Solar Racing (Lesson Plan)

(The Design, Construction and Evaluation of a Solar-Powered Car)

Suggested Grade Level 6-8

Overview

In this design challenge, students will harness the power of the sun to design, construct and evaluate a solar-powered model car of their creation. Students will utilize the design process and undergo review by their peers to select an optimal gear ratio and components for their car. As a culminating activity, students compete in a "Solar Sprint" race modeled after the National Renewable Energy Laboratory's Junior Solar Sprint competition. Depending upon the depth of investigation, the suggested time frame for this lesson is four to ten (4-10) 50-minute class periods.

Standard Statements

2.1.8. D	Apply ratio and proportion to mathematical problem situations involving distance, rate, time and similar triangles.
3.1.7 A	Explain the parts of a simple system and their relationship to each other.
3.2.7 C	Apply the elements of scientific inquiry to solve problems.
3.2.7 D	Identify and apply the technological design process to solve problems.
3.4.7 B	Analyze energy sources and transfers of heat.
3.4.7 C	Identify and explain the principles of force and motion.
3.8.7 C	Identify the pros and cons of applying technological and scientific solutions to address problems and the effect upon society.

Content Objectives

Students will know that

1. Solar energy is a renewable energy source, and its utilization has numerous benefits for our environment.
2. The angle at which a solar cell is positioned in relation to the sun affects its power output.
3. The amount of current produced by a photovoltaic cell is proportional to the amount of the light hitting the cell; therefore, increasing light intensity or increasing the size of the cell itself will increase the power output of the cell.
4. In order to construct a solar powered system that will work at maximum efficiency, numerous factors pertaining to the design, such as gear ratio and power output, must be considered.

Process Objectives

Students will be able to

1. Describe three factors influencing a solar car's power needs: friction, air drag, and acceleration.
2. Calculate the gear ratio used in the drive system of their solar powered car.
3. Describe the motion of their solar car based upon its position, direction, and speed.
4. Explain how the solar car design was optimized based upon gear ratio and materials used.
5. Utilize the design process to construct a solar-powered car.

Assessment Strategies

1. Evaluation of the completed student handouts and of the student's participation in class discussions.
2. Observation of student's participation throughout the process of designing a solar car.
3. Student participation in a team presentation of their solar-powered car design.
4. Completion of the student's solar car design evaluation.

Materials

Per Group:

- Solar Sprint kit (from the Junior Solar Sprint website)
  - Solar panel
  - Motor with lead wires and clips
  - Motor mounting bracket with screws
  - Gears for motor shaft
- Solar Sprint accessories kit (from the Junior Solar Sprint website)*
  - 2 shafts
  - 4 wheels with tires
  - 2 spur gears

  * Instead of purchasing Solar Sprint kits, many accessories can be extracted from old toys, VCRs, tape recorders, old "Spirograph" gears and reused as shafts, wheels and gears
- Various reused materials to construct a body for the car (foam core, Blue board, wood, corrugated cardboard)
- Stopwatch

Teacher Tools:

- Soldering Iron
- Sharp Utility Knife or Coping Saw
- Cool-Melt Glue Gun
- Needle-Nose Pliers
- 1/8" Drill Bit or Electric Drill with Bit
- 2 C-Clamps
- Rulers
- Pencils
- Wire Strippers and Wire Cutters

Multimedia:

- "Solar and Car Fundamentals" PowerPoint presentation[1] (Part 2)
- Junior Solar Sprint PowerPoint presentation, titled, "Build_Junior_Sprint_Car" (optional)

Procedure

Part 1: The Design Process *(1, 50 minute Class Period)*

1. Introduce students to the U.S. Department of Energy's contest, Junior Solar Sprint using background information and rules from this website: http://www.nrel.gov/education/jss_hfc.html. (An optional introductory video produced by

[1] Created in 2005 by Andy Lau and Dale and Toby Short for the Penn State University (PSU)/Middle Schools Solar Racers Workshop.

