IB Physics

Magnetism and Induction

Chapter 20, 21 Syllabus

	Class	Due on this class
1 Jan 21	**DI**-Demos and the three right hand rules **GW**-20.1, 20.2a-d	**VF 20A, 20B, 20C** Turn In Labs: Internal Resistance of a battery, Light Bulb and Diode, Oscilloscope, Resistance of a Wire
2 Jan 29	**DI**-Hysteresis Demo **GW**-20.2e **GW**-FA20.1, 20.2	**VF 20D, 20E, 20F**
3 Jan 31	**SA 20.1 and 20.2 (First 40 minutes)** **VF**-20H-Ampere's Law **DI**-Galvanometers, Speakers, Motors (20G)	Turn In FA 20.1, 20.2
4 Feb 4	**DI**-Demos and direction of current **GW**-21.1, 20.2a-c	**VF 21A, 21B, 21C**
5 Feb 6	**DI**-Demos - Transformers, and Alternators (21D) **GW**-21.2de **GW**-21.1, 21.2	**VF 21E, 21F**
6 Feb 10	**SA 21.1, 21.2 (First 40 minutes)** **VF**-20I, 20K **DI**-da Labs	Turn In FA 21.1, 21.2
7 Feb 12	**GW**-Magnaprobe lab **GW**-Specific Heat Of Water lab **GW**-Magnet Lab	**VF 21G**
8 Feb 18	**GW**-Magnaprobe lab **GW**-Specific Heat Of Water lab **GW**-Magnet Lab	Turn In: FA20.3 (no summative)
Feb 20	**Atomic and Nuclear!!!!**	**VF 27A, 27B, 27C**

Assignments

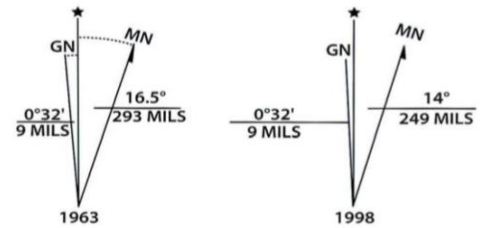
- 3 Labs:
  - MagnaProbe Lab – Station exploration of magnetic fields
  - Magnet Lab – student designed lab – no handout
  - Specific Heat of Water lab
  - Index of Refraction EC lab (IB)
- 5 Formative, 4 Summative Assessments
  - 20.1 – Right Hand Rules
  - 20.2 – Forces on Wires and Particles
  - 20.3 - Ampere's Law (no summative)
  - 21.1 – Lenz's Law
  - 21.2 – Electrical Induction

Noteguide for Basic Magnetism - Video 20A **Name**___________________________

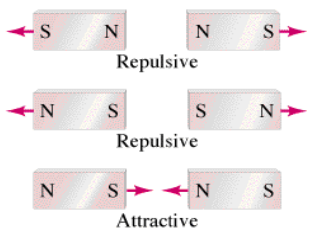
Definition of N and S poles

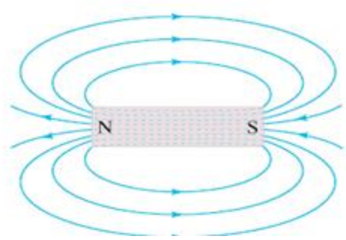
Finding polarity of a magnet

Shocking revelation



Magnetic declination for the Sugar House quadrangle (Salt Lake City area) in 1963 and 1998, showing a 2.5-degree decrease in magnetic declination over this time period. Since 1998, it has decreased an additional 1.5 degrees.





Magnet

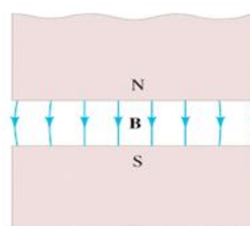
How do magnets pick things up?

