SOLAR CAR (version 2)

DESCRIPTION

The *SOLAR CAR (version 2)* is a basic four-wheeled vehicle, driven by an electric motor, powered by a purpose designed solar panel. Power to the wheels is transferred from the motor by gears. This car will run on a smooth level surface from 25% sunlight upwards

The Solar panel consists of two sections, each of 1.5 Volts and 0.2 Amps, which can be connected in series or parallel.

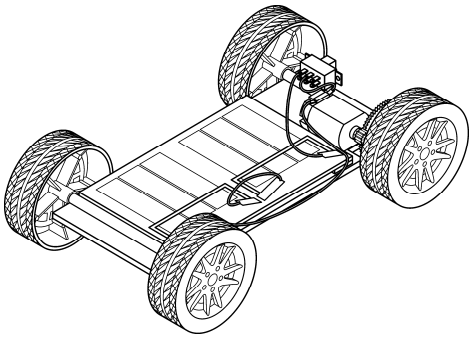

Figure 1 The SOLAR CAR

The illustration shows the prototype vehicle. The concept has scope for variation. Students should design a vehicle to suit their own needs.

COMPONENTS REQUIRED

a. COMPONENTS SUPPLIED

The following components are supplied in the kit:

1 x 1.5-4.5 volt electric motor (flat)
1 x Solar module 2x1.5Vx0.2Amp (#11)
1 x Sliding switch (DPDT - small)
2 x Steel shaft 2.5 dia. x 125mm long
2 x PVC Guide tube (white) 100mm long
4 x 52mm diameter Wheels
1 x 50T/10T spur gear – 2.4dia. hole
1 x 60T/10T spur gear – 2.4dia. hole
1 x 12T Pinion gear – 1.9dia. hole
1 x 10T Pinion gear – 1.9dia. hole
1 x 8T Pinion gear – 1.9dia. hole

b. ADDITIONAL REQUIREMENTS

b.1 The following material and parts are to be supplied by the student: material for the platform (plastic and plywood are both suitable), fine electrical wire, double sided tape, hot glue gun.
NOTE: We used 3.0mm thick PVC sheet (approximately 70mm x 160mm) for this project. (For plastic sheet refer the Yellow Pages under the heading "Plastics Fabricators.")
b.2 if you choose to modify the design, or carry out testing, as described later, our component range has an assortment of items that may be useful. These include: on-off-on toggle or slide switches, alligator clips & wires and steering components.

1. DESIGN CONSIDERATIONS

1a. GENERAL

The drawings provided are a starting point for the student.
Before starting construction, the student needs to carefully plan and layout all of the components.
The plan view of our prototype vehicle is shown in Figure 2.
The exploded view indicates the relationship between the various components. The design of the *SOLAR CAR* should be considered as a complete unit, not just as separate parts.
The design should be carried out with the testing envisaged, and the end usage in mind.
The student needs to determine the material from which the platform is to be constructed.

When deciding on the platform's size and shape:

- The platform can be made from any size piece of material, even a very narrow one, in which case stability needs to be considered.
- The axle shaft and guide tube length provides an upper limiting factor for the width (ie. across the wheels).
  NOTE: Cut-outs may be made for the wheels to allow a wider vehicle to be constructed.

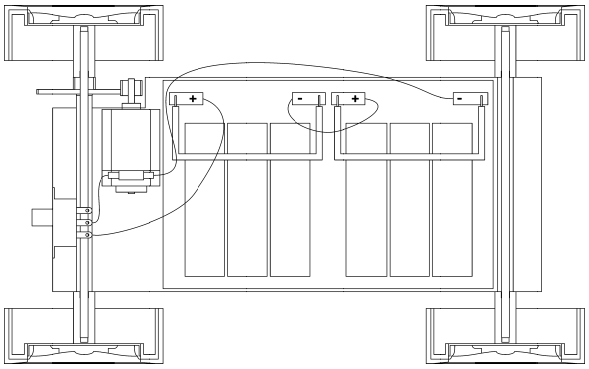

Figure 2 Top View

Other things to consider:

- the guide tubes are used as bearings for the axle shafts.
- the vehicle as shown in our drawings is basic, but it also allows scope for the student to develop and make a more sophisticated vehicle.
- the vehicle can only travel in a fixed direction - either straight ahead or in a predetermined circle. This (circular travel) can be achieved by putting the front axle shaft on an angle.
  - a selection of spur and pinion gears are provided. This provides the designer with scope, to select the desired top speed of the vehicle. A number of combinations are possible with the supplied gears, and provides the designer a choice of different vehicle speeds. Consider the effect of different gear ratios have on top speed.
  - the student should calculate the ratios available.
  - determine which spur gear / pinion gear combination to use.
  - how do these various ratios translate into actual speed? Take into account wheel size and motor speed (how fast does it spin under full sunlight? On an overcast day?).

Note 1: the maximum motor speed, at maximum efficiency, is approximately 4,500 rpm.
Note 2: to investigate gearing further, we have more information in our *DRAGSTER* teaching unit (downloadable from our website). Alternatively, the program *"Crocodile Clips"* is a useful program for simulating the operation of gears, and investigating their operation.

1b. ITEMS FOR INVESTIGATION

This project provides a number of different aspects of the *SOLAR CAR* for investigation. Some ideas are listed below.

- The Solar panel is a purpose designed unit, consisting of 2 sections, and these are able to be connected in series or parallel. The use of 2 sections is useful for experimentation, as it means that you could experiment with the output of the panel in 3 different configurations:
  - only one section to see how much power is output, what speed is attained
  - both sections connected in Series
  - both sections connected in Parallel.
- Establish conditions for using the solar panel's sections in series or parallel. Set up a test schedule for these experiments.
- If working in a class, you may wish to assemble a number of these vehicles with different gearing. This will allow you to test the theory / calculations made for the various gearing combinations. This can be tested using a stopwatch over a known length of track (or a variety of distances – to establish when top speed is reached, and what it is)
- How are these speeds affected by having the sections connected in series? In parallel?
- Evaluate the suitability of various materials, such as PVC, acrylic and plywood or balsa wood
- Investigate adding steering. This could be either manual (set the steering in a chosen direction before each use) or controlled (how would you control it? Remote control? Or by a wired controller?). For some ideas on steering, you could look at our *FORKLIFT*, *RADIO CONTROLLED VEHICLE* and *FOLLOW WHITE LINE VEHICLE*.
- You may wish to incorporate forward / reverse operation.

2. THEORY

2.1 HOW THE SOLAR PANEL WORKS

Silicon solar cells generate electricity when exposed to sunlight, but a halogen lamp can also be used. Each cell produces 0.5 Volts. The current (amps) produced is proportional to the cell's surface area. The cell's power is rated at "full sunlight". When the sky is overcast, the sun's power is lower, and the amount of amps produced is less, while the voltage remains 0.5volts.
NOTE: The power output also decreases as the temperature of the panel increases.

Each of the sections in our panel has 3 cells connected in series, to give a voltage of 1.5 Volt. Each section is designed to be 0.2 Amps at full sunlight.

- At full sunlight, when the solar panel's two sections are connected in series the car will run fast. As the sunlight diminishes, the speed will also gradually diminish until finally the *SOLAR CAR* will stop. The *SOLAR CAR* stops because the current is too low.
- When the current gets too low (with the sections in series), reconnect the two sections in parallel. This provides double the current, and the motor will start running again – although slower, due to the voltage being reduced.

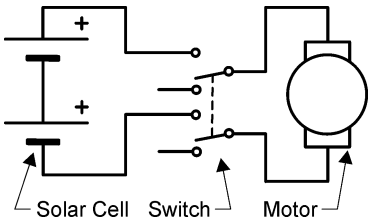

Figure 3 Series Circuit

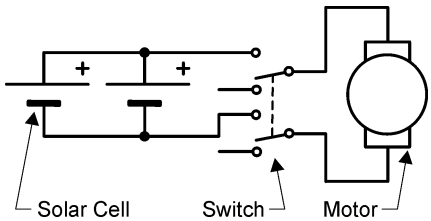

Figure 4 Parallel Circuit

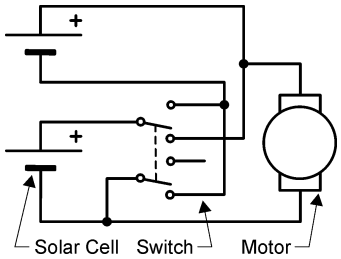

Figure 5 Series/Parallel Circuit

2.3 HOW THE CIRCUIT WORKS

The motor is powered by a solar panel, consisting of two sections. In bright sunlight, each section produces 1.5Volts at 0.2Amps. These can be connected in different ways.

