Junior Solar Sprint – Introduction & Overview

Students Objectives
The student:
- will know rules governing the construction and racing of Junior Solar Sprint vehicles
- will explain the basic design processes necessary to build 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
- notebooks for Design Notebooks
- Science Journal

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

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. Several states hold Junior

Solar Spring competitions, including Florida, Colorado, Texas, Virginia, and New York. In Florida, the Junior Solar Sprint is held in several regional events (Expos) in the spring with the culminating event at the Florida Solar Energy center in May. Each year at the EnergyWhiz event at FSEC over 60 teams from throughout Florida and other surrounding states compete in race and design competitions. Check the FSEC website **http://www.fsec.ucf.edu/go/energywhiz** for the current year's dates and places.

The goal of this engineering challenge is for the team to design and build a race-worthy, solar-powered vehicle that can rapidly transport a ping-pong ball down a 20 meter track.

Procedure

1. Show Junior Solar Sprint video: **https://vimeo.com/fsec/jss2001.** Lead a classroom discussion about the Junior Solar Sprint.
2. Assign students to small groups of 2 – 4 students per team.
3. Distribute the *Race Rules* pages to each team.
4. Students should complete the *Science Journal* pages.
5. Students should brainstorm and sketch their ideas in their team Design Notebook.

Tips For Success

- Working in teams, the members can share their strengths, and also hone their teamwork skills.
- A good Design Notebook can help the students make their thoughts cohesive and document their ideas before they are forgotten.
- Good sources of recycled parts are: bottles, syrofoam trays, and boxes for bodies; CDs, and old toy parts for wheels; parts recycled from broken printers, VHS machines and other electronics for gears.
- Weight is the number one concern. Because of their weight, some items are not good for JSS cars, such as: Legos, most toy R/C car parts, and wood other than balsa.
- Too large is not good either. JSS cars are usually small and do not come close to the maximum allowable size.
- JSS cars can have any number of wheels–3 and 4 wheels are the most common.
- Many teachers request teams construct a "rolling chassis" (without motor, panel, and finishing details), and then test their chassis to make sure they roll easily and straight. Extra friction that occurs from misaligned axles is a major problem with JSS vehicles, and it can be difficult to correct after the motor is attached.
- It is extremely important that the students manage their construction deadlines so that they have ample time to test, fix, modify, test (again), fix, modify, etc. This is not a project that can be started just a few days before the race.

Evaluation and Student/Team Assessment
Using the rubic below, assess each student/group periodically or at the project completion with the scale:

4 - exemplary 3 - above average 2 - average 1 - needs improvement

Weekly Progress	
Assignments kept current	
Design process documented	
Notebook	
Log has required components	
Meetings are recorded with the contribution of each member	
Sketches	
Notes include testing of vehicle and parts	
Teamwork	
All team members contribute	
Work load was fairly distributed	
Leadership roles are assumed for tasks by different members	
Final Car	
Durability	
Wheels (placement, stability, use of bushings)	
Efficiency (weight, use of materials, etc)	
Gears (mounting, size, placement)	
Proper installation of guide-hook	
Car successfully holds ping-pong ball	
Creativity/ Innovation	
Craftsmanship	
Speed	
TOTAL	

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

http://fsec.zenfolio.com/ew
Photo gallery of past year's EnergyWhiz JSS entries.

https://www.nrel.gov/workingwithus/car-competitions.html
National Junior Solar Sprint web site sponsored by the National Renewable Energy Laboratory

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://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.solarcarchallenge.org/
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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Standards 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.

Florida NGSS Standards & Related Subject Common Core

			.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.

National Next Generation Science Standards - Sixth to Eighth Grade Standards
Science–Engineering Design

- MS-ETS1-1 - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 - Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3 - Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4 - Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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Note: Before beginning construction, make sure to check the rules posted online for any updates or clarifications. These can be found at: ***http://www.fsec.ucf.edu/go/jss****.*

These rules are the official rules for the Junior Solar Sprint competition at Florida EnergyWhiz Expos, and the statewide EnergyWhiz competition held at the Florida Solar Energy Center. These rules are also compatible with the Junior Solar Sprint events held at regional SECME events and Technology Student Association (TSA) competitions.

Junior Solar Sprint Race Rules

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 must 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 Made 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 panel and motor are permitted per car. Any modification to the solar panel or motor will result in disqualification.

At least one wheel must be directly 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), and
- 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:

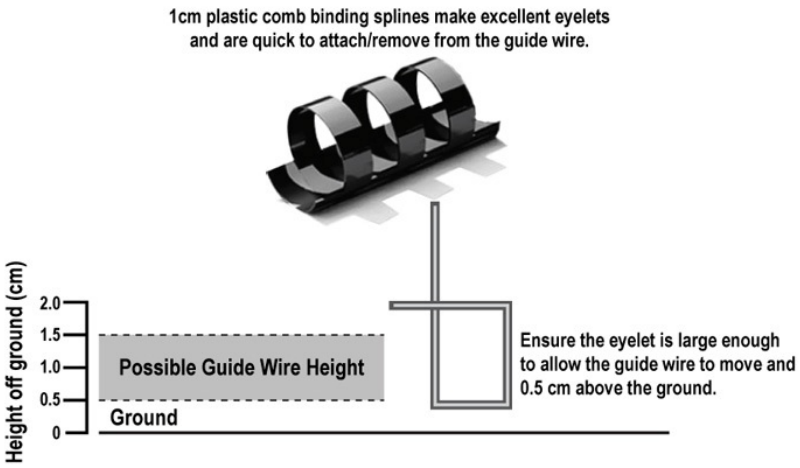
- wheels
- car body/chassis
- axles
- wiring
- connectors
- gears
- eyelet

