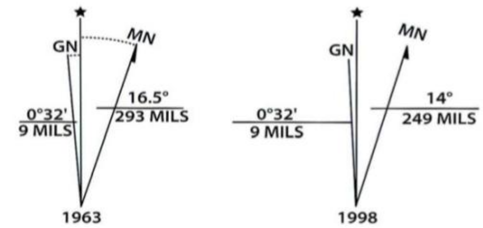
Noteguide for Basic Magnetism - Video 20A **Name**____________________________

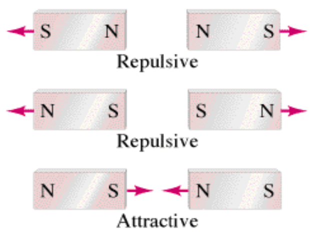
Definition of N and S poles

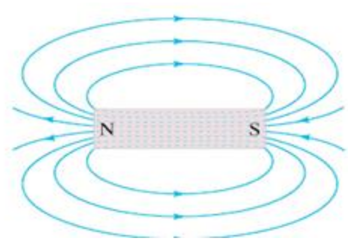
Finding polarity of a magnet

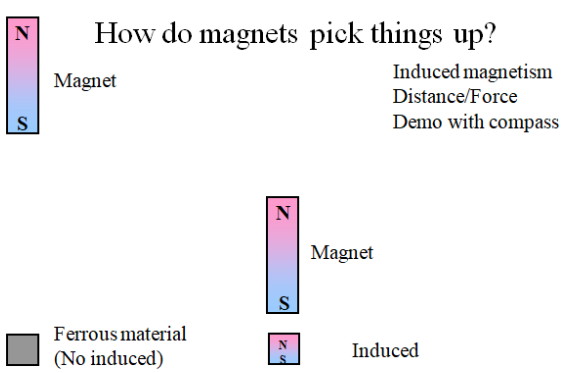
Shocking revelation

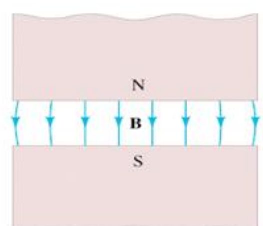


Magnetic declination for the Sugar House quadrangle (Salt Lake City area) in 1963 and 1998, showing a 2.5-degree decrease in magnetic declination over this time period. Since 1998, it has decreased an additional 1.5 degrees.







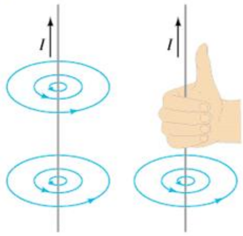


Remember – B Field Lines:

- Leave the N pole
- Enter the S pole

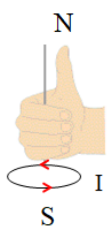
Right Hand Rule #1 - Magnetic Fields encircle wires:

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:

$F = Il \times B = IlB\sin\theta$ (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)

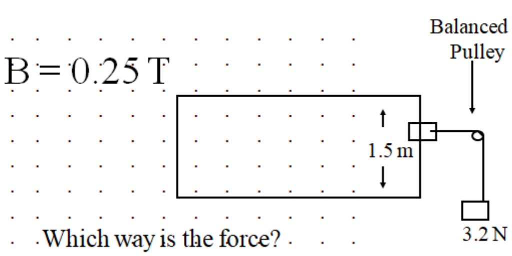
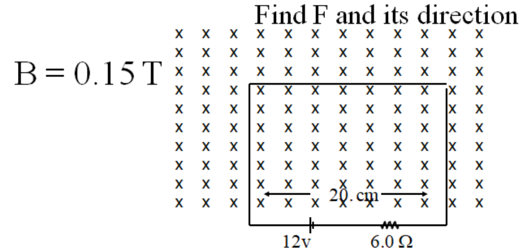
Example: A 0.15 T magnetic field is 27^{o} east of North What's the force on a 3.2 m long wire if the current is 5.0 A to the West?

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 0.5×10^{-4} T to the North? (4×10^{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? (2.9×10^{-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**______________________

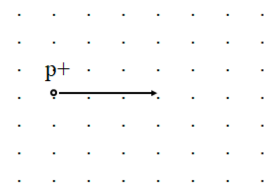
Recall

$F = IlB\sin\theta$

Derive

$F = qvB\sin\theta$

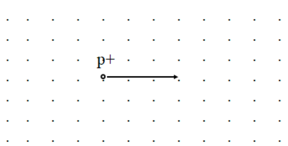
- F = force on moving particle
- q = charge on particle (in C) (+ or -???)
- v = particle's velocity
- θ = angle twixt v and B



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) $q = 2(1.602 \times 10^{-19}\text{ C}) = 3.204 \times 10^{-19}$ C $v = 0.17 \times 3.00 \times 10^{8}\text{ m/s} = 5.1 \times 10^{7}$ m/s

