



Purpose

The resources provided in this document are not required to be used in preparation for your lab. They are simply resources that we thought might be helpful to you and engaging for your students. It is your choice to use them and you may pick as few or as many to implement as you like.

**If you are receiving a Title I scholarship for your lab, you are required to implement a vocabulary or journal activity prior to your lab visit.*

Grade Levels 4-8	Lab Summary This is a hands-on, “how-to” workshop for students to develop the knowledge, habits, and skills of designers and innovators. Students will learn how to make electricity work for them — without flying a kite in a thunderstorm! Before firing up their final creations, students will learn about static electricity, how to troubleshoot a circuit, and how to design and build Scribble Bots.	Student Outcomes Students will: <ul style="list-style-type: none"> • Test and accurately categorize materials as conductors and insulators. • Explore the difference between static electricity and direct current electricity. • Design, build and test series and parallel circuits capable of powering an electrical load.
	Common Core Language Arts Standards <i>Speaking and Listening</i> Grade 3: SL.3.1b-d, SL.3.3, SL.3.4a Grade 4: SL.4.1b-d, SL.4.4a Grade 5: SL.5.1b-d, SL.5.4 Grade 6: SL.6.1b-d Grade 7: SL.7.1b-d Grade 8: SL.8.1b-d	

State and National Standards Connections

Next Generation Science Standards

	Engineering Design	Physical Science	Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
Grade 4	3-5- ETS1-1 3-5- ETS1-2 3-5- ETS1-3	4-PS3-2 4-PS3-4	PS3.A ETS1.A PS3.B ETS1.B ETS1.C	Energy and Matter	1, 2, 3, 6
Grade 5	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3		PETS1.A ETS1.B ETS1.C	Systems and System Models Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6



Grades 6-8	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	<i>Forces and Interactions</i> MS-PS2-3	ETS1.A ETS1.B ETS1.C	Structure and function	1, 2, 3, 6
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Preparing for the Lab Experience

There are many ways to help prepare your students before the lab and help them reinforce their knowledge after the lab, including the content you are covering in the classroom. Below you will find a chart of some materials we offer to help support your classroom.

	Description	Recommended	Time, Materials & Support Needed
Lab Journal	Includes: <ul style="list-style-type: none"> • Vocabulary • Pre- and post-journal • Venn diagram • Tech Interactive notes & connections • Questions about the lab 	<ul style="list-style-type: none"> • Pre-lab activities • Activities during field trip • Post-lab activities • Vocabulary definitions and journal prompts provided in this resource guide* 	<ul style="list-style-type: none"> • 5-60 minutes (1+ days) • Print the journals • Assemble the journals • Writing utensils
Lab Related Activities			
Cooking with the Sun	Your students will deepen their understanding of solar power and the engineering design process behind building solar ovens.	<ul style="list-style-type: none"> • Post-lab activity 	<ul style="list-style-type: none"> • 40 minutes building time • 45-60 minutes cooking time
Drawing Circuits	Students will learn how to draw circuit diagrams and figure out if their circuit diagram will produce a working circuit.	<ul style="list-style-type: none"> • Either pre or post lab 	<ul style="list-style-type: none"> • 45 minutes • Circuit materials (optional) <ul style="list-style-type: none"> • Wires • Batteries • Light bulbs • Buzzers • Switches
Lemon Battery	Students will create a simplified version of the batteries used in everyday electronics.	<ul style="list-style-type: none"> • Either pre- or post-lab • Activity to be done in groups of 4-5 students 	<ul style="list-style-type: none"> • 45 minutes • Specialized materials: <ul style="list-style-type: none"> • 1 penny (pre-1982 if possible) or 4" length of copper wire • 1 galvanized nail or 3" zinc strip • Voltmeter (optional) • Alligator wires • Small LED's



Squishy Circuits	Students will explore and play with an unconventional conductive material to make circuits.	<ul style="list-style-type: none"> • Post-lab activity 	<ul style="list-style-type: none"> • 1 hour to make conductive and insulating dough (to be made by an adult in advance) • 30-45 minutes exploration time • Specialized materials: <ul style="list-style-type: none"> • LEDs • Double (AA) battery pack with wire leads
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Related Links and Games

The following links and games provide additional information about energy, electricity and circuitry. We are not endorsing the following organizations, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.

