CE CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

Solar Mobile Design Challenge

Lessons 2: Exploring Circuits and Optimum Power

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DESCRIPTION
This lesson is an exploratory learning cycle that will give the instructor input as to where students are in their understanding of circuits and also scaffolds student learning. This lesson starts by engaging students by using an Energy Stick. Then, students start by working with small lamps and LEDs to build simple series and parallel circuits. Students then move on to testing motors with propellers and then add a battery pack to the circuit. In the end, students should build a circuit that they feel will be the best for their future mobile aircraft.

GRADE LEVEL(S)
6, 7, 8

SUBJECT AREA(S)
Low voltage solar panels, circuits, series circuits, LED testing, Lamp testing, motors with propellers

ACTIVITY LENGTH
2-3 class periods (~55 minute class periods)

LEARNING GOAL(S)

1. Students build series circuits using “grain of wheat bulb” and LEDs powered by various low voltage solar panels.

2. Students build parallel circuits using grain of wheat and LED bulbs powered by various low voltage solar panels.
3. Students demonstrate and draw the energy transfer using solar energy.
4. Students draw a circuit diagram of their final optimal circuit.
5. Students design an optimal circuit model that will be used in their final project.

CONTENT BACKGROUND

STUDENT BACKGROUND

This exploratory lesson is used to engage students and help the instructor gauge prior knowledge of circuitry. Students can be guided through the process using the worksheet or use the worksheet and record in an engineering notebook. There are several websites listed to aid student understanding.

EDUCATOR BACKGROUND

Educators should be familiar with:

- Series and parallel circuits to facilitate discussions and help students problem solve.
- LEDs (Light Emitting Diodes) have polarity
- Electron flow through a simple DC circuit
- Use of an Energy Stick to explain electron flow and polarity

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Student Engineering Notebooks
- Simple Solar Circuits for Solar Mobiles Worksheet

CLASSROOM SUPPLIES

- Wire cutters/strippers
- Needle Nose Pliers
- Energy Stick

ACTIVITY SUPPLIES (PER GROUP FO 3 – 4 STUDENTS)

- 2-3 ,3 mm LED (light emitting diodes)
- Grain of Wheat bulbs
- Leads (alligator clips)
- 2v, 1.5v, and .5v solar panels
- Simple switch
- Sun or light stand with light bulb
- AA batteries

- AA battery holder
- 2 motors
- Light stand with 60W incandescent bulb
- 2 propellers with 2mm opening for motor
- Circuit diagram resource (for drawing final circuit in notebook)

LESSON PROGRESSION

PLANNING AND PREPERATION

This lesson is designed as an exploration spanning 1 to 3 days, with the last day to focus on optimal designs for students' Solar Mobiles. Students need to record findings in their Engineering Notebooks for each day or use the provided "**Simple Circuits for a Solar Mobile**" worksheet. Each partner group receives an "**engineering kit**" for each day's activity that includes:

Engineering Materials Kit (in shoebox type plastic storage container):

- 4-6 Alligator Clips
- 2-3 LEDs
- 2-3 Grain of Wheat bulbs
- 1 simple switch
- 2v, 1.5v, and .5v solar panels
- Sun or light stand with light bulb 60W incandescent light bulb

Materials given out after initial testing:

- 2-motors
- 2-propellers (inexpensive hobby store)
- 1-1.5 V double battery pack
- 2-1.5 V batteries

LESSON SEQUENCE

DAY 1: EXPLORING CIRCUITS

1. **(10 min) Student engagement:** Have students form a circle with their left hand held out flat and their right pointer finger touching the center of the hand of the person to their right. Being part of the circle, take the Energy Stick in your hand and ask the person next to you to touch a metal contact on the stick.

   The stick begins to make noise and flash, causing a lot of student excitement.

Ask any student to break the chain and observe that noises and flashing stop. Have various students break the connection and have some students be in charge of the energy stick.
QUESTIONS: What is flowing through our bodies that makes this phenomenon occur? Engage in a short dialogue about what is happening.

