# Electricity Lesson 3: *The Engineer*

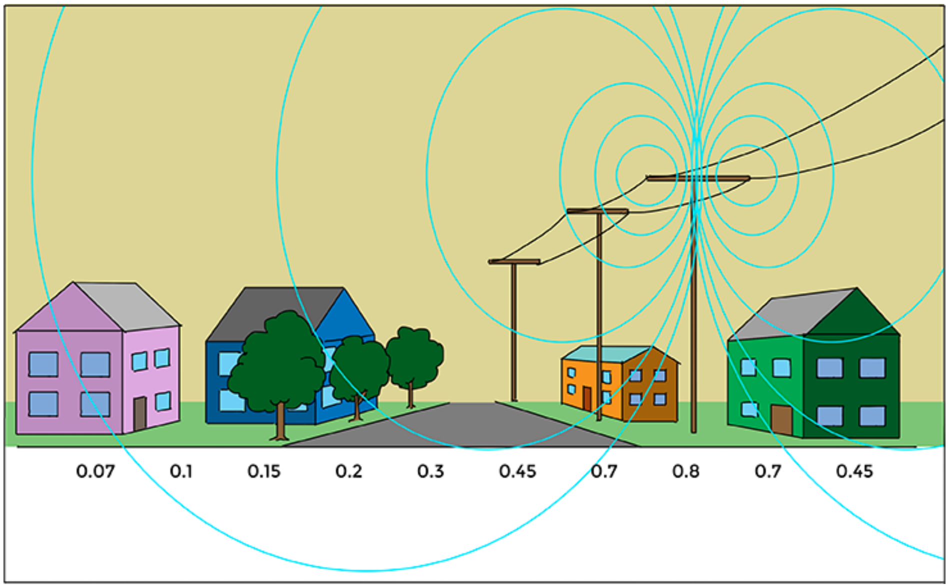
## Educator's Lesson Plan

**Objective**

In *The Engineer*, students will:

1. Demonstrate understanding of the relationship between electricity and magnetism.
2. Design an advocacy campaign that will:
    a. Educate homeowners about how electricity and magnetism work.
    b. Advocate for avoiding the negative impacts of exposure to magnetism from high current power lines.

**Time Required:** 150 minutes



| Materials Required for Teams of 3 - 4 |
|---|
| Note: If doing this virtually, no materials are required. Instead, video links of the activities are provided to students in the student guide.<br>● Lab investigation supplies (*Note: many of these will be the same materials as used for *The Make*)<br>○ 1 pencil (long)<br>○ 2 ring magnets (sides of magnet labeled with a + for positive and - for negative)<br>○ 2 bar magnets<br>○ plastic-insulated wire (for each group, cut one 6-in segment. Strip about 1 cm of insulation off both ends of each wire, using wire cutters)<br>○ 1 compass<br>○ 1 9-volt battery<br>○ battery cap, usually with red and black wire leads (available at Radioshack)<br>○ 1 miniature light bulb (available at Radioshack)<br>○ 1 miniature light bulb socket (available at Radioshack)<br>○ electrical tape<br>○ flat-head screwdrivers, to tighten wires in light bulb sockets<br>○ 2 electrical clips<br>● Research resources<br>○ Magnetism Investigation Cards (Appendix A)<br>○ Negative Impacts of Magnetism Exposure Resource Card (Appendix B)<br>○ computers<br>● Student Guide<br>● poster paper<br>● colored pencils/markers<br>● other optional materials for Advocacy Campaign. For example, a video camera |
| **Safety Consider-ations** |
| None |
| **Science & Engineering Practices** |
| ● Designing solutions<br>● Communicating findings/design (oral presentation) |

**Inquiry Scale: Leveling Information**

**Level 1**: **most teacher-driven** (*recommended for grades 4-5)*
Demo the magnetism investigations class-wide while students do the same investigations at their tables in groups of 3-4 (see Appendix A below). Complete discussion questions in a class-wide discussion format. Assign students a medium for their advocacy campaign (billboard, video, brochure, etc.). Lead Part A of the planning process as a class-wide discussion. Then give students the Negative Impacts of Magnetism Exposure Resource Card (see Appendix B below) so they can gather research for their advocacy campaign. Students complete the rest of *The Engineer* process in groups of 3-4 as you check in with groups frequently to support the execution of each step.

