

# The Path of Least Resistance Lesson Plan

Michigan Grade Level Content Expectations, Common Core State Standards  
and Next Generation Science Standards

## Fourth

### SCIENCE

- S.IP.04.11 Make purposeful observation of the natural world using the appropriate senses.
- S.IP.04.12 Generate questions based on observations.
- S.IP.04.13 Plan and conduct simple and fair investigations.
- S.IP.04.14 Manipulate simple tools that aid observation and data collection
- S.IA.04.12 Share ideas about science through purposeful conversation in collaborative groups.
- S.RS.04.14 Use data/samples as evidence to separate fact from opinion.
- S.RS.04.15 Use evidence when communicating scientific ideas.
- P.EN.04.51 Demonstrate how electrical energy is transferred and changed through the use of a simple circuit.
- P.EN.04.52 Demonstrate magnetic effects in a simple electric circuit.
- P.PM.04.53 Identify objects that are good conductors or poor conductors of heat and electricity.
- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another

### SOCIAL STUDIES

#### Public Discourse, Decision Making, and Citizens Involvement

##### P4.2 Citizen Involvement

- 4 – P4.2.2 Participate in projects to help or inform others

### ENGLISH LANGUAGE ARTS

#### Reading Standards for Informational Text (RI)

##### Integration of Knowledge and Ideas

- RI.4.7—Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

#### Writing Standards (W)

##### Research to Build and Present Knowledge

- W.4.1b—Provide reasons that are supported by facts and details.
- W.4.2d—Use precise language and domain-specific vocabulary to inform about or explain the topic.

##### Research to Build and Present Knowledge

- W.4.8—Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

#### Speaking and Listening Standards (SL)

##### Comprehension and Collaboration

- SL.4.1c—Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- SL.4.1d—Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.

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**Presentation of Knowledge and Ideas**

- SL.4.4—Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

**Language Standards (L)****Conventions of Standard English**

- L.4.1—Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- L.4.3—Use knowledge of language and its conventions when writing, speaking, reading, or listening.

**Vocabulary Acquisition and Use**

- L.4.4c—Consult reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation and determine or clarify the precise meaning of key words and phrases.

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## Fifth

### SCIENCE

#### Science GLCEs

- S.IP.05.11 Generate scientific questions based on observations, investigations, and research.
- S.IP.05.12 Design and conduct scientific investigations.
- S.IP.05.13 Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens) appropriate to scientific investigations.
- S.IA.05.12 Evaluate data, claims, and personal knowledge through collaborative science discourse.

### SOCIAL STUDIES

#### Public Discourse, Decision Making, and Citizens Involvement

##### P4.2 Citizen Involvement

- 5 – P4.2.2 Participate in projects to help or inform others

### ENGLISH LANGUAGE ARTS

#### Reading Standards for Informational Text (RI)

##### Integration of Knowledge and Ideas

- RI.5.7—Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

#### Writing Standards (W)

##### Text Types and Purposes

- W.5.1b—Provide logically ordered reasons that are supported by facts and details.
- W.5.2d—Use precise language and domain-specific vocabulary to inform about or explain the topic.

##### Research to Build and Present Knowledge

- W.5.8—Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

#### Speaking and Listening Standards (SL)

##### Comprehension and Collaboration

- SL.5.1c—Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- SL.5.1d—Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

##### Presentation of Knowledge and Ideas

- SL.5.4—Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

#### Language Standards (L)

##### Conventions of Standard English

- L.5.1—Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- L.5.3—Use knowledge of language and its conventions when writing, speaking, reading, or listening.

##### Vocabulary Acquisition and Use

- L.5.4c—Consult reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation and determine or clarify the precise meaning of key words and phrases.

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## Sixth

### SCIENCE

- Science GLCEs:
  - S.IP.06.11 Generate scientific questions based on observations, investigations, and research.
  - S.IP.06.12 Design and conduct scientific investigations.
  - S.IP.06.13 Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens) appropriate to scientific investigations.
  - S.IA.06.12 Evaluate data, claims, and personal knowledge through collaborative science discourse.
  - S.IA.06.13 Communicate and defend findings of observations and investigations using evidence.
  - S.RS.06.11 Evaluate the strengths and weaknesses of claims, arguments, and data.
  - S.RS.06.12 Describe limitations in personal and scientific knowledge.
  - S.RS.06.13 Identify the need for evidence in making scientific decisions.
  - S.RS.06.14 Evaluate scientific explanations based on current evidence and scientific principles.
  - P.EN.06.41 Explain how different forms of energy can be transferred from one place to another by radiation, conduction, or convection.

