Preview of Period 17:
Induction Motors and Transformers

17.1 Induced Current

How can we use induce current in a wire?

17.2 Generators

How is electricity generated?

17.3 AC and DC Induced Current

Is the induced current AC or DC?

17.4 Induced Magnetism

How can the magnetic field of an induced current be used?

17.5 Induction Motors

How do induction motors operate?

17.6 Transformers

How does a transformer use induced current and magnetism to trade voltage for current?

17.7 Superconductivity and Induced Magnetism

How can we use a superconductor to make a magnet "float"?

Induced Current

Moving charge (current) flowing through a wire near a magnet causes the magnet to move.

- **The current induces a changing magnetic field around the wire.**
- **The changing magnetic field alternately attracts and repels another magnet.**
- **The interaction between these magnetic fields causes the motor's rotor to spin.**

The opposite is also true. A moving magnet induces moving charge (current) in a wire.

- **The moving magnet creates a changing magnetic field.**
- **The changing magnetic field induces a changing current in a nearby wire.**
- **The induced current in the wire induces a magnetic field around the wire.**

Generators

Generators convert kinetic energy into electrical energy

- A moving magnet creates a changing magnetic field.
- The changing magnetic field induces an electric current in a nearby wire.

Motors convert electrical energy into kinetic energy.

- A changing current flowing through a wire creates a changing magnetic field around the wire.
- The changing magnetic field alternately attracts and repels another magnet.
- The interaction between these magnetic fields causes the motor's rotor to spin.

Generating Electricity

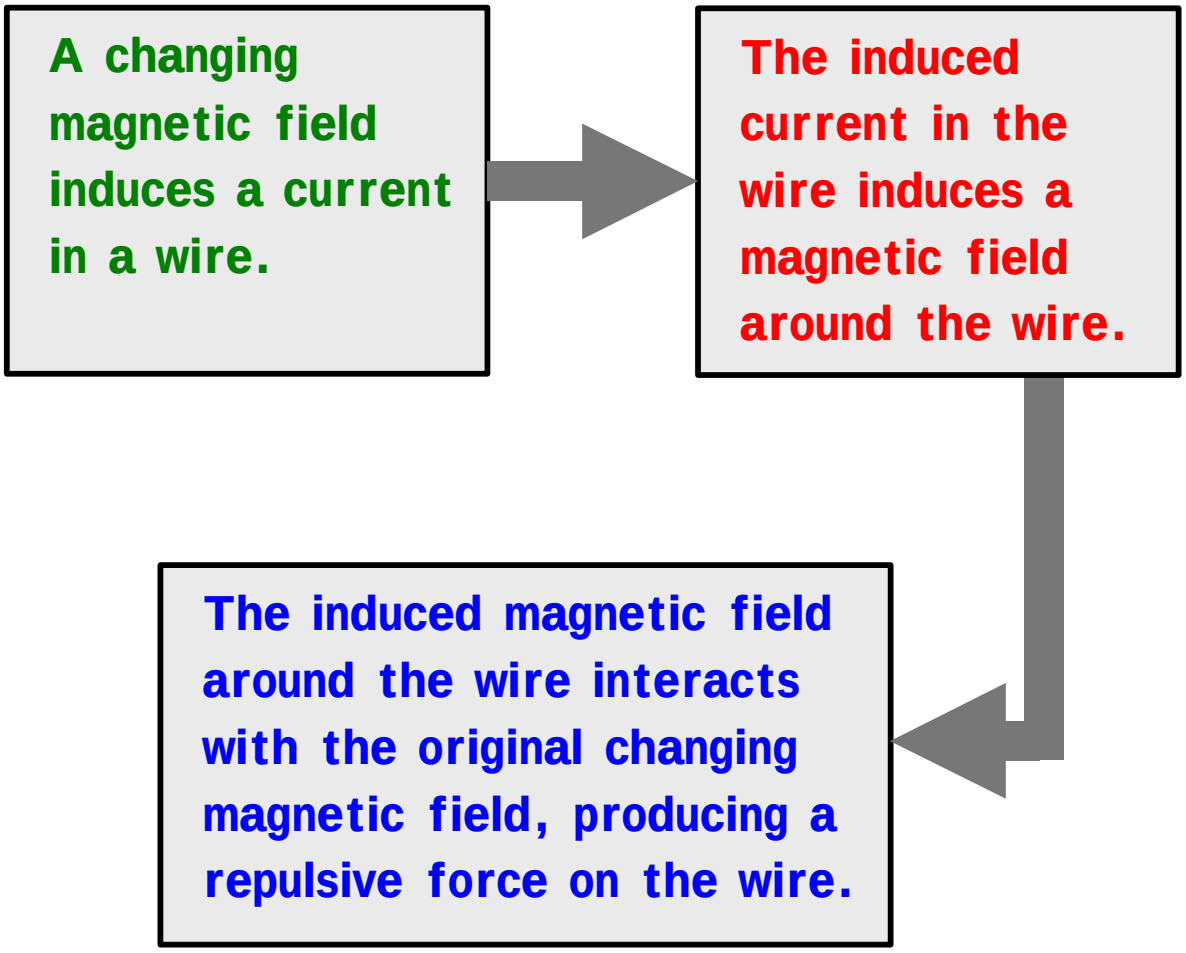
- Generating plants convert kinetic energy into electrical energy by rotating magnets near coils of conducting wire that are wrapped around iron cores.

