Electromagnetism

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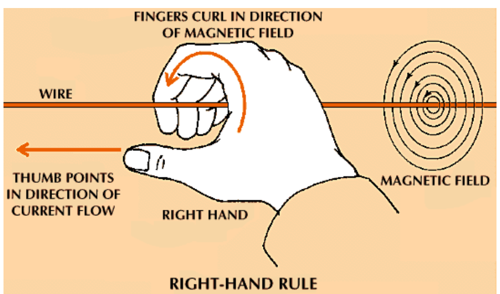
- On 21 April 1820, during a lecture, Oersted noticed a compass needle deflected from magnetic north when an electric current from a battery was switched on and off.
- This showed a direct relationship between electricity and magnetism
- **Moving electric charges (current) create magnetic fields**.

Right Hand Rule (the first)

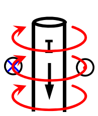


Current Carrying Wire

- To draw magnetic fields around current carrying wires use the Right Hand Rule
  - point the thumb of your right hand in the direction of the current flow
  - wrap your fingers as if you are grabbing onto the wire.
  - Your fingers will show you the direction of the magnetic field.

Current Carrying Wire

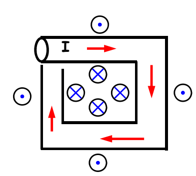
Feathers (into the page)



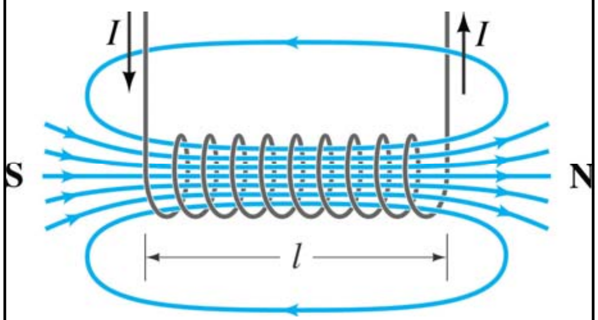
Bullets (out of the page)

If current is flowing down the wire the magnetic field is directed INTO the page on the left of the wire (feathers) and out of the page on the right of the wire (bullets)

Wire in a Loop

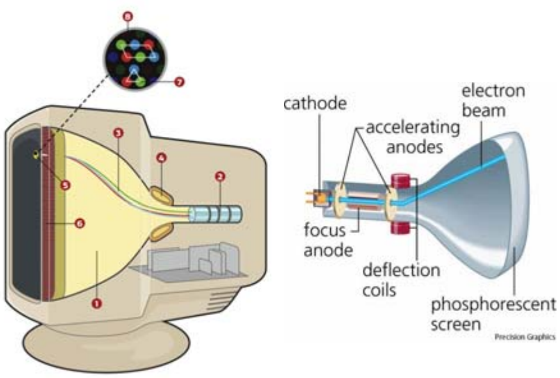


- Notice that there are a greater concentration of feathers inside the loop than bullets on the outside of the loop
  - The magnetic field is stronger inside the loop of wire.
- If you keep looping the wire then you keep increasing the strength of the magnetic field.
- The direction of the magnetic field depends on the direction of the current flow through the wire.



Solenoid

- A coil of wire is called a **SOLENOID**
- You can magnetize a solenoid by running electrical current through it.
- An **ELECTROMAGNET** is a solenoid that is wrapped around a Ferromagnetic core.
- To make an electromagnet all you need is:
  - WIRE (the more loops the better)
  - BATTERY (the more voltage the better)
  - FERROMAGNETIC CORE



Magnetic Force

- Two magnets will apply a force on each other.
- If you have a moving electric charge (which has a magnetic field around it) it can be forced to move by another magnetic field.

$$F_m = q\,v\,B$$

F_m = Force (Newtons)
q = Charge (Coulombs)
v = Velocity (m/s)
B = Magnetic Field (Tesla)

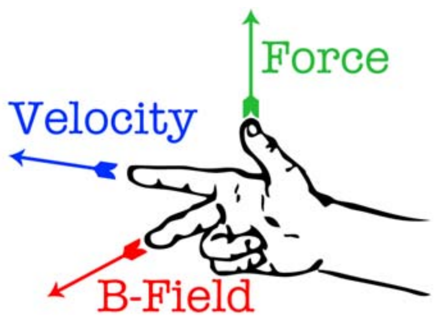
Magnetic Force

- Many charges moving in a wire is called current so the previous equation can be written as:

$$F_m = BIL$$

F_m = Force (Newtons)
B = Magnetic Field (Tesla)
I = Current (Amps)
L= length (meters)

Right Hand Rule (second)

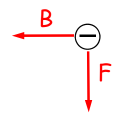


Another Right Hand Rule

- A charge will feel the greatest force when it is moving PERPENDICULAR to the B-field. It will feel no force if it is moving PARALLEL to the B-field.
- To determine the direction of the magnetic force, current, and magnetic field (B-Field) you will need to know the "Physics' Signs"
  - Thumb represents force
  - First finger represents direction of velocity
  - All other fingers represent the B-field, where your knuckles are at the North Pole of the magnet.
- ***(IF YOU WEREN'T IN CLASS FOR THIS YOU MUST GET HELP FROM SOMEONE!)***

Sample

- An electron in an electron beam experiences a downward force of 2 E -14 N while traveling in a magnetic field of 8.3 E -3 T directed to the west.
- Find the DIRECTION and MAGNITUDE of the velocity of the electron.



The velocity is into the page

Sample, cont.

F_m = 2 E -14 N
q = 1.6 E -19 C
B = 8.3 E -3 T
v = ?

F_m = q v B

2 E -14 N = (1.6 E -19 C)(v)(8.3 E -3 T)

v = 1.5 E 7 m/s; into the page

Practice

- A proton moving to the right at 2.5 E 4 m/s enters a magnetic field of 6.3 E 3 T pointed down the page. Determine the magnitude and direction of the magnetic force on the electron.

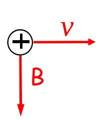
$q = 1.6E-19C$ $\quad B = 6.3E3T$

$v = 2.5E4m/s$ $\quad F_m = ?$

$$F_m = qvB$$

$$F_m = (1.6E-19C)(2.5E4m/s)(6.3E3T)$$

$$F_m = 2.52E-11N$$



Use the right hand rule to determine direction

into the page

Practice

- What is the force on a 3 meter wire carrying a 9.50 A current when perpendicular to a 0.80 T magnetic field?

$B = 0.80T$

$I = 9.50A$

$L = 3m$

$F_m = ?$

$$F_m = BIL$$

$$F_m = (0.80T)(9.50A)(3m)$$

$$F_m = 22.80N$$

Extra Resources

- Hyper Physics –
  - http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html
- Physics Classroom
  - http://www.physicsclassroom.com/
- Textbook
  - http://www.essential-physics.com/TX/sbook
  - Campus Access Code: 742 - 661 - 8230