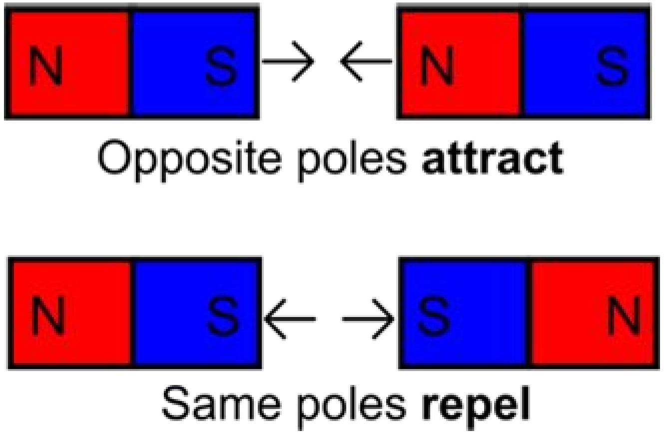
Magnetism

By: Ashley Medina, Lauren Zaren, John Park, Pinky Brandeau, and Gabby Lazarte

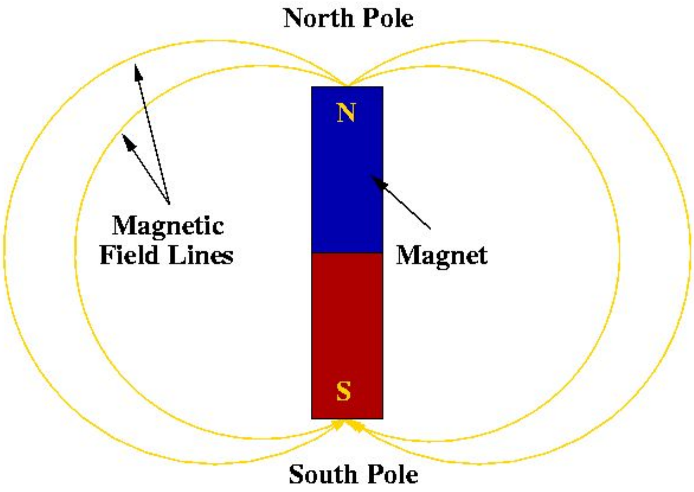
Magnetic Poles

- Every magnet has has two ends called poles
- Every magnet has a north and south pole (like poles repel, unlike poles attract)
- Cannot separate north and south poles



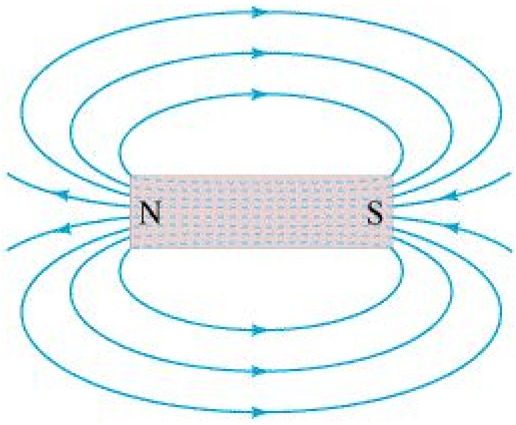
Magnetic FIelds

- There is a magnet field that surrounds the magnet and is seen by the magnetic field lines
- Magnetic field lines point from north to south and never cross
- The density proportional to the strength of the field



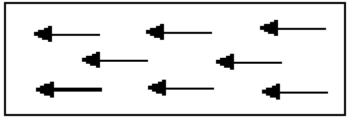
Making Magnets

- Magnetic fields are produced by the motion of electric charge
- A moving charge is surrounded by a magnetic field
- Charges in motion have an electric and magnetic field

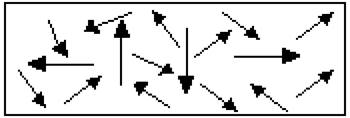


Domains

- Clusters of aligned atoms in a metal are called magnetic domains
- The difference between a regular and a magnet are the alignments of the domains



Magnetised
(domains lined up)

