Student Sheet PA.1: What’s Inside Electric Devices?

**Directions:** Use this student sheet to complete Investigation PA.1.

**Table A. What’s Inside?**

<table>
<thead>
<tr>
<th>Device</th>
<th>What It Does</th>
<th>Power Source</th>
<th>Number of Components</th>
<th>Components List</th>
<th>Drawings of Components of Device</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

STC My Generation™: Electricity, Waves, and Information Transfer

Pre-Assessment
Student Sheet 1.GS: Modeling a Leyden Jar Experiment

1. Use appropriate symbols and labels to show the flow, storage, and release of electrical energy to complete the diagrams.

2. Describe in words what is happening in each figure above.
Student Sheet 1.3: Batteries and Current in Circuits (page 1 of 2)

1. Identify the independent and dependent variables in your investigation.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Write a hypothesis about how changing the number of batteries will affect the current.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

3. Write a short procedure describing how you will change the batteries and measure the current.
Include a schematic for your test circuit(s).

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

4. Make a prediction about what you will observe once you have changed the number of batteries in the circuit and closed the switch.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

5. Draw a data table to record your data. Carry out your procedure, and enter your data in your table and note any observations you make during your experiment.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
6. Display your data on the graph below:

Title: ____________________________________________

7. Analyze your data and write a conclusion about how changing the number of batteries affected the current. Support your conclusion with evidence.

________________________________________________________________________________________

________________________________________________________________________________________

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________________________________________________________________________________________

________________________________________________________________________________________
1. Record your data from Investigation 2.1, Steps 2–6.

   Voltage across Resistor A: _______
   Current through Resistor A: _______
   Resistance: _______

   Voltage across Resistor B: _______
   Current through Resistor B: _______
   Resistance: _______

   Show all calculations here:

2. Write your answers to the following questions, and then discuss your answers with the class:
   a. What did you conclude about the relative resistance of the two resistors?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

   b. How was current related to resistance in each of the circuits you built?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

   c. How would you describe the function of a resistor in a circuit?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
3. Use the equation for power and your knowledge of Ohm’s law to calculate power for the circuits in this investigation. Then use those answers to calculate the voltage across the resistors.

Show all calculations here:
Student Sheet 2.2: Wires and Resistance

1. Record your data from Investigation 2.2 in Table A.

Table A. Measuring Wire Resistance

<table>
<thead>
<tr>
<th>Wire Gauge</th>
<th>Wire Length</th>
<th>Voltage Across the Wire</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Predictions: ______________________________________________________

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

3. Conclusion: ______________________________________________________

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Student Sheet 2.3: Electric Devices and Resistors (page 1 of 2)

Resistance of Resistor A: __________

Resistance of Resistor B: __________

1. Hypothesis: ___________________________________________________________________
   _____________________________________________________________________________
   _____________________________________________________________________________
   _____________________________________________________________________________
   Independent variable: ___________________________________________________________
   Dependent variable(s): _________________________________________________________
   Predictions: ___________________________________________________________________

2. Record your observations from Investigation 2.3 Step 7 in Table A and explain whether your predictions were or were not correct.

Table A. Observations of Fan Speed

<table>
<thead>
<tr>
<th>Observation of Fan Speed with Resistor A</th>
<th>Observation of Fan Speed with Resistor B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Were your predictions correct? Why or why not?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
3. Discuss the questions below with your group and then record your answers.

| VOLTAGE = CURRENT × RESISTANCE | POWER = CURRENT × VOLTAGE |

a. Based on your knowledge of Ohm’s law and how power is calculated, is the power used by the fan greater when Resistor A or Resistor B is in the circuit? Explain your answer.

_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________

b. Do your observations of the fan’s speed support your answer? Why or why not?

_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________

c. Do your data and observations support your hypothesis? If so, how? If not, why not?

_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
_________________________________________________________________________________________
Scientific arguments are based on evidence from data and reasoning from known scientific principles. You will use evidence and reasoning to write an argument that answers the question, **Where does the kinetic energy of a spinning coil motor come from?** You will write your final argument in your science notebook. Be prepared to share your argument with the class.

The questions below will help you organize evidence from Investigation 4.2 to build your argument. After you have completed them, write your response to the prompt above in your science notebook.

1. What happens in the bare and insulated copper wires when they are connected to the battery in the closed circuit? Explain your answer.

2. What happens to the properties of the coiled wire in the closed circuit? Explain your answer.

3. What part of your motor had kinetic energy when the switch was closed? Explain your answer.

4. What was the role of the flexible magnet in your spinning coil motor? Explain your answer.

5. What energy transformations can you identify in your closed circuit.
Student Sheet 6.1: Examining Convex Lenses (page 1 of 2)

Directions: Complete this student sheet as you conduct the experiments in Investigation 6.1.

