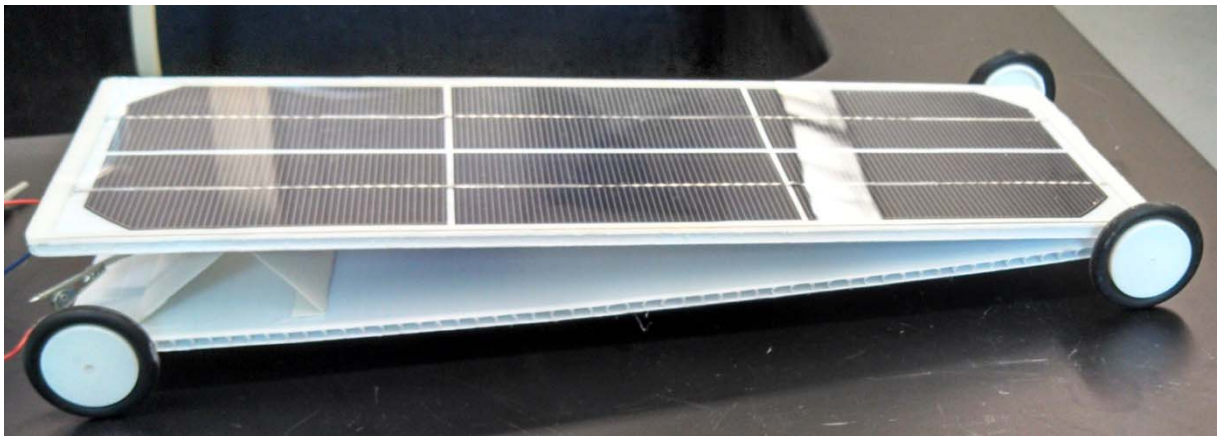
Elementary School Solar Challenge

Florida Gulf Coast University



The Elementary School team competition consists of a model solar car race. The model solar car is designed around the parts used in the Junior Solar Sprint competition originated by the National Renewable Energy Laboratory (NREL).

The races will be held in several heats where up to 8 teams race their solar cars head to head on a 30-50ft. straight track to see who can cross the finish line first. We are planning double elimination format to determine race winners (min. two races per team).
A second part of the competition is based on team knowledge of solar-electric vehicles, renewable energies, and other STEM topics.

Racing cars must have no more than a 3V/1Amp panel generating a max 3 W power. Each car will be inspected during check-in. The rest of the car is up to you!

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Materials

Kits for construction of the model car are available for purchase on line from the Solarmade company. It is recommended that teams obtain two items from Solarmade: (1) the Junior Solar Sprint Kit (JSS-KIT $23.99) and (2) the Accessory Bag (JSS-ACC $3.99). This will provide the student teams with:

The main kit contains:

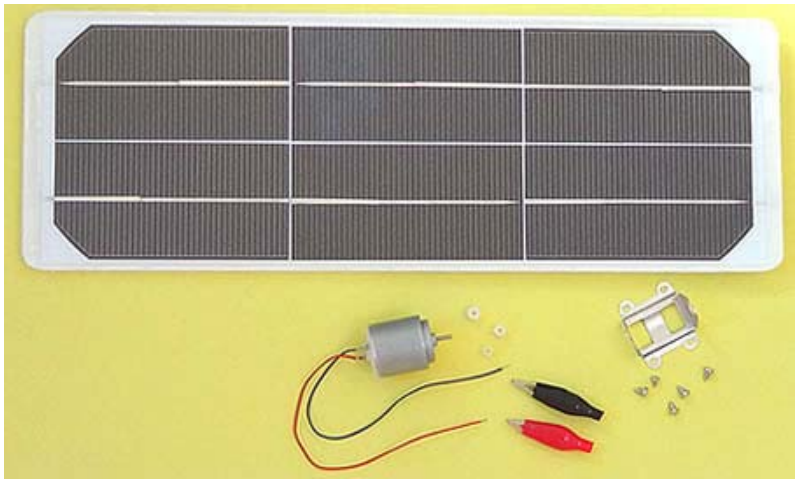
1 solar panel – 3 volts at 1 amp which gives 3 watts of power.

1 small electric motor with 6-in leads.

2 alligator clips.

Gears for the shaft of the motor.

Mounting bracket for the motor.



The accessory kit contains:

4 Plastic wheels

4 Rubber rings to act as tires

2 Metal axles

3 Gears of different sizes

The solar panel can be mounted on a stiff plate and covered by a plastic sheet. DO NOT pierce through the solar panel support plate to install the motor or axles. An additional board must be attached below the solar panel (this can be done with tape or glue). This additional panel supports the motor and the axles for the wheels. (See the photo below the title on the previous page).