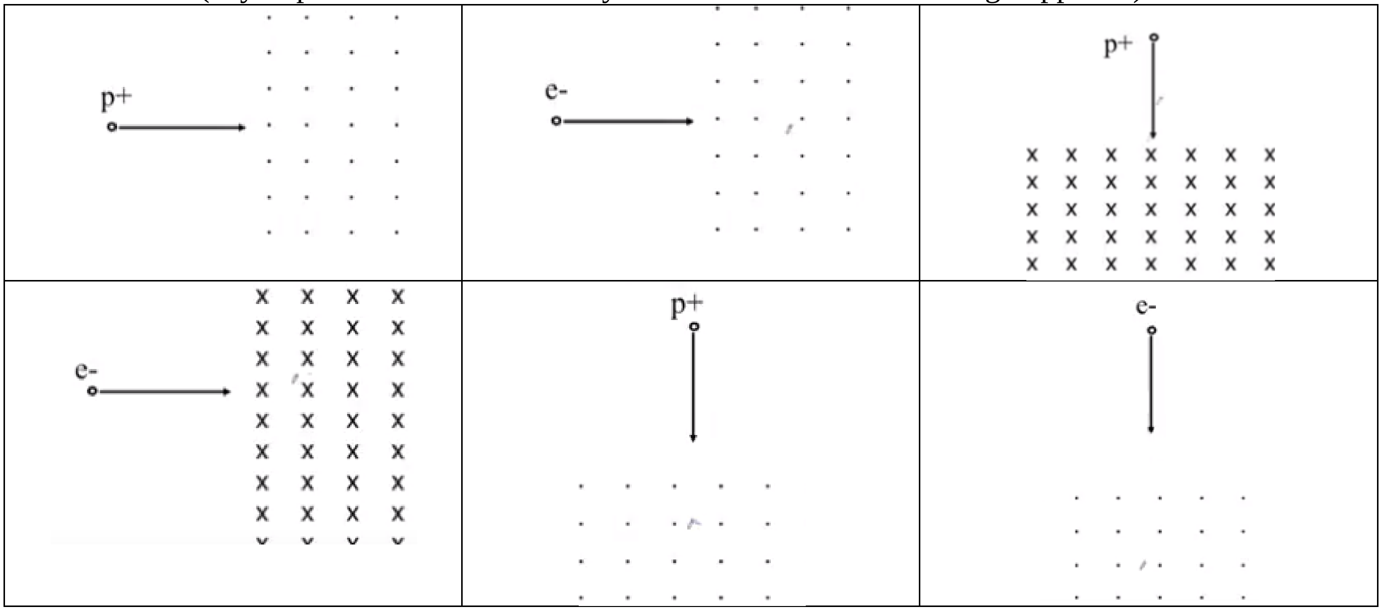
Example - proton going 4787.81 m/s
in earth's magnetic field (5.0×10^{-5} T) What radius?



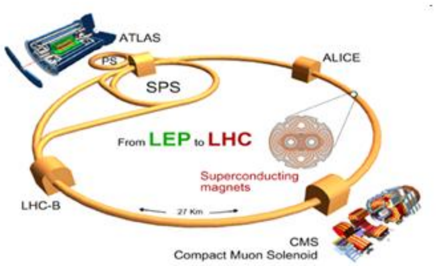
Whiteboards

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)

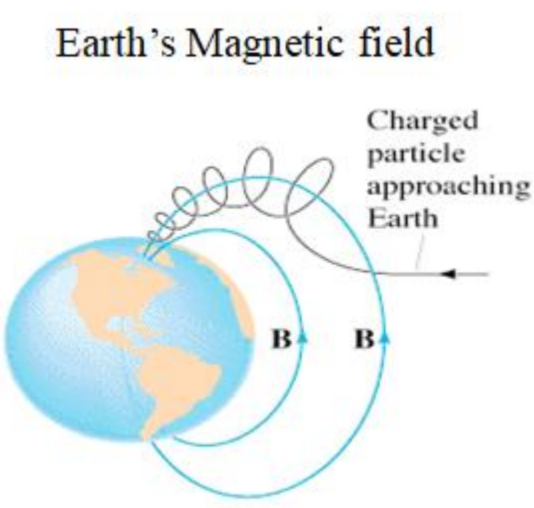


Particle Accelerators:



Superconducting magnets
Energy of particles
Why we have particle accelerators

The Aurora Borealis: (Northern Lights)



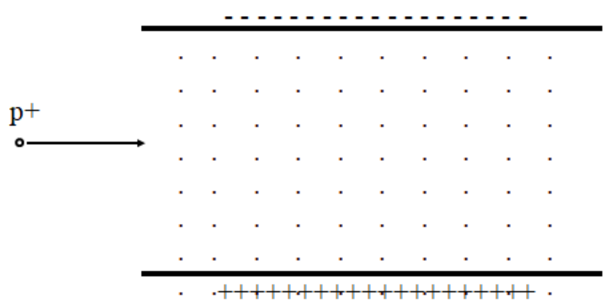
Explain angle to B-Field (vertical B field, velocity angled upward)

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

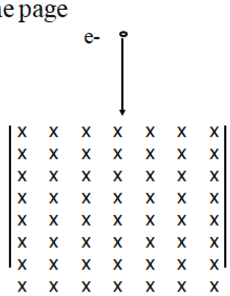
(Which way F from B, which way E is to prevent this. What E is, what direction, does the charge matter?, does the mass matter?)