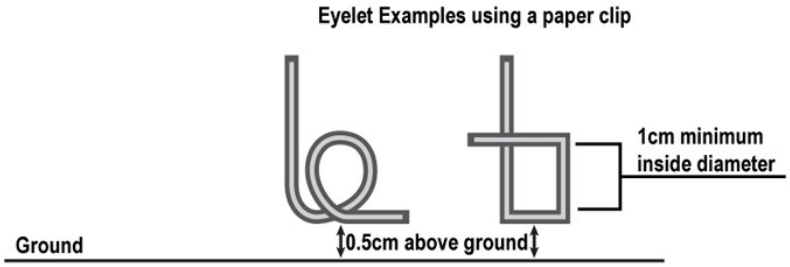
Individual decals may be affixed, and the body may be decorated at the teams discretion, but a 3 cm. square space must be left free on each side for the Sprint decal number.

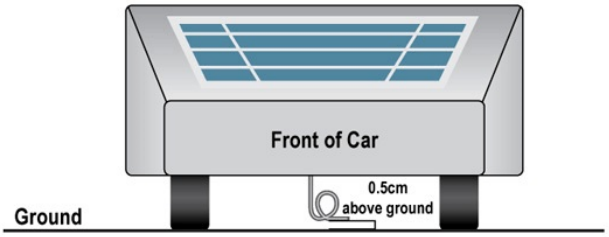
The material for the body of the car can be any type of light material.

Steering

An eyelet (see examples below) must be attached to the bottom of the car (our example shows placement on the 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.







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.

Design Notebook

A Design Notebook is required to be submitted with the vehicle for technical judging. It is used to help the design judges understand the decisions made during the design and construction process.

The Design Notebook 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 Design

Notebook does not have to be a finished, "polished" document, but rather a collection of notes, sketches, and test results of the design in progress.

The Design Notebook should be secured in a binder cover or notebook, and **must** contain:

- **Title page** that includes the team name, school represented, and the team member's names.
- **Project log** which documents each team meeting or work session. Entries include: the date, task(s) worked on, time spent on this task, team members present (initials or first names are okay), obstacles encountered (if any), and modifications to car design (if any). This can be prepared in a table if desired.
- **Design drawings** (minimum of 2) that include measurements and dimensions.
- **Finished car specifications** that include: car size, weight, sheel size, gear ration, and a **list of the components** used including the cost of each (include receipts, or copies, of items purchased). Recycled and reused components should be included and listed as such.
- **Test results** (minimum of 3), each test must include the weather (sunny, hazy, cloudy, etc.), distance traveled, time elapsed, speed (distance divided by time), comments on performance, and ideas to help improve performance.
- **Photos** of the completed car or during stages in the construction of the car.

The Design Notebook **may** contain:

- electrical schematics
- formulas and calculations used
- anything else the team wants to include for the design judges

Team Interviews

Judges will interview teams about their car's design and its construction. The interview is used to help the judges understand the roles each member played in the process, the team member's prior skill knowledge and lessons learned, team dynamics involved, and also to ask the team questions about any novel design features or unusual materials.

The interview will last approximately five minutes. The interview times will be assigned the day of the event. All team members are expected to participate in the interview. If an interview time is missed, it will not be rescheduled.

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.

Race Divisions

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.

The Race

- 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 EnergyWhiz Expos and the statewide EnergyWhiz event, a non-slick vinyl surface will be used for the track lanes.

The race will be conducted in two phases–time trials and a head-to-head double elimination competition for each division.

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 the 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 time will move to the head-to-head competition.

Head-to-Head Competition – The head-to-head competition is a 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.

Track Rules

At 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.

Decisions made by the racing officials are final.

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 irradiance meters monitored by race officials) 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 or Expo coordinators 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 race officials 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.

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.
- EnergyWhiz Expos and the statewide EnergyWhiz competition use a heavy gauge PVC coated material (used in the construction industry for containment barriers) for the track lanes.

Layout

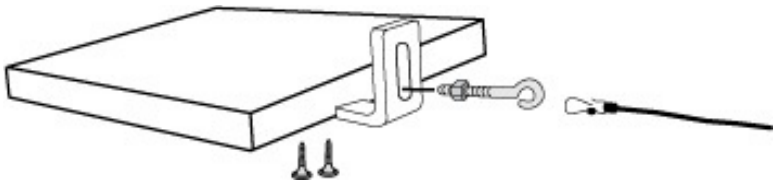
- Security roping should be placed around the perimeter of the track, as the guide wires are difficult to see.
- A second level of security roping should be used for team movement and to keep spectators off the track.
- A staging area near the start line and a run-off area beyond the finish line is necessary.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

Guide Lines

- Monofilament fishing line (60-lb test is adequate). Braided line works best for hot sunny days.
- The guide line should be suspended 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 corner-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 or buckets of sand are acceptable) and moved apart to give the desired line tension.



Detail of guide wire ends

Finish Line

- 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.