- **US Energy Information Administration:** This site provides information on the basics of electricity, how it is generated, how it is measured, how it relates to magnetism, circuits and much more. This site also includes energy experiments, games and activities, and teacher resources. <http://www.eia.gov/kids/index.cfm>
- **Neo K-12:** This site provides simple definitions for electricity as well as a variety of short videos about electricity, circuits and much more to show your class. <http://www.neok12.com/Electricity.htm>
- **Energy Meter Madness:** This game by Wonderville is a great combination of math skills and science. Students have to go through the house and list the appliances they want to use then show what their energy meter would look like when using those appliances. This is a fantastic game to help students develop base 10 properties and understand energy efficiency. <http://www.wonderville.ca/asset/energy-meter-madness>
- **Circuit World:** This simulator by Cumbria and Lancashire Education Online (CLEO) allows students to construct and test circuits online using symbols, animated characters or 'real-world' components. Students can print or save the schematics for their circuits. The platform functions on both e-whiteboards and individual computers. http://www.cleo.net.uk/consultants_resources/science/circuitWorld/index.html
 - In order to run this simulator you need to have the latest version of flash player installed – there is a link at the website to download the flash player.
 - Teacher tips: To identify the different pieces, hover the cursor over the library -- it will provide both a description and measurement (volts/ohms) if applicable. To rotate pieces left, click on the grid location once it has been placed. If pieces are not correctly connected, switches are not closed (left click once circuit is running), or energy needs are not met, nothing will happen when the circuit is run.
- **Highlight an Electrical Engineer:** Let students explore the work of electrical engineers from all over the world. <https://www.thefamouspeople.com/electrical-engineers.php>

Related Texts

The following titles may provide students with a greater contextual understanding of electricity. Included in the list are narratives (fiction/nonfiction), referential texts and books that extend learning beyond the scope of the lab. We are not endorsing the following authors, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.



Narratives

- “Frank Einstein and the Electro Finger.” By Jon Scieszka.
 - Recommended for grades 2-6.
 - Kid genius, Frank Einstein, along with his robot companions and friend Watson team up to combat T. Edison in a scientific battle over energy. With the evildoer T. Edison attempting to monopolize Midville’s power plant, can Frank Einstein and his team come up with a way to deliver wireless energy to their town and foil T. Edison’s plans?
- “Electrical Wizard: How Nikola Tesla Lit Up the World.” By Elizabeth Rusch.
 - Recommended for grades 1-4.
 - A picture-book biography covering the life and works of Nikola Tesla from childhood to college and adult inventions. It includes detailed explanations of the Tesla-Edison rivalry as well as diagrams and text on AC vs. DC.
- “Michael Vey.” By Richard Paul Evans.
 - Recommended for grades 7-12.
 - A secondary-level science fiction threaded with so much good science that it was named an NSTA/CBC Outstanding Science Trade Book for 2012.
- “Oscar and the Bird: A Book about Electricity.” By Geoff Waring.
 - Recommended for grades 2-3.
 - When Oscar the kitten finds a tractor in a field and accidentally turns on the windshield wipers, he is full of questions about electricity. With the help of his friend, Bird, Oscar finds out how electricity is made and stored, which machines need electricity to work, and why it is important to be careful around wires, batteries, plugs and sockets.

Reference

- “Electricity! (Discover your World Series).” By Kurt Zimmerman.
 - Recommended for grades 3-5.
 - An illustrated guide through the subject of electricity, this is a straightforward explanation of electricity basics, including how it’s made, how it’s used and how it affects everything we do.
- “Charged Up: The Story of Electricity (Science Works).” By Jacqui Bailey.
 - Recommended for grades 3-6.
 - Describes how electrical energy is generated and then transported from the power station to people’s homes.
- “Power Up!: A Visual Exploration of Energy.” By Shaker Paleja.
 - Recommended for grades 3-5.
 - Through infographics, charts, diagrams, maps, and illustrations, topics such as the pros and cons of energy sources, and the energy of the future are covered. Discover where energy is produced and how it gets to where we need it.