**Level 2** (*recommended for grades 5-6)*
Demo the magnetism investigations class-wide while students do the same investigations at their tables in groups of 3-4 (see Appendix A below). Students complete discussion questions as think-pair-shares before coming back together for a whole-class review. Students choose a medium for their advocacy campaign (billboard, video, brochure, etc.). Students complete Part A of the planning process in their groups, but then come back together to review this in a class-wide discussion. Then give students the Negative Impacts of Magnetism Exposure Resource Card (see Appendix B below) so they can gather research for their advocacy campaign. Students complete the rest of *The Engineer* process in groups of 3-4 as you check in with groups frequently to support the execution of each step.

**Level 3** (*recommended for grades 6-7)*
Students do the magnetism investigations independently at their tables in groups of 3-4 (see Appendix A below). Students complete discussion questions in their groups, but come back together for a whole-class review. Students choose a medium for their advocacy campaign (billboard, video, brochure, etc.). Students complete Part A of the planning process in their groups, conducting their own computer research, but then come back together to review in a class-wide discussion. Students complete the rest of *The Engineer* process in groups of 3-4 as you check in with groups frequently to support the execution of each step.

**Level 4**: **most student-driven** (*recommended for grades 7-8)*
Students do the magnetism investigations independently at their tables in groups of 3-4 (see Appendix A below), completing discussion questions independently. Students independently complete all aspects of *The Engineer* process, planning their own explanations of electricity and magnetism, making their own recommendations to homeowners, and designing their own persuasive advocacy campaigns.

**Agenda**

**I. Show PowerPoint to introduce *The Engineer* Activity (20 minutes)**
The PowerPoint will extend essential concepts learned in *The Make* and provide context for the students' upcoming *Engineer* challenge.

**Answers to Magnetism Investigation Discussion Questions**

Invisible Force Fields (Video for Remote Use)
1. What happened when you placed the positive side of one magnet next to the negative side of the other magnet?
   *The magnets stuck together.*
2. What happened when you placed the negative side of one magnet next to the negative side of the other magnet?
   *The top magnet floated above the other magnet and they did not touch.*

Interacting Magnets (Video for Remote Use)
1. What happened when you placed the South side of the magnet next to the North side of the other magnet? *The magnets were attracted to one another. The South side of one magnet is attracted to the North side of the other magnet.*
2. What happened when you placed the South-South or North-North sides of the magnets together? *The magnets repelled each other and moved away from one another.*
3. What does this prove about the law of magnetic attraction and repulsion? *Identical poles of magnets repel one another while opposite poles attract.*

Confused Compass (Video for Remote Use)
1. Why was everyone's compass needle pointing in the same direction at first?
   *The tip of the compass needle is a positive magnet, so it is always attracted to the North Pole, which is magnetically negative.*
2. What happened to the compass needle after you connected the circuit? Why do you think this happened?
   *The circuit created an invisible magnetic field around it that was interacting with the magnetic fields of the compass and the North Pole. The compass needle was deflected as the wire was moved closer to, then farther away from, the compass.*
3. What happened to the compass needle after you disconnected the wire from the battery? Why do you think this happened?
   *When you disconnect the wire from the battery, the compass needle returns to pointing North. This is because there is no longer electricity flowing through the wire, so there is no longer a magnetic field.*

**II. *The Engineer* Activity (110 minutes)**

As guided by the organizer, students will:

1. Choose a medium for their advocacy campaign. It could be a billboard, informative brochure, infographic flyer, video, or town hall meeting presentation.
2. Prove that magnetic fields exist around conductors of electricity and that these magnetic fields increase in force as electricity increases.
3. Research the negative impacts of exposure to magnetism.
4. Design and present their advocacy campaign:
    a. Educating homeowners about how electricity and magnetism work
    AND
    b. Advocating for avoiding negative impacts of exposure to magnetism from high current power lines.

