Junior Solar Sprint – Introduction & Overview

Students Objective
The student
- will be able to explain the rules governing the construction and racing of Junior Solar Sprint vehicles
- will be able to explain the basic design processes necessary to building a JSS vehicle

Key Words
disqualification
innovation
Junior Solar Sprint
parameter
photovoltaic

Materials (this lesson)
- Junior Solar Sprint video (available online–see Procedure section)
- race rules
- large sheets of paper
- team journals
- Researcher's Portfolio

Time (this lesson):
1 class period
Time (entire Junior Solar Sprint project):
2 - 6 weeks

Materials (future sessions)
- solar panel and motor (from kit)
- wheels – found, recycled or purchased
- gears – found, recycled or purchased
- various materials for car body and chassis such as balsa wood, styrofoam, foam core, aluminum, plastic, heavy paper, and recycled containers
- rods for axles
- plastic and metal tubing for bearings and bushings
- various glues such as hot glue, wood glue, and contact cement
- various tools such as soldering iron and solder, needle nose pliers, screwdriver, razor knife, scissors, wire cutters, small adjustable wrench, electric drill & bits (inc. hole saw)
- small vice or clamps
- wire
- alligator clips
- electrical tape
- velcro
- safety glasses

Background Information

If you are unfamiliar with the Junior Solar Sprint, you may want to preview the video and read the rules before class.

The Junior Solar Sprint competition was started by the US Department of Energy in 1991

to expose students to photovoltaics and its potential for their future. The competition challenges students to design, build and race model solar cars powered entirely by solar energy. The students are challenged to use scientific know-how, creative thinking, experimentation and teamwork to design and build a solar-powered electric vehicle.

Procedure

1. Show Junior Solar Sprint video. The video is available online in streaming video at: **http://media.fsec.ucf.edu/ref_movies/2103_medium_ref.mov** or a dvd copy may be purchased from the Florida Solar Energy Center.
2. Lead a classroom discussion about the Junior Solar Sprint
3. Assign students to small groups of 2 - 4 students per team
4. Distribute the *Race Rules* pages to each team
5. Students should complete the *Science Journal* pages
6. Students should brainstorm and sketch their ideas on the large sheets of paper.

Key Words & Definitions

- **disqualification** - to become ineligible to participate
- **innovation -** to use something in a new or unique way
- **Junior Solar Sprint** - a program begun in the early 1990s by the U.S. Department of Energy. The program was created for teams of middle school students who design and construct model sized, solar powered vehicles for competition.
- **parameter -** characteristic
- **photovoltaic -** the effect of producing electric current using light

Related Research

1. How can photovoltaics be utilized in full sized cars? Research full sized solar race cars. When and where is the next race going to be held?
2. How could solar be used to charge an electric car? Draw a diagram or find a photograph on the internet of an electric car that charges its batteries using photovoltaics.

Internet Sites

http://www.nrel.gov/education/jss_hfc.html
National Junior Solar Sprint web site sponsored by the National Renewable Energy Laboratory

http://www.fsec.ucf.edu/go/jss
Florida Solar Energy Center's Junior Solar Sprint web page.

http://doolittle.icarus.com/jss/
Larry Doolittle of Lawrence Berkeley National Laboratory has written a program that simulates a Junior Solar Sprint race based on the variables of your car.

http://science.howstuffworks.com/178-how-solar-cars-work-video.htm
How Stuff works video, How Solar Cars Work. Interview with captain of the University

of Michigan solar car race team, describing the race car, its parts and how they work.

http://tryengineering.org/play-games/solar-car-racing-game

Try Engineering, solar car race game. Pick the components of your solar race car and then race it on the track.

http://www.worldsolarchallenge.org/

World Solar Car Challenge, annual solar car race held in Australia.

http://americansolarchallenge.org/

American Solar Challenge, a college level competition to design, build and race solar-powered cars across America.

http://www.winstonsolar.org/challenge/

A long distance solar car race for high school students.

https://www.youtube.com/watch?v=OXcPFuAhvkk

Dragon Fly TV's episode on solar cars. Kids do experiments using a Junior Solar Sprint car.

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Benchmarks are listed for each sub activity of this unit in that specific unit. Listed below are the benchmarks for the Junior Solar Sprint activity in general, if none of the sub activities are used in the process.

			.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12
Grade 6														
Practice of Science	# 1	SC.6.N.1				**X**								
Energy Transfer & Transformation	# 11	SC.6.P.11	**X**											
Grade 7														
Practice of Science	# 1	SC.7.N.1			**X**									
Energy Transfer & Transformations	# 11	SC.7.P.11		**X**										

Sixth Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.6.N.1.4 - Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.