1. Record your observations and measurements of the appearance of the letters on the page as you move the thicker convex lens. ________________________________
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

2. Write a description of what you observe when you look through the thicker lens at the other side of the classroom or out the window. __________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

3. Write a paragraph explaining how light bends to produce one of the images you saw through the lens. As needed, use a simple model to help you explain this phenomenon. __________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________
4. Record your observations and measurements of the appearance of the letters on the page as you move the thinner convex lens.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

5. Write a description of what you observe when you look through the thinner lens at the other side of the classroom or out the window.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

6. Write a paragraph explaining why you think your observations differed for the two lenses. Use the concept of refraction in your explanation.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

7. After reading Building Your Knowledge: “How a Convex Lens Focuses Light,” revise your answer to question 6 above as needed. Write your revised answer here.

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

8. Which lens has a longer focal length? How do you know?

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Student Sheet 9.1: Reaction Time Data

**Directions:** Record your data from Investigation 9.1 in Table A. Use Table B to convert distances (cm) to reaction times (s).

Below Table A, record your average reaction time.

<table>
<thead>
<tr>
<th>Response</th>
<th>Distance (cm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average reaction time:**

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>Time (sec)</th>
<th>Distance (cm)</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>17</td>
<td>0.19</td>
</tr>
<tr>
<td>2</td>
<td>0.06</td>
<td>18</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>0.08</td>
<td>19</td>
<td>0.20</td>
</tr>
<tr>
<td>4</td>
<td>0.09</td>
<td>20</td>
<td>0.20</td>
</tr>
<tr>
<td>5</td>
<td>0.10</td>
<td>21</td>
<td>0.21</td>
</tr>
<tr>
<td>6</td>
<td>0.11</td>
<td>22</td>
<td>0.22</td>
</tr>
<tr>
<td>7</td>
<td>0.12</td>
<td>23</td>
<td>0.22</td>
</tr>
<tr>
<td>8</td>
<td>0.13</td>
<td>24</td>
<td>0.22</td>
</tr>
<tr>
<td>9</td>
<td>0.14</td>
<td>25</td>
<td>0.23</td>
</tr>
<tr>
<td>10</td>
<td>0.14</td>
<td>26</td>
<td>0.23</td>
</tr>
<tr>
<td>11</td>
<td>0.15</td>
<td>27</td>
<td>0.23</td>
</tr>
<tr>
<td>12</td>
<td>0.16</td>
<td>28</td>
<td>0.24</td>
</tr>
<tr>
<td>13</td>
<td>0.16</td>
<td>29</td>
<td>0.24</td>
</tr>
<tr>
<td>14</td>
<td>0.17</td>
<td>30</td>
<td>0.25</td>
</tr>
<tr>
<td>15</td>
<td>0.17</td>
<td>31</td>
<td>0.25</td>
</tr>
<tr>
<td>16</td>
<td>0.18</td>
<td>32</td>
<td>0.26</td>
</tr>
</tbody>
</table>
1. Suppose a dolphin sends an echolocating click into a bed of kelp that absorbs much of the sound and reflects only a little. Will the reflected signal be quieter than the outgoing signal? Will it give the impression of coming from much farther away than it is? Explain your answers.

| Table A. Hearing Ranges for Selected Animals |
|-----------------|-----------------|
| Species         | Hearing Range   |
| Humans          | 64–23,000 Hz    |
| Dogs            | 67–45,000 Hz    |
| Cats            | 45–64,000 Hz    |
| Mice            | 1,000–91,000 Hz |
| Gerbils         | 100–60,000 Hz   |
| *Bats           | 2,000–110,000 Hz|
| *Beluga whales  | 1,000–123,000 Hz|
| *Porpoises      | 75–150,000 Hz   |
| Goldfish        | 20–3,000 Hz     |
| Owls            | 200–12,000 Hz   |
| Chickens        | 125–2,000 Hz    |

*Capable of echolocation
Source: www.lsu.edu/deafness/HearingRange.html

2. On the grid on page 2 of this student sheet, arrange the hearing-frequency bands listed in Table A, making a bar graph that shows the ranges over which various species can hear, and note areas where more than two bars overlap. Use hertz (Hz) as the x-axis.

3. Look at the bar for mice. As far as we know, mice do not echolocate. However, their hearing extends nearly to the range of the echolocators’. Why might mice have evolved to hear such high-frequency noises if they are not echolocating?

4. Examine your graph. What is the likely top frequency range for noises intended as communication, rather than echolocation? Explain your answer.

5. Can chickens hear what you say?
### Student Sheet 11.1a: Analysis of Medical Imaging Technologies

<table>
<thead>
<tr>
<th>Benefit(s)</th>
<th>Potential Risk(s) to Patients</th>
<th>Cost to Patient (Per Scan)</th>
<th>Average Equipment Purchase Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray</td>
<td></td>
<td>$100</td>
<td>$8,000</td>
</tr>
<tr>
<td>Computed Tomography (CT Scan)</td>
<td></td>
<td>$700</td>
<td>$25,000</td>
</tr>
<tr>
<td>Magnetic Resonance Imaging (MRI)</td>
<td></td>
<td>$800</td>
<td>$150,000</td>
</tr>
<tr>
<td>Positron Emitted Tomography (PET Scan)</td>
<td></td>
<td>$2,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Ultrasound</td>
<td></td>
<td>$200</td>
<td>$4,500</td>
</tr>
</tbody>
</table>
# Student Sheet 11.1b: Diagnostic Protocol

