WELCOME TO PERIOD 13

Homework Exercise #12 is due today.

Watch video 3 *Edison’s Miracle of Light* for class discussion one week from today.
• How can electric charges do work?
• How does a leyden jar store energy?
• What is voltage?

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• Remember to put away your phone. No calls or texting during class.
Electromagnetic force

Fundamental Forces:
- Gravitational
- Electromagnetic = Electrical + Magnetic
- Weak Nuclear
- Strong Nuclear

Gravitational forces act between masses.
**Electrical forces act between charges.**
Magnetic forces act between moving charges.
Electric charge

Electric charge can be positive or negative.

- Charges of opposite signs (one negative and one positive) attract one another.
  
  ![Diagram of opposite charges attracting]  

- Charges of the same sign (both positive or both negative) repel one another.
  
  ![Diagram of same charges repelling]  

The attraction or repulsion between charged objects with an excess of positive or negative charge results in an electrical force on the objects.
Electric charge produces force

Electric charge is measured in units of coulombs (coul) 
The symbol for charge is \( Q \)

Electric Force Equation:

\[
F_{\text{elect}} = k \frac{Q_1 Q_2}{D^2}
\]

\( Q_1 \) and \( Q_2 \) = charge on the objects (in coul) 
\( D \) = distance between objects (in meters) 
\( k \) = a constant = \( 8.99 \times 10^9 \) N m\(^2\)/coul\(^2\)
Force equations

Compare the equations for gravitational and electrical force!

\[ F_{\text{elect}} = \frac{k Q_1 Q_2}{D^2} \]

\[ F_{\text{grav}} = \frac{G M_1 M_2}{D^2} \]
Strength of the electrical force

The strength of the electrical force decreases as square of the distance between the charged objects increases.

Electrical Force versus Distance
Electrical force on a floating ring

Which two forces act on a floating ring?

How do the sizes of these forces compare?

How can these forces be used to find the electrical force on the floating ring?
Electrical conductors

1) Negative electrons in metal are repelled by the negative charge on the rod.

2) The negative electrons move away from the negative rod. The metal now has more positive charge at the end near the rod and more negative at the other end.

3) The negative rod attracts the positive charge more strongly than it repels the negative charge.

4) Result: the metal is attracted to the negative rod.
Electrical insulators

1) Electrons in an insulator cannot move because each electron is bound to its individual atom.

2) The atoms deform slightly so that the negative charges lean away from the negative rod and the positive charges lean toward it.

3) Result: The insulator is attracted to the negative rod.
Electric charge on a pith ball

Bring a charged rod near the pith ball:

✓ Negative charges on the rod repel the negative charges on the pith ball.
✓ The side of the pith ball closer to the rod is positively charged.
✓ The pith ball is attracted to the rod.

Touch the charged rod to the pith ball:

✓ Negative charges from the rod give the pith ball a net negative charge.
✓ The negatively charged rod repels the negatively charged pith ball.
✓ The pith ball moves away from the rod.
Electrostatic oscillator

The negative foil ball is repelled by the negatively charged pan.

Negative charge moves from the ball to the can. The ball is now neutral.

The positively charged side of the ball is attracted to the negative pan.

The can remains neutral because it is so much larger than the ball.
Electric charge on a Leyden jar

Place negative charge on one metal Leyden jar.

Hold one end of small neon bulb and touch the other bulb end to the jar.

Is the bulb brighter when touched to one jar or to two charged jars separated by a plastic liner?
A charged Leyden jar lights a bulb

Negative charge flows from the inner Leyden jar, through the bulb filament, and onto the positively charged outer jar.

This flow of charge is an electric current.

Negative charge flows from the outer jar through the ground wire. The outer jar becomes positive.

Ground wire
Electrical potential energy and voltage

- Electrical forces store electrical potential energy when work is done to push charges of the same sign together.

- Electrical potential energy is converted into electrical energy when the charges are allowed to move apart.

\[ E_{pot} = Q \cdot V \]

- \( E_{pot} \) = the potential energy (in joules)
- \( Q \) = the amount of charge (in coulombs)
- \( V \) = the voltage (in volts)

Voltage = the potential energy per charge.

Voltage is measured in volts (V)

1 volt = 1 joule of energy/1 coulomb of charge
Tin can voltmeter

Place negative charge on the inner Leyden jar.
Measuring voltage across a battery

1) Turn the dial to the voltage symbol \( V \).

2) Attach the two wire leads to the two outlets on the lower right of the meter.

3) To measure voltage across a battery, touch the ends of the leads to each end of the battery.
Measuring voltage across a bulb

1) Turn the dial to the voltage symbol $V$

2) Attach the two wire leads to the two outlets on the lower right of the meter.

3) To measure voltage across a bulb, connect the ends of the leads to each side of the bulb.
Voltage boosts and drops

Voltage Boosts

✓ The potential energy per unit of charge, or voltage, increases when charge flows through a battery.

✓ When batteries are connected in series, charges get a voltage boost from each battery.

Voltage Drops

✓ Voltage drops occur as current flows through load devices (resistors) in the circuit.

✓ The voltage boost from the battery is divided among the load devices in the circuit.

✓ The sum of the voltage boosts and drops in a closed circuit are equal.

In a circuit, VOLTAGE BOOSTS = VOLTAGE DROPS
BEFORE THE NEXT CLASS…

✓ Read textbook chapter 14
✓ Complete Homework Exercise 13
✓ Bring a blank Activity Sheet 14 to class.
✓ Watch video 3  *Edison’s Miracle of Light*  for discussion during period 15