### SOCIAL STUDIES

#### P2 Inquiry, Research, and Analysis

- P2.5 Use deductive and inductive problem-solving skills as appropriate to the problem being studied.

### ENGLISH LANGUAGE ARTS

#### Writing Standards (W)

##### Text Types and Purposes

- W.6.2d—Use precise language and domain-specific vocabulary to inform about or explain the topic.

#### Speaking and Listening (SL)

##### Comprehension and Collaboration

- SL.6.1c—Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

##### Presentation of Knowledge and Ideas

- SL.6.4—Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

#### Language (L)

##### Conventions of Standard English

- L.6.1--Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

##### Knowledge of Language

- L.6.3—Use knowledge of language and its conventions when writing, speaking, reading, or listening.

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## Seventh

### SCIENCE

- **Science GLCEs:**
  - S.IP.07.11 Generate scientific questions based on observations, investigations, and research.
  - S.IP.07.12 Design and conduct scientific investigations.
  - S.IP.07.13 Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens, thermometer, models, sieves, microscopes, hot plates, pH meters) appropriate to scientific investigations.
  - S.IA.07.12 Evaluate data, claims, and personal knowledge through collaborative science discourse.
  - S.IA.07.13 Communicate and defend findings of observations and investigations.
  - S.RS.07.11 Evaluate the strengths and weaknesses of claims, arguments, and data.
  - S.RS.07.12 Describe limitations in personal and scientific knowledge.
  - S.RS.07.13 Identify the need for evidence in making scientific decisions.
  - S.RS.07.14 Evaluate scientific explanations based on current evidence and scientific principles.

### SOCIAL STUDIES

#### P2 Inquiry, Research, and Analysis

- P2.5 Use deductive and inductive problem-solving skills as appropriate to the problem being studied.

### ENGLISH LANGUAGE ARTS

#### Writing Standards (W)

##### Text Types and Purposes

- W.7.2d— Use precise language and domain-specific vocabulary to inform about or explain the topic.

#### Speaking and Listening (SL)

##### Comprehension and Collaboration

- SL.7.1c— Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.
- SL.7.1d—Acknowledge new information expressed by others and, when warranted, modify their own views.

##### Presentation of Knowledge and Ideas

- SL.7.4—Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

#### Language (L)

##### Conventions of Standard English

- L.7.1—Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

##### Knowledge of Language

- L.7.3—Use knowledge of language and its conventions when writing, speaking, reading, or listening.

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## *Eighth*

### **SCIENCE**

#### **Science GLCEs:**

- 8th grade Science GLCE standards are included under the high school science standards in the state of Michigan and can be found in the High School section below.

### **SOCIAL STUDIES**

#### **P2 Inquiry, Research, and Analysis**

- P2.5 Use deductive and inductive problem-solving skills as appropriate to the problem being studied.

### **ENGLISH LANGUAGE ARTS**

#### **Writing Standards (W)**

##### **Text Types and Purposes**

- W.8.2d— Use precise language and domain-specific vocabulary to inform about or explain the topic.

#### **Speaking and Listening (SL)**

##### **Comprehension and Collaboration**

- SL.8.1c— Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
- SL.8.1d— Acknowledge new information expressed by others and, when warranted, qualify or justify their own views in light of the evidence presented.

##### **Presentation of Knowledge and Ideas**

- SL.8.4—Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

#### **Language (L)**

##### **Conventions of Standard English**

- L.8.1—Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

##### **Knowledge of Language**

- L.8.3—Use knowledge of language and its conventions when writing, speaking, reading, or listening.

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## *Ninth and Tenth*

### SCIENCE

#### Science GLCEs

- P1.1A Generate new questions that can be investigated in the laboratory or field.
- P1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.
- P1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
- P1.1E Describe a reason for a given conclusion using evidence from an investigation.
- P4.10C Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.
- P4.10D Discriminate between voltage, resistance, and current as they apply to an electric circuit.

### ENGLISH LANGUAGE ARTS

#### Writing Standards (W)

##### Text Types and Purposes

- W.9-10.2d—Use precise language and domain-specific vocabulary to manage the complexity of the topic.

#### Speaking and Listening (SL)

##### Comprehension and Collaboration

- SL.9-10.1c—Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.
- SL.9-10.1d—Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.

##### Presentation of Knowledge and Ideas

- SL.9-10.4--Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

#### Language (L)

##### Conventions of Standard English

- L.9-10.1—Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking.

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## *Eleventh and Twelfth*

### **SCIENCE**

#### **Science GLCEs**

- P1.1A Generate new questions that can be investigated in the laboratory or field.
- P1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.
- P1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
- P1.1E Describe a reason for a given conclusion using evidence from an investigation.
- P4.10C Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.
- P4.10D Discriminate between voltage, resistance, and current as they apply to an electric circuit.