You try this one:

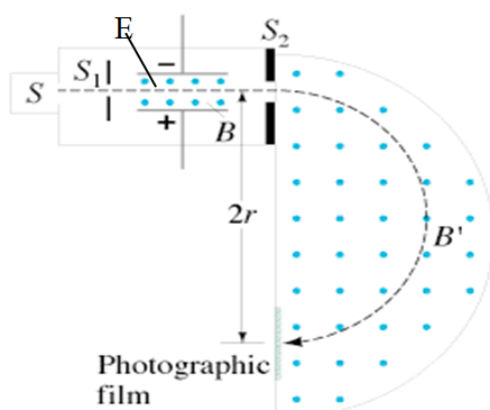
Electron going 1.27×10^{5} m/s, m = 9.11×10^{-31} kg, B = 0.0120 T
What electric field in what direction will make the electron go straight down the page

1520 N/C to the left



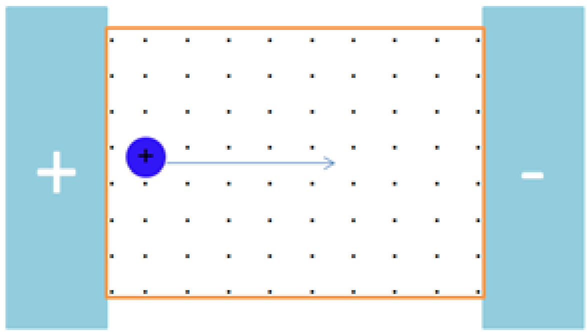
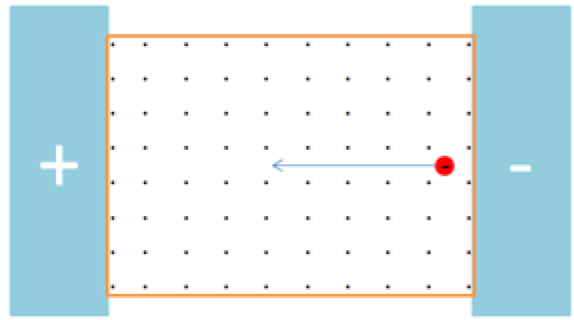
First Region:
V=?

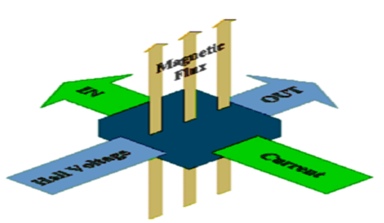
Second Region
q/m = ?

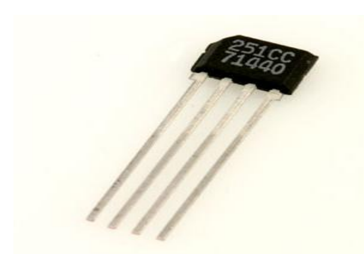


Noteguide for The Hall Effect - Videos 20E **Name__________________**

Two Possible Scenarios:

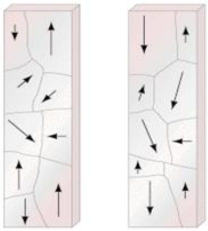
Positive Charge Carriers in wire: (incorrect) Conventional Current is to the right	Negative Charge Carriers in wire: (correct) Conventional Current is to the right
	





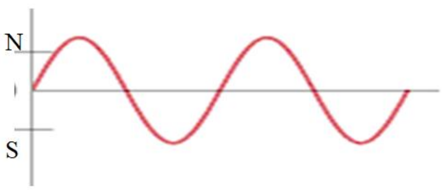
Noteguide for Hysteresis and Magnetization - Videos 20F **Name__________________**

Freakin' magnets, how do they work?

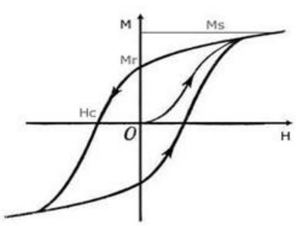


(a) (b)

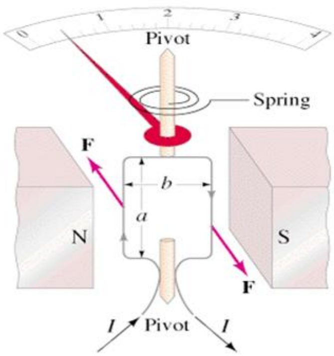
•Domains - small bits (1mm) that are aligned
•a - unmagnetized = random orientation
•b - slight preference down (N pole)