It is helpful to have students test the conductivity of adding different materials into their chain. EXAMPLE - if someone is touching a clothed arm it will not work. Add a glass of water as a connection point. Wooden pencils. Maybe a coin or conductive piece of metal. Explain to students that the fully linked conductive pathway the class created for electrons to travel is called a "circuit."

The following explanation was taken from Discrepant Events in Physical Science by Carl Wozniak www.carlwozniak.com

"Energy sticks are plastic sticks with two metal contacts. When both contacts are touched in a completed circuit the balls light up and make noise. Our bodies are moderate conductors of electricity (all that salt water).

A common misconception is that electrons are zipping around the circle that is formed by everyone holding hands. Actually, an electric current is zipping around, but this is not the same thing as electron flow.

A good visual analogy is to set up a long PVC pipe horizontally with an elbow at each end pointing upward. Put a short extension pipe on one of the elbows so that the opening on one side is higher than the other. If you fill the pipe completely full of water, so that water starts to overflow the lower end, you have something akin to a circuit. If you pour more water into the taller end, the water immediately starts to flow out the lower end. The water molecules that you just poured aren't magically flowing through the pipe and exiting the other side. Rather, the water molecules along the entire pipe bump into each other and cause an almost instantaneous expulsion on the other end.

Energy balls are great for demonstrating series and parallel circuits, and will easily work with a group of 30 students."

2. **(30-35 min) Introduce the "Engineering Kit" and Simple Circuits**

Explain the activity and set goals using the **"Simple Solar Circuits for a Solar Mobile"** worksheet. If students need background in calculating power, as is noted in the worksheet, go over the P=IV formula with them and discuss the ratings for each solar panel. Students will spend most of the class period exploring circuits with the available materials, going through the instructions on the worksheet. As the instructor roams around the room, answer questions and ask students about what is happening in the circuits.

3. **(10-15 min) Debrief and Clean-up**

Ask some students to demonstrate their circuits and discuss what is happening with the current flow and how energy is transferred from the Sun or light bulb. Point out series and parallel circuits. Give students time to add more information to the drawings in their engineering notebooks.

DAY 2-3: CIRCUIT EXPLORATION, CONTINUED

1. **(10 min) Review Prior Day's Circuits**

   Have a few students share their drawings in their engineering notebooks. Review technical drawings and the labeling of circuit diagrams. Review the material in the "**engineering box**" and note that some items have been added to the kit. Show students motors, propellers, batteries, and battery holders. Demonstrate how the batteries go into the battery holders and remind them that all batteries should be removed at the end of class.

   Be sure to remind students that their final goal is to make a circuit that will be used on their solar mobile aircraft.

   Depending on how precise you want the students to draw at this time you might want to introduce circuit diagramming. See extensions below.

2. **(30-35 min) Continue Exploration:**

   Students will continue exploring circuits with the available materials, running through Part 2 of the worksheet. As the instructor roams around the room, answer questions and ask students about what is happening in the circuits. Direct students to make the optimal circuit that will be used for their solar aircraft. Depending on the experiences of your students you might want to spend an extra day on circuit testing/redesigning.

3. **(10-15 min) Clean-up and Discussion**

   Have students clean-up. Afterwards have them focus on their circuit drawings. Discuss what circuits students designed and ask how they will be used on the solar aircraft. Discuss the use of batteries and whether or not they should be included in the final project. Remind students of the design of the solar impulse and the struggles they encountered with weight.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Student's engineering notebook drawings and written explanations plus student discussions should be evaluated as to whether or not more time needs to be given to the basic circuitry needed for the solar aircraft.

SUMMATIVE ASSESSMENT

The final Solar Mobile Engineering Design Challenge incorporates the optimum circuit that was developed in this lesson although it may change as students work on designing and redesigning their final mobile.

LESSON EXTENSIONS

Circuit Diagrams - You may want to extend this lesson to having students use electronic symbols in diagrams instead of drawings. This is an interactive that students enjoy:

Physics and Chemistry by Clear Learning – Electromagnetism and Electricity Interactives:

http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/circuits_diagram.htm

http://www.physics-chemistry-interactive-flash-animation.com/electricity_interactive.htm