Electricity and Magnetism: 4.F.2

Conductors vs. Insulators

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>4</th>
</tr>
</thead>
</table>
| Sessions    | Session 1 – 20-35 minutes  
             | Session 2 – 40-55 minutes  |
| Seasonality | N/A |
| Instructional Mode(s) | Small Group Activity |
| Team Size    | 2 – 4 students |
| WPS Benchmarks | 04.SC.IS.03  
                 | 04.SC.IS.06  
                 | 04.SC.PS.05  
                 | 04.SC.PS.06  
                 | 04.SC.PS.07  
                 | 04.SC.TE.01  
                 | 04.SC.TE.02  
                 | 04.SC.TE.05  
                 | 04.SC.TE.06  |
| MA Frameworks | 3-5.IS.3  
                | 3-5.IS.6  
                | 3-5.PS.6  
                | 3-5.PS.7  
                | 3-5.TE.1.1  
                | 3-5.TE.1.2  
                | 3-5.TE.2.2  
                | 3-5.TE.2.3  |
| Key Words    | Electricity, circuit, insulator, conductor, material testing |

Summary

The students will build a complete circuit with a battery, wires, and a light bulb. The students will then apply what they have learned about insulators and conductors and test a variety of different materials to determine which materials are insulators and which materials are conductors. The students will then use what they have learned about conductors and insulators to design a safe electronic toy.

Learning Objectives

2002 Worcester Public Schools (WPS) Benchmarks for Grade 4

04.SC.IS.03 Keep accurate records while conducting simple investigations or experiments.
04.SC.IS.06 Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

04.SC.PS.05 Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat and sound.

04.SC.PS.06 Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.

04.SC.PS.07 Determine the electrical conductivity of a collection of materials by testing the materials with a simple battery/bulb circuit.

04.SC.TE.01 Identify materials used to accomplish a design task based on a specific property, i.e., weight, strength, hardness, and flexibility.

04.SC.TE.02 Identify and explain the appropriate materials and tools (e.g., hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) to construct a given a prototype safely.

04.SC.TE.05 Describe different ways is which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.

04.SC.TE.06 Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.

**Additional Learning Objectives**

1. 04.SC.IS.03 Keep accurate records while conducting simple investigations or experiments.

2. 04.SC.IS.06 Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

3. 3-4.PS.6 Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat and sound.

4. 3-5.PS.7 Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.
5. **3-5.TE.1.1** Identify materials used to accomplish a design task based on a specific property, i.e., weight, strength, hardness, and flexibility.

6. **3-5.TE.1.2** Identify and explain the appropriate materials and tools (e.g., hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) to construct a given a prototype safely.

7. **3-5.TE.2.2** Describe different ways is which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.

8. **3-5.TE.2.3** Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.

**Required Background Knowledge**

1. Basic understanding of electricity.

**Essential Questions**

1. What is an insulator?
2. What is a conductor?
3. What are a few examples of insulators and conductors that you see everyday?
4. Why is it important to know if a material is a conductor or insulator?

**Introduction / Motivation**

Ask the students what a circuit is. The students should be able to create a circuit out of a battery, wire, and light bulb. The teacher should then ask the students what an electrical conductor and electrical insulator is.

**Procedure**

**Part I – 20-35 minutes**

The instructor will:

1. Review what a conductor and insulator is. (See *What is a conductor?* and *What is an insulator?*) (5-10 minutes)

2. Ask the students why we need conductors and insulators. Conductors are used to carry electricity and insulators protect us from that electricity. What would
happen if wires weren’t covered with insulation? Or what would happen if underwater cameras or remote controlled boats didn’t have any insulation to protect the electrical parts? (5 minutes)

3. Tell the students that they will be doing an experiment to find out what materials are conductors and insulators. Ask the students how they can test the materials. Divide the students into groups (group size depends on the availability of supplies). Pass out How to Build a Circuit if necessary. Pass out Conductors and Insulators. (5-10 minutes)

4. Pass out the materials. After all of the groups have completed the experiment, have a discussion about what the students have found. (5-10 minutes)

Part II – 50 minutes

The instructor will:

1. Review what the students learned in the last session. (5 minutes)

2. Tell the students that they will be using what they learned in the last session to design a safe electronic toy. Divide the class into small groups. Pass out Toy Design Engineering Challenge. If your class is constructing prototypes, distribute materials as each group completes step 5. (30 minutes, 45 minutes if building prototype)

3. After the students have completed their worksheets, discuss possible ways to test the toys of safety. (5 minutes) Some possibilities are:
   a. Have a group of children play with the toys for a certain amount of time and watch how they play with them. Have adults close enough to step in if one of the children is about to get hurt.
   b. Put the toys in a tub of water and then measure the amount of electricity in the water.