**III. Presentation and Assessment (20 minutes)**

Presentation/Assessment

Students present their final design solutions as if they are presenting to concerned homeowners. Assessment parameters are suggested below.

***The Engineer* Assessment:** Project Grade and Rubric Score Sheet - Electricity

Project Submitted by ________________________________________

Electricity *Engineer* Checklist: Content Concepts and Practices

Your Challenge: Design an advocacy campaign for homeowners living near power lines

Project Completion:

- ❏ Completion of all aspects of Engineering Planning Guide including:
  - ❏ Magnetism Investigations
  - ❏ Planning of Advocacy Campaign
- ❏ Advocacy Campaign:
  - ❏ Advocacy campaign is in the form of a billboard, informative brochure, infographic flyer, video, or town hall meeting presentation
  - ❏ Contains explanations and visuals for the following points:
    - ❏ How electricity works
    - ❏ How electricity travels from one location to another
    - ❏ Magnetic field surrounding electrical wires
    - ❏ Comparison of power line wires to electrical appliance wires
    - ❏ Negative impacts of living by high current power lines
    - ❏ Recommendation to homeowners
  - ❏ Presentation is well-organized and filled with visuals that are neat and in color

DCI Standards Checklist:

- ❏ Magnetism Investigation Data:
  - ❏ Accurately communicates magnetic forces
  - ❏ Accurately communicates the relationship between electricity and magnetism
- ❏ Advocacy Campaign:
  - ❏ Accurately explains how electricity works
    - ❏ Explanation includes an identification of the materials that allow electricity to travel from one location to another
    - ❏ Corresponding visual is accurate and labeled
  - ❏ Accurately connects electricity to magnetism
    - ❏ Gives multiple sources of accurate and detailed lab evidence to support the claim that magnetic fields exist
    - ❏ Corresponding visuals are accurate and labeled
  - ❏ Explains how the strength of the electric current corresponds to the strength of the magnetic field
    - ❏ Applies this specifically to power lines versus other conductors of electricity
  - ❏ Accurately outlines the negative impacts of living near high current power lines
  - ❏ Makes a recommendation to homeowners about living near power lines and gives a brief but persuasive justification to support this recommendation.

Science & Engineering Practices Rubric

| | Emerging (1) | Developing (2) | Proficient (3) | Advanced (4) |
|---|---|---|---|---|
| **Designing Solutions** | Applies no scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system. | Applies minimal scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system. | Applies adequate scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system. | Applies complete scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system. |
| **Communicating Findings/Design (Oral Presentation)** | Findings/design are incompletely and inaccurately communicated. Or no evidence of using appropriate eye contact, adequate volume, or clear pronunciation. | Findings/design are completely communicated with some misconceptions. Or uses minimal eye contact, inappropriate volume, or inconsistent pronunciation. | Findings/design are completely communicated but lacking depth and complexity. Or often uses eye contact and engaging and appropriate volume and pronunciation, but is inconsistent. | Findings/design are completely communicated with depth and complexity. Or mostly uses eye contact and engaging and appropriate volume and pronunciation. |

Teacher Comments:

Final Score: Final Grade:

## Appendix A: Magnetism Investigation Cards

| | | |
|---|---|---|
| **Invisible Force Fields**<br>(Video for remote use)<br><br>Materials<br>● 1 pencil<br>● 2 ring magnets (sides of magnet labeled with a + for positive and - for negative) | Procedure<br>1. Hold a pencil (eraser down) on the table so that it sticks straight up.<br>2. Carefully place a ring magnet onto the pencil so that it settles all the way onto the table, negative (-) side up.<br>3. Take the other ring magnet and lower it onto the pencil, positive side down (+). *Record observations and diagrams in your Student Guide.*<br>4. Remove the top magnet and turn it over. Lower the ring magnet onto the pencil, this time negative side down (-). *Record observations and diagrams in your Student Guide.* | Discussion Questions<br>*Answer in your Student Guide.*<br>1. What happened when you placed the positive side of one magnet next to the negative side of the other magnet?<br><br>2. What happened when you placed the negative side of one magnet next to the negative side of the other magnet? |
| **Interacting Magnets**<br>(Video for remote use)<br><br>Materials<br>● 2 bar magnets (sides of magnets labeled North and South) | Procedure<br>1. Push both bar magnets together, South side to North side. *Record observations and diagrams in your Student Guide.*<br>2. Push both bar magnets together, South side to South side. *Record observations and diagrams in your Student Guide.*<br>3. Push both bar magnets together, North side to North side. *Record observations and diagrams in your Student Guide.* | Discussion Questions<br>*Answer in your Student Guide.*<br>1. What happened when you placed the South side of the magnet next to the North side of the other magnet?<br><br>2. What happened when you placed the South-South or North-North sides of the magnets together?<br><br>3. What does this prove about the law of magnetic attraction and repulsion? |

