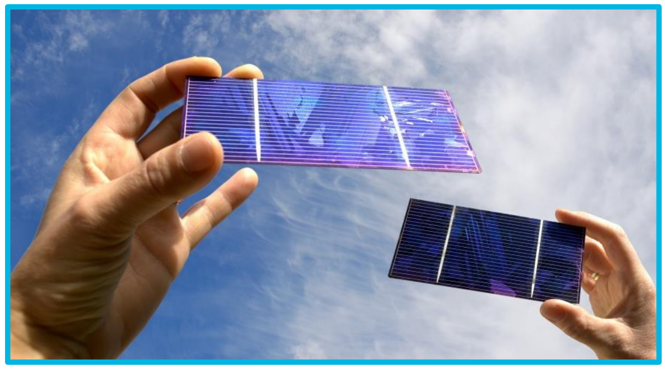
Here Comes the Sun

Lesson Focus

Lesson focuses on solar panel design, and its application in the standard calculator. It explores how both solar panels and calculators operate and explores simple circuits using solar power.



Lesson Synopsis

The Here Comes the Sun activity explores the concept of how solar energy is gathered by solar panels and adapted to provide power to a variety of machines, from calculators to spacecraft. Students disassemble a solar powered calculator and explore the component parts. Students work in teams to suggest design enhancements to the calculator to improve performance.

Age Levels

8-18.

Objectives

- Learn about solar power and solar panel design and operation.
- Learn about how calculators work and how the product is comprised of many different component parts.
- Learn about teamwork and the engineering problem solving/design process.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- solar power and solar panel engineering
- calculator design and operations
- impact of engineering and technology on society
- engineering problem solving
- teamwork

Lesson Activities

Students learn about how solar energy is gathered and transferred to electrical energy in solar panels. Topics examined include solar panels, simple circuits, and the inner workings of a simple calculator. Students work in teams to disassemble a calculator, evaluate the design and operation of its component parts, recommend changes to improve functionality through redesign and/or material selection, and present to class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheets (attached)
- Student Worksheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- U.S. Department of Energy, Solar Energy Technologies Program (https://www.energy.gov/eere/solar/solar-energy-technologies-office)
- National Renewable Energy Laboratory (www.nrel.gov)
- History of Solar Energy (www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf)

Recommended Reading

- Solar Electricity Handbook, 2010 Edition: A Simple Practical Guide to Solar Energy - Designing and Installing Photovoltaic Solar Electric Systems by Michael Boxwell (ISBN: 978-1907670008)
- Power from the Sun: A Practical Guide to Solar Electricity by Dan Chiras (ISBN: 978-0865716216)

Optional Writing Activities

- Write an essay or a paragraph describing how solar panels have been engineered into a product you find in your home or school. Explain why solar energy is a good choice for powering this product.

For Teachers:
Teacher Resource

◆ Lesson Goal
Explore solar power and how solar panels operate. Students learn about engineering design by taking apart a solar powered calculator and examining the component parts, how they interact, and determine a design improvement which they present to the class.

◆ Lesson Objectives
- Students learn about solar power and solar panel design and operation.
- Students learn about how calculators work and how the product is comprised of many different component parts.
- Students learn about teamwork and the engineering problem solving/design process.

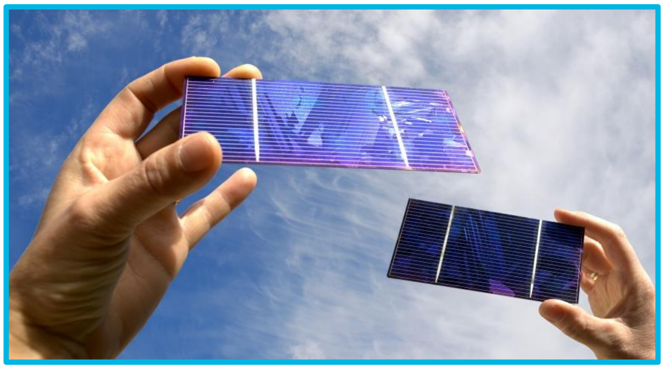
◆ Materials
- Student Resource Sheets
- Student Worksheets
- One set of materials for each group of students:
  - One old or new calculator (many less than $5) -- look for ones with screws on back for easy disassembly
  - Eyeglass Repair Kit or mini screwdriver (must be very small gauge)
  - scotch tape