- When magnets spin near coils of wire, an electric current is produced in the wire.

- To rotate the magnets, generating plants use kinetic energy from steam or from water falling over a dam's spillway to turn turbines.

- Generating plants burn fossil fuels or use nuclear energy to heat water for steam to turn turbines.

Induced Current and Magnetism



Induced Magnetism

- **A moving magnet induces moving charge (current) in a wire.**
- **The induced current in the wire induces a magnetic field around the wire**
- **This induced magnetic field experiences a force from the first magnetic field, attracting or repelling the magnet.**

Induction Motors

- Induction motors use magnetic fields from two electromagnets. (Induction motors require no permanent magnets.)
- One of the electromagnets is stationary in the circular shell of the motor.
- The second electromagnet is induced around the rotor. The rotor is made of a nonmagnetic material, such as aluminum.
- The changing (AC) current in the stationary magnet induces a changing current in the rotor.
- The induced current in the rotor induces a changing magnetic field around the rotor.
- The rotor's changing magnetic field interacts with the magnetic field of the stationary electromagnet and the rotor spins.

Calculations with Transformers

Transformers trade voltage for current or current for voltage, while keep the power nearly the same.

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

N_p = **Number of turns in the primary coil**

N_s = **Number of turns in the secondary coil**

V_p = **Voltage in the primary coil (in volts)**

V_s = **Voltage in the secondary coil (in volts)**

(Example)

A transformer reduces 240 volts to 120 volts. If the secondary coil has 150 turns of wire, how many turns does the primary coil have?

Solve the equation for N_p by multiplying both sides of the equation by N_s and canceling.

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

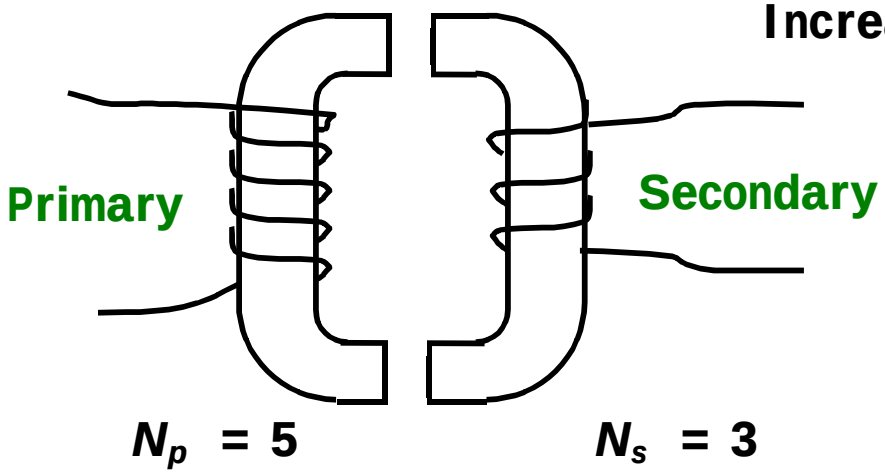
$$\frac{\text{240 volts x 150 turns}}{\text{120 volts}} = \text{300 turns}$$

