Solar Car Derby Activity

Overview

Raycatcher and SunZoom Lite Model Cars

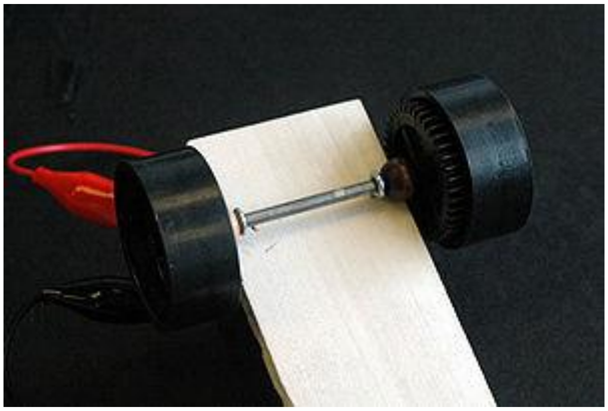
Model car races are a common science and engineering activity for youth groups because they are engaging, open-ended and have the excitement of competition. This gives us the chance to work in some great science concepts and engineering practices. The level of presentation can also be modified for different audiences. The Pitsco Sunzoom Lite ($8.95) and Ray Catcher Sprint Kit ($69) have all the materials for an extremely basic solar powered model car.

Procedure

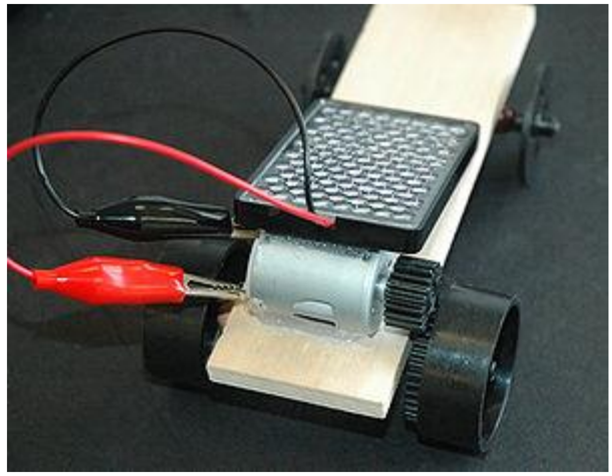
In modeling good scientific experimental practice and engineering design methods it's good to start with a basic "control" version of the car just as the kit instruction describe and then try to optimize various factors.

Basic construction

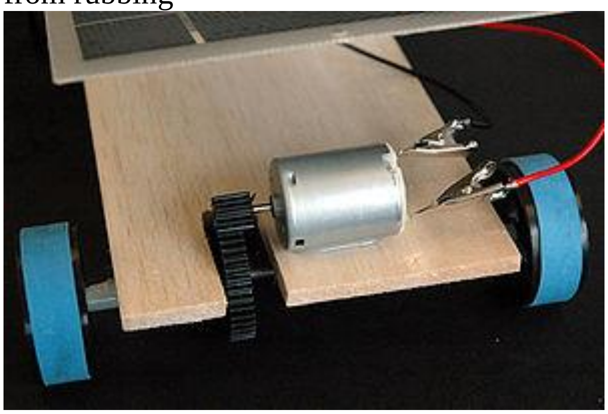
The basic design of the car is a piece of thin wood with screw eyes or plastic tubes that serve as bearing for attaching the axles. The kits come with a set of gears which fit either on the motor shaft or on the axles. Be sure to make sure the motor engages the drive gear on the axle without rubbing or slipping. You can attach the motor with hot glue because it most likely will not have to change. It’s better to attach the cell (s) with foam tape or rubber band so you can try different arrangements. If you have short time you can pre-assemble the screw eyes, motor and gears so that student just do the last step.



Screw eyes form bearings, spacers keep wheels from rubbing



The motor is positioned so it engages the gears.



The raycatcher requires a cut out for gear clearance

Dialogue

Building the car is really **a reason to have a conversation about solar energy**. Depending on the grade level you might try some of these questions with students.

Where does the energy for a regular car come from? Where does the energy from this car come from?