Induced magnetism
Distance/Force
Demo with compass

Magnet

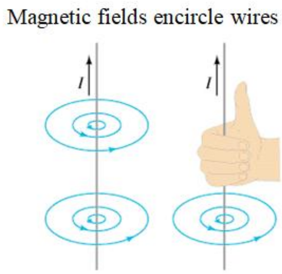
Ferrous material
(No induced)

Induced



Remember – B Field Lines:
- Leave the N pole
- Enter the S pole

Right Hand Rule #1 - Magnetic Fields encircle wires:



Thumb in direction of I, fingers wrap as B (Magnetic field)
Demo with Magnaprobe/Giant Solenoid

Right Hand Rule #2 - Loops of Wire act as magnets with a N and S pole:

Wrap your Rt. fingers with the current, and your thumb
is the N pole, the butt of your hand is the S Pole

Right Hand Rule #3 - Magnetic Fields exert a force on Current Carrying wires that is perpendicular to both the Magnetic Field, and the Current:

Direction of force:

Index finger -	Direction of Il
Middle finger -	Direction of B
Thumb -	Direction of Force

Noteguide for Force on Current-Carrying Wires - Videos 20B   **Name______________________**

Force on a current carrying wire:

F = IlxB = IlBsinθ (rt hand direction)

- x is vector cross product
- F = force on wire (N)
- I = current (A)
- l = length of wire in B field (m)
- B = magnetic field in Teslas (1 T = 1 N/Am)
  - 1 T = 10,000 Gauss
- θ = Angle twixt B and l (tail to tail)

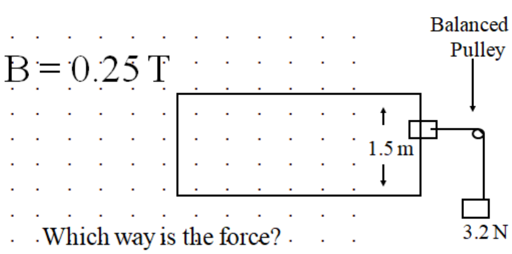
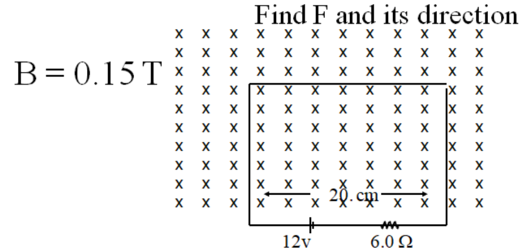
Example: A 0.15 T magnetic field is 27^o east of North What's the force on a 3.2 m long wire if the current is 5.0 A to the West?

N

W E

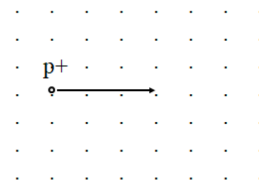
S

Whiteboards

1. What current in what direction would you need to have a force of 10.0 N to the west in 50.0 cm of wire perpendicular to Earth's magnetic field of 0.5 x 10^{-4} T to the North? (4 x 10^{5} A upward)	2. A 17 cm wire forms a 37^o angle with an unknown magnetic field. What is the magnetic field if the force equals 0.015 N and I = 5.0 A? (2.9 x 10^{-2} T)
Find I and its direction in the B-Field  3. (8.5 A, ACW)	Find F and its direction  4. (0.060 N, Up)

Noteguide for Particles in a Magnetic Field - Videos 20C **Name______________________**

Recall
F = IlBsinθ
Derive
F = qvBsinθ

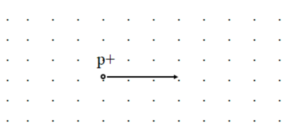


- F = force on moving particle
- q = charge on particle (in C) (+ or -???)
- v = particle's velocity
- θ = angle twixt v and B

Whiteboards

1. What is the force acting on a proton moving at 2.5×10^{8} m/s to the North in a 0.35 T magnetic field to the East? (1.4×10^{-11} N, Downward) $q = 1.602 \times 10^{-19}$ C	2. What magnetic field would exert 1.2×10^{-12} N on an alpha particle going 17% the speed of light? alpha = 2p2n (0.073 T) $q = 2(1.602 \times 10^{-19}\ C) = 3.204 \times 10^{-19}$ C $v = 0.17 \times 3.00 \times 10^{8}$ m/s $= 5.1 \times 10^{7}$ m/s