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Operation:

Solar panel – The solar panel consists of a thin film of silicon which produces electricity when exposed to sunlight. (The fluorescent lights or incandescent lights in the house or garage are not sufficient to drive the motor.) Current is produced in the silicon photocell across its thickness. The cells produce electrons at the top surface when exposed to sunlight. If you look carefully, you will see very thin wires running across the cells. These wires collect the electrons produced across the thickness of the silicon cells. The thick wires cross the thin wires and collect their electrons. This defines the negative side of the circuit. The positive side of the circuit is not seen without taking the cell apart. (This is why we don't want you to pierce the supporting board.) The positive connections are made under the cell and are supported by the support board. So the current generated runs ***across*** the solar panel, from top to back surface. There are 3 cells in the solar panel. The 3 cells are connected in series. You can see that the thick wires of the left-most cell go under the middle cell and those wires go under the other cell. This forces the current produced by the cells to flow through all three cells. As a result each cell provides 1 volt of voltage which adds up in a series connection. (It's like having 3 waterfalls. If you stack them on top of each other, then you have only one waterfall but it is 3 times as high and powerful as a single waterfall. The water starts form a higher position and runs faster by the time it gets to the ground. This is a series connection.) So the series connection gives you 3 volts. Each cell produces 1 amp of current. This does no change in a series connection, so the 3-cell panel produces only 1 amp of current. Power is current times voltage (1 amp x 3 volts = 3 amp-volts which is called Watts) and is 3 Watts.

Motor – The motor is a DC motor and consists of 2 stationary permanent magnets facing in opposite directions forming the stator field between them. One magnet points its South magnetic field toward a rotating coil of wire that conducts the current from the solar panel. The other magnet on the other side of the coil points its North magnetic field toward the coil. When the current goes one way through the motor wires the magnet turns the motor shaft in one direction, but as the coil aligns between the magnets, then a switch that connects the current to the coil (the commutator) changes the direction of flow of the current through the coil. This pushes the coil to continue to turn until it again lines up between the magnets. Again the commutator reverses the flow of current through the wire loop and the rotational motion continues. As a result, if you connect a DC motor with the current flowing one way its shaft will spin in one direction and if you connect the current backwards, the shaft will rotate in the opposite direction. So, if your model racing car goes in reverse, then all you need to do is switch the connection between the motor wires and the solar panel. An illustration of the operation of brushed DC motors is seen in Wikipedia (http://en.wikipedia.org/wiki/DC_motor).

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Construction:

The model racing car can be any shape and size. To work best, it needs to have the solar panel from the kit be the top surface, so that it gets exposed to solar light. It is required that the motor and the axles are not mounted on the solar panel, so you will need a cardboard panel to make the base of the car.

Here we describe a simple and light construction. The student teams can either make a more interesting car or you can use this one. Remember the race is for speed. You have the same solar panels and same motors, so the best place to innovate are as follows:

(1) For the body: Lightweight is best for going fast and a streamlined design avoids air friction

(2) For the wheels: traction comes from the rubber ring around the plastic wheels and from good contact to the race course floor. This race is outdoors on asphalt pavement of a parking lot. If the car is designed as a wedge, the air flow over the top pushes down on the wheels and improves contact to the course floor. But in order to best capture solar light, the top panel should be flat. You can incline it a little, since the race is in the late morning and the Sun will be high in the sky. But if you make the wedge angle too steep, then you will not capture as much solar energy. You can if you like use rear wind deflectors like in race cars. And design the rest of the car to be flat.

(3) Some body designs can use vertical or tilted surface with mirrors to increase the sunlight on the solar panel. But then, you need to make sure that these surfaces are well aligned with the axles so they don't drag. On a windy day, the vertical surfaces can be a problem.

(4) For the wheels, they need to be aligned to make the car go straight. So the position and alignment of the two axles is critical and so is the mounting of the wheels on the axles. The race is designed to avoid steering by using a guide wire to make the car go straight, so you won't have the embarrassment of seeing your car go in circles off the track if the alignment of the axles is not good. However, a good alignment makes the car go straight on its own and increases speed.

To build the car body, students can use a cardboard base the same size as the solar panel. The base can be attached to the bottom of the solar panel at the front (opposite the side where the strip electrodes are). Glue or tape can be used to attach the two ends.