Materials List

<table>
<thead>
<tr>
<th>Session 1</th>
<th>Amount</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eraser</td>
<td>1</td>
<td>Supermarket, office supply store</td>
</tr>
</tbody>
</table>
Partnerships Implementing Engineering Education  
Worcester Polytechnic Institute – Worcester Public Schools  
Supported by: National Science Foundation

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper clip</td>
<td>1</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Plastic button</td>
<td>1</td>
<td>Drugstore, craft store</td>
</tr>
<tr>
<td>Glass marble</td>
<td>1</td>
<td>Craft store, toy store</td>
</tr>
<tr>
<td>Craft stick</td>
<td>1</td>
<td>Craft store</td>
</tr>
<tr>
<td>Paper</td>
<td>1</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Nail</td>
<td>1</td>
<td>Home improvement store</td>
</tr>
<tr>
<td>Pencil</td>
<td>1</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Battery</td>
<td>1</td>
<td>Electronics store, supermarket</td>
</tr>
<tr>
<td>Wires</td>
<td>2</td>
<td>Electronics store</td>
</tr>
<tr>
<td>Bulb</td>
<td>1</td>
<td>Electronics store</td>
</tr>
</tbody>
</table>

Session 2 (only necessary if building toy prototypes)

<table>
<thead>
<tr>
<th>Materials per group/student</th>
<th>Amount</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard</td>
<td>Teacher discretion</td>
<td>Free at Supermarket</td>
</tr>
<tr>
<td>Paper clips</td>
<td>Teacher discretion</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Yarn or string</td>
<td>Teacher discretion</td>
<td>Craft store</td>
</tr>
<tr>
<td>Tape</td>
<td>Teacher discretion</td>
<td>Craft store, office supply story</td>
</tr>
<tr>
<td>Markers</td>
<td>1 set</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Paper</td>
<td>Teacher discretion</td>
<td>Supermarket, office supply store</td>
</tr>
<tr>
<td>Straws</td>
<td>Teacher discretion</td>
<td>Supermarket</td>
</tr>
</tbody>
</table>

Vocabulary with Definitions (in alphabetical order)

1. Circuit - A path along which negative charges move.
2. Conductor – Any material that allows negative charge to flow freely through it.
3. Electricity – The flow or movement of negative charges.
4. Insulator - Any material that does not allow negative charges to flow freely through it.

Assessment / Evaluation of Students

The instructor may assess the students in any/all of the following manners:

1. Check worksheets: ensure that students understand what conductors and insulators are and understand the engineering design process.
Lesson Extensions

The instructor may want to talk about what is inside each light bulb. The students can figure out how the electrical circuit is set-up within the light bulb.

Attachments

1. What is a conductor?
2. What in an insulator?
3. Conductors and Insulators
4. Building a Circuit
5. Engineering Design Task
6. Toy Engineering Design Challenge

Troubleshooting Tips

None

Safety Issues

None

Additional Resources

None

Key Words

Electricity, circuit, insulator, conductor, material testing
What is a conductor?

A conductor is a substance that transfers electric charge.

Can you think of a material that is an electrical conductor?

Can any of you think of a way to test materials to find out if they are electrical conductors or electrical insulators?
What is an insulator?

An insulator is a material that does not transfer electric charge.

Can you think of a material that is an electrical insulator?

Why are insulators so important?
Conductors and Insulators

Here is a list of materials you will test. To test these materials hold both wires from your circuit to different areas of the material. **Do not touch the wires together!** If the material is a conductor, the light bulb will light. If the material does not light, it is an insulator.

Write down what each material is in the boxes below.

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductor or Insulator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>eraser</td>
<td>insulator</td>
</tr>
<tr>
<td>paper clip</td>
<td></td>
</tr>
<tr>
<td>plastic button</td>
<td></td>
</tr>
<tr>
<td>glass marble</td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td></td>
</tr>
<tr>
<td>paper</td>
<td></td>
</tr>
<tr>
<td>nail</td>
<td></td>
</tr>
<tr>
<td>pencil (wooden part)</td>
<td></td>
</tr>
<tr>
<td>pencil (metal part)</td>
<td></td>
</tr>
</tbody>
</table>

Why do the electrical insulators keep the light bulb from lighting?

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
Building a Circuit

1. Read all directions

2. Gather all of the following supplies for your circuit.

   2 Wires
   1 Battery Holder
   1 Battery
   1 Light bulb

3. Listen carefully for instructions on how to put your circuit together.
Global Toy Company has asked for your help designing a safe electronic toy for young children.

The key things to consider are the following:

* The toy will have a complete electronic circuit inside of it.

* You can design the toy to be whatever you think younger kids would like (examples: a robot, a motor boat, a walking pony).

* The toy must be safe. If the toy is dropped in water it must not harm anyone (the electrical circuit must be well insulated and waterproof).
Toy Design Engineering Challenge

Directions: Use the Engineering Design Process to complete the toy design.

Step 1: Identify the Need or Problem

Step 2: Research the Need or Problem
Think back to when you were younger and consider what you have learned about conductors and insulators.

Step 3: Develop Possible Solution(s)
Draw and label three different designs. Be sure label what materials you would use for each part of the toy.
Toy Design Engineering Challenge (continued)

Step 4: Select the Best Possible Solution(s)
Discuss with your group. Circle the best design.

Step 5: Construct a Prototype
Write a list of materials you will need to construct a prototype.

Step 6: Test and Evaluate the Solution(s)
How would you test how safe your toy is?

Step 7: Communicate the Solution(s)
Be sure to turn in turn in your work.

Step 8: Redesign
What would you improve about your toy if you had unlimited materials?