◆ Procedure
1. Show students the various Student Reference Sheets. These may be read in class or provided as reading material for the prior night's homework.
2. Divide students into groups of 3-4 students; provide one set of materials per group.
3. Ask students to complete the student worksheet. As part of the process, the students work in teams to dissect a calculator, evaluate the component parts including the solar panel, and in teams of "engineers" to design a new enhancement to the calculator. They plan and present their ideas to the class.

◆ Time Needed
One to two 45 minute sessions.

Student Resource: How Solar Panels Work

◆ Solar Panel is Used Everywhere!



Solar panels work by converting the energy of the sun into electricity. This is used to power many products on earth and support power on spacecraft too. In this lesson we are working with solar powered calculators, which have been a simple but effective application for many years. If you look carefully, you will find many applications in your town or school including stoplights and road signs. You may even have decorative solar powered lights in your yard to help guide you safely at night. As solar technology advances and becomes more efficient, the applications for solar power continue to expand. Solar phone chargers, like the one to the right, help hikers keep in touch which can be lifesaving in an emergency.

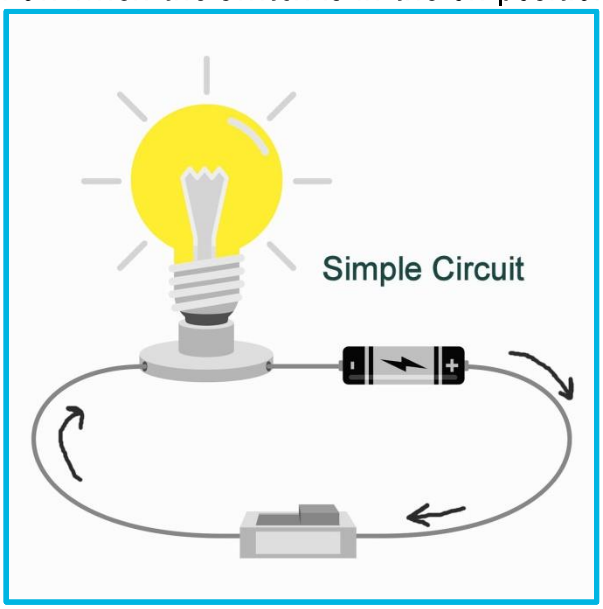
◆ Flexibility

Solar panel can now be flexible which helps with building design and opens all sorts of applications not available ten years ago. The illustration below depicts a flexible solar panel powered bus stop which would allow those waiting to charge their phones, have lighting after dark, and potentially communicate bus arrival schedules or delays.

Student Resource:
What is a Simple Circuit?

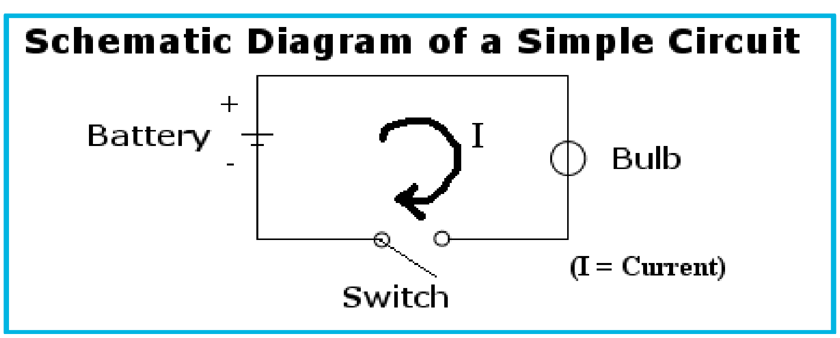
Simple Circuit

A simple circuit consists of three minimum elements that are required to complete a functioning electric circuit: a source of electricity (battery), a path or conductor on which electricity flows (wire) and an electrical resistor (lamp) which is any device that requires electricity to operate. The illustration below shows a simple circuit containing, one battery, two wires, a switch, and a bulb. The flow of electricity is from the high potential (+) terminal of the battery through the bulb (lighting it up), and back to the negative (-) terminal, in a continual flow when the switch is in the on position so current can flow.