If the team plans to thread the axles through the channels inside the cardboard, the base must be cut so that these channels align perpendicular to the direction of motion of the car. Another approach is to run the axles below the cardboard and attach them

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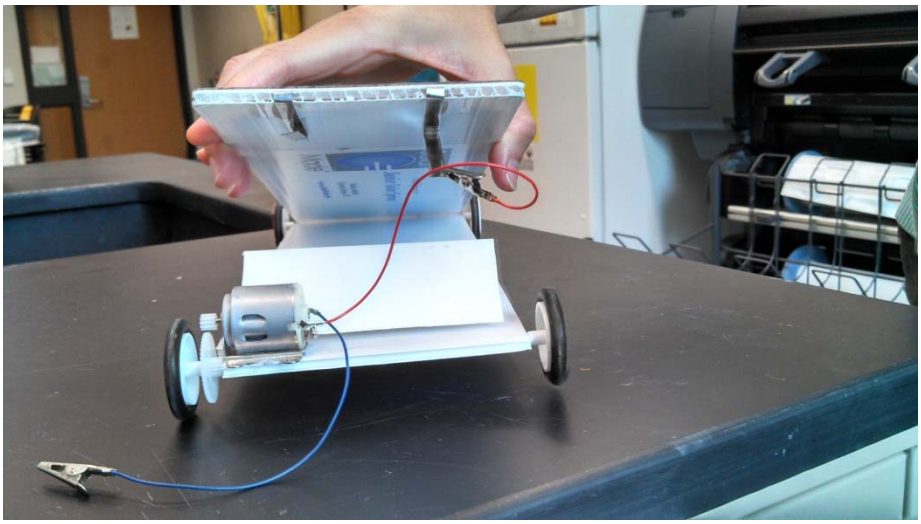
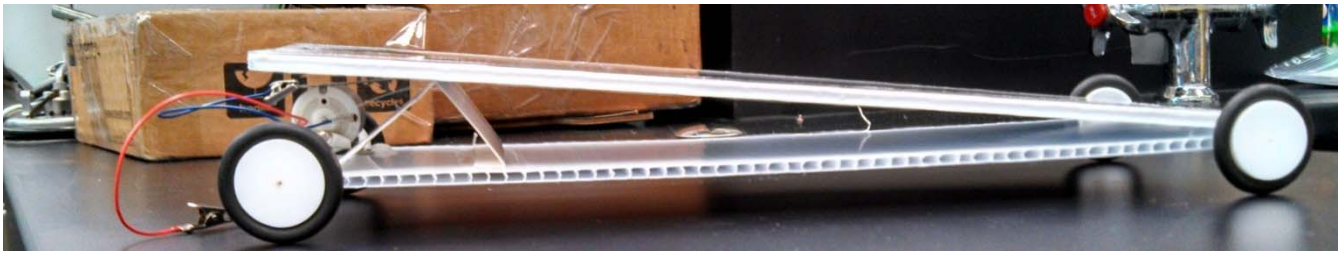
with a sleeve to the bottom of the cardboard. There should be a short sleeve at each end of the axle and it should be loose enough to allow the axle to spin without too much friction. This approach allows you to align the axles more accurately than using the channels in the cardboard.

The motor can be attached at the end of the base as shown in the figure. Here you need to make sure that the rear axle is long enough to make room for the gear and the wheel on the side where the motor is attached. A small cardboard roof is placed ahead of the motor to hold the solar panel above the motor. This also gives you the wedge shape of the car.





The rubber rings are placed over the wheels to serve as tires, as shown, and the wheels are mounted on the axles.

What is left is to choose the gears to use to drive the wheels. Here you must try several options until you find the best.

If the drive gear is smaller (fewer teeth), then it takes fewer engine rotations to turn the wheels, so you get higher speed but this provides less power to the car. On a flat race track, this is not a problem, but on asphalt one needs to be careful.
If the drive gear is larger (more teeth), then it takes more rotations of the engine to turn the wheels, so the car will be slower, but there is more power.