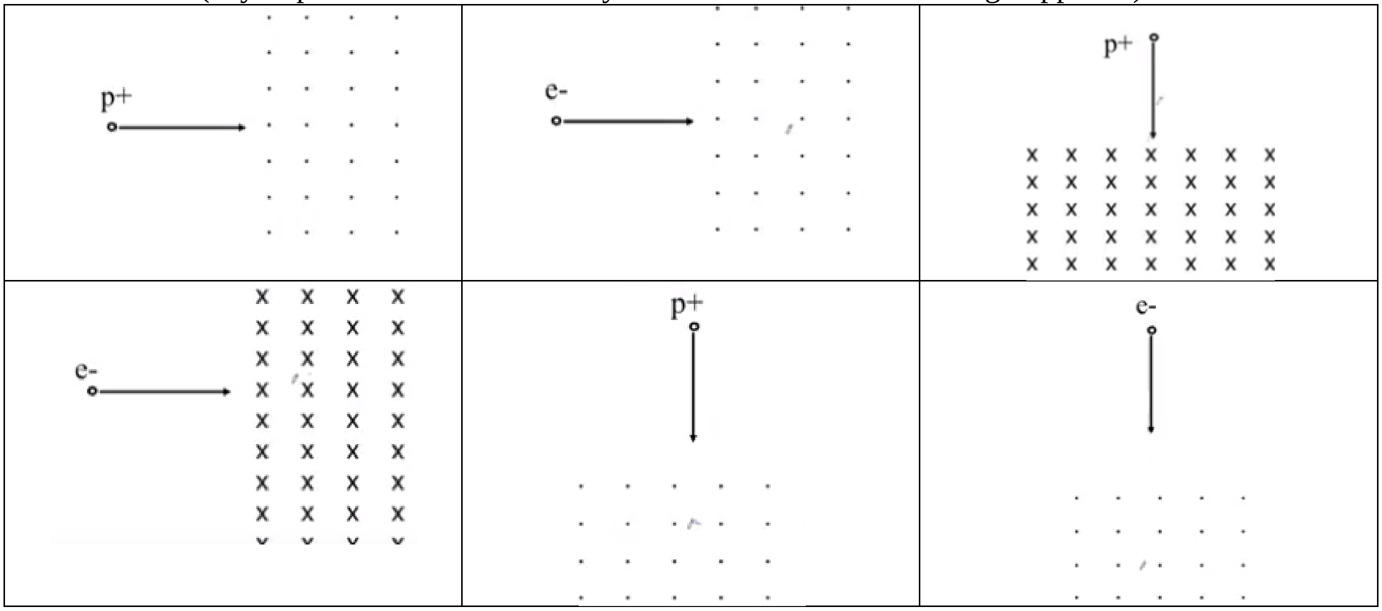
Example - proton going 4787.81 m/s
in earth's magnetic field (5.0×10^{-5} T) What radius?



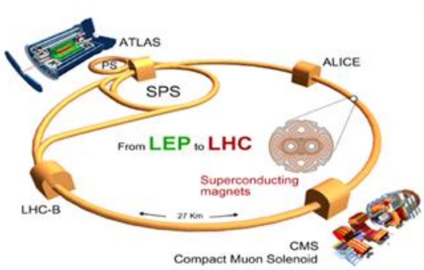
Whiteboards

1. If the electron is going 1.75×10^{6}m/s, and the magnetic field is .00013 T, what is the radius of the path of the electron? (7.7 cm) $m = 9.11 \times 10^{-31}$ kg $q = 1.602 \times 10^{-19}$ C	2. What B-Field do you need to make a proton going 2.13×10^{7} m/s go in a 3.2 cm radius circle ACW in the plane of this page? (7.0 T into the page) $m = 1.673 \times 10^{-27}$ kg $q = 1.602 \times 10^{-19}$ C