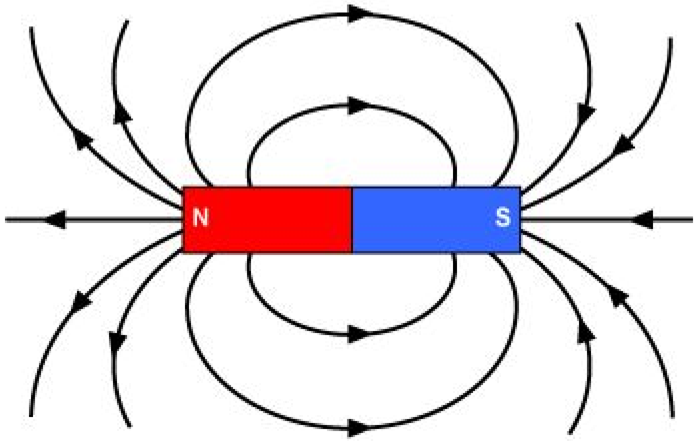


Unmagnetised
(randomly orientated domains)

Common Mistake

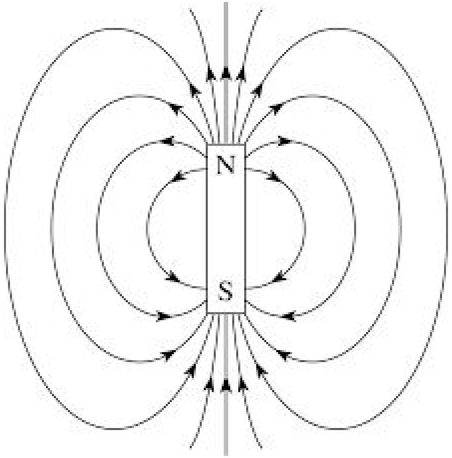
A common mistake is the direction a magnetic field travels.

Always remember that magnetic poles travel from north to south.



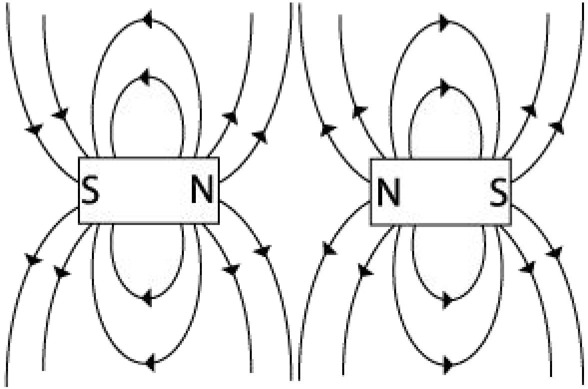
Example

Which one is **incorrect**?