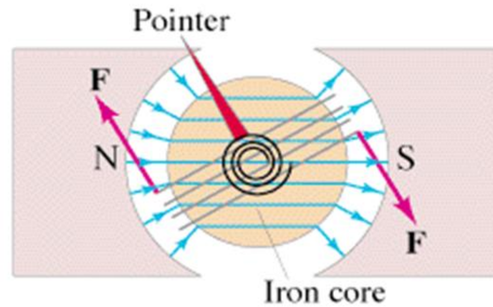
Hysteresis



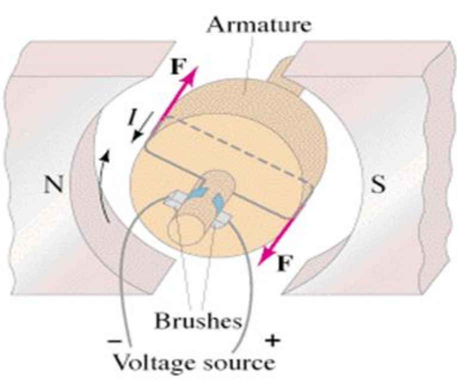
A Galvanometer

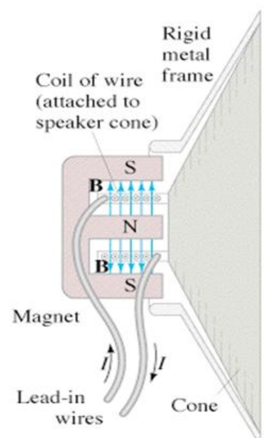


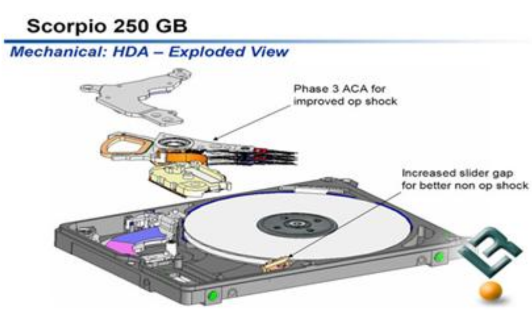
A Galvanometer

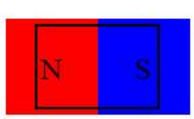


A DC Motor





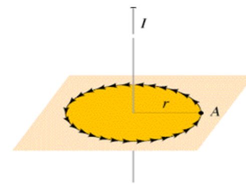




Noteguide for Ampere's Law - Videos 20H **Name__________________**

For a circular path around a wire:

$\Sigma B{\cdot}dl = B2\pi r = \mu_o I$



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

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:

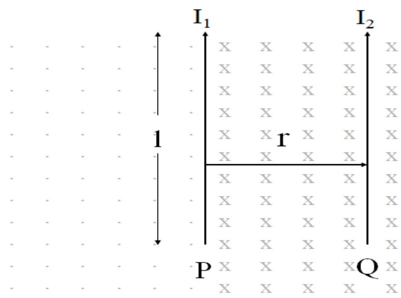
Magnetic field due to P at Q is:

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

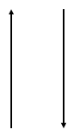
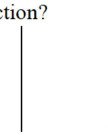
Force on Q is

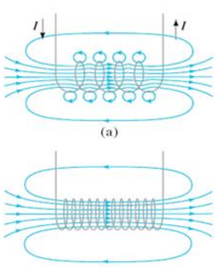
$F = I_2 l B =$

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



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. (8.1x10^{-4} N to the right)	The wire to the left experiences a force to the left of 3.15 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. (5.05x10^{-2} A up the page)



(a)

(b)

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

$Bl = N \mu_o I$

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

N = number of windings

$\mu_o = 4\pi \times 10^{-7}$ 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.

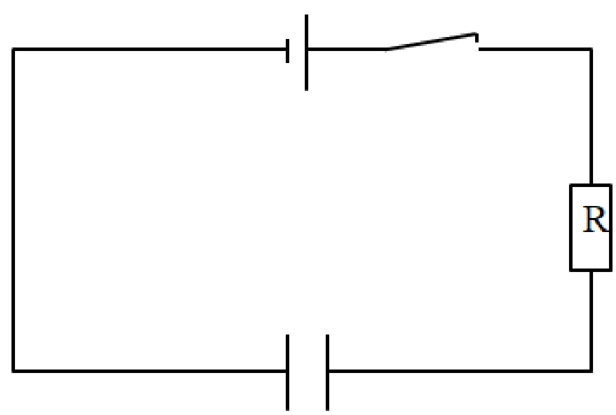
$$F = \frac{\mu_o I_1 I_2 l}{2\pi r}$$

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)

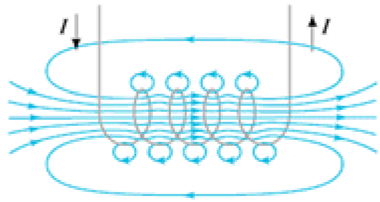
B fields encircle moving charge:



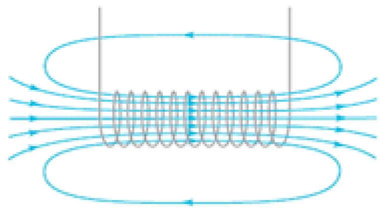
Noteguide for Basic Field Patterns - Video 20K **Name**______________________________

Solenoids

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

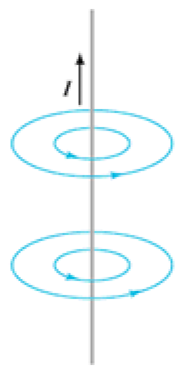


(a)


(b)

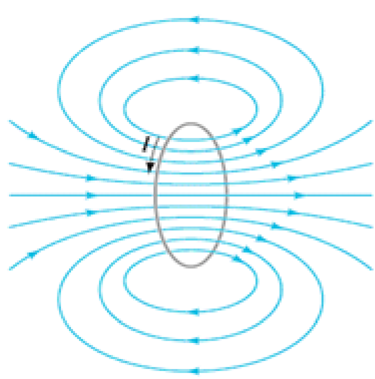
Straight wires

Show example
review rt hand rule



Flat circular coils (loops)

Show example
review rt hand rule

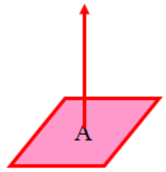


Noteguide for Lenz's Law - Video 21A **Name**______________________________

Magnetic Flux:

$\Phi = BA\cos\theta$

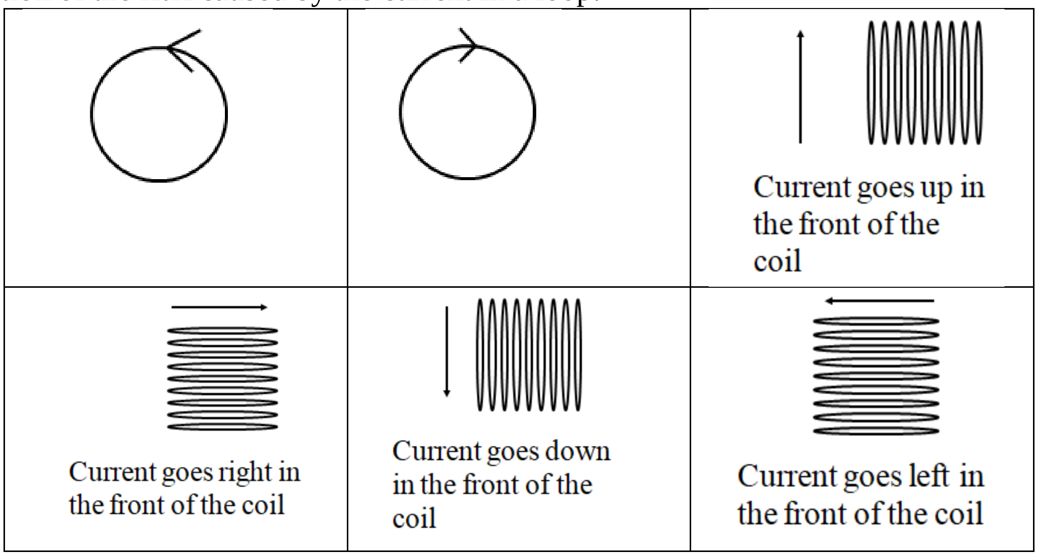
- Φ - Magnetic Flux in Webers
- B - Magnetic Field in T
- A - Area in m^2
- θ - Angle twixt B and A



For now, think of magnetic flux as the magnetic field multiplied by the area.

Lenz's Law states that if the flux in a loop of wire changes, it will induce a current whose flux <u>opposes</u> that change. Watch the videos so that you understand:

1. The direction of the flux caused by the current in a loop:

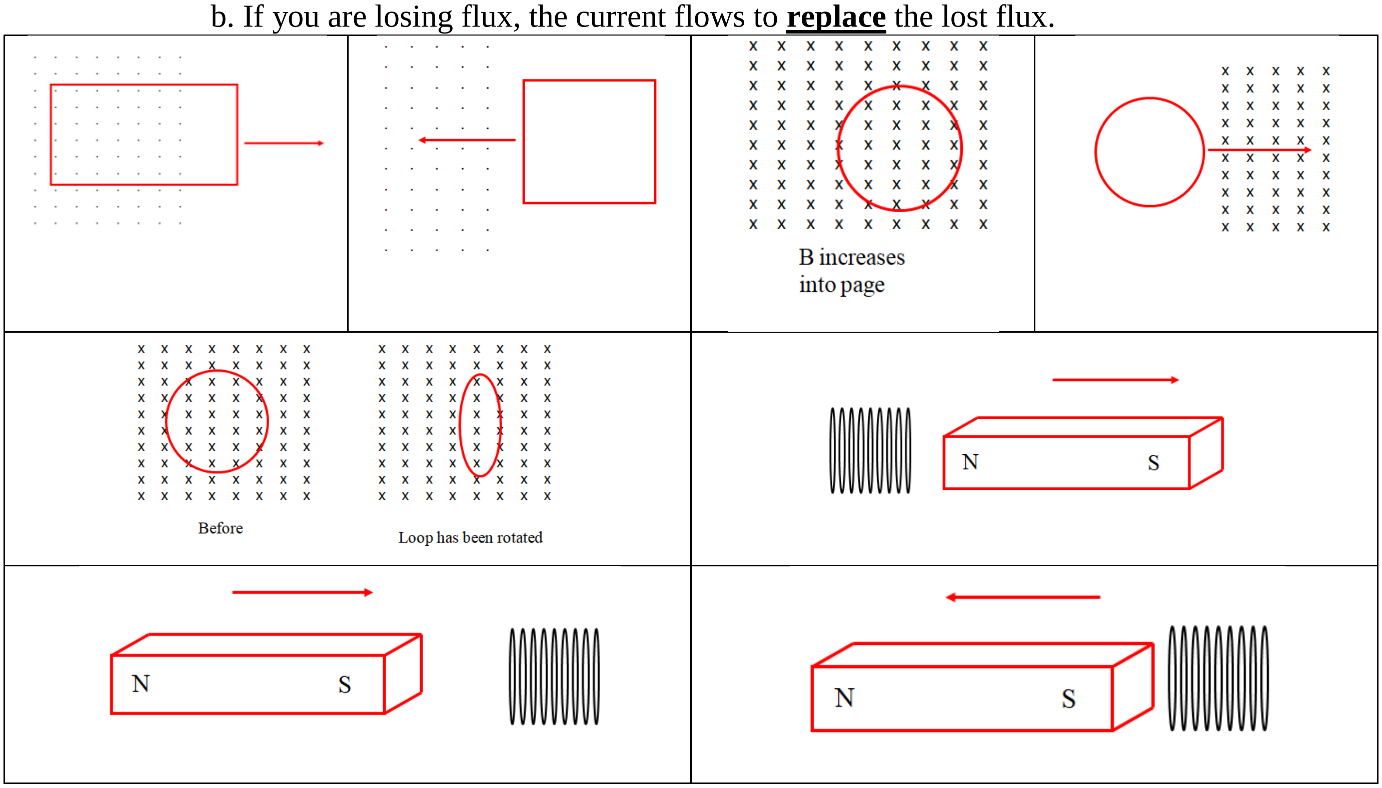


2. The direction the current flows in the loop or solenoid due to a change in flux: (three steps)

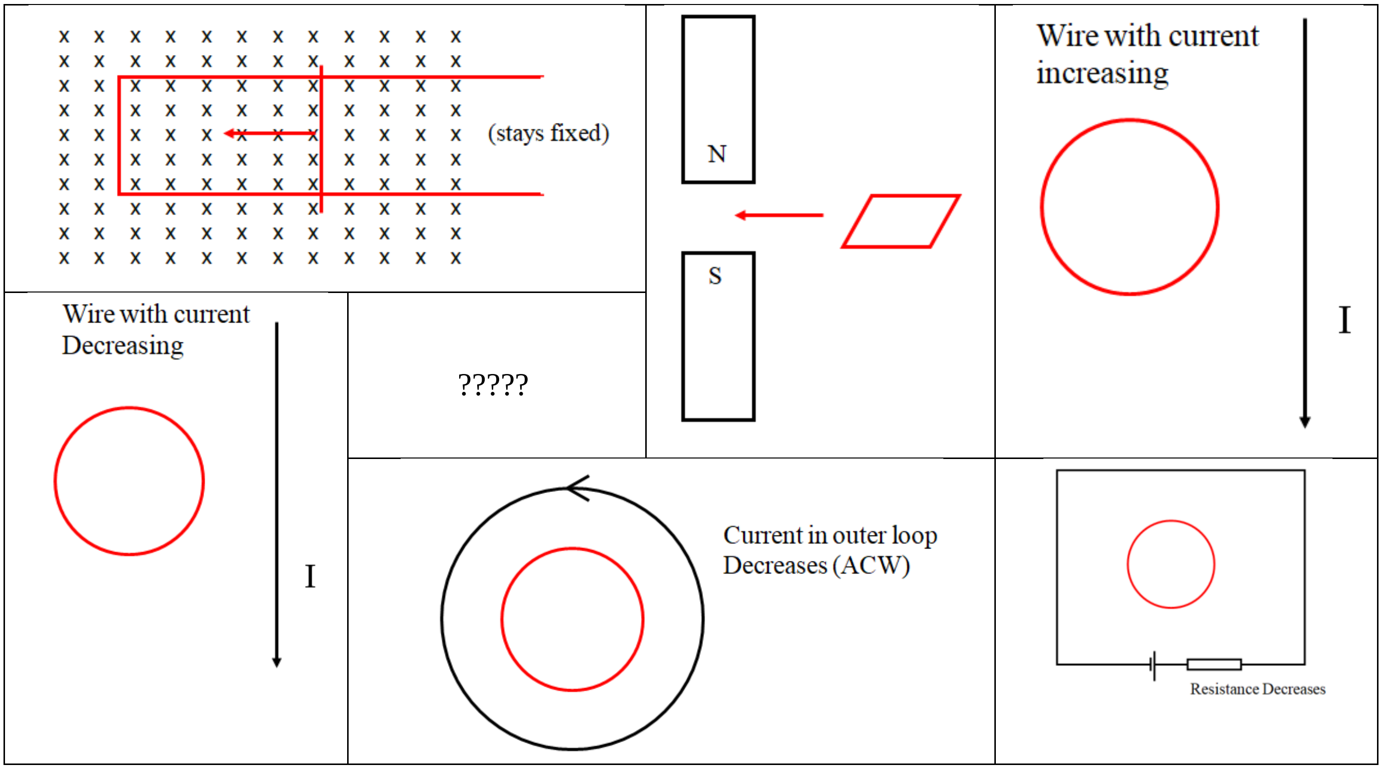
Find the direction of the change of flux. Are you gaining or losing flux, and which way is it?

a. If you are gaining flux, the current flows to **<u>oppose</u>** the change.

b. If you are losing flux, the current flows to **<u>replace</u>** the lost flux.



(more on the back)

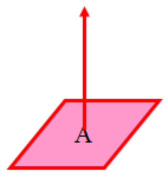

(stays fixed)
N
S
Wire with current increasing
I
Wire with current Decreasing
I
?????
Current in outer loop Decreases (ACW)
Resistance Decreases

Noteguide for Faraday's Law - Videos 21B **Name**____________________________

Magnetic Flux:

$\Phi = BA\cos\theta$

- Φ - Magnetic Flux in Webers
- B - Magnetic Field in T
- A - Area in m^2
- θ - Angle twixt B and A



Ways to change flux: (show)

$\Phi = BA\cos\theta$

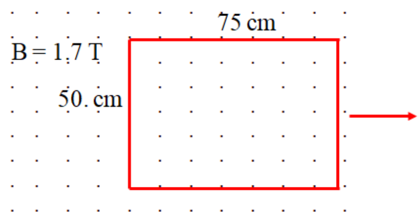
- Change B (magnetic field)
- Change A (area)
- Change θ (angle - rotate)
- Change any combination:

$\Delta\Phi = BA\cos\theta - BA\cos\theta$
(final) - (initial)

Faraday's Law: $\mathcal{E} = -N\dfrac{\Delta\Phi}{\Delta t}$
(Maxwell's 3rd law)

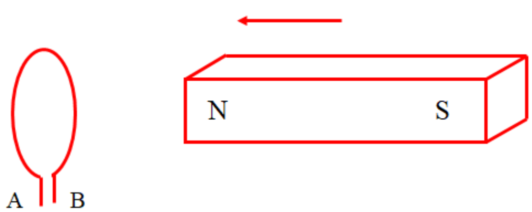
- ε - Electromotive force (voltage)
  (Current flows in a direction that opposes the change in flux)
- N - # windings
- $\Delta\Phi$ - Change in Magnetic Flux
- Δt - The time elapsed