Whiteboards: (Try to predict the direction they curve - remember electrons go opposite)

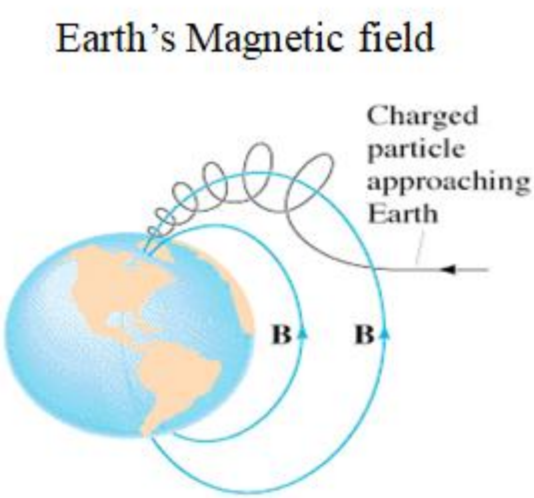


Particle Accelerators:



Superconducting magnets
Energy of particles
Why we have particle accelerators

The Aurora Borealis: (Northern Lights)



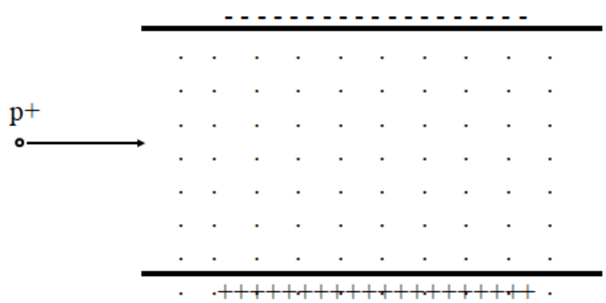
Explain angle to B-Field (vertical B field, velocity angled upward)

Noteguide for Crossed Fields and Mass Spec - Videos 20D **Name__________________**

Crossed Fields Example:

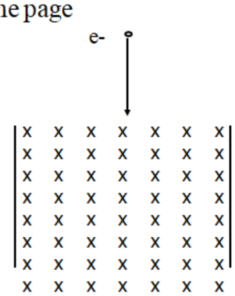
Proton going 2.35×10^{7} m/s, m = 1.673×10^{-27} kg, B = 0.0145 T

(Which way F from B, which way E is to prevent this. What E is, what direction, does the charge matter?, does the mass matter?)



You try this one:

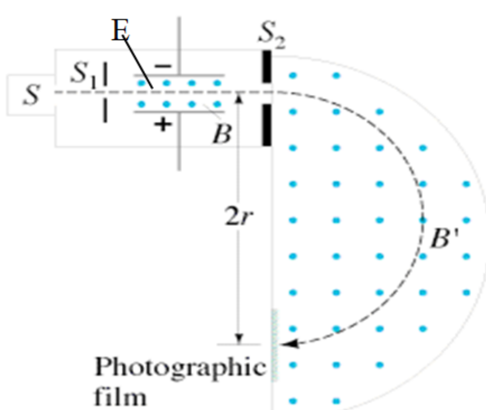
Electron going 1.27×10^{5} m/s, m = 9.11×10^{-31} kg, B = 0.0120 T
What electric field in what direction will make the electron go straight down the page