### **ENGLISH LANGUAGE ARTS**

#### **Speaking and Listening (SL)**

##### **Comprehension and Collaboration**

- SL.11-12.1c—Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.
- SL.11-12.2d—Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.

##### **Presentation of Knowledge and Ideas**

- SL.11-12.4—Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

#### **Language (L)**

##### **Conventions of Standard English**

- L.11-12.1—Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking.



**Grades 6-12 Literacy in History/Social Studies, Science, & Technical Subjects**Grade Bands 6<sup>th</sup>–8<sup>th</sup>, 9<sup>th</sup>--10<sup>th</sup>, & 11<sup>th</sup>--12<sup>th</sup>**Reading Standards for Literacy in Science & Technical Subjects****Key Ideas and Details**

- RST.6-8.3—Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- RST.9-10.3—Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.11-12.3—Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

**Integration of Knowledge and Ideas**

- RST.6-8.9—Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
- RST.9-10.9—Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
- RST.11-12.9—Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects****Text Types and Purposes**

- WHST.6-8.2d—Use precise language and domain-specific vocabulary to inform about or explain the topic.
- WHST.6-8.2f—Provide a concluding statement or section that follows from and supports the information or explanation presented.
- WHST.9-10.2f—Provide a concluding statement or section that follows from and support the information or explanation presented (e.g., articulating implications or the significance of the topic).
- WHST.11-12.2f—Provide a concluding statement or section that follows from and support the information or explanation provided (e.g., articulating implications or the significance of the topic).

### Lesson Outcome

The student will apply understanding of electricity and circuits to explore how resistance affects the path of electricity.

### Rationale / Purpose for Lesson

Conductors and Insulators are frequently viewed by students as absolutes rather than objects containing a property that falls along a spectrum. This lesson provides opportunities for students to gain a more precise understanding of conductors and insulators. Additionally, students will recognize that electricity often has multiple paths available and that the properties of the objects within its path will determine the path it takes. Further exploration of circuits can easily be added to this lesson.

### Resources / Materials Required

- Conductive Dough (See instructions at end of lesson)
- Insulating Dough (See instructions at end of lesson)
- One to two AA Battery packs with attached terminals for each student or group
- One or more 10mm LEDs for each student or group (Other light bulbs can be used, but will not exhibit polarity if you choose to explore this concept.)
- Copies of "The Path of Least Resistance" handout
- Pen or pencil to record observations
- **Optional Items**
  - A buzzer or motor for each student or group with attached terminals and a current rating of 30mA or less

### Anticipatory Set

- Depending on the student's prior knowledge, it may be necessary to define or review the definitions of the following words: conductor, insulator, resistance, polarity, and short circuit.
- At the front of the room, have a variety of objects that can be classified as either insulators or conductors. Have the students sort the objects into groups. Then, start with the conductors and ask the students whether they believe some of the objects are better conductors than others. Repeat with the insulators. Explain that part of the experiment will investigate this idea further.
- Ask the students where electricity wants to travel. (to ground) Have the students vote on whether they would take a 2 mile walk through the swamp to the library or a 2 mile walk on a paved sidewalk to the library. Explain that electricity is always looking for the easiest path, so in the

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example above, electricity would take the sidewalk instead of the swamp. Explain that the other part of this experiment will look at the path that electricity takes when traveling.

### Procedures

- Bring out the conductive dough and distribute to the students. Give them a few minutes to play around with the dough and have them describe the characteristics. Likely answers include:
  - Soft
  - Squishy
  - Smooth
- Explain to the students that this dough is a conductor. Also provide them a battery pack and one LED. Ask the students to guess whether they think the electricity will prefer to travel through the dough or the LED. Next, have them insert the wires into the dough on opposing sides with the LED in the center.
  - Have the students or groups complete Question 1 on their handout. After they have completed Question 1, have some students explain what happened and provide an explanation for why they think the LED didn't light up.



The LED doesn't light up because the easiest path for the electricity to travel is through the dough.