Science–Big Idea 11: Energy Transfer and Transformations

- SC.6.P.11.1 - Explore the Law of Conservation of Energy by differentiating between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.

Seventh Grade Benchmarks

Science–Big Idea 1: The Practice of Science

- SC.7.N.1.3 - Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.

Science–Big Idea 11: Energy Transfer and Transformations

- SC.7.P.11.2 - Investigate and describe the transformation of energy from one form to another.

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Note: Before beginning construction, make sure to check the rules posted online at: ***http://www.fsec.ucf.edu/go/jss****, for any recent changes or additions.*

Each team is responsible for designing and building a solar powered race car. The kit your team purchases will contain a motor and solar panel; the chassis, wheels and transmission are made from any other materials that you choose. Cars are judged on design, innovation and performance. Each team's effort is focused toward the final event – a 20 meter, wire-guided sprint race where the best design and construction techniques will pay off with the win!!

Car Parameters
The dimensions of a Junior Solar Sprint car **cannot exceed**:
- 30 cm. in width
- 60 cm. in length
- 30 cm in height

Teams will not be allowed to bolt the axles and wheels to the solar cell. Each vehicle mush have a panel on the side which is large enough to display a 3cm x 3cm number decal. Which will be provided by the race committee.

Each entry begins construction with a kit containing:
- a 3V photovoltaic panel (Solar Mae or Pitsco
- a motor matched to the PV panel

The solar panel may not be modified. The motor may not be modified (i.e. rewound, lightened, etc.). The specific motor supplied with the panel (in the kit) must be used. If a replacement motor is needed, it must be purchased from the company who supplied the panel, and be the model of motor originally supplied with the panel. One solar cell and motor are permitted per car. Any modification to the solar panel or motor will result in disqualification.

At least one wheel must be driven by the motor.

Each vehicle shall:
- carry a standard, unmodified table tennis ball (aka ping-pong ball) of approximately 40mm in diameter,
- NOT glue, tape, or otherwise permanently affix the ball to the vehicle,
- NOT wedge the ball between the chassis and solar panel (using only those two things to hold the ball in),
- be designed to allow for the purposeful removal of the ball with minimal effort, and
- transport the ball (without losing it) down the entire track.

Each vehicle must include:

- a battery holder mounted that is capable of holding 2 AA batteries. In the event of a severely overcast day, rechargeable batteries that have been previously charged by solar, will be supplied by the Florida Solar Energy Center (see Inclement Weather section below).
- a switch or other easy to operate method of 'switching on' the battery power at the starting line.

Construction

Each team, on their own, will provide the additional parts needed for the construction of the car:

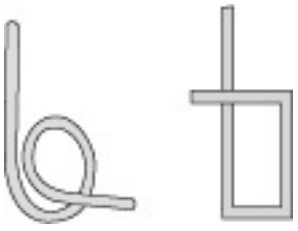
- wheels
- car body/chassis
- axles
- wiring
- connectors
- gears
- brackets

Individual decals may be affixed, and the body may be decorated at the teams discretion, but a 3 cm. square space must be left free on each side and the bottom for the Sprint decal number.

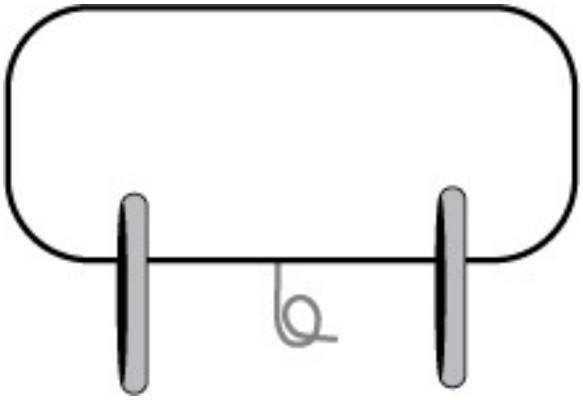
The material for the body of the car can be any type of light material.

Steering

An eyelet (see examples below) must be attached to the bottom of the car (our example–bottom front of the chassis, however any placement on the vehicle is okay). A guide wire, 1 cm.(+/- .5cm) from the surface of the track, will go through the eyelet, serve as the steering mechanism, and keep the car in its lane. The vehicle must be easily removable from the guide wire, without disconnecting the guide wire. This is the only allowable method of steering the car. No radio control is permitted in Junior Solar Sprint cars. Lane changing/crossing will result in disqualification.



Eyelet examples



Front of Vehicle (End View)

The vehicle must be safe to contestants and spectators (i.e. no sharp edges, projectiles, etc). Any energy-enhancing devices, like mirrors, must be attached to the vehicle.

Failure to meet these expectations will result in disqualification.

Team Log/Journal
A Team Log which includes a component list is required to be submitted with the vehicle for technical judging.