What are advantages of solar energy? (it doesn’t pollute or make carbon dioxide, it doesn’t run out, its free once you buy the equipment)

What do you have to do to make a complete circuit? (connect both sides of the motor to different leads from the solar panel.)

What do you do if your car run backwards? (reverse the wires, reverse the polarity and the motor will run the other direction)

Where do so solar panels usually go? (on the roof of buildings or in flat fields)

When does the panel capture the most energy? (When it is facing the sun directly)

What angle would be best for today? If it is late in the day the panel will have to tipped up.

What is one big problem with solar cars? (They won't work at night or in the shade)

How could you overcome this problem? (add batteries which can charge up in the sun)

What are the differences you notice between the different cells? (size, patterns, covering, number of cells within a panel)

What are two things you can measure with a multimeter (voltage and current- you can try to explain the difference with the water in a hose analogy- voltage is the pressure, the size of the hose and amount of water flowing is the current)

What is the voltage of a single solar cell? (about .5 volts)

How can you get a higher voltage? (wire several cells together in series)

How can you get higher amperage? (have larger cells, or cell wired in parallel)

How do you measure power? (multiply the voltage by the current to get watts- the load or resistance in the circuit will change both of these. The peak power point in the combination of voltage and current which produces the highest power)

What different kinds of solar cells are available? (monocrystalline solar cells are the most efficient, followed by polycrystalline, amorphous silicon, Copper Indium Gallium selenide – CIGS, dye sensitized cells and plastic solar cells.)

Let the races begin... When you have the basic model ready try a race. You can set up a side by side race or a race against a stop watch. Keeping track of times and variation in design reinforces the idea of methodical data collection in experimentation. In full sun either car should run freely until it reaches shade or an obstacle. If it's not full sun or the surface is very rough you might have to give the cars a push to get them rolling. Let the students help develop the rules for the race, and develop categories if they feel that would be fairer.

If you are using artificial light it is best to use 500 watt halogen work lights or incandescent spot lights because they have a focused beam and they emit part of their light in the infrared where silicon has extended absorption. Place the spotlight bulb in a clip on reflector holder which protects you from touching the outside of the bulb which can get very hot. Clip the light to a table or carefully hand hold it.

If you are racing on a table top it is helpful to build a race track out of 1x2 pine boards assembled into a 2ft x 6ft frame with screws. This low wall prevents the cars from shooting off the end. Two double 500 watt work lights on stands are adequate to illuminate this size track.

Some cautions:

- The halogen bulb produces enough heat that if left directed at these solar cells 2 ft from away they can melt the plastic casing of the cells in 20 minutes. Its better to turn on the lights only during a race and follow the car along the race course with the beam of the light.
- These bulbs are not meant for rough use. Be careful when moving the holder or setting the holder down, especially if the bulb is turned on, or else you can jar the filament and burn out the bulb.
- Watch out for heat. Only adults should attempt hand hold the light. If you use worklights on the ground make sure the area is clear and that people do not walk near the lights.

Variations / New Designs

Once you have completed and raced the basic kits the students should have gained feeling for what factors might make a difference. Now it is time to design and build some variations. Rather than just turning kids loose with materials it is good to have them create a design on paper with these elements.

- Name of trial/model
- Sketch of model
- Special features
- How special features work

As a leader you can guide students through this process with a "socratic" dialogue. For example ask "What could you do to make your car go faster, and win the race?" If they suggest adding more solar cells then "How would you connect the additional solar cells?”, "How would you support them?", and "What do you predict the result will be?

