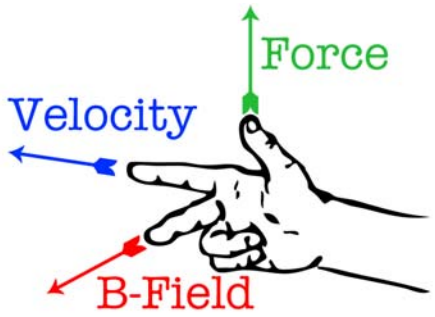
Induction & Transformers

Right Hand Rule (second)



Physics Signs (AKA Right Hand Rule)

- If you were a positively charged particle headed toward the Earth's equator from outer space which way would the Earth's magnetic field force you?
- Magnetic field (B-field) points up
- velocity (v) into the page
- Charge (q) is positive
- so the **Force** would be to the **RIGHT**!!

Physics Signs (AKA Right Hand Rule)

- If you were positively charged and moving toward the Earth at either pole then what would happen?
- **NOTHING**. . .the direction of the velocity and the B-field are **parallel** to each other so **NO FORCE** is felt!!
- This is what causes the Northern and Southern Lights.
  - Charged particles entering the Earth's magnetic field.

Electromagnetic Induction

- Michael Faraday: if you move a magnetic field it will create an electric current
- This is called **ELECTROMAGNETIC INDUCTION**
- Faraday's Law says that you can create (induce) more voltage by
  - moving the B-field faster
  - moving it into and out of more coils of wire

Speaker Operation

- Variable alternating current from the tuner
- Moves through speaker wire
- Into a coil of wire
- Produces a variable alternating magnetic field around the coil
- Causes a permanent magnetic to be attracted and repelled from the coil,
- Resulting in vibrations which can be heard.
- **A speaker is a MOTOR!!! It turns electrical energy into mechanical energy**

Electromagnetic Induction

- A **GENERATOR** uses electromagnetic induction.
  - It turns mechanical energy into electrical energy.
- A **MOTOR** uses electromagnetic.
  - It turns electrical energy into mechanical energy
- So a motor is to a generator as a speaker is to a microphone.

Lenz's Law

- Lenz's Law provides a rule for finding the direction of the induced current.
- The magnetic field of the induced current opposes the change in the applied magnetic field.
- The field of the induced current does not oppose the applied field, but rather the change in the applied field.
- In other words nature doesn't like change and the induced current tries to keep the total field strength constant.
- Sounds like **CONSERVATION OF ENERGY** again.

Transformers

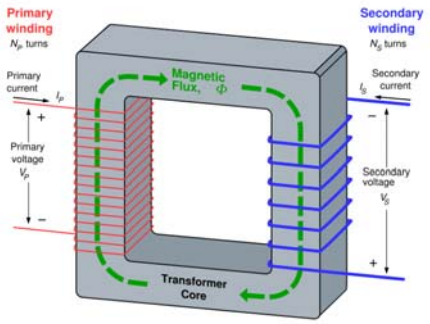
- A transformer makes use of **Faraday's law** and the ferromagnetic properties of an iron core to efficiently raise or lower AC voltages.
- It of course cannot increase power so that if the voltage is raised, the current is proportionally lowered and vice versa.

REMEMBER P = VI

IN TRANSFORMERS

$P_{IN} = P_{OUT}$

$VI_{IN} = VI_{OUT}$



$$\frac{V_p}{N_p} = \frac{V_s}{N_s} \qquad V_s = \frac{N_s}{N_p} \times V_p$$

Step-up Step-down Transformers

- Not only is a transformer employed to transfer electric energy from one circuit to another; it can also be used to raise or lower the voltage to meet certain operating requirements.
- For example, in practically all alternating current power lines, the voltage is "stepped up" at the power station, carried long distances, and then "stepped down" at the place where it is used.
- Also in practically all electronic apparatus designed to operate from 120-volt ac circuits transformers are used to lower the voltage for some circuits and raise it for others.
- The ratio between the number of turns in the primary and the secondary is called the **Turns Ratio**

Sample

- A 1:150 transformer has a primary voltage of 4500 V.
  a. Is this a step up or step down transformer?

     step up
  b. What is the voltage in the secondary coil?
  c. If the transformer consumes 45 W, what are the currents in the primary and the secondary coils?

- Voltage of the secondary V_s =?
- Number of turns primary N_p = 1
- Number of turns secondary N_s = 150
- Voltage of primary V_p = 4500 V

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

$$V_s = \frac{150}{1} 4500V \qquad V_s = 675{,}000V$$

- $P_p = P_s$ = 45 W
- V_p = 4500 V
- V_s = 675,000 V
- I_p = ?
- I_s = ?

$$P = VI$$

$$45W = (4500V) I_p$$

$$I_p = 0.01A$$

$$45W = (675{,}000V) I_s$$

$$I_s = 6.67E-5A$$

Practice

- A transformer has 1,000 turns on the primary and 10,000 turns on the secondary. The voltage of the primary is 120 V and the current is 8 A.
  a. Is this a step up or step down transformer?
  Step up
  b. What is the Power of the primary?
  960 W
  c. What is the Power of the secondary?
  960 W
  d. What is the voltage of the secondary?
  1200 V
  d. What is the current of the secondary?
  0.8 A