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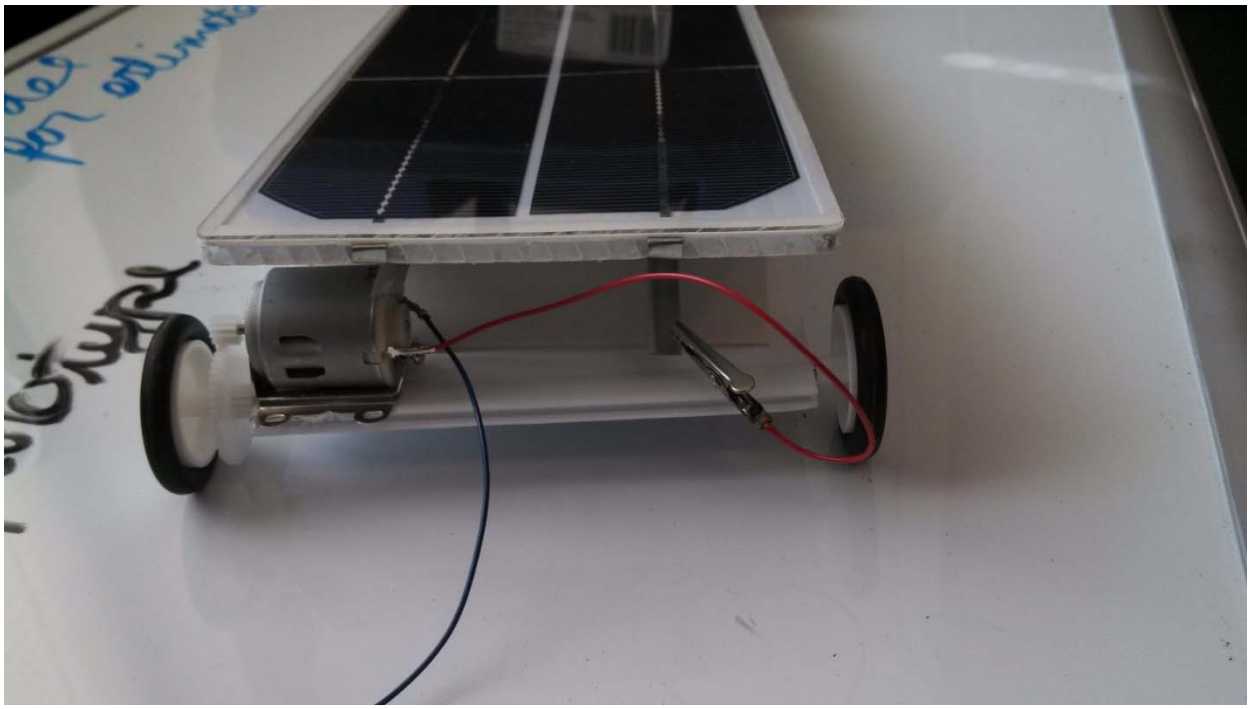

The motor mount can be simply glued to the cardboard base as seen here. Screws can be used if the team prefers a more secure attachment.

In order to make the electrical connection between the panel and the motor, you need to attach the alligator clips to the 2 wires from the motor. There is a red alligator clip and a black one, and there is a red wire and a black or blue one. You need to match the wire color to the alligator clip color (black and blue are interchangeable).

The alligator clips are covered by a plastic insulator. Under the plastic cover the alligator clip body is metal. The insulating cover is needed to keep the metal from the two clips from touching and shorting the current. In this device, there is no problem with shorting the alligator clips together, except that the motor will not run.

Pass the wire through the back hole in the plastic cover of the clip and pull the plastic cover back off the clip, so that the metal is exposed and the cover has the wire going through it. The wire is also covered by a plastic insulator, to avoid shorting the wires. But the end of the wire is frayed and uncovered metal. Pull your fingers along the end of the wire to smooth out the frayed uncovered metal and place the uncovered metal inside the U shape at the end of the alligator clip that is opposite the biting end. With needle-nose pliers, bend the sides of the U over the bare wire to hold it in place. This also makes a good electrical contact. If you have help, you may also add a drop of solder with a soldering gun to make a tight joint.

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The solar panel support plate has two flat wire electrodes to deliver the current for the motor. Connection between the motor and the solar panel electrodes is done through the two provided alligator clips. When connecting the solar panel electrodes to the motor, please insure that the correct polarity is maintained. Also the red alligator clip should go on the positive wire and electrode. The black clip goes to the negative wire and electrode. If not done correctly, the motor will run in reverse.

Race Rules:

The track will be 30-50 ft. long with up to 8 lanes and consists of a smooth metal roofing material.

The cars line up at the start and the starting gate is covered by a plywood cover. At the start whistle, the covering is removed and the cars should proceed down the track. Races will be recorded so that places can be definitively determined. Race heats will consist of a double-elimination format so each team will get to race at least two times.

A second part of the competition is based on team knowledge of solar-electric vehicles, renewable energies, and other STEM topics.

Points are awarded for each race heat and team knowledge. The winner will have the total best combined score.

Important websites:

All this information is found at the Whitaker Center Website and the STEM websites below:

The Junior Solar Spring kits can be ordered from Solar Made and they can be found at http://www.solarmade.com/store/category/junior-solar-sprint you can purchase the accessories and spare parts there too, or use other wheels, it is up to you!

The Florida Solar Energy Center has an events page that shows a similar race. at http://www.fsec.ucf.edu/en/education/k-12/energywhiz_olympics/index.htm

The National Renewable Energy Lab has put together a comprehensive guide for building the car and other car types at https://www.nrel.gov/workingwithus/car-competitions.html

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