LESSON PLAN

Cost-Effective Solar Cells

Lesson #2: Engaging with Solar Panels

AUTHOR

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DESCRIPTION

This lesson is designed to span 2 days with 80-minute sections. On the first day, the teachers will challenge the students to assemble circuits with solar panels that can power up 1) a motor with fan, 2) a music-playing circuit, and 3) an LED. Students will discover through trial and error circuits and solar panels that generate and utilize electricity. Teachers should encourage students to play and discover interesting new combinations and arrays. On Day 2, Teachers will demonstrate use of a multimeter, demonstrate series and parallel circuit diagrams and have students take measurements of voltage and current indoors and outdoors. Teachers should be familiar with the operation of a multimeter. Teachers should be familiar with the concepts of voltage, current, power, serial circuits, and parallel circuits for curious students. However, they will teach the concepts expressly in Lesson 3.

- *Day 1: Solar panel array construction, discovery and play*
- *Day 2: Solar panel array testing and data gathering*

GRADE LEVEL(S)

9, 10, 11, or 12

SUBJECT AREA(S)

Chemistry, Physics, Solar Panels, Solar Cells, Power, Current, Voltage, Electricity Generation

ACTIVITY LENGTH

2 days X 80 minutes

LEARNING GOAL(S)

1. Students will construct working solar panel arrays to power LEDs, fans, and music boxes
2. Students will sketch models of working solar circuits

CONTENT BACKGROUND

STUDENT BACKGROUND

- Students participating in this lesson should be familiar with the following scientific practices and concepts:
    - Planning and carrying out investigations
    - Developing and using models
    - Recording data

EDUCATOR BACKGROUND

Solar panels are made up of smaller units called solar cells. Typical classroom and home-mounted solar panels are silicon based and generate electricity upon exposure to sunlight. Smaller panels can be used in the classroom to facilitate understanding of basic circuitry, wiring diagrams, and light power generation.

Circuit:

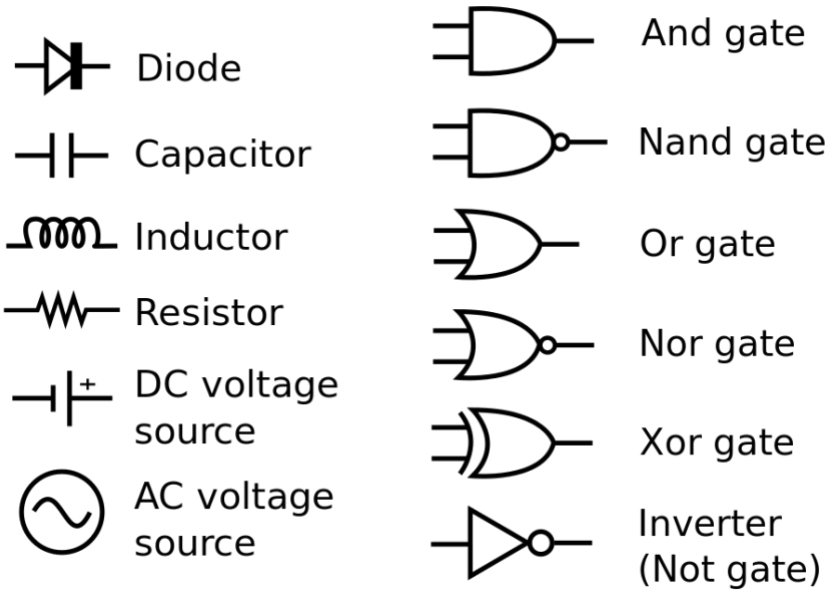
A circuit is a circular path by which electricity flows from a power source (solar module in this case) to a device that does work (water pump in this case) and then back to the power source. Several power sources can be linked together in a circuit series to produce more energy.