Tech Interactive Gallery and Exhibit Connections

The Tech Exploration Gallery (Lower Level)*

- *Energy Tower*: Using light reflected onto solar panels and personally designed wind turbines in a wind tunnel, students learn to work together and combine the energies to power the tower. Once fully powered, the top of the tower will light up green!
 - Connection to Lab:
 - Builds on the different methods of quantitatively measuring electricity.
 - Extends students’ understanding of electricity as a form of energy that cannot be created or destroyed (law of conservation of energy).
 - Also encourages the design challenge process.



- Activity to complete at this exhibit:
 - First, focus all light onto solar cells until the mini-city is completely lit. At this point the tower should not be fully charged. Record the voltage output given on the solar panel screen. Leaving the solar panel section as is, move over to the wind tunnel and fix the turbines to where they only have two blades on each hub. Test by closing doors to activate the fan. Explore with different types, angles, and quantities of blades noticing the change in voltage output.
- Questions to guide student learning:
 - What was the maximum amount of electricity produced by the solar panels?
 - What was the maximum amount of electricity produced by the wind tunnel?
 - How much electricity was required to power the tower?

**Please note that the Exploration Gallery will close in January 2020 for renovations.*

Social Robots (Lower Level)

- Students put together their own robot using pre-programmed cubes. When the input cubes and output cubes are correctly connected to the power source and connected together via wires, they create a circuit!
 - Connection to the lab:
 - Builds on the vocabulary used in the lab including: circuit, conductor, series circuit, and parallel circuit.
 - Challenges students to build simple circuits using preprogrammed inputs and outputs in order to meet a design challenge.
 - Extends vocabulary to include inputs and outputs as a component of digital electrical systems.
 - Activity to complete at the exhibit:
 - Have each group build a robot and create a diagram for their robot. Make sure to label inputs, outputs and the power source. Teams can swap diagrams and challenge other groups to recreate their robot design.
 - Questions to guide student learning:
 - What is the **power source** for your robot?
 - *The rechargeable battery for the robot is in the base of the robot tower.*
 - What inputs and outputs did you use on your robot? Why?
 - How did you connect the inputs and outputs?
 - *The inputs and outputs are connected by a single blue wire that is attached to the metal magnetic circles labeled in blue on the blocks.*
 - Where are the **conductors** on your robot? Why do you have to connect red-to-red and blue-to-blue?
 - *There are conductors in each red port on the robot tower, on the red portion of the input and output blocks, on the blue squares on the input and output blocks, and on the ends of each of the blue wires. The conductors are needed to transfer electricity from the tower to the blocks and to transfer electronic data from the input to the output blocks.*
 - Are you using **series** or **parallel** circuits to create your robot?
 - *Your robot is an example of a parallel circuit. If you attempt a series circuit (multiple inputs to an output or vice versa) the inputs/outputs will not work.*



Design Challenge Learning Resources

Design Challenge Learning is a dynamic way for learners to become creative problem-solvers. The below link will take you to short guides created by educators at The Bowers Institute on facilitating design challenges, promoting engineering and fostering innovator mindsets.

<https://www.thetech.org/content/bowers-institute/resources>

Writing Prompts

The following writing prompts and questions are just a few examples of journal topics to incorporate writing into your students' lab experience. If you feel that one of the below prompts does not meet your needs, you are welcome to use your own, but please make sure it is related to the chosen lab experience. If you have a related writing prompt you would like to share with The Tech and other teachers, please let us know on our teacher survey that will be available in the lab.

Most of the writing topics could be used as either pre-lab or post-lab writing. You may choose the prompts that work best for your class and schedule.