the National Renewable Energy Laboratory is available for $10 and is listed in the additional Resources section.)
2. Allow them to get into teams and select a name, colors and number, etc.
3. Briefly describe the components of the solar car (Solar panel, Chassis; Wheels, Axles & Bearings; Transmissions; Body Shells) about which students will be able to make design choices. If your students have not worked with solar panels previously, you may need to spend more time discussing and exploring how a solar panel works.
4. Share the Design Process diagram (Figure 1 in Teacher Notes and on page 1 of the Student Handout) with students and give them a general overview of where and when they will apply the steps of the process in making their cars. The Chimacum School Junior Solar Sprint website has an excellent description of how each step of the design process is connected to building successful solar cars and it can be accessed at: http://eagle.csd49.org/middle/jss/Course_DsgnProc.htm.
5. Allow teams to work together to get their initial car concepts onto paper and prompt them to generate a list of questions they have before they can select a design.
6. Be sure that your students are clear about the task before them. Make sure that you articulate that the students should be thinking about the design of the chassis, wheels and bearing, body and the solar energy source.

Part 2: Experiment with Principles and Prototypes *1 or 2-50 minute Class Periods*

1. Field any questions students have generated and share the "Solar and Car Fundamentals" PowerPoint presentation with your students, highlighting the concepts that direct the goals of the solar-powered car project.
2. Focus specifically on how to calculate gear ratio and give students team-time to make decisions about their transmissions and work through the Gear Ratio calculations section beginning on page 4 of the student handout.
3. Allow students to return to teams to further time to conceptualize their design and prepare for their class presentation.

Parts 3 & 4: Design Review and Solar-Powered Car Construction *Multiple Class Periods*

1. Allow teams to complete page 9 of the student handout and make presentations of their designs to their classmates that explain their decisions regarding the four major car components (transmission, chassis, wheels and bearings, body and Photovoltaic array) with a rationale for each.
2. After teams have taken time to revisit the "drawing board" on page 10 of the student handout, set them off to construct their cars. (A materials list for tools is also included. If students will be using any tools, instruct them to make safety a priority.)
3. Encourage and allow time for some test runs. If you are lacking sun, halogen lamps work well to power cars in a short distance test-track area.

Part 5: Design Test: Solar Racing! *1-50 minute Class Period*

1. Get ready to race. Spend some time prior to race day looking at the following website: http://eagle.chimacum.wednet.edu/middle/jss/Course_Rules.htm for information on official rules for the contest. The Chimacum School District Junior Solar Sprint website is a wonderful all-around resource. If you are interested in spending a full two weeks on the project, an extensive model program for creating solar-powered cars with embedded investigations on each stage of the design process is available.
2. Celebrate the teams' design successes with a solar-power awards ceremony.

Part 6: Make Connections: What other applications can the sun power? *20 minutes*

1. Debrief the project and allow teams to work together to complete Part 5 of the student handout.
2. Spend time as a class sharing ideas and reflecting upon how technology and science solutions impact our society.

Extension

1. Apply solar-powered car knowledge to designing a component for a home such as a solar water heater using a 16-ounce bottle of water.

Additional Resources

Video:

- A video on Junior Solar Sprint is available for $10 from the Northeast Sustainable Energy Association (NESEA)
  http://www.nesea.org/education/jssvideo.html

Websites:

- National Renewable Energy Laboratory (NREL) Education page on Junior Solar Sprint Competition:
  http://www.nrel.gov/education/jss_hfc.html
- National Junior Solar Sprint (JSS) Web site with six lesson packets:
  http://www.nrel.gov/education/natjss.html
- Suggested JSS lessons and background information on solar power:
  http://eagle.chimacum.wednet.edu/middle/jss/index.htm
  - For more information on Using the Design Process:
    http://eagle.csd49.org/middle/jss/Course_DsgnProc.htm
- An on-line elementary/middle school instruction set on solar energy:
  http://www.fsec.ucf.edu/ed/teachers/
- Two interdisciplinary middle school units on transportation:
  - Getting Around Clean and Green
    http://www.nesea.org/education/CandG.html
  - Getting Around Without Gasoline:
    http://www.nesea.org/education/GAWG.html