<table>
<thead>
<tr>
<th>Illness / Injury and Patient Information</th>
<th>Devices to Avoid</th>
<th>Reason to Avoid</th>
<th>Preferred Devices</th>
<th>Reason Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected lung tumor, adult, pregnant, no medical implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected brain tumor, adult, no pregnancy, no medical implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected broken rib, adult, no pregnancy, no medical implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected growth in the abdomen, adult, no pregnancy, metal knee replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected osteoporosis (bone-weakening disease), elderly adult, unknown if patient has medical implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected irregular kidney structure, infant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected heart disease, adult, no pregnancy, metal hip implant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected torn ligament, child</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspected broken arm, child</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Student Sheet A.1a: Equipment Planning

Directions: Use this student sheet to complete the Performance Assessment.

Table A. Available Equipment

<table>
<thead>
<tr>
<th>Available Equipment</th>
<th>General Function of Equipment</th>
<th>Possible Use in Remote Medical System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit systems kit (any kit components that you have used in this unit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-size halogen lightbulbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clamp lamps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashlights with batteries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension cords (various sizes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet-cell car batteries with voltage converters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPS receiver (battery powered)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable EKG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable AED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable ultrasound equipment with data transfer capabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable X-ray machine with data transfer capabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satellite phone with email and data transfer capabilities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Student Sheet A.1b: Map of Disaster Area

Medical Center
Town Hall
Elementary School
Business Center
Tech Center
Middle School
Elementary School
High School
Shopping Mall
Downtown
Damage Boundary
Damage Boundary
PATH OF TORNADO
0 .5 1 Mile
Medical Base
Military Base

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STC My Generation™: Electricity, Waves, and Information Transfer
Assessment
Multiple Choice

1. What happens in a simple circuit that includes a battery when the circuit is closed?
   A. Electric charges flow through the empty space inside the hollow wires.
   B. Electric charges flow through the metal core of the wires.
   C. Electric charges build up in the battery and do not flow through the wires.
   D. Electric charges are used up in the battery and do not flow through the wires.

2. What happens with energy in an electric motor when it is part of a closed circuit?
   A. Energy is created by the motor as long as the motor is on.
   B. Energy is used up in the motor until all the energy is gone.
   C. Energy is transformed in the motor from kinetic energy to chemical energy.
   D. Energy is transformed in the motor from electrical energy to kinetic energy.

3. Which of the following best describes an action potential in a neuron?
   A. A constant current that flows through the axon
   B. A rapid voltage change that travels along the axon
   C. A transmission of light waves along the axon
   D. A transformation of sound waves into light waves in the axon

4. Which of the following changes would you make to the circuit below if you were trying to minimize the transformation of electrical energy into thermal energy?

   A. Remove the resistor
   B. Remove the capacitor
   C. Add another resistor
   D. Add another capacitor
5. Imagine you need to send multiple copies of data over a long distance and with high accuracy. Would it be better to use digital or analog data? Give two reasons for your answer.

6. Why is it useful for engineers designing complex systems to test several different design solutions or several different modifications to a solution? Respond in a short paragraph.

7. A wire that is part of a closed circuit is placed near a magnet. The table below shows the change in electromagnetic force when the amount of current flowing through the wire is changed.

<table>
<thead>
<tr>
<th>Current (Amperes)</th>
<th>Force (Newtons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20</td>
<td>0.001</td>
</tr>
<tr>
<td>0.25</td>
<td>0.00125</td>
</tr>
<tr>
<td>0.30</td>
<td>0.0015</td>
</tr>
<tr>
<td>0.35</td>
<td>0.00175</td>
</tr>
<tr>
<td>0.40</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Design a graph to display the data in the table on the grid provided on your answer sheet. Then, in a few sentences, describe the relationship shown in the graph between current and electromagnetic force. Make sure that someone could understand the relationship by looking at the graph alone, or by reading the sentences alone.

8. A student studying echolocation presents the following argument to the class: “Dolphins are better at echolocation than bats because sound waves travel faster through water, where dolphins live, than through air, where bats live.” Write two questions you might ask this student to better determine whether or not the argument is likely to be correct.

9. Create four simple hand-drawn models of what happens to light waves in each of the interactions with matter listed below. For each interaction, assume that the light wave starts out traveling through the air. Label your model with the all the type(s) of matter and any boundaries or surfaces you have shown. In one or two sentences below each model, explain the representations you used and what they show.

   a. Reflection          c. Transmission
   b. Refraction          d. Absorption

10. In a short paragraph, describe any and all changes in energy that would happen in the circuit shown at right when the switch is closed.
Student Sheet A.2b: Written Assessment Answer Sheet (page 1 of 2)

Multiple Choice

Directions: Circle the letter of your answer choice.

1. A  B  C  D
2. A  B  C  D
3. A  B  C  D
4. A  B  C  D

Constructed Response

5. _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________

6. _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________

7. _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________
   _______________________________________________________________________________

8. _______________________________________________________________________________
   _______________________________________________________________________________
9. a. Reflection:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

b. Refraction:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________


c. Transmission:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

d. Absorption:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

10. ______________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________