Pre-Visit Writing Topics/Prompts

Generic

- We will be attending __lab name__ at The Tech Interactive; what do you think we will learn about in the lab? What do you want to know about this topic? What do you already know about this topic?
- We will be attending __lab name__ at The Tech Interactive; what are you looking most forward to in this lab? Why?

Specific to Simplicity of Electricity

- Every day you probably turn a light switch on and off at least 30 times. Explain how you think a light switch works to turn the lights on and off. Why do you think it works this way?
- If we didn't have electricity in our classroom, we would...

Post-Visit Writing Topics/Prompts

Generic

- We learned a lot in our _lab name_ lab. What were your two favorite things you learned in the lab? Why?
- The principal is excited to hear all about your lab experience. Explain what you did and learned about in the lab since she or he was unable to attend the lab.

Specific to Simplicity of Electricity

- In the lab you learned about two types of circuits: series and parallel. Explain the difference between the two in a way that someone who didn't go to the lab would understand.
- How would your school day run differently if the school's electricity ran in one series circuit? Why would it run this way?
- How could your classroom be made more energy efficient?
- (Take photos of student's scribble bots during the lab). Ask students to review the scribble bots and write about problems they had building their device? How did they solve these problems?



Pre-Visit Vocabulary

These are words and concepts that we will discuss in the lab. Your students' experience will be enhanced if they are familiar with these terms prior to your visit. Below you will find several graphic organizers and games to aid in your vocabulary review.

Terms and Definitions

Circuit	An electrical device that provides a path for electrical current to flow.
Conductor	A material that allows electricity to flow through it easily.
Current	The flow of moving electric charge in a closed path. The flow of current from negative to positive.
Insulator	A material that does not allow electricity to flow through it easily.
Open Circuit	A circuit that is interrupted so that electricity will not flow.
Parallel Circuit	A circuit in which each device has an independent connection to the power source.
Series Circuit	A circuit in which devices are arranged in a row, one after another on a single path. Devices in series share the energy from the power source.
Short Circuit	A path in the circuit that has no element between two different voltage potentials.
Volt	A measuring unit of power.

Vocabulary Activities

Graphic Organizers

- *Frayer Graphic Organizer:* The Frayer Graphic Organizer is a great tool for vocabulary development. It allows students to write their own definitions, define characteristics, and provide examples and non-examples. This tool will lead your students to a deeper understanding of the vocabulary and how it relates to their lives. On page 10 you will find a blank Frayer Graphic Organizer for your use in the classroom.
 - For more information on the Frayer Model and how to implement it, please visit the following link: <http://www.theteachertoolkit.com/index.php/tool/frayer-model>
- *Vocabulary Graphic Organizer:* This graphic organizer is a great tool for younger students as well as English Language Learners. Although very similar to the Frayer Model, this graphic organizer includes a drawing of the vocabulary term and its use in a sentence. On page 11 you will find a blank Vocabulary Graphic Organizer for your use in the classroom.
- *Circle Map:* This graphic organizer is a great tool for helping all students develop an overall sense of a topic. It is also very helpful for beginning and early intermediate English Language Learners. This graphic organizer lets students brainstorm what a term or concept means to them and provides a frame of reference for the term. On page 12 you will find a blank Circle Map for your use in the classroom.
 - For more information on the Circle Map and other Thinking Maps, please visit the following link: <http://thinkingmaps.com/why-thinking-maps-2/>