Example: The loop is removed in 0.012 s. What is the EMF generated? Which way does the current flow? (N = 1)



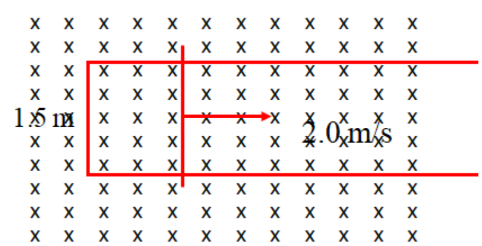
Whiteboards:

The approach of the magnet makes the B field inside the 3.0 cm **diameter** loop go from 0.025 T to 0.175 T in 0.0035 s. What is the EMF, direction of the current, and which electrode is + (current flows out of it)



(0.030 V, ACW, A is +)

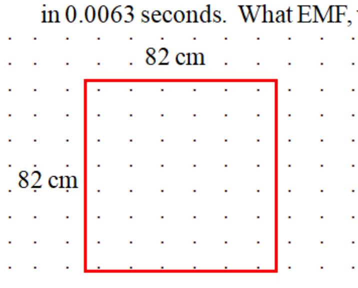
The bar moves to the right at 2.0 m/s, and the loop is 1.5 m wide. What EMF is generated, and which direction is the current?

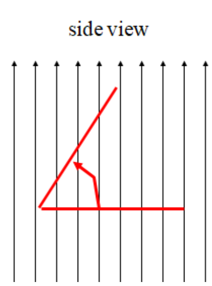


B = 3.2 T

(9.6 V, ACW)

The loop is rotated about an axis that lies in this page from its current position to an angle of 57° with the page in 0.0063 seconds. What EMF, what direction current?





B = 5.3 T

(260 V, ACW)

Noteguide for Moving Conductors - Videos 21C **Name**______________________________

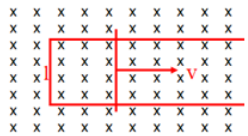
$\mathcal{E} = -N\dfrac{\Delta\Phi}{\Delta t}$

$\Phi = BA\cos\theta$

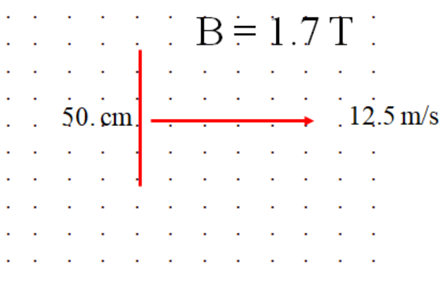
Derive

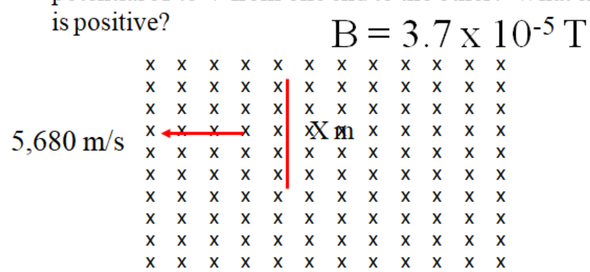
$\mathcal{E} = Bvl$

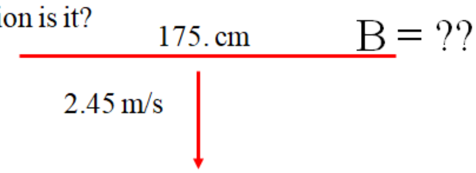
- B = mag field in T
- v = velocity of conductor in m/s
- l = length of conductor in m
- show direction with x product



Whiteboards:

<table>
<tr>
<td>The wire moves to the right at 12.5 m/s. What is the EMF generated? Which end of the wire is the + end?


(11 V, bottom is +)</td>
<td>How long does the wire need to be to generate a potential of 45 V from one end to the other? What end is positive?


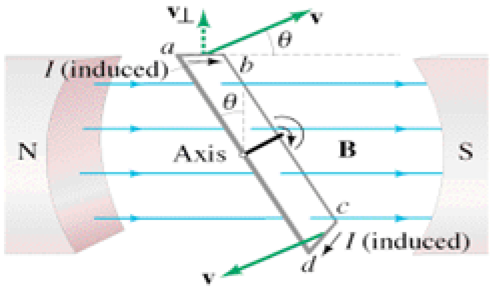
(210 m, bottom is +)</td>
</tr>
<tr>
<td>The wire has a potential of .215 V, and the right end is positive. What is the magnetic field, and which direction is it?


(0.0501 T ,into page)</td>
<td>this space for rent</td>
</tr>
</table>

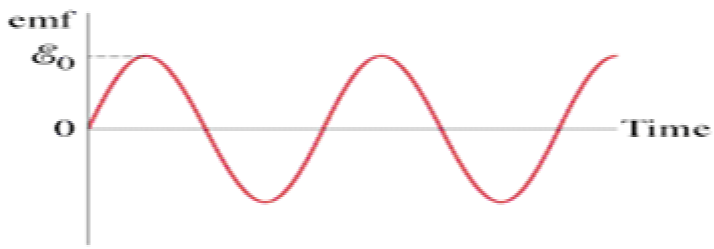
If the moving conductor is not just a wire, but a sheet of conducting material, this gets more interesting. Currents are induced by changing flux. We can talk about this in class next time. I have demos.