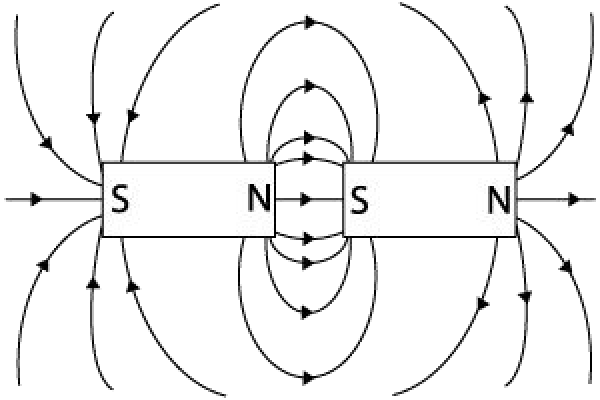


A

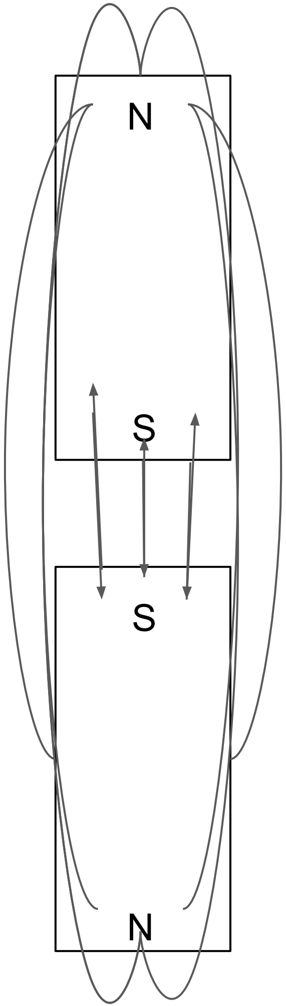
B



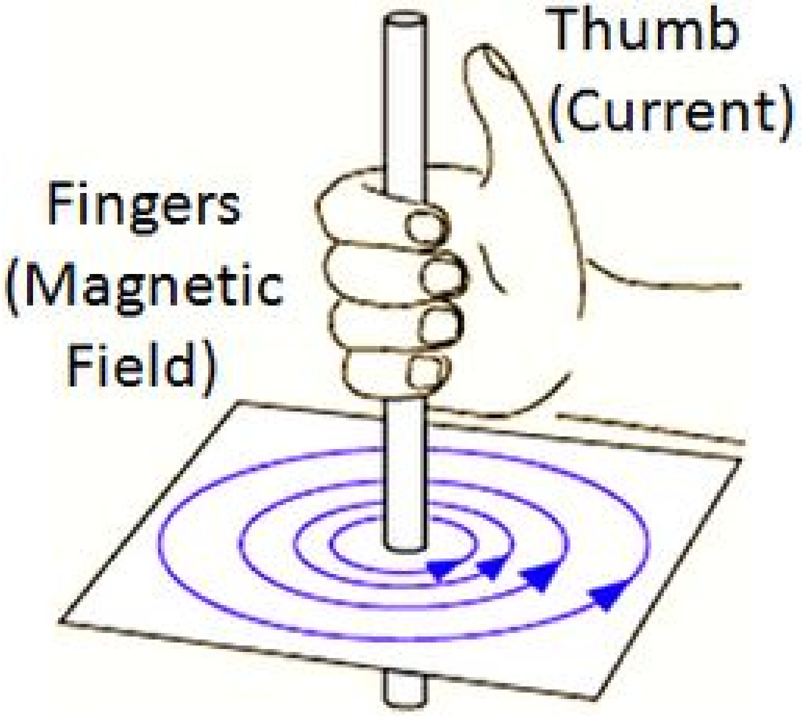
C



D



Right Hand Grip Rule



The strength of the magnetic field is dependent on two on two quantities:

- Current (I)
- Radius (r)

$$B=\mu_0 I/2\pi r$$

B - Magnetic Field

μ_0 - $4\pi\times10^{-7}$ permeability of free space

I - Current

r - radius

Example 1

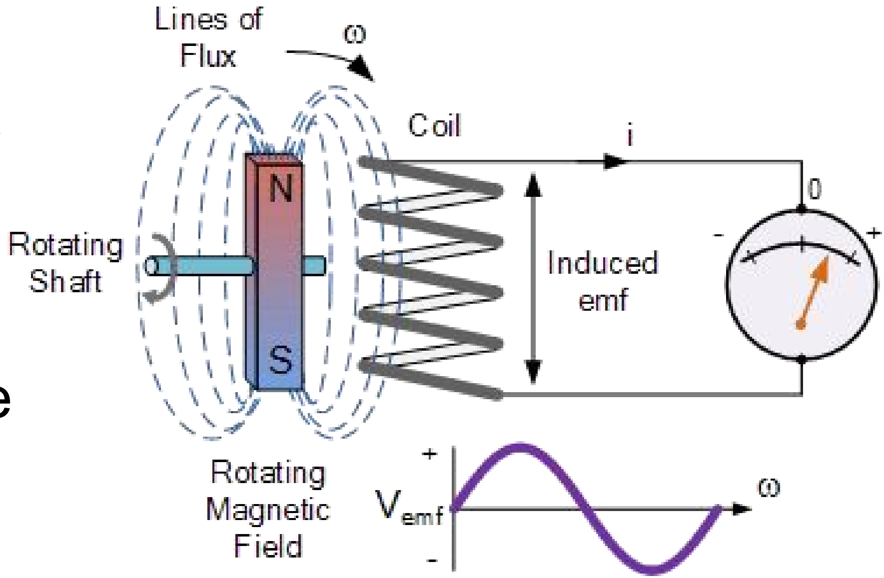
A horizontal current carrying wire has a current of 5A that is traveling out of this slide. What is the magnitude and direction of the magnetic field 30 cm to the left of the wire?

Electromagnetic Induction

Occurs when voltage is induced by a changing magnetic field.