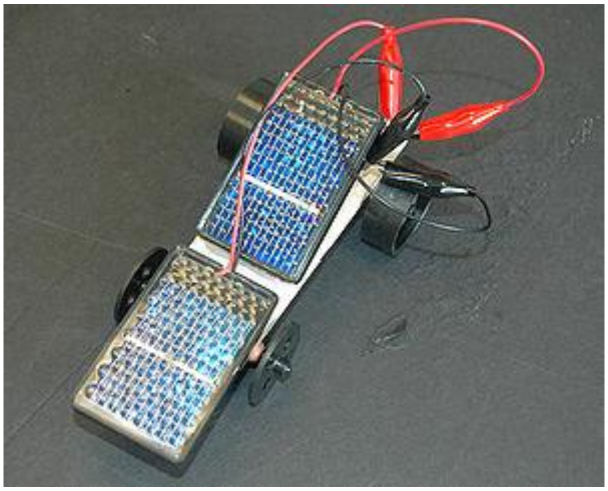
Solar Cell Angle

After you trouble-shoot the basic drive train, wheels and body assembly-- the first variation that students may discover is that of angle of the panel. Students can fashion supports that turn the cell to be perpendicular to the incoming rays. Explain that the solar cells capture incoming solar energy according for an area equal to the shade. Use a loose solar cell to show how changing the angle changes the size of the shadow. Ask them to determine what angle would capture the most light. Some of the cells have a lens pattern on the cover glass which is supposed to help them work at wider range of angles. You can make angle more important by arranging a race direction that is not advantageous for the current sun or light angle.

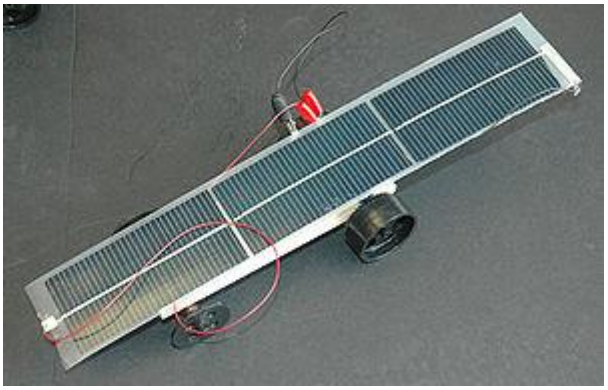
Solar Cell area

Adding more, bigger or better solar cells is the sure-fire method to improve power. Have students predict the winner for variations such as adding 2 or three additional cells, changing to a larger panel, adding reflectors to capture more light. Use an electric meter to measure the current and voltage that the proposed cells can produce in the given light. Compare this to the output from a single cell. They could also connect their cells to a motor and compare the speed rotation. Consider also the effect of wiring pattern. See wiring below.

Once they have selected the cells to use they have to figure way to attach and support them on the basic chassis. This may involve adding an additional support panel made from foam core or balsa.

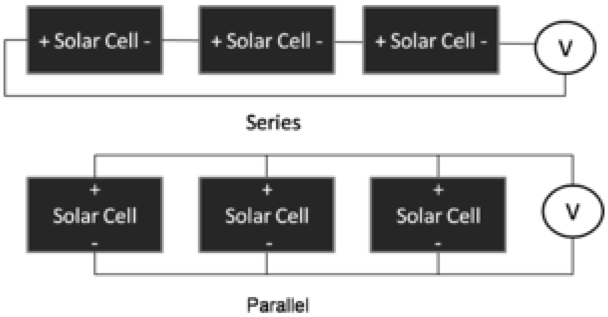


Two cells added to sunzoom



Large 1.5V x 1.2 amp panel added to SunZoom

Wiring



Two or more solar cells can be added with parallel or series wiring. In series the voltage of each cell is added and current is the same as any single cell. In parallel the current of each cell is added and the voltage is the same as an individual cell. Power is voltage x current. So for considering two cells.

.48V x 86 ma (parallel) = 41 mW = .96V x 43 ma (series)

Thus different wiring should not influence the total power delivered.

