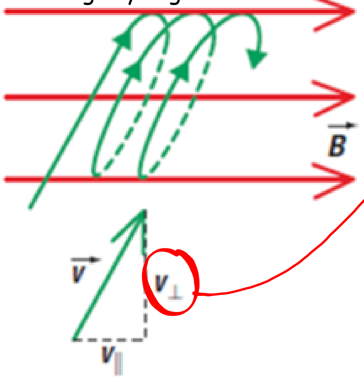


Motor Effect - Complicated (Pt 2)

A magnetic field deflects a moving charged particle that is moving ***perpendicular*** to it.

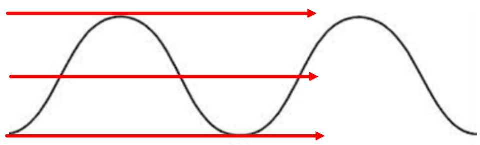
(c)

Slightly angled view.



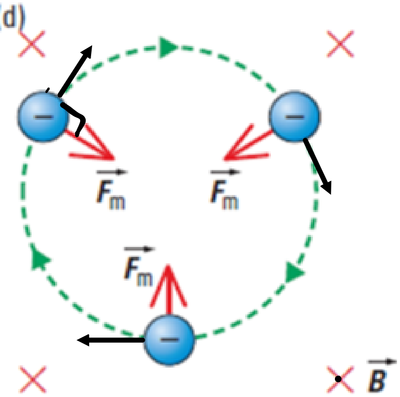
$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$

Perpendicular component will cause circular motion.
Parallel motion means "spiraling" forward.



Side view. The charged particle
DOES NOT "double back" on itself.

(d)



Circular Motion again.

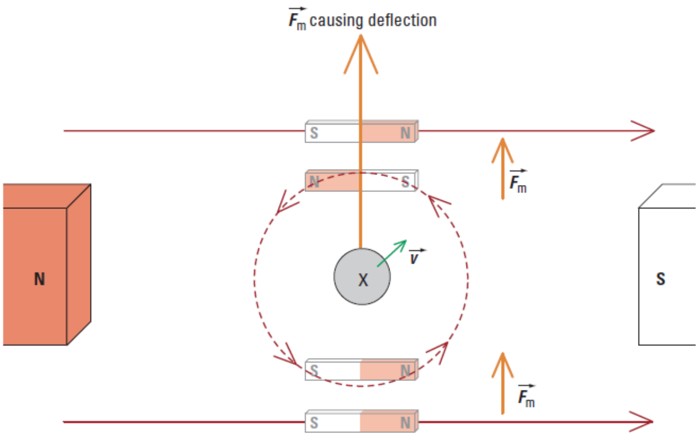
U/S → $F_m = qvB$ $F_c = \frac{mv^2}{r}$

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

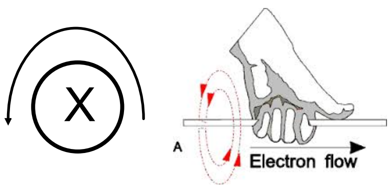
100% of circ. mot.

Motor Effect - Complicated (Pg 3)

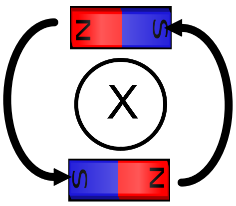
Why do the Motor Effect work the way it does?



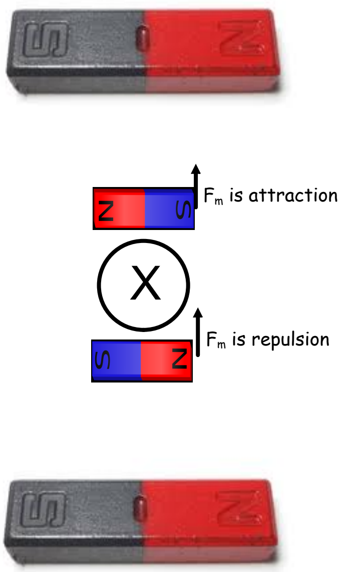
Step #1: What is happening with the moving electron's magnetic field?