## Appendix A Continued: Magnetism Investigation Cards

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<td>The Confused Compass<br>(Video for Remote Use)<br><br><u>Materials</u><br>● 1 compass<br><br>*Use same circuit from The Make<br>● plastic-insulated wire<br>● 1 9-volt battery<br>● battery cap<br>● 1 miniature light bulb<br>● 1 miniature light bulb socket<br>● electrical tape<br>● flat-head screwdrivers<br>● 2 electrical clips</td>
<td><u>Procedure</u><br>1. Place the compass on the table and note in which direction it is pointing.<br>Record observations and diagrams in your Student Guide.<br>2. Construct your circuit: Place the battery and electrical clips in the battery holder and connect the short piece of wire to the two clips. Place the compass next to but not touching the circuit.<br>Record observations and diagrams in your Student Guide.<br>3. Move the compass to different positions closer to and farther away from the circuit.<br>Record observations and diagrams in your Student Guide.<br>4. Disconnect your circuit by removing one of the sides of the wire from the electrical clip.<br>Record observations and diagrams in your Student Guide.</td>
<td><u>Discussion Questions</u><br>Answer in your Student Guide.<br>1. Why was everyone’s compass needle pointing in the same direction at first?<br><br>2. What happened to the compass needle after you connected the circuit? Why do you think this happened?<br><br>3. What happened to the compass needle after you disconnected the wire from the circuit? Why do you think this happened?</td>
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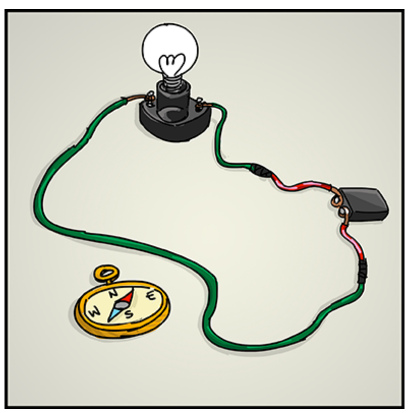
<td colspan="3"></td>
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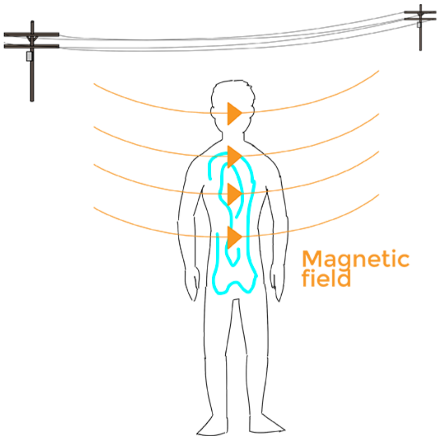
## Appendix B:

### Negative Impacts of Magnetism Exposure Resource Card

Our world's population is growing and so is our need for electricity! This means more power lines, each carrying huge amounts of power over long distances. We know that when electricity travels through conductive wires, magnetic fields are created around those wires.

If the electric and magnetic forces are really high, this creates electric currents in the body. The amount of current in the body depends on the force of the magnetic field and distance from the source.




These forces, called *electromagnetic fields*, have been reported to cause short-term health problems, such as headaches, fatigue, and/or burning skin, rashes, and muscle pain. More seriously, if people are near strong electromagnetic fields for long periods of time, long-term health problems like cancer may arise.

For more information:

- http://electrical-engineering-portal.com/how-hv-transmission-lines-affects-humans-plants
- http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html