Multimeters

Multimeters are tools used to measure voltage, amperage, or resistance in electrical circuits. A multimeter cheat sheet for measure voltage and current can be found on the Clean Energy Bright Futures website: https://cebrightfutures.org/sites/default/files/multimeter-cheatsheet.pdf

Circuit diagrams:

Circuit diagrams show a visual representation of the components of a circuit. Components have common symbols as illustrated by the below diagram (from https://en.wikipedia.org/wiki/Circuit_diagram)



Examples of parallel and series circuit diagrams are found below:

Parallel Circuit Wiring: https://cebrightfutures.org/learn/parallel-circuit-wiring

- Voltage in Parallel Wiring: https://cebrightfutures.org/learn/parallel-circuit-wiring#Voltage%20in%20Parallel%20Wiring
- Current in Parallel Wiring: https://cebrightfutures.org/learn/parallel-circuit-wiring#Current%20in%20Parallel%20Wiring

Series Circuit Wiring: https://cebrightfutures.org/learn/series-circuit-wiring

- Voltage in Series Wiring: https://cebrightfutures.org/learn/series-circuit-wiring#Voltage%20in%20Series%20Wiring
- Current in Series Wiring: https://cebrightfutures.org/learn/series-circuit-wiring#Current%20in%20Series%20Wiring

Solar Cell Wiring Diagram:

Examples of solar cell wiring diagrams that students might generate during this lesson can be found below:

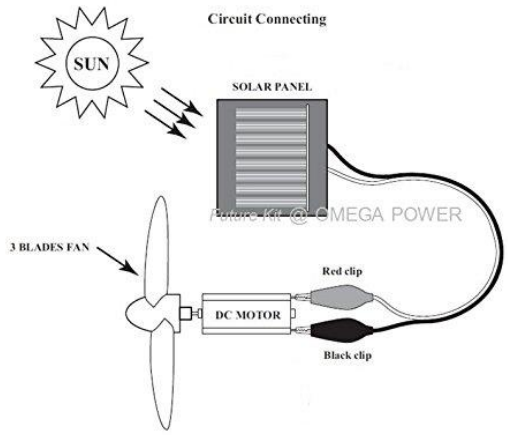


Image from: https://www.amazon.in/Solar-Electronic-Circuit-Student-Learning/dp/B00KUL9VX6

Solar Cell Circuit

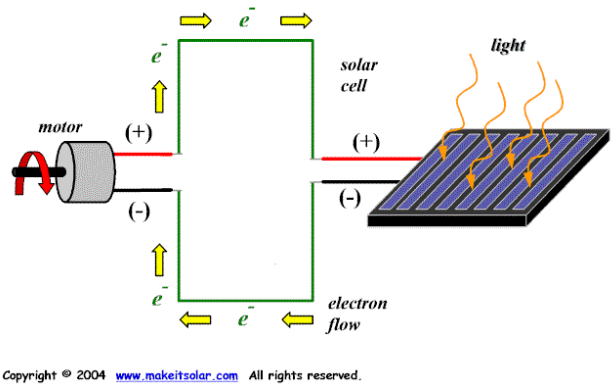
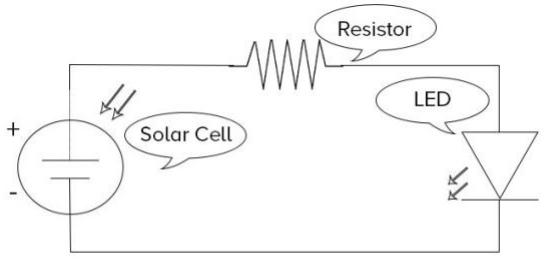


Image from: http://www.makeitsolar.com/science-fair-ideas/07-solar-parallel-circuit.htm



science FRIDAY EDUCATE

Image from: https://www.sciencefriday.com/educational-resources/hack-a-solar-circuit/

Solar Energy: https://cebrightfutures.org/learn/solar-energy

Incident Angle of Sunlight: https://cebrightfutures.org/learn/incident-angle-sunlight

Photovoltaic Effect: https://cebrightfutures.org/learn/photovoltaics#Photovoltaic%20Effect

Photovoltaic Materials: https://cebrightfutures.org/learn/photovoltaics#Photovoltaic%20Materials

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Solar Panel notes worksheet: https://drive.google.com/file/d/1XGo4sVI0qjj32PAH9gFkrjIGD93BmT88/view

CLASSROOM SUPPLIES

- Clamp-on desk lamps with light bulbs-for cloudy days
- (Optional) Halogen workshop lights

ACTIVITY SUPPLIES (PER GROUP OF 3-4 STUDENTS)