Step #2: Magnetic field lines point away from North.



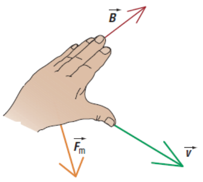
Step #3: How do these magnetic field lines interact with the external magnetic field?

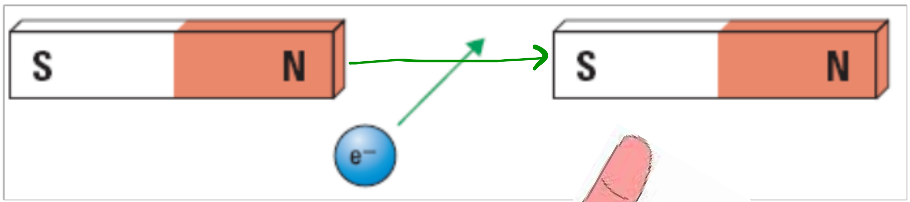


Motor Effect – Magnitude of Magnetic Force

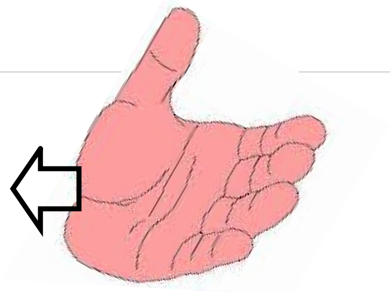
$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$

Q1: An electron is travelling at 3.20 x 10^5 m/s perpendicular to an external magnetic field of magnitude 2.20 x 10^{-1} T. Determine the magnetic force acting on the electron.





$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$
$$= (1.60\times10^{-19})(3.20\times10^{5})(2.20\times10^{-1})$$
$$= 1.1264\times10^{-14}\ \mathrm{N}\ [\mathrm{up}]$$



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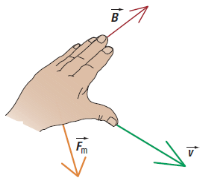
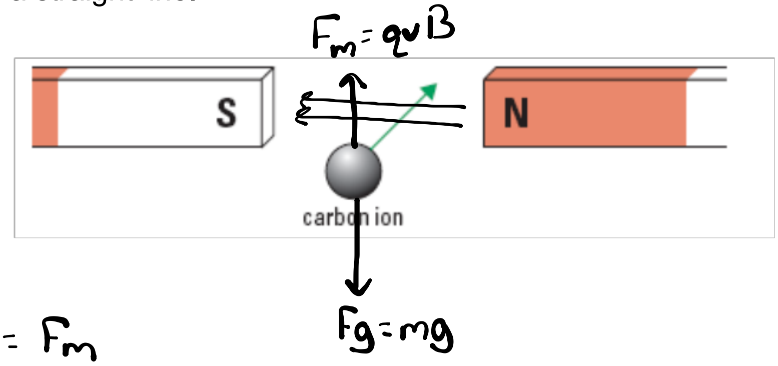
Q2: A carbon ion with a mass of 2.01×10^{-26} kg and a positive charge of magnitude 1.60×10^{-19} C enters the region of an external magnetic field of magnitude 6.32×10^{-5} T. Find the perpendicular speed at which the magnetic deflecting force will balance the gravitational forces such that the carbon ion will travel in a straight line.





$$\left|\vec{F}_{\mathrm{m}}\right| = qv_{\perp}\left|\vec{B}\right|$$

$$F_g = F_m$$

$$mg = qvB$$

$$(2.01\times10^{-26})(9.81) = (1.60\times10^{-19})v(6.32\times10^{-5})$$

$$1.97181\times10^{-25} = (1.0112\times10^{-23})v$$

$$\boxed{v = 1.95\times10^{-2}\ m/s}$$