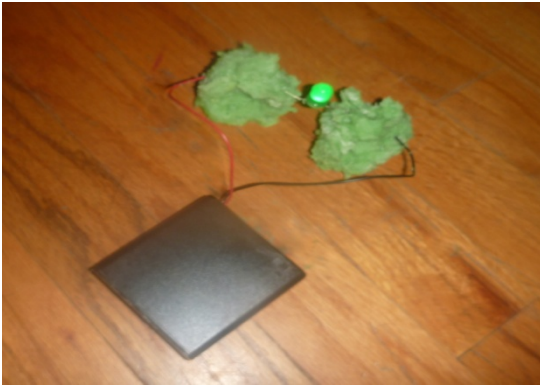
- Now have the students separate the dough into two small pieces. Have them put the black wire in one piece of dough and the red wire in the other piece of dough. The LED should straddle between the two pieces. Some of the students should see their LED light up and others will not.
- Have all the students switch the LED so the leg that was previously in the dough with the black wire is now in the dough with the red wire and the leg that was previously in the dough with the red wire will now be in the dough with the black wire. Those whose LED didn't light up before should now see it lit and those whose LED was lit before should see that it doesn't light up.
  - Have the students or groups complete Question 2 on their handout. After they have completed Question 2, have some students explain what happened and provide an explanation for why they think the LED would only light up when the longer leg was in the dough with the red wire.

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The LED will only light up when the longer leg is in the dough with the red wire due to a concept called polarity. This means that the LED will only work in one direction. The longer terminal leg must be connected to the positive (red) wire.

- Have the students arrange their two pieces of dough and battery so the light is lit. Then, have the students slowly push the bottom parts of the dough so the two pieces touch at the bottom only. The light should go out.
  - Have the students or groups complete Question 3 on their handout. After they have completed Question 3, have some students provide an explanation for why they think the LED would go out when the two pieces of dough touch.



By pushing the two pieces of dough together, the student created a short circuit and caused the electricity to alter its path. Even though the intended path through the LED is available and working, as soon as the short circuit is created, the electricity will change its path because there is less resistance.

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- Distribute the insulating dough. Tell the students not to mix the two types of dough together or otherwise the experiment will not work properly. Give them a few minutes to play around with the insulating dough and have them describe the characteristics. Likely answers include:
  - Hard
  - Thick
  - Rough
- Explain that this dough is insulating dough. Ask the students to guess how strong of an insulator the dough will be. Next, have them insert the wires into the insulating dough on opposing sides with the LED in the center similar to question 1.
  - Have the students or groups complete Question 4 on their handout. After they have completed Question 4, have some students provide an explanation for why they think the LED didn't light up.



Just like in question 1, the LED will not light up because the electricity will choose to travel through the easiest path, which is the dough. It is clear that if electricity was able to travel through the dough, it is not completely insulating because otherwise the electricity would have to go through the LED.

- Now have the students separate the dough into two small pieces. Have them put the black wire in one piece of dough and the red wire in the other piece of dough with the LED straddling between the two pieces similar to question 2. Just like in question 2, some of the students should see their LED light up and others will not.
- Have all the students switch the LED so the leg that was previously in the dough with the black wire is now in the dough with the red wire and the leg that was previously in the dough with the red wire will now be in the dough with the black wire. Those whose LED didn't light up before should now see it lit and those whose LED was lit before should see that it doesn't light up. The students should notice when the LED is lit, that it is either much dimmer than when using the conductive dough or the light will flicker on and off.
  - Have the students or groups complete Question 5 on their handout. After they have completed Question 5, have some students explain why they believe the LED acted differently in the insulating dough. Does anyone remember the term for why the direction of the terminals matters?(polarity)

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The LED will only light up when the longer leg is in the dough with the red wire due to polarity as described in question 2. The LED will be dimmer or flicker because electricity can travel through the insulating dough but there is more resistance.

- Have the students reconnect the wires to the conductive dough so the LED is lit. Next, have them take some of the insulating dough and put it in the middle so it connects the conductive dough and looks sort of like a hamburger. The two pieces of conductive dough cannot touch. The electricity should travel through the LED.
  - Have the students or groups complete Question 6 on their handout. After they have completed Question 6, have some students explain why the electricity would travel through the LED when it was just proven that electricity was able to travel through the insulating dough.



Although electricity can travel through the insulating dough, it is not an easy path. When the insulating dough is placed between the conductive dough, the electricity goes through the LED to avoid the path through the insulating dough.

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### Closure

- Ask students to describe the difference between an insulator and a poor conductor. What are some practical reasons for why it is necessary to understand this distinction? Do you think this means there could still be some current traveling through the more difficult path even if the light bulb is lit?
- A bird or squirrel can walk across a bare electric wire that is in the air and not be electrocuted or shocked. However if the bird or squirrel is standing on the ground and touches a downed wire, they will get hurt. Clearly, since the location of the power line determines whether or not the animal will be injured, it can't be an innate quality of the animal that keeps it from getting hurt on a power line in the air. Have students come up with an explanation for why the bird or squirrel is safe when touching a power line in the air, but not on the ground.