Noteguide for Alternators - Video 21D Name_______________________________

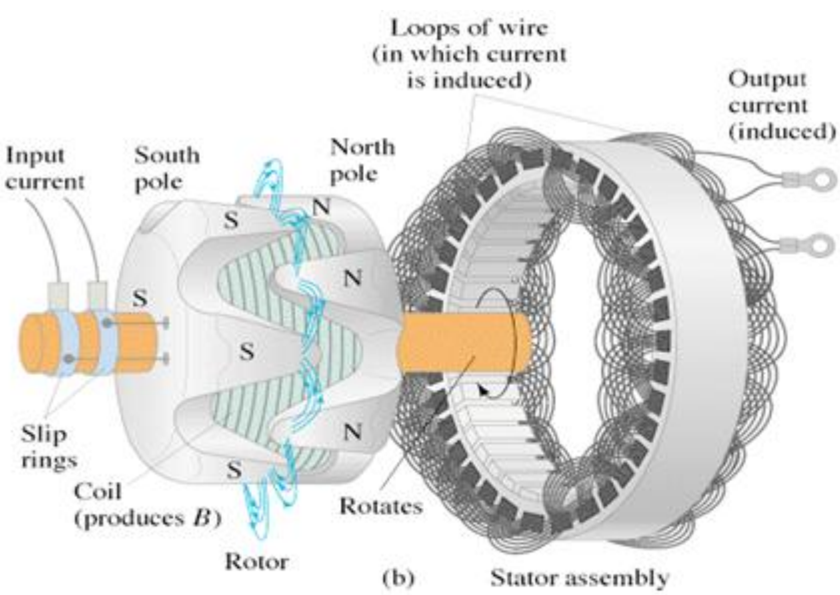
Loop Rotating in B field (show)



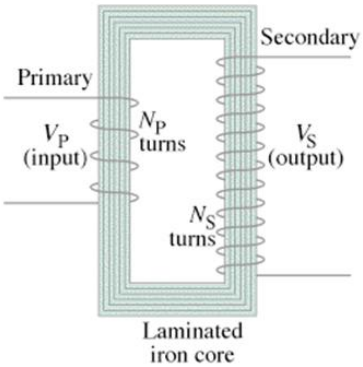
$$\mathcal{E} = -N\frac{d\,BA\cos(\omega t)}{dt}$$



Solution for $\mathcal{E}$:



Noteguide for Transformers - Videos 21E **Name**______________________________



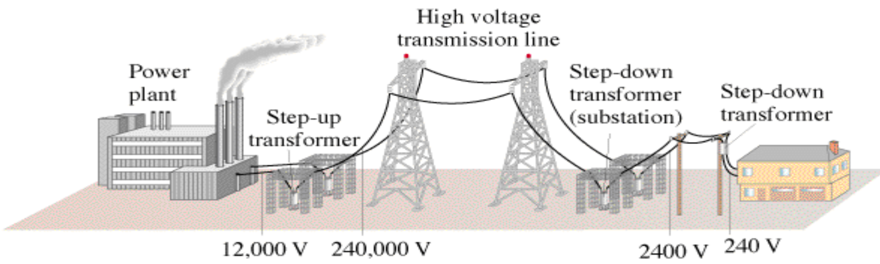
$$\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Example: A transformer has 120 primary windings, and 1450 secondary. If there is an AC voltage of 15 V, and a current of 350 mA on the primary, what is the current and voltage on the secondary?

Whiteboards:

<table>
<tr>
<td>1. A transformer has 120 primary windings, and 2400 secondary windings. If there is an AC voltage of 90. V , and a current of 125 mA in the primary, what is the voltage across and current through the secondary? (1800 V, 6.25 mA)</td>
<td>2. A transformer is operating at 12.5 W. It steps 110 VAC down to 9.6 VAC. There are 320 primary windings.
A) How many secondary windings are there?
B) What is the current in the primary and secondary?
(28 windings, 0.11 A, 1.3 A)</td>
</tr>
<tr>
<td colspan="2">3. An AC Arc welder can deliver 550 Amps of current. If it draws 18 amps from the wall at 120 VAC, what is the delivered voltage? If the primary has 1200 windings, how many does the secondary have? (3.9 V, 39)</td>
</tr>
</table>

Noteguide for Power Transmission - Videos 21F **Name____________________________**



Example:
If you transmit 1000. W at 120 V on wires that have a resistance of 2.0 ohms, what power is lost?

If you transmit 1000. W at 12,000 0V on wires that have a resistance of 2.0 ohms, what power is lost?

Whiteboards:

1. If you transmit 1300. W of power at 600. VAC, how much power is lost if the lines have a resistance of 1.70 Ω? (7.98 W)	2. If you wanted to transmit 7800. W of power over 5.20 Ω power lines, what voltage would you need to use to waste only 6.30 W? (7086 V)
3. You transmit 23,000. W of power at 19,300 VAC and waste only 8.20 W. What is the resistance of your transmission lines? (5.77 Ω)	4. You are wasting 9.50 W of power, when you transmit at 32,400 VAC on 2.30 Ω transmission lines. What is your transmitted power? (65,848 W)

Noteguide for Maxwell's Equations - Video 21G **Name**______________________________

Differential equations	Meaning
$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$	The electric flux leaving a volume is proportional to the charge inside.
$\nabla \cdot \mathbf{B} = 0$	There are no magnetic monopoles; the total magnetic flux through a closed surface is zero.
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	The voltage induced in a closed circuit is proportional to the rate of change of the magnetic flux it encloses.
$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$	The magnetic field induced around a closed loop is proportional to the electric current plus displacement current (rate of change of electric field) it encloses.