Schematic Diagram of a Simple Circuit

The following is a schematic diagram of the simple circuit showing the electronic symbols for the battery, switch, and bulb.

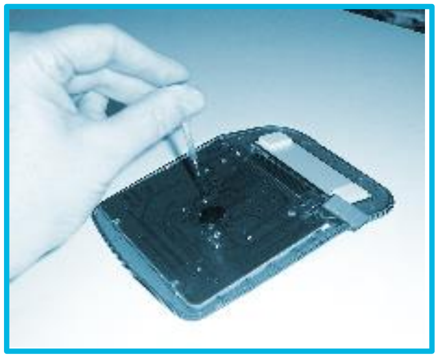


Student Worksheet:
Dissect a Solar Powered Calculator

Step One: As a team, observe whether the calculator operates when you completely block the solar power panel. What happens if you partially block the solar panel? Write you observations, and explanations of what you found below.

Step Two: Suggest five other products you can think of that are either completely or partially powered by solar panels.

Step Three: As a team, disassemble either a new (inexpensive) or old unusable solar powered calculator, using the materials provided to you. Be sure that you remove all the small screws that hold the top and bottom together, some are often hidden under pads or rubber strips. You will need to use a very small screwdriver, such as the type commonly found in eyeglass repair kits. And, you will need to unscrew the circuit board from the front panel of the calculator too -- there are many screws. ***Safety Note:*** Be careful touching the solar panel and the LCD (liquid crystal display) as the glass edges may be sharp.



Step Four: As a team, observe the solar panel and see how it is connected to the other parts of the calculator. Examine all the other parts of the calculator, and discuss what you find. Then answer questions below.

Questions:

1. How many individual parts did you find? Describe them.

2. What surprised you the most about the interior parts of the calculator?

3. How was the solar panel connected to the circuit board?

Student Worksheet:

Dissect a Solar Powered Calculator (continued)

4. If there was a battery backup for this calculator, how was it connected to the circuit board?

5. Some calculators will still operate in the disassembled state, as long as the wires from the solar panel and battery are still connected to the circuit board. Does your calculator still operate? If you reconnect the wires with scotch tape, does it still work?

6. Why do you think there was a rubber or plastic sheet separating the circuit board from the buttons you press?

7. What type of material do you think is embedded under the plastic or rubber sheet and the circuit board? Why do you think engineers included this sheet in their design?

8. Assuming you could repower your calculator, if you reconstructed your calculator with all the buttons in different positions, would it still work properly? Why, why not?

9. Is there anything you would recommend, as part of an engineering team, to improve the functionality of the calculator you disassembled? Attach a drawing or sketch of your proposed component part or improvement, and answer the questions below:

What new materials will you need (if any)	What materials or parts will you eliminate (if any)	How will this new product improve the functionality of a calculator?	How do you think your new design will impact the cost of this calculator? Why?

5. Present your ideas to class.

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:
- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆**National Science Education Standards Grades K-4 (ages 4-9)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of
- Properties of objects and materials
- Light, heat, electricity, and magnetism

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- Abilities of technological design
- Understanding about science and technology

◆**National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of
- Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop
- Abilities of technological design
- Understandings about science and technology

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- Abilities of technological design
- Understandings about science and technology

For Teachers:
Alignment to Curriculum Frameworks

◆**Next Generation Science Standards – Grades 3-5 (Ages 8-11)**

Energy

Students who demonstrate understanding can:

- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

◆**Next Generation Science Standards - Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆**Standards for Technological Literacy - All Ages**

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

For Teachers:
Alignment to Curriculum Frameworks

◆**Standards for Technological Literacy - All Ages**

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.