It does not matter if the conductor moves past the magnetic field or vice versa, both produce the same result.

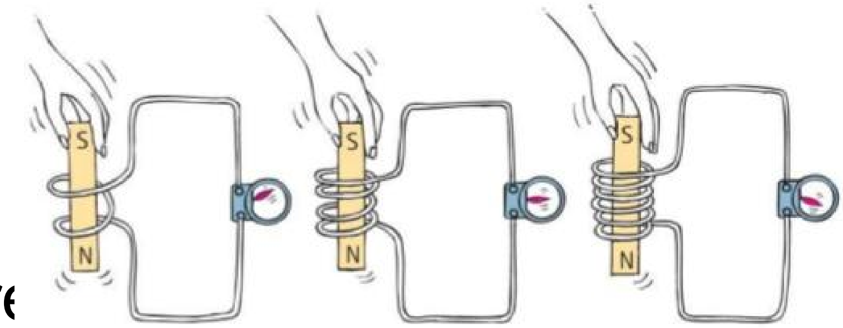
However, the induced current will always resist the magnet's motion.



Factors That Affect Electromagnetic Induction

- The speed of the wire through the magnetic field

(faster = higher induced voltage)



- The number of loops in the wire

(more loops = higher induced voltage)

Faraday's Law

Predicts the magnitude of an induced voltage.

The magnitude can be affected by

- The strength of the magnetic field
- The cross-sectional area of the coil (its width)

Magnetic Flux = (mag field strength) x (cross-sectional area of coil)

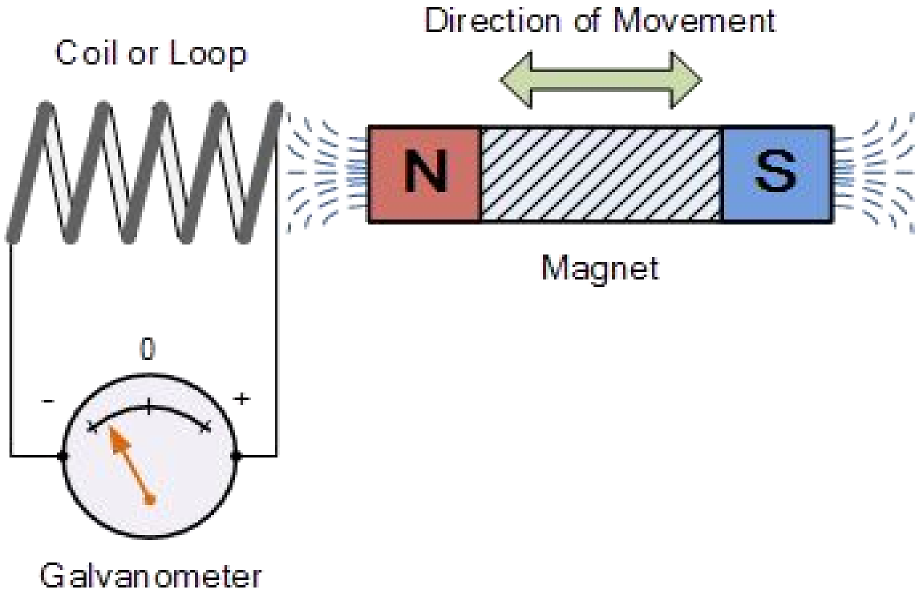
The Magnetic Flux is measured in units of Webers (Wb)