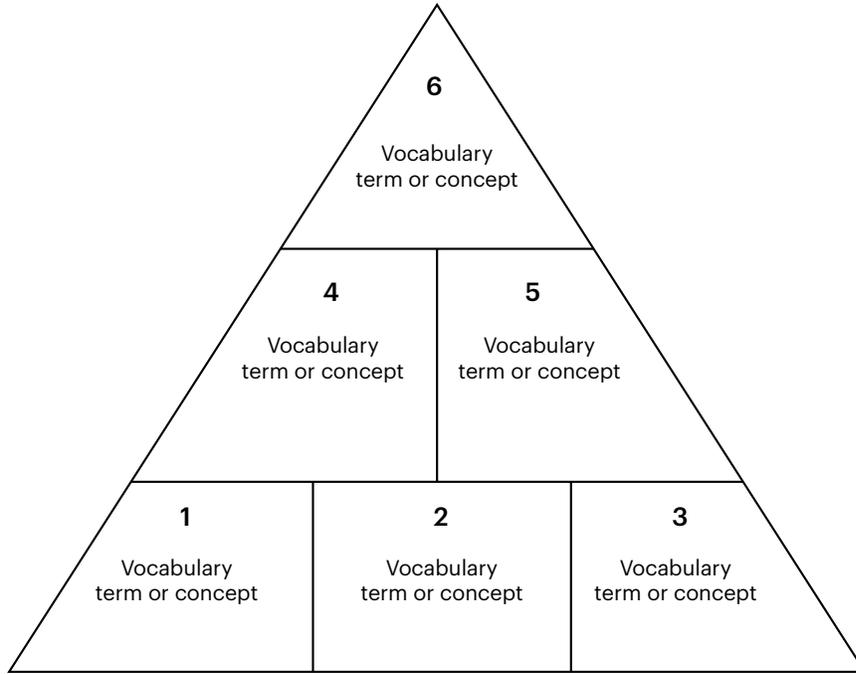
Vocabulary Review Games

- *Quiz, Quiz, Trade*: This is a fun cooperative game for students to review vocabulary terms. For more details and to see an example of Quiz, Quiz, Trade in action, please visit the following link:
<http://www.theteachertoolkit.com/index.php/tool/quiz-quiz-trade>
 1. Create questions or vocabulary cards. On one side of an index card, write the question or vocabulary term; on the other, the answer or definition. Pass out the cards to students. If there are not enough terms for everyone to have a different card, try using different “back” sides to the same cards (e.g., instead of the definition again, have a drawing, a question about the term, characteristics of the term or an example of the term).
 2. Pair up. When all cards have been passed out, students find a partner to quiz with their card.
 3. Hands up. When both partners have completed the quizzes correctly, they put their hand up to show other students that they are ready for a new partner to quiz.
- *Back-words*: This game is part Charades, part 20 Questions. In this review game, students have to guess the vocabulary term that is on their back by asking questions of a partner or having the partner act out the term.
 1. Write your vocabulary terms on index cards. If there aren't enough terms for each student to have a different one, you can make two sets and divide the class into two groups. You may also add in other related vocabulary terms that you have been studying in class.
 2. Tape one term onto the back of each student so that he or she cannot see the word.
 3. Have students pair up. Each partner should look at the word on their partner's back. Partners take turns asking questions or acting out or gesturing about the term that is on their back. (e.g., “Am I an element? Am I part of an atom? Do I make up all matter?”) Partners must ask at least two questions before guessing their word.
 4. When both partners have correctly guessed their word, they put a hand up to signal that they are in need of a new partner. Continue game play until everyone has guessed their word.
- *\$10,000 Pyramid*: This review game is exactly like the classic game show. Students will work in pairs, taking turns to describe the words and to guess the words.
 1. Break up the terms into two groups. Each partner will take on one group of words.
 2. Have each partner fill out the worksheet on the next page with their group of words.
 3. For the first round, Partner A will be the one describing the term and Partner B will be the one guessing the term. Partner A will describe the term (starting with 1) using the words he or she wrote down on the worksheet. From the description, Partner B will guess what the term is.
 4. When Partner B guesses the word correctly, Partner A moves on to the next word.
 5. When Partner B correctly guesses all the words in Partner A's pyramid, they switch places and Partner B will describe the terms on his or her pyramid while Partner A guesses the terms.
 6. You can time this activity like on the quiz show, but it may intimidate some students



Student Name: _____

\$10,000 Pyramid



Write descriptive clues about each vocabulary term or concept:

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____



Frayer Graphic Organizer

Definition	Characteristics
Examples	Non-Examples

Vocabulary Word



Vocabulary Graphic Organizer

Definition	Characteristics
Sentence	Drawing

Vocabulary Word



Circle Map

