Activity 3: Electricity

3.1 Electric Charge, Voltage and Energy

1) Electric charge Your instructor will demonstrate a Wimshurst machine, which separates electric charge.
   a) Describe what happens to the hanging soda cans as electric charge from the Wimshurst machine flows onto the cans.
   b) Why do you see sparks between the cans or between the balls of the Wimshurst machine?

2) Voltage Your instructor will discuss voltage, which is a measure of the amount of energy per charge. (voltage = energy/charge)
   a) A Leyden jar consists of two metal cylinders separated by a plastic cup. Using a connecting wire, attach the outer cylinder to the ground wire above your table.

      Use two connecting wires to attach a tin can voltmeter to the Leyden jar. Clip the end of one connecting wire to the bottom of the tin can voltmeter and the other end to the ground wire. Attach the second connecting wire from the top of the voltmeter to the handle of the Leyden jar.

      Place a charge on the inner cylinder by rubbing a plastic rod with foam and sliding the rod along the ball on the cylinder’s handle. Repeat 5 or 6 times without touching the ball with your hand.

      How much voltage does the charge you placed on the Leyden jar have?

      ____________

   b) Group Discussion Question: Students typically measure thousands of volts with the tin can voltmeter. Even household voltages of 120 volts can be dangerous. Why isn’t this activity dangerous?
3.2 Electric Current

3) Electricity is moving charge:

Disconnect the tin can voltmeter from Leyden jar. Keep the ground wire attached to the outer cylinder.

Place a charge on the inner cylinder by rubbing a plastic rod with foam and sliding the rod along the inner cylinder handle as you did in the previous activity.

Now touch one wire of a small neon bulb to the outer cylinder and the other bulb wire to the handle of the inner cylinder.

a) Describe what happens. What causes the bulb to light?

b) Plug the incandescent light bulb into the wattmeter. Measure the amps of current through the bulb. ____________

c) How many coulombs of charge per second flow through this circuit? ________

d) Group Discussion Question: What is the difference between electric charge and electric current?

3.3 How Is Electric Current Generated?

4) Generating an electric current

a) Connect the tan coil of wire to the large galvanometer that measures electric current. Move a magnet near and into the wire coil. What does the galvanometer needle indicate?

b) Hold the magnet still and move the coil of wire. Describe what happens.

c) What happens if neither the magnet nor the wire is moving?

d) What must happen in a power plant to generate electricity?
Activity 3.4: How Is Electricity Transmitted?

5) Joule heating Your instructor will discuss joule heating in transmission wires.
   a) Considering the equation for joule heating, \( P_{\text{joule}} = I^2R \), why could reducing
      the current cause a large decrease in joule heating?

   b) Considering the equation relating power, voltage, and current, \( P = IV \), how could the current be reduced while keeping the same amount of power?

6) Circuits with transformers: Your instructor will demo circuits with transformers.

   Circuit #1: One light bulb: Note the brightness of one bulb with no transformer.

   Circuit #2: A step-down transformer connected to one light bulb: 
   
   ![Step Down Circuit](image)
   How does the brightness of the bulb compare to the brightness in circuit #1?
   Explain any difference in brightness.

   Circuit #3: A step-down transformer, a step-up transformer, and one bulb: 
   
   ![Step Down Step Up Circuit](image)
   How does the brightness of the bulb compare to the brightness in circuit #1?
   Explain any difference in brightness.

   Circuit #4: A step-down transformer, high resistance wires, a step-up transformer, and one bulb: 
   
   ![Step Down Step Up Circuit](image)
   How does the brightness of the bulb compare to the brightness in circuit #1?
   Explain any difference in brightness.
7) **Electricity transmission:** Since large amounts of electricity cannot be easily stored, electricity is generated as needed and transmitted long distances to customers. Should electricity be transmitted at high voltage or low voltage?

Your instructor will demonstrate two methods for transmitting electricity using high resistance wires, step-down transformers, and 4 bulb trays. In circuit #1, the step-down transformer reduces the voltage *before* the current flows across the high resistance wires. In circuit #2, the voltage is reduced *after* the current has crossed the high resistance wires.

![Circuit Diagrams](image)

- **Circuit #1**
- **Circuit #2**

<table>
<thead>
<tr>
<th>a) In which circuit are the bulbs brighter?</th>
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<tbody>
<tr>
<td><strong>Prediction:</strong> __________________________</td>
</tr>
<tr>
<td><strong>Answer:</strong> ______________________________</td>
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b) Which of the two circuits transmits electricity at a higher voltage through the high resistance wires? Explain why.

c) Which circuit has more current flowing through the high resistance wires? Explain why.

d) Which circuit wastes more energy as joule heating? Explain why.

e) Group Discussion Question: What is the major advantage of transmitting electricity at high voltages?
Activity 3.5: How Much Does Electricity Cost?

8) Measuring Electricity with a Kilowatt-hour Meter
   a) Plug a hair dryer into the kilowatt-hour meter and describe what happens to the meter when the dryer is set on “low.”

b) What happens when the dryer is changed to “high”?

c) How long must a 1,000 watt clothes dryer be connected to a kilowatt-hour meter before the meter reading increases by one kilowatt-hour? ______

d) How many kilowatt hours of electricity are required when a 500 watt space heater is used for 5 hours?

e) If electricity costs $0.12 per kilowatt-hour, how much does it cost to operate this heater for 5 hours?
Period 3 Exercises: Electricity

1. Finding the cost of using electricity:
   a) How much does it cost to use a 15 watt compact fluorescent bulb for 6 hours per day for one week? Assume the cost of electricity is $0.12 per kilowatt-hour.

   b) How much does it cost to use a 75 watt incandescent bulb for 6 hours a day for one week? The cost of electricity is $0.12 per kilowatt-hour.

2. Transmitting electricity:
   Write several sentences explaining the advantages and disadvantages of transmitting electricity at high voltages.

3. Mastering symbols and units:
To help you become more familiar with the new units introduced into the course, fill in the table below. As an example, the answers for electrical force are given.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Symbol</th>
<th>Unit</th>
<th>Unit Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Force</td>
<td>F</td>
<td>newton</td>
<td>N</td>
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<tr>
<td>Electric Charge</td>
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<td>Voltage</td>
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<td>Power</td>
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<tr>
<td>Resistance</td>
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