- Solar Classroom Set
    - 32 0.5-Volt solar panels (3-4 per group)
    - 8 3-Volt solar panels (1 per group)
    - 18 small DC motors with fan attachments (1 per group)
    - 18 small-load music players (1 per group)
    - 18 LEDs (1 per group)
    - 36 alligator clips (3-4 per group)
    - Multimeter (1 per group)

LESSON PROGRESSION

PLANNING AND PREP

This lesson is designed to span 2 days. On Day 1, students will play with solar panel sets and try to construct functional circuits to accomplish 4 challenges. On Day 2, students will learn about wiring diagrams, series and parallel circuits, multimeters and will then build solar panel circuits for each of the four challenges, recording voltage and current data indoors, with enhanced lighting, and outdoors (weather-dependent).

Ahead of each day, it is suggested to divide materials up into the kits for each group, with some extra loads and panels available for students to explore more complicated circuits as they have time. Students will not need multimeters for day 1.

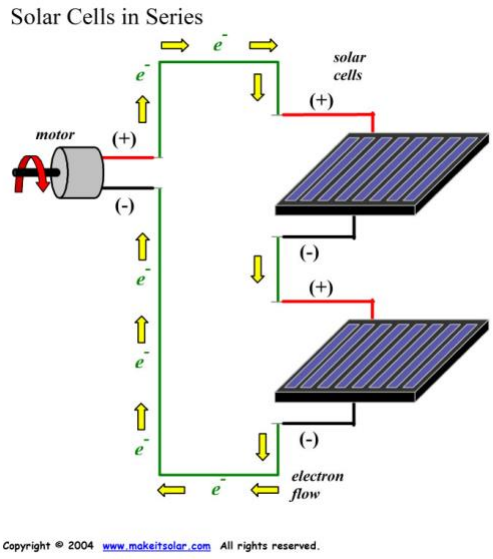
LESSON SEQUENCE

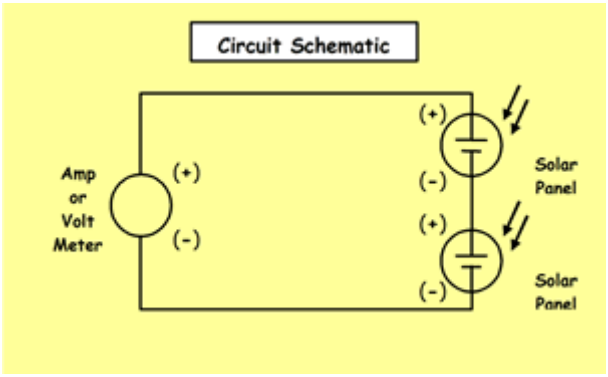
Day 1: Solar panel engagement and play

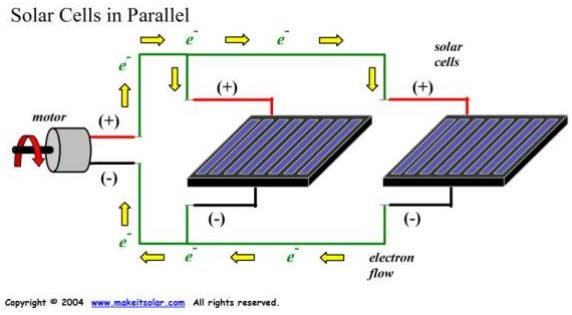
1. **(5 minutes).** Break students into groups of 3-4. Introduce the solar classroom sets to the students and pose the 4 following challenges. No detailed instruction is needed for the challenge—just allow students to discover and play with the materials in small groups. Have one area of the classroom set up with additional light bulbs (incandescent or halogen) to provide students with an enhanced lighting area. If possible (depending on classroom location or available para-educators), allow students to test their circuits outdoors and indoors.
    - **Challenge #1:** Use the solar panels to get a fan to spin
    - **Challenge #2:** Use the solar panels to get a fan to spin *in the opposite direction*
    - **Challenge #3:** Use the solar panels to light an LED bulb
    - **Challenge #4:** Use the solar panels to run a small-load music player
2. **(50-60 minutes).** Circulate around the groups and check in with the students on their learning progression. Here are a few more additional scenarios and challenges for the students:
    - Construct solar panel circuits that work with just ambient indoor lighting
    - Construct solar panel circuits that work with fewer or smaller solar panels
    - Construct solar panel circuits that can operate multiple loads (fan, LED, and/or music player)
    - Construct a solar panel circuit with the 3-volt panel that can run as many loads as possible
    - Challenge multiple student groups to team up to form bigger or more complex circuits
3. **(15-25 minutes).** Have students share their learning with the class.
    - **Oral presentations:** Student groups can stand up and demonstrate their successful circuits to their classmates. Encourage other groups to ask questions and share successful solutions that are different from each other.
    - **Visual presentations:** Alternatively, you can have groups make simple drawings of successful circuits on the chalkboard / dry erase boards for all to see. Label the board with “Challenge 1,” “Challenge 2,” “Challenge 3,” “Challenge 4,” and “Other Circuits.”