$\Phi = B_{\square} A = BA \sin\theta$

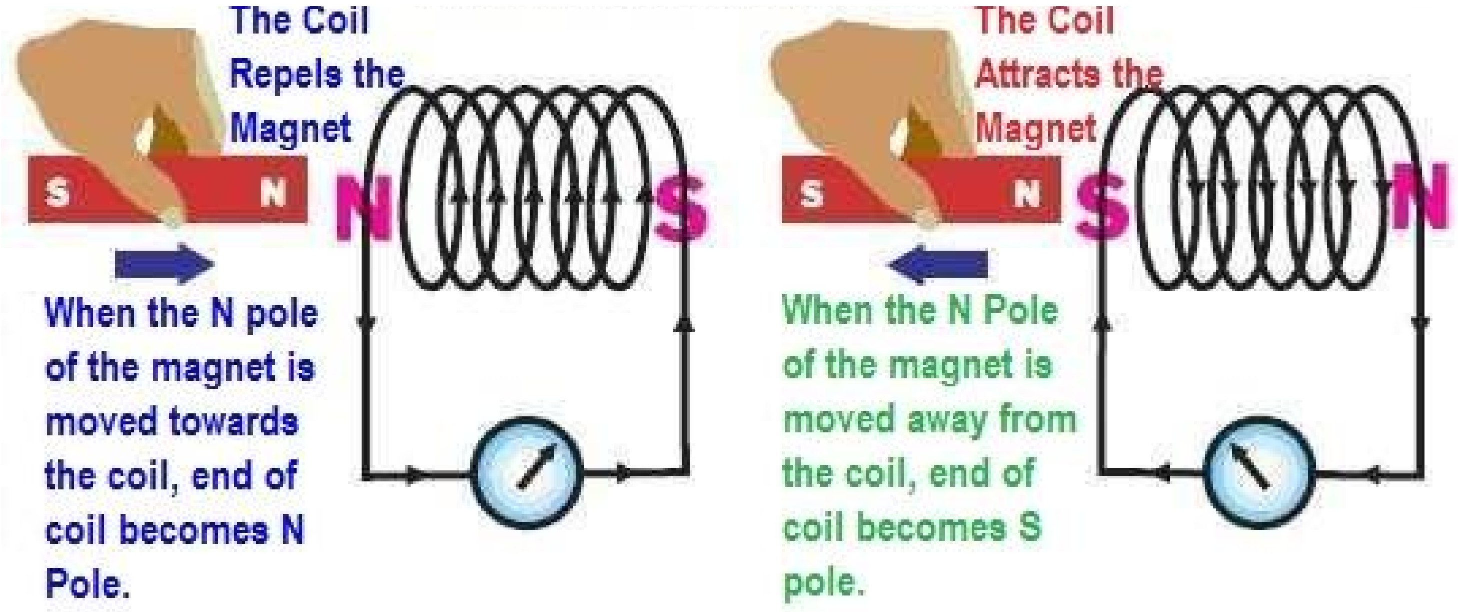
Faraday's Law of Induction

$V = N\Delta\Phi/\Delta t$

Voltage Induced = (# of loops) x (change in flux over change in time)



Lenz's Law



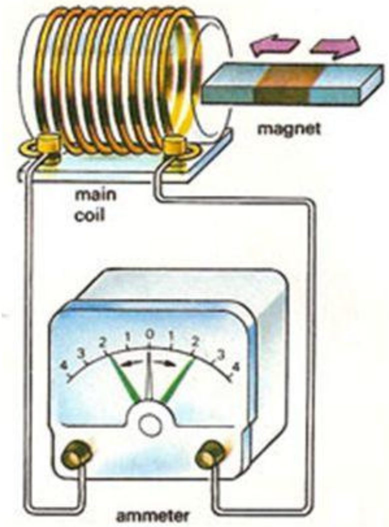
Predicts the direction of the induced voltage

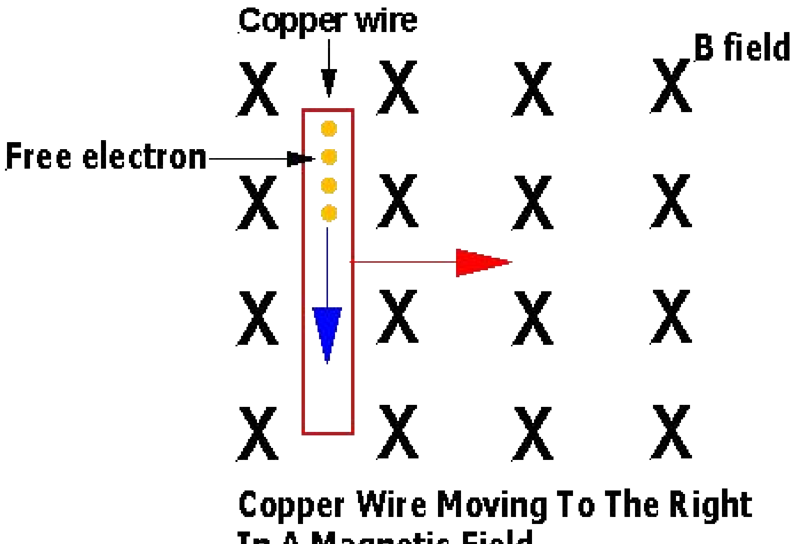
The magnetic field of the current will always oppose the magnetic field that produced it

Common Misconception

An easy mistake to make is to approach problems where a conductor is moving past a magnetic field differently compared to problems when the magnetic field is moving past a conductor.

