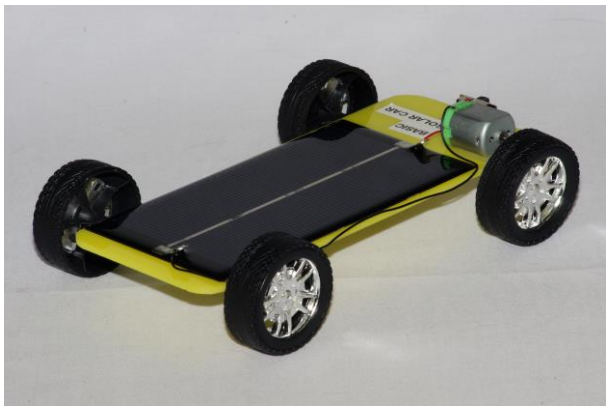
SOLAR CAR – NO SOLDER

CONTENTS:

DESCRIPTION

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



SECTION 1: GENERAL AND PLANNING INFORMATION

1. DESIGN CONSIDERATIONS

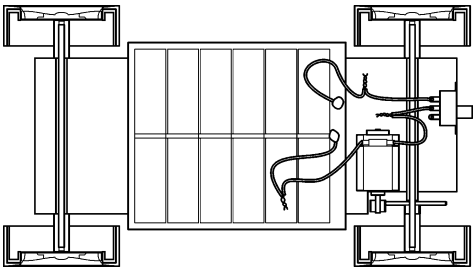
1.1 GENERAL

The major parts of this project are the vehicle's planning, design, construction and assembly stages. To this can be added such things as usage and performance.

1.2 DESIGN

- The drawings in this unit show the basic construction of the vehicle.
- The student has to make a full size drawing to determine the size of the vehicle's platform, the size and position of wheels, and the location of the motor, switch and solar panel. The body can be made from a single long piece of wood or plastic. The plan view of our prototype vehicle is shown in Figure 2.
- The PVC guide tubes are used as bearings for the axles, and are attached (glued) to the platform. The tubes should be 2-3 mm longer than the width of the platform. This prevents the wheels rubbing against the base, and slowing the vehicle down.
- When defining the width of the vehicle, the axle shaft provides an upper limiting factor. However, if a much wider vehicle is desired, cut-outs can be made for the wheels to allow wider material to be used (for an example, refer to the DRAGSTER unit on our website)
- In regard to the width, the platform can be made from any piece of material, even a very narrow one, but stability needs to be considered.
- With this vehicle only fixed steering is possible. However, you may wish to make it, so that the steering turns the car in one direction all the time, by mounting the front axle at a slight angle.

- 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.
- Evaluate the suitability of various materials, such as PVC, acrylic