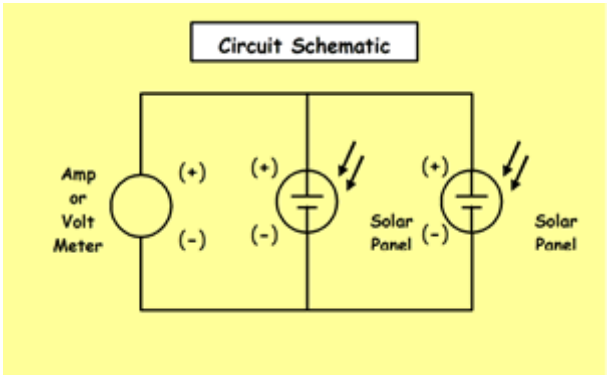
Day 2: Solar Panel Measurement and Data Collection

1. **(10 minutes).** Break students into groups of 2-4. Explain how to use the multimeters. A short video can be found here: https://www.youtube.com/watch?v=TdUK6RPdIrA . Show students how to connect the multimeters to the alligator clips in the Solar Classroom sets.
   *Solar panels generate DC (direct current), so all settings for multimeters should be DC.
2. **(10 minutes).** Show the students how to draw a wiring diagram by explaining the differences between a series and parallel circuit. Examples of series and parallel circuit diagrams are found below and at http://www.makeitsolar.com/science-fair-ideas/06-solar-series-circuit.htm and http://www.makeitsolar.com/science-fair-ideas/07-solar-parallel-circuit.htm . You can explain the functional effects on voltage and current of the two types of circuits for deeper understanding or allow students to discover these phenomena through testing and experimentation.









3. **(55 minutes).** Hand out the Solar Panel notes worksheet (https://drive.google.com/file/d/1XGo4sVI0qjj32PAH9gFkrjIGD93BmT88/view) to student groups. Have the students test circuits and collect data indoors and outdoors (weather-dependent).
4. **(5 minutes).** Have students clean up their materials and turn in worksheets.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Day 1 allows student groups to accomplish the 4 challenges without the pressure of assessment, data gathering, or simple circuit diagrams. Students are planning, discussing, and carrying out investigations that align with NGSS Science & Engineering Practice #3. Cross-cutting concepts (CCC1, CCC2, CCC4, and CCC5) are being used by student groups as they play, experiment, and collect data in Days 1 and 2.

SUMMATIVE ASSESSMENT

During Day 2, students will be collecting solar panel data. Student group work and the Solar Panel worksheets can be assessed on the following standards:

- NGSS HS-PS3-3:
  Design, build, and refine a device that works within given constraints to convert one form of energy into another.
- NGSS SEP2:
  Developing and using models.
- NGSS SEP3:
  Planning and Carrying Out Investigations.

LESSON EXTENSIONS

This lesson could lead into deeper investigations into solar panels and engineering, depending on the curricular goals of the class. Three challenges are recommended:

- Solar Car Challenge: https://cebrightfutures.org/teach/teacher-activity-center/build-solar-cars-lesson-3
- Solar Boat Challenge: https://cebrightfutures.org/teach/teacher-activity-center/building-solar-boats-lesson-7
- Solar Cell Phone Recharger: https://cebrightfutures.org/teach/teacher-activity-center/designing-solar-phone-charger-lesson-7