1520 N/C to the left

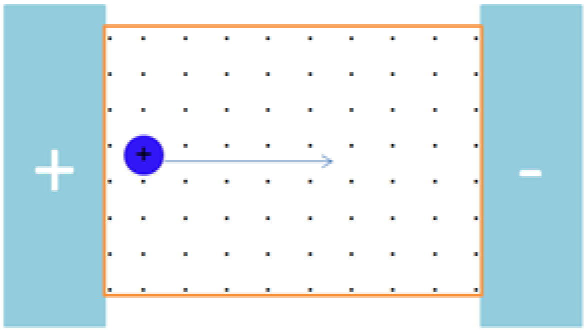
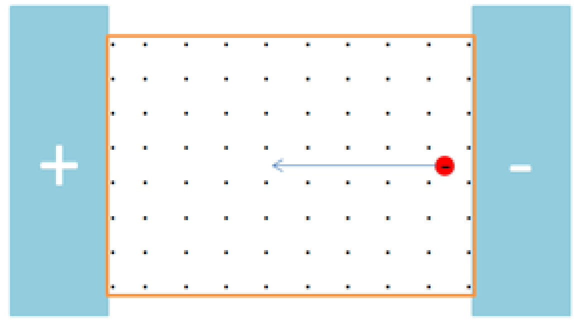
First Region:
V=?

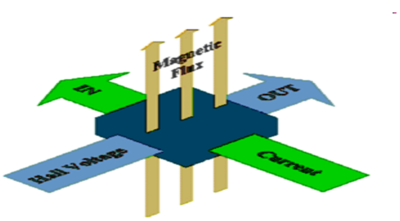
Second Region
q/m = ?

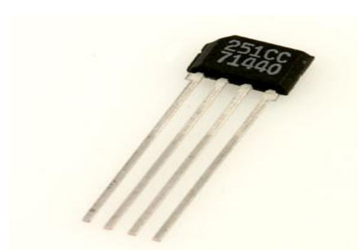


Noteguide for The Hall Effect - Videos 20E **Name__________________**

Two Possible Scenarios:

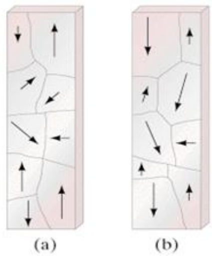
Positive Charge Carriers in wire: (incorrect) Conventional Current is to the right	Negative Charge Carriers in wire: (correct) Conventional Current is to the right
	





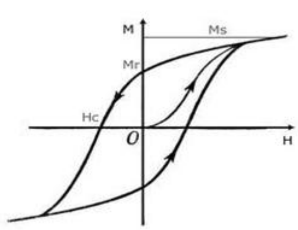
Noteguide for Hysteresis and Magnetization - Videos 20F **Name__________________**

Freakin' magnets, how do they work?

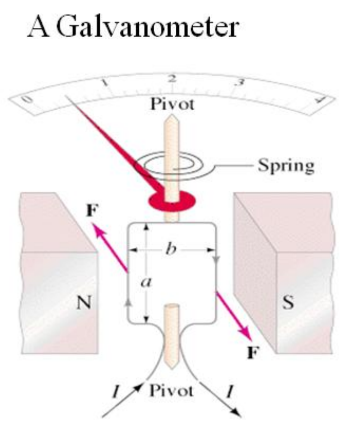


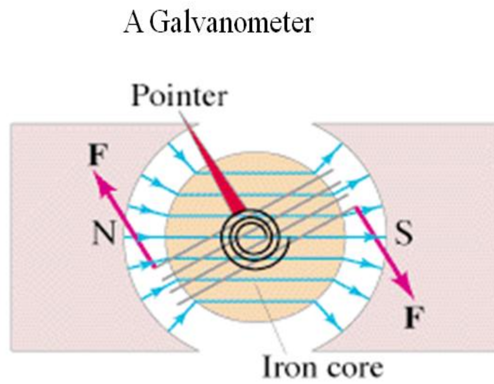
- Domains - small bits (1mm) that are aligned
- a - unmagnetized = random orientation
- b - slight preference down (N pole)