- When the two sections are connected in series (Figure 3), in bright sunlight the motor receives approximately 3.0Volts at 0.2Amps.
- When the two sections are connected in parallel (Figure 4), in bright sunlight the motor receives approximately 1.5Volts at 0.4Amps.
- You may choose to construct a circuit, so that the two sections can be switched between the two variants (ie. series or parallel – Figure 5). It is recommended that a DPDT switch with a central "off" position (not supplied) be used for this option.

3. ASSEMBLY

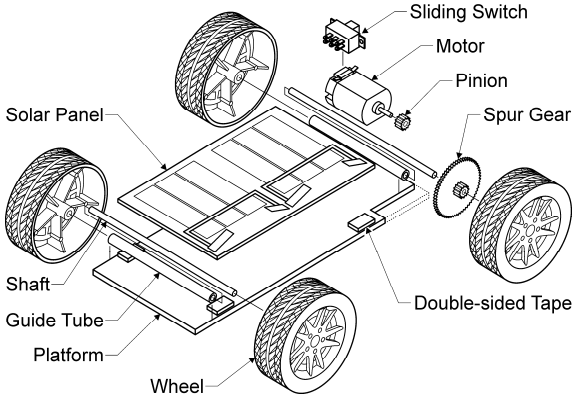

Figure 2 Exploded View

3.1 FABRICATION

- Cut the platform material to the required size.
- Cut the steel shafts to the required length and de-burr the ends.
- Press the selected spur gear onto the rear shaft, with enough of the shaft protruding, through the gear, for the wheel to be pushed on. Hint: use a piece of wire to measure the depth of the hole in the wheel
- Insert the shafts into the guide tubes. Press the wheels onto both shafts.
- Support the motor on a firm surface and push the pinion gear onto the shaft.

WARNING: Don't just push the motor down by hand as this can push the motor armature out of its bearings and jam the motor.
Hint: Place the gear on the bench, insert the motor shaft into the pinion gear's hole and gently tap the end of the shaft (where it exits the motor) with a small hammer. Stop when the pinion gear is level with the end of the shaft - do not push the gear too far, or it will rub on the motor casing.

3.2 ASSEMBLING THE CAR

NOTE: the best methods for attaching items to the chassis are either hot glue of double sided tape.
WARNING: Take care if using hot glue to avoid burns.

- Attach the solar panel to the platform, in the position chosen, using double-sided foam tape.
- Attach the pre-assembled front axle (guide tube, shaft and wheels) to the platform with hot glue. NOTE: Ensure that the shaft guide tube is at right angles to the car's platform and both guide tubes are parallel to each other – unless you have chosen for the car to travel in a circular path.
- Attach the pre-assembled rear axle to the platform
- Use hot glue or double-sided foam tape to attach the motor to the platform. The pinion gear should engage the larger diameter gear of the rear wheel's spur gear, and the motor and wheels should turn freely.
- Attach the switch to the platform.

3.3 WIRING

3.3.1 GENERAL

You may wish to carry out a range of experiments, using the various combinations of the solar panel (one section, series or parallel). If so, you might like to be able to change the connections as and when required. If this is the case, we recommend that the connections between the solar panel's sections are made using alligator clips and wires, rather than soldering leads in place.

3.3.2 SOLDERING

NOTE: When soldering wires, strip a short piece of insulation from the end of the wire, twist the strands and use a hot soldering iron (approx. 350°C) to apply solder.
WARNING: Take care when soldering to prevent burns.

- If you have decided on a specific configuration (series, parallel or switchable), solder wires between the sections of the solar panel, switch and motor.

Test the operation of your *SOLAR CAR*

- If the car goes backwards, swap the wires connected to the motor, and solder them in place.
- If the car goes forward as expected, solder the motor's wires in place.

Congratulations! This completes the *SOLAR CAR.*

HAVE FUN!