This can be avoided by remembering that it does not matter which is moving and both can be approached using the same method.





Magnetic Forces on Electric Current

Newton's Third Law: An electric current exerts a force on a magnet; therefore, a magnet exerts a force on a current carrying wire

The magnitude of force on electric current due to magnetic field depends on these factors:

1. Strength of the magnetic field
2. Current in the wire
3. Length of the wire in the magnetic field
4. Angle the wire makes with the magnetic field

Example Problem

A wire carrying a current of 23 A has a length of 9 cm and lies perpendicular to the magnetic field. The magnetic field has a strength of 20 T. What is the force that the magnetic field exerts on the wire?

Magnetic Forces on Moving Charges

Magnetic fields exert a force on moving charges

Magnitude of the force on moving charge due to magnetic field depends on the

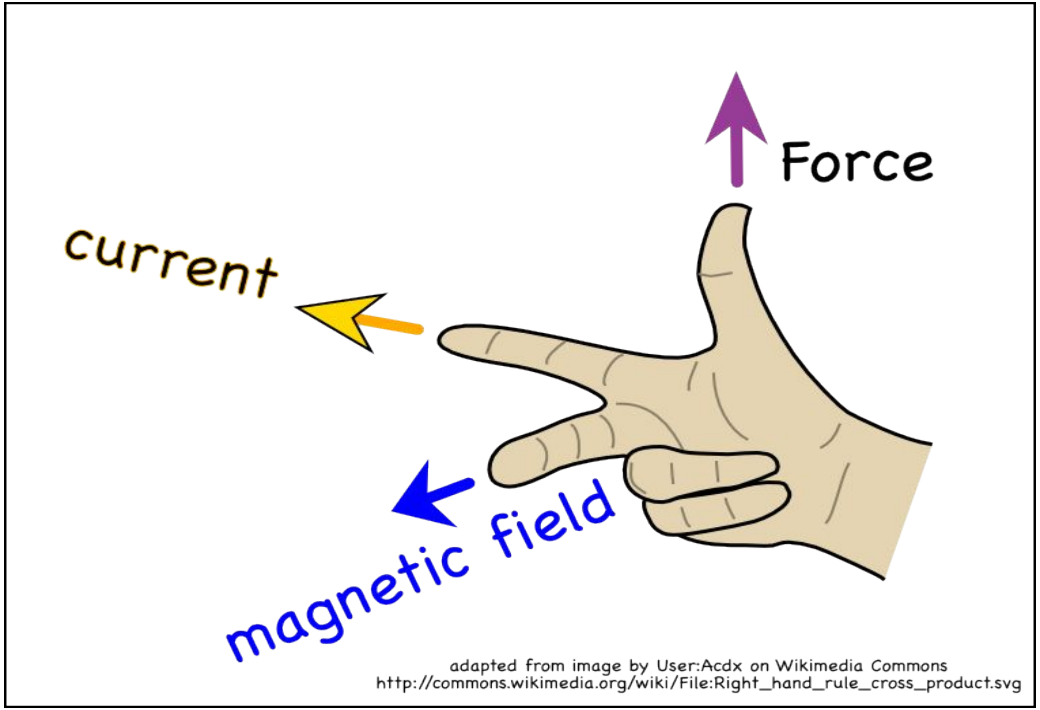
1. strength of the magnetic field
2. charge of the particle
3. velocity of the particle
4. angle the velocity with the magnetic field

$$FB = qvB\sin\theta$$

Right-Hand Rule, Part 2

Magnetic force in perpendicular to the current and magnetic field.

Common Mistake: For negative charges, don't forget to use your left hand instead of your right.