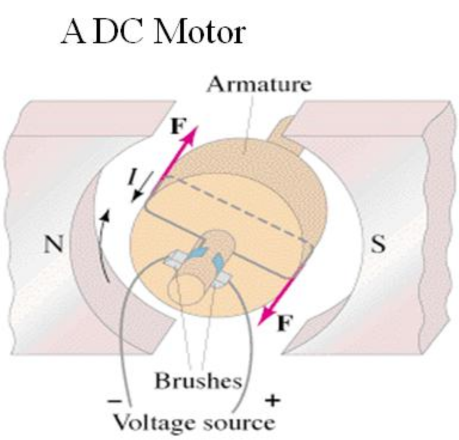
Hysteresis

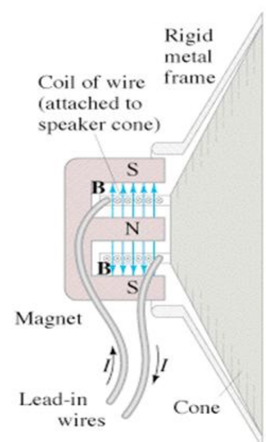


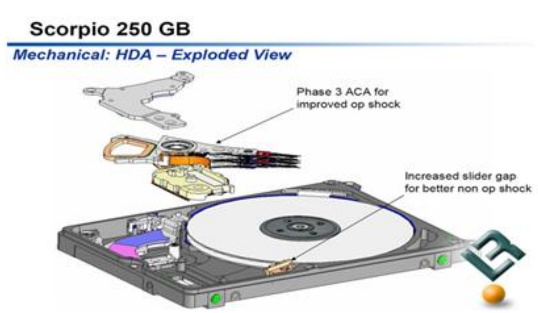
Noteguide for Motors, Galvanometers, and Speakers - Videos 20G **Name___________________**

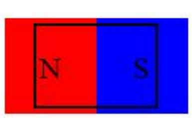










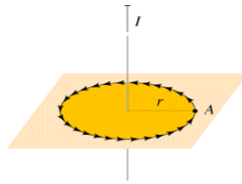


Noteguide for Ampere's Law - Videos 20H

Name__________________

For a circular path around a wire:

$\Sigma B \cdot dl = B 2\pi r = \mu_o I$



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

B = magnetic field

r = distance from wire

I = current in wire

$\mu_o = 4\pi \times 10^{-7}$ Tm/A

Ampere's Law

$\Sigma B \cdot dl = \mu_o I$

$\Sigma B \cdot dl$ = sum of B in the direction of dl

$\mu_o = 4\pi \times 10^{-7}$ Tm/A

(Magnetic permeability of free space)

Whiteboards:

1. What is the magnetic field 13 cm from a wire that is carrying 45 A? (6.9×10^{-5} T)	2. At what distance from a wire carrying 1.20 A is the magnetic field 1.50×10^{-4} T? (1.6×10^{-3} m)
3. If a wire has a magnetic field of 1.15×10^{-4} T at a distance of 2.51 cm from its center, what is the current flowing in the wire? (14.4 A)	

Two wires:

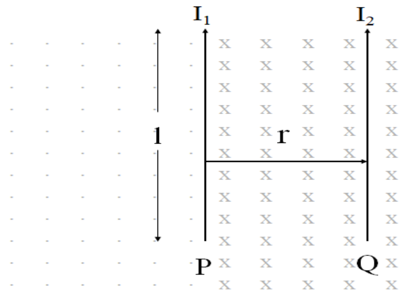
Magnetic field due to P at Q is:

$$B = \frac{\mu_o I_1}{2\pi r}$$

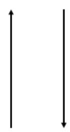
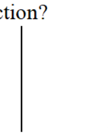
Force on Q is

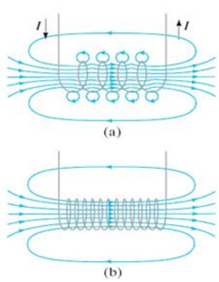
$F = I_2 l B =$

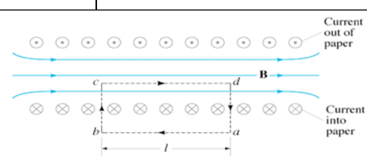
$$F = \frac{\mu_o I_1 I_2 l}{2\pi r}$$



Whiteboards:

What is the force on the wire to the right? The wires are 15.0 cm apart, the one on the left is carrying 30. A, the right, 45 A. They are 45 cm long  1. ($8.1\text{x}10^{-4}$ N to the right)	The wire to the left experiences a force to the left of $3.15 \text{ x } 10^{-8}$ N. If both wires are 5.15 m long, separated by 3.50 m, and the wire to the right carries 2.12 A, what current is flowing in the left wire, and in which direction?  $F = \frac{\mu_o I_1 I_2 l}{2\pi r}$ 2. ($5.05\text{x}10^{-2}$ A up the page)





$\Sigma B \cdot dl = \mu_o I$

$Bl = N \mu_o I$

$$B = \frac{\mu_o N I}{l} = \mu_o n I$$

N = number of windings

$\mu_o = 4\pi \text{ x } 10^{-7}$ Tm/A

I = current A

l = length of solenoid m

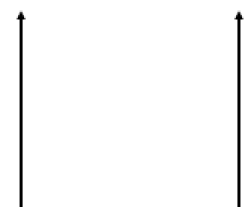
n = windings/m (N/l)

Whiteboards:

1. A solenoid has 360 windings. It is 13 cm long, and carries a current of 1.75 A. What is its internal B-Field? (0.0061 T)	2. A solenoid needs to generate 1.0 T of B-field. it is 20 cm long, and has 100. windings. What current does it need? (1600 A)

Noteguide for The Definition of the Ampere - Video 20I **Name____________________________**

What is the force on the wire to the right? Each wire is carrying 1.0 A of current, and they are 1.0 m long, and 1.0 m apart.

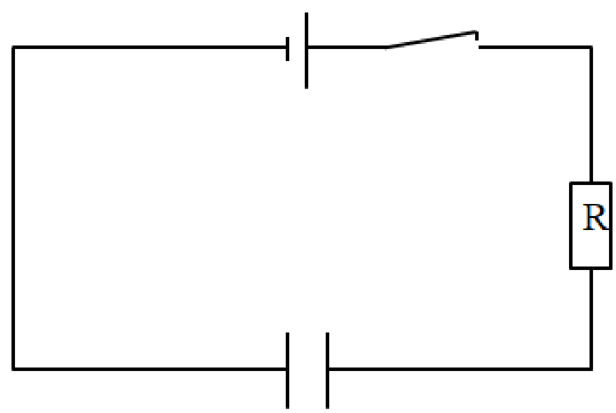


$$F = \frac{\mu_o I_1 I_2 l}{2\pi r}$$

Definition of an ampere:

An **ampere** is defined as the current flowing in each of two long, straight and parallel wires exactly one meter apart so that there is a force of exactly 2 x 10^{-7} N per meter of length acting on the wires.
(A coulomb is an Amp Second)

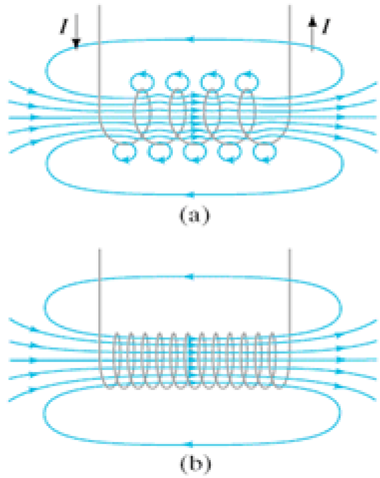
B fields encircle moving charge:



Noteguide for Basic Field Patterns - Video 20K **Name____________________________**

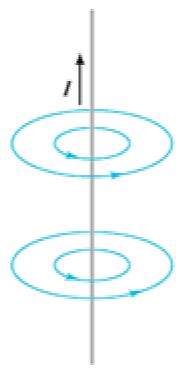
Solenoids

Show examples
B field is interior
little b-field near edge outside
show with hall probe



Straight wires

Show example
review rt hand rule



Flat circular coils (loops)

Show example
review rt hand rule