The Team Log should contain notes on the design process, important points of the car's design and concrete decisions taken by the team to arrive at the final product. The Team Log should not be a finished, 'polished' document, but rather a collection of notes, sketches and test results of the design in progress. The purpose of this document is to help the design judges understand the decisions made during the design and construction process. These documents will not be returned to the teams, and parts of these documents may be published or disseminated to future participants. Failure to turn in a Team Log will result in loss of points in the design portion of judging.

The log document **must** include:
- team member names and roles/strengths
- amount of time spent on the vehicle
- specifications of final vehicle (size, weight, wheel size, gear ratio, etc.)
- component list--all parts purchased for your vehicle, including the name of the supplier and the price of the part
- design and assembly process
- greatest obstacles (issues and problems encountered and modifications made)

The log document **might** include:
- design drawings
- electrical schematics
- formulas and calculations used
- photos taken periodically during construction process
- anything else the team wants to include for the design judges

Design Judging
Teams must submit their cars for initial inspection before Design Judging. It is the team's responsibility to arrive on time to complete the inspection. Cars arriving late will not be considered in the Design Judging.

Energy Whiz Expo/Olympics Race Parameters

Race Divisions
The race will be conducted in two phases: time trials and a head-to-head competition for each division.

The Green Division is composed of teams where the member in the highest grade is in the 4th through 6th grade. The Blue Division is composed of teams where the member in the highest grade is in the 7th or 8th grade.

Time Trials

During the time trial phase of the race, teams have the opportunity to attempt to have their vehicle drive down the track (a run) up to three times. After each run, the vehicle's time will be recorded. A 'DNF' or 'Did Not Finish' will be recorded for vehicles that lose their table tennis ball, drive off the track, do not cross the finish line, or are otherwise disqualified.

Time trials will be offered every two minutes for a given period of time. Event times will be posted the day of the race; teams are encouraged to perform their runs as soon as possible. It is a team's responsibility to line up and run their vehicle (up to three times) within the time allotted. Any teams in line when the end of the time trial event is called by the judges will not be allowed to run. When 'Go' is called, vehicles that do not start moving before the other vehicle reaches the finish will be given a DNF and must be removed from the track immediately. If neither vehicle moves, the teams will be given 30 seconds after 'Go' is called before DNF's are given to both vehicles. Vehicles are then to be promptly removed.

The ten teams in each division with the fasted individual run times will move to the head-to-head competition.

Head-to-Head Competition

The head-to-head competition is an ten-team, double elimination event. This means that a team must lose twice before being eliminated from the competition. Teams will race against other teams in their division to determine the first, second, and third place winners.

The Track

- The racetrack is 20 meters long and 60 centimeters wide
- The track is set up on a hard, flat, smooth surface such as a tennis court. For the Florida Energy Whiz Expos and the Energy Whiz Olympic event, a non-slick vinyl surface will be used for the track lanes.

The Starting Line

- One team member will hold a piece of cardboard or other shading device over the panel, and remove it when the start signal is given.
- Team members may not push a vehicle to start it.
- Team members may not accompany the vehicle in its lane during the race.

During the Heat

- One team member may free the vehicle from wire binding or track imperfections should such problems occur.
- Team members may not push the vehicle or give any other physical assistance.
- Team members may not change the vehicle's mechanical or electrical characteristics (e.g. shift a transmission) after the start of the heat.

Between Heats

- Repairs may be made to vehicles as necessary between heats. However, no extra time will be given for repairs, and the race will not be paused for repairs to be completed.

The Finish Line

- One team member must be present at the finish line to stop the vehicle, preventing any damage to it.
- The vehicle must remain in its lane at the finish line until the order of the race vehicles has been established.

Failure to meet these expectations will result in disqualification.

Inclement Weather

Partially Cloudy - Because weather in Florida is changeable, the race will not be postponed for partly cloudy or mostly cloudy weather. Teams should be prepared to race in all moderate weather conditions.

Severely Overcast - If the solar irradiance (amount of sunlight) averages less than 500 Wm2 during a 15 minute period (as measured by equipment at the Florida Solar Energy Center) just prior to the start of either the Time Trials or one of the Head-to-Head Competitions, the race will be switched to a battery powered race. The Florida Solar Energy Center will loan the teams (2) AA rechargeable batteries that have been charged by solar and tested for charge level prior to distribution, as well as a 'shade' to cover the photovoltaic panel. Only the batteries supplied by FSEC may be used. From the time that the race is changed to batteries, it will remain battery powered and not switch back to solar, regardless of increasing irradiance levels. (Note: a typical full sun day at solar noon in Florida is usually 1000 Wm2)

Rain/Thunderstorms - If the solar irradiance averages less than 500 Wm2 during a 15 minute period plus the amount of rain occurring makes the track unusable or unsafe, the race will be canceled. If one division has already raced, then only the second division's race will be canceled. If only the time trials have been run, those times will be used to award the race winners. If the time trial portion has not been completed, then only design awards will be given and no race will occur. The decision whether or not to cancel the race portion will be made by the JSS administrative team, and from the time that the race is canceled, it will not be reinstated even if the weather clears.