Generators and Motors

➔ **Electric Motors** convert electrical energy into mechanical energy

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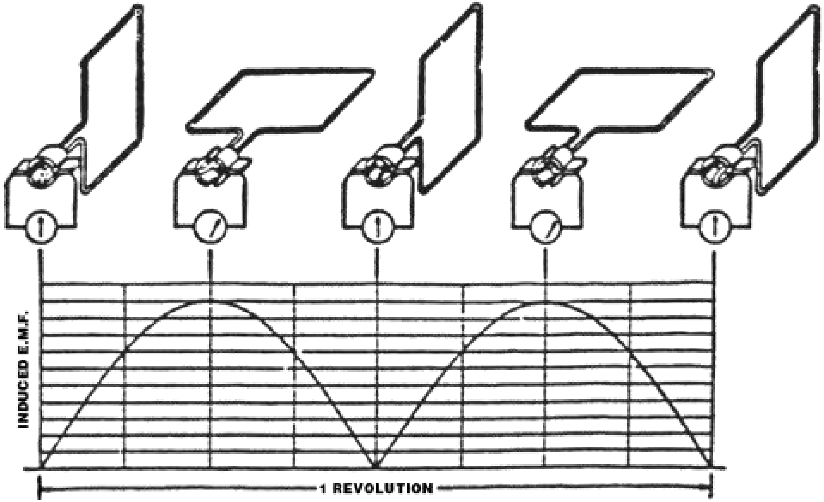
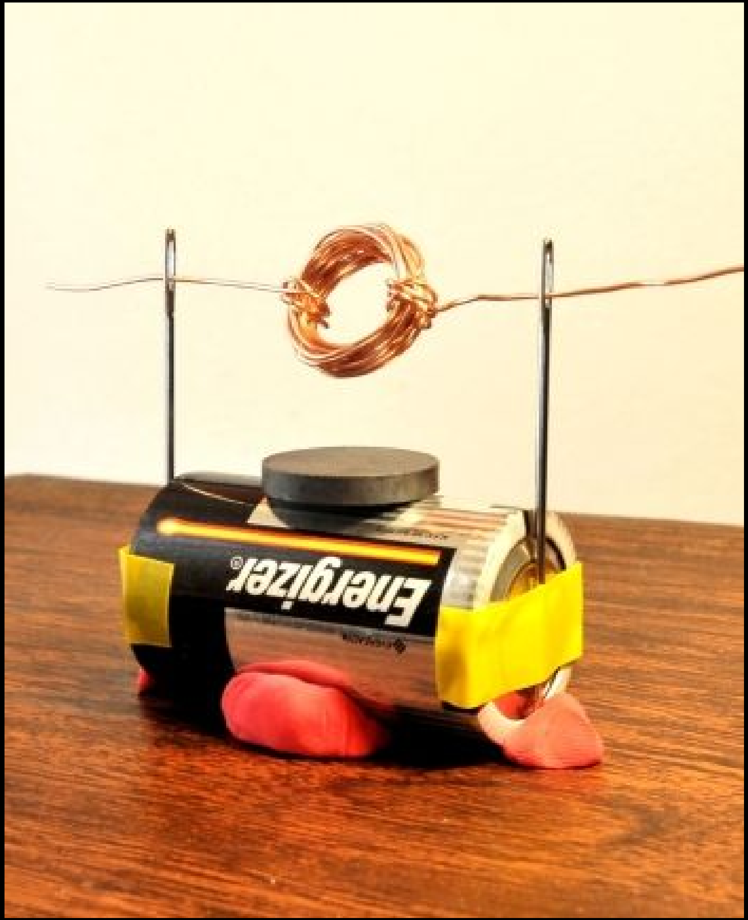
- The exact opposite of a motor

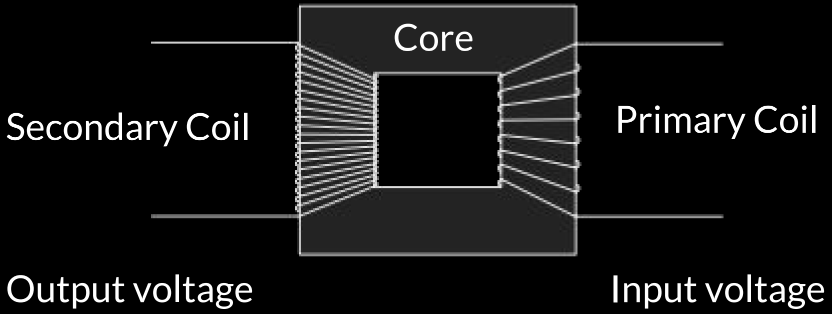
- As the loop rotates, voltage is induced
- Each full rotation is one complete voltage cycle
- Because the voltage goes from negative to positive, it is called **Alternating Current**