### Extensions

- Allow students to explore more with additional LEDs, battery packs, buzzers or motors. Which arrangements can they develop that allow electricity to travel without using the dough? What kinds of circuits can they come up with?
- Have students help you create the two different types of dough. Have them identify the ingredients in the two mixtures that give the two types of dough their distinctive properties. (Making the conductive dough requires access to a stove or burner)
- Have students research semi-conductors. How are they used and how are they related to this lesson?

### Dough Recipe

#### Conductive Dough (makes enough for a classroom of around 25)

- Ingredients
  - 4 ½ cups Flour(separate the 4 cups from the ½ cup)
  - 9 Tbsp. of Cream of Tartar
  - ¾ cup table salt
  - 2 Tbsp. vegetable oil
  - 3 cups water
  - Green food coloring (any color can be used, but make sure to change the color on the handout if you use a color other than green)
- Directions
  - Mix everything together except the food coloring and a ½ cup of the flour in a large pan
  - Place the pan over medium heat and continuously stir the ingredients together until it begins to thicken

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- Add several drops of the food coloring until the mixture turns into the appropriate color
- Once the ingredients thicken, use a spoon to bring the ingredients together into a ball
- Roll out the ball onto a counter or cookie sheet and let it cool enough so you can touch it
- Sprinkle the remaining flour on the rolled out dough and knead it back into a ball that is smooth and pliable
- Store the dough in an airtight container like Tupperware or a Ziploc bag. If water droplets form on the dough inside the bag, just knead it a little before using. This dough should last for several days.

### **Insulating Dough (makes enough for a classroom of around 25)**

- Ingredients
  - 4 cups Flour
  - 3 Tsp. of Granulated Alum
  - 1 ½ cups sugar
  - 9 Tbsp. vegetable oil
  - 1 ½ cups distilled water
  - Blue food coloring (any color can be used, but make sure to change the color on the handout if you use a color other than blue)
- Directions
  - Mix everything together in a large bowl except the distilled water and the food coloring
  - Start adding in the distilled water just a little bit at a time until all of the water is absorbed
  - Add several drops of the food coloring until the mixture turns into the appropriate color
  - Once the ingredients are well blended, use a spoon to bring the ingredients together into a lumpy ball. If necessary, add more distilled water until it is a little bit sticky and a smooth as you can get it
  - Roll out the ball onto a counter or cookie sheet and let it cool enough so you can touch it
  - Sprinkle the remaining flour on the rolled out dough and knead it back into a ball that is smooth and pliable
  - Store the dough in an airtight container like Tupperware or a Ziploc bag. If water droplets form on the dough inside the bag, just knead it a little before using. If the dough is really hard or dry when you remove it from the airtight container, knead in a little more distilled water. This dough should last for several days.



## **The Path of Least Resistance Student Handout**

**Name:** \_\_\_\_\_

Definitions you should know:

**Conductors:** If an object is a conductor, it allows electricity to freely flow through it (Green Dough)

**Insulator:** If an object is an insulator, it will resist the flow of electricity. Electricity may still be able to flow through it, but it will be more difficult (Blue Dough)

**Resistance:** Hindering the flow of electric current

**Polarity:** Behaving differently depending on which terminal is at a higher voltage, or which direction current is flowing through it

**Short Circuit:** When electricity travels through an unintended path because there is less resistance

1. Take some of the green dough. Insert the wires into the dough on opposing sides with the LED in the center. What happens and why?
  
2. Now, break up the dough into two pieces. Put the black wire in one piece and the red wire in the other piece. Does it light up? If not, take the LED and put the longer leg in the dough with the red wire and the shorter leg in the dough with the black wire. What happens and why?

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3. Now, make sure the longer leg is in the dough with the red wire. Once the light is lit, push the two pieces of dough, so they are just touching at the bottom. The light should go out. Why do you think this happened?
  
  
  
  
  
  
  
  
  
  
4. Now, take the blue dough. Insert the wires into the dough on opposing sides with the LED in the center. What happens? If the LED doesn't light up, why do you think this could be? Isn't this dough insulating?
  
  
  
  
  
  
  
  
  
  
5. Break up the blue dough into two pieces. Put the black wire in one piece and the red wire in the other piece. Take the LED and put the longer leg in the dough with the red wire and the shorter leg in the dough with the black wire. What happens and why? Do you notice anything different compared to the green dough?
  
  
  
  
  
  
  
  
  
  
6. Reconnect the wires to the green dough. Take some of the blue dough and put it in the middle so it connects the green dough. Make sure the pieces of green dough aren't actually touching each other, just the blue dough. What happens and why?