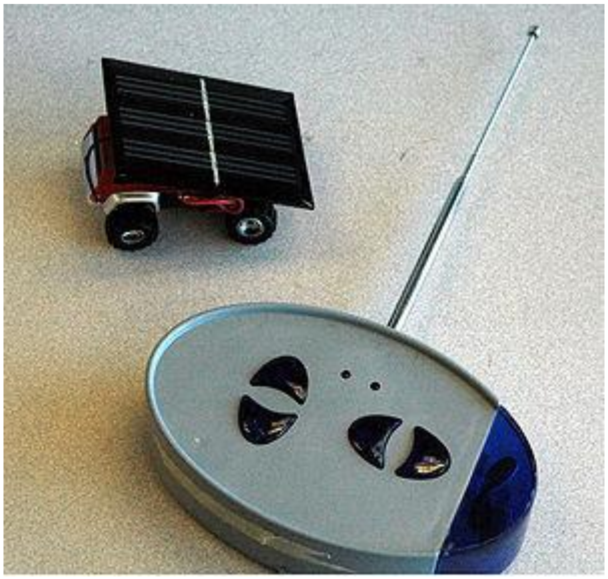
However motors are rated for a certain voltage range such as 1.5-6 volts. Each motor has its own characteristic performance issues such as needing a higher amperage to get started and then requiring more voltage to turn faster. One characteristic is needed to get rolling but another to win the speed race. A series circuit is sensitive to internal resistance of the cells. Furthermore, the maximum power output from a solar cell occurs at a certain combination of voltage and current. It is possible to force a cell to output at a combination of volts and amps that is not optimized for that cell.

The easiest way to answer the question of series and parallel wiring for multiple cells is to do the experiment!

Other factors

A solar car made at the National Science and Engineering Festival DC, 2010

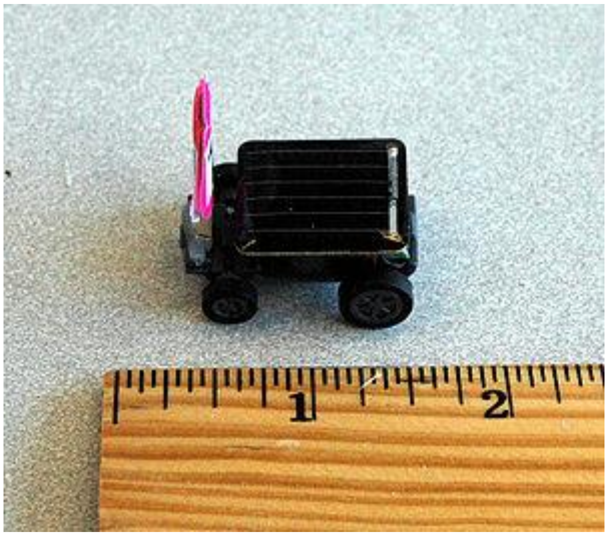
Students always want to streamline their models so they look cool and hope they will go faster. Wind resistance increases with the square of the speed. For this size model and at these low speeds wind resistance is a negligible factor.



Other factors that do make a difference is resistance against the axles, poor alignment of the drive gears, rubbing wires or rubbing wheels and chassis, and variability of each solar cell outputs.

Students can explore using some of the other gears in the kit. A smaller gear on the motor and bigger gear on the wheel will make it easier to get started if for example light conditions are low, but limit the speed once rolling. Increasing the gear on motor increases the relative speed of the wheels.

Derby Tools and Materials



Mini cars are fun but still need full sun

A 3 volt solar panel is wired into the charging jack on bottom of a mini remote control car. In full sun it runs great or charges internal battery under lights.

Tools

- Hot glue gun and low temperature hot glue

- Foam double sticky Tape
- Duct tape
- Rubber bands
- Utility knife
- Clip leads
- Volt /multimeter
- Clip on light bulbs
- 100 Halogen Spotlight (gets a little when used very close)
- 100W fluorescent (good for prolonged exposure up close)
- 500 Halogen worklight on stand (very hot- works best for indoor race)
- Stopwatch
- Smooth surface for races

Materials

- Foam core
- Balsa
- Cardboard
- aluminum foil or aluminized mylar

External Links

NREL Model Solar Car Lesson Plan

NREL solar Car hints

2007 Philadelphia Solar Sprint Derby

2008 Philadelphia Solar Sprint Derby

2009 Philadelphia Solar Sprint Derby

2010 Philadelphia Solar Sprint Derby

Source for Materials

Pitsco sunzoon lite car $8.95

Pitsco sunEzoon car $12.95

Pitsco polycrystalline solar panel with clips $2.95

Raycatcher car (big panel) $69

Electronics Goldmine solar cells

Solar mini car- $2.29 direct from China dealextreme- (delivery is slow)

Solar mini car from Amazon $1.99

Allpower solar panel from Amazon

remote control car

Double 500W work lights