Transformers

- ➔ A transformer changes an AC voltage
- ➔ They consist of two coils of wire: **primary** and **secondary** coils
- ➔ They are linked with a soft iron core or interwoven with insulated wire

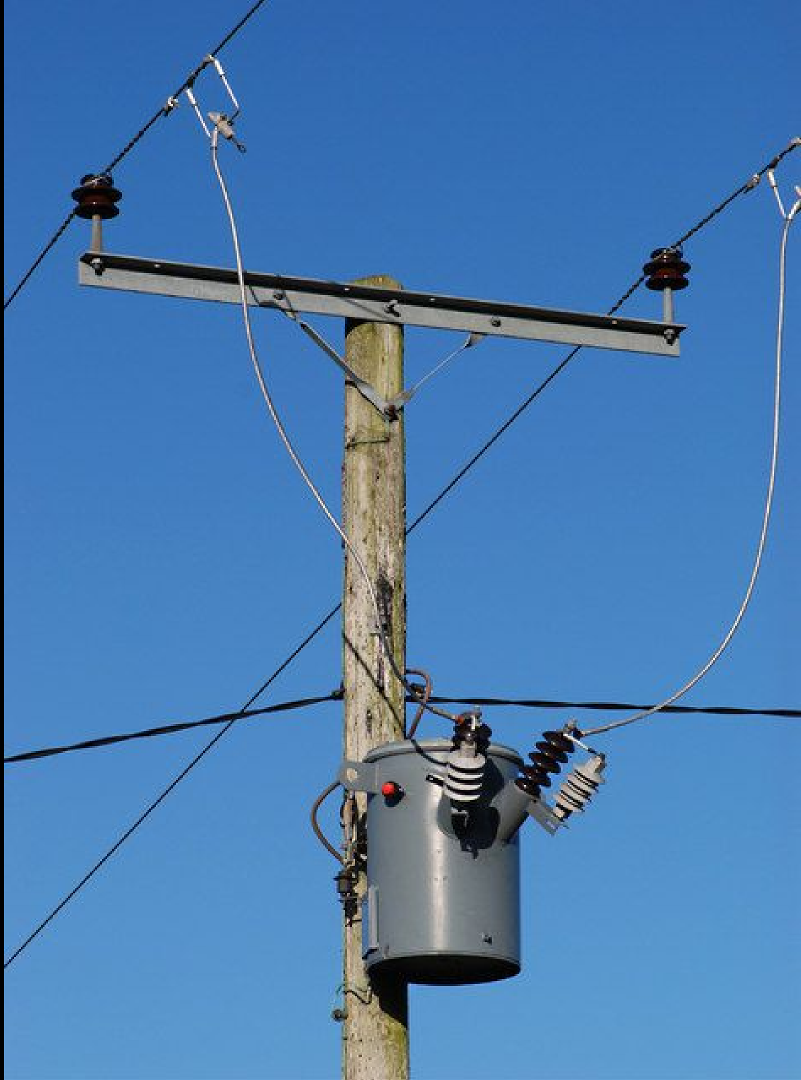


Transformers

➔ Induced voltage is proportional to the number of loops in the coil

$$\frac{\text{Primary voltage}}{\text{Number of Primary turns}} = \frac{\text{Secondary Voltage}}{\text{Number of Secondary Turns}}$$

➔ $V_p/N_p=V_s/N_s$



Transformers

If the secondary coil has more loops than the primary coil it has a greater voltage.

Step Up Transformer

If the secondary coil has less loops than the primary coil it has a lesser voltage.

Step Down Transformer

One common mistake is thinking both voltage and current increases. If voltage increases, current decreases.

P=IpVp=IsPs

Transformers

If you want to step down 200V to 120V and have a transformer with a 100 loop primary coil, how many loops does the secondary coil have?

?

Works Cited

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