Transformers

We assume the amount of power into the transformer equals the amount of power out.

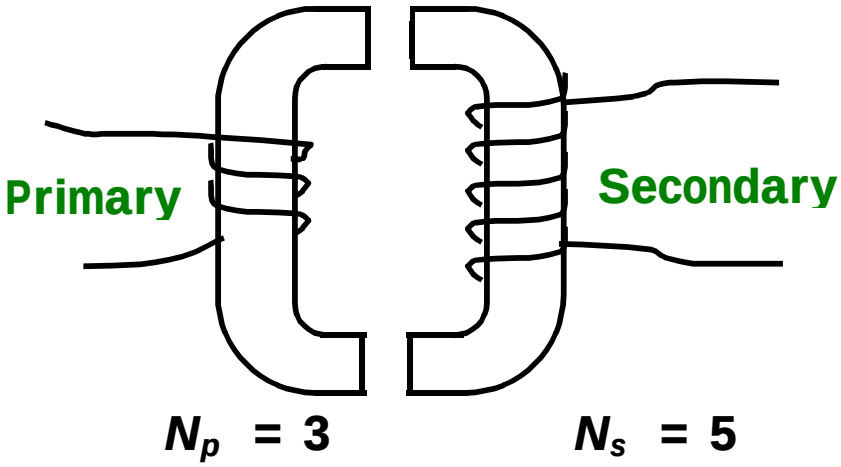
Step-Down Transformer Coil

Decreased voltage
Increased current



Step-Up Transformer Coil

Increased voltage
Decreased current



Superconductivity and Induced Magnetism

- When superconducting material is cooled to a very low temperature, it has zero resistance.
- Material with zero resistance allows current to flow continually through it.
- A small change in a magnetic field can induce a current in a superconductor.

Hold the small magnet above the superconducting disc. What happens when you release the magnet?

(Please do not lose the small magnet!)

Period 17 Summary

17.1: **A changing magnetic field induces a current in a nearby wire.**

Electricity is generated when magnets spin near coils of wire. Falling water or steam pressure turns turbines, which spin the magnets.

17.2: **When a changing magnetic field induces a current in a wire, the current induces a second magnetic field around the wire. The repulsive force between these two magnetic fields can do work.**

The magnetic forces between such magnet fields are the basis of induction motors.

17.3: **Transformers induce currents and magnetic fields to raise or lower voltage.**

The voltage across each coil is proportional to the number of turns of wire wrapped around that coil.

Period 17 Summary, Continued

A step-up transformer increases the voltage and decreases the current.

A step-down transformer decreases voltage and increases current.

17.4: Superconducting materials have zero resistance and can transmit electricity with no energy wasted as joule heating.

Period 17 Review Questions

R.1 How does a power plant generate electricity? Why don't generating plants use falling water or steam pressure to spin the magnets directly without the use of turbines?

R.2 Explain how an induction motor works. How does an induction motor differ from a DC motor?

R.3 Could a transformer be used to change the amount of energy supplied to an electric device? Why or why not? What does a transformer change?

R.4 In what way is a transformer similar to a simple machine, such as a lever?

R.5 What are the advantages of superconducting materials? What are the problems associated with their use?