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Track Specifications:

Lane Length:
20 meters

Lane Width:
60 centimeters

Number of Lanes:
- Depends upon the total number of entrants and the time available. Less than 25 teams can be run on one (two lane) track.
- Time trials are done during a set amount of time (½ hour to 1 hour depending on the number of vehicles entered). Allow 1 hour for each division's double elimination.

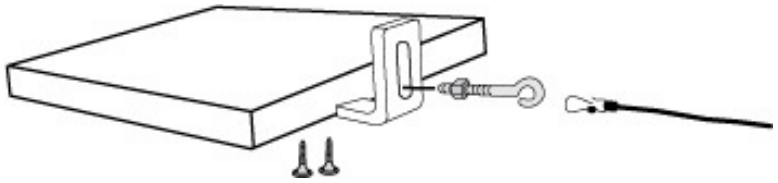
Track Surface:
- As smooth as possible, flat and level or slightly downhill in the direction of the race.
- Fully exposed to the sun all day.
- Oriented if possible, so that prevailing winds are behind the vehicles as crosswinds can be a problem.
- Energy Whiz Expos and the Energy Whiz Olympics use a heavy gauge PVC coated material (used in the construction industry for containment barriers) for the track lanes.

Layout:
- Security roping should be placed around the perimeter of the track, as the guide wires are difficult to see.
- A second level of security roping should be used for team movement and to keep spectators off the track.
- A staging area near the start line and a run-off area beyond the finish line is necessary.
- A pit area is needed for tune-ups between races. This area should have two practice guide lines.

Guide Lines:
- Monofilament fishing line, 60-lb test is adequate, braided line works best for hot sunny days.
- The line should be suspended about 1 cm (+/- .5 cm) off the ground.
- Lines must be kept taut. Check the line periodically during the event and pull taut as needed.

One way that the guide lines may be attached (see diagram following instructions):

- A 12" x 12" piece of 3/4" plywood may be used to anchor both ends of the guide wire.
- A threaded eye-bolt can be attached to a comer-reinforcing bracket to allow for height adjustment of the guide wire.
- Pre-measured guide wires can be attached to the eye bolts with fishing tackle clips.
- Once assembled, plywood should be anchored with 40lbs. of ballast (concrete blocks are acceptable) and moved apart to give the desired line tension.



Detail of guide wire ends

Timer:

- During time trials, one timing official is needed for each lane.
- During double elimination, the timer need not measure speed but must be able to determine the winner. (Note: Just like car or horse racing, the nose of the car crossing the finish line is the deciding event)

Communication:

- Efficient communication is needed between the starting line, the finish line, and the scoreboard. During time trials, it is helpful to have runners take the finish times from the timers to the scoreboard.
- A loudspeaker or bullhorn is helpful for public announcements and crowd control.

Intramural Racing:

- The purpose of the intramural race is to determine your class or school's entry to the regional race conducted by your Junior Solar Sprint host site.
- There are several options for determining your school's entry:
    - Teacher decision – It is not mandatory to conduct an intramural race.
    - By the clock – A school may set up one lane and race each vehicle against the clock. The vehicle with the best average time becomes the entry to the regional race. However, it is important that the vehicles run on a guide wire, as how well the car can run on a wire is a big factor in the car's performance.
    - Lane races – Construct lanes and conduct a double elimination race.
    - Full-scale intramural race – The JSS is a great opportunity for publicity at many levels. Invite as many people as possible to the event including parents, scientists, teachers, students, and the media.

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You will be designing and building a solar powered vehicle to compete in a 20-meter, wire guided race.

1. List below topics you would like to research, questions that you want answered, and experts you would like to contact. Write down which team member is responsible for gathering information on each item.

    1.

    2.

    3.

    4.

    5.

    6.

    7.

    8.

2. Junior Solar Sprint vehicles use many different materials in their construction, many of them recycled and found materials. You will need to be thinking of items that you may already have around the house, as well as how to use common everyday items in a new way. Make a list below of items that you want to bring in to investigate and possibly use in the design of your vehicle.

3. As you conduct your research make notes below of the important information you learn and the source you used. You may use the internet, textbooks, magazines, books and experts in their field. Make sure to include a variety of resources. You may also download or copy printed material and highlight the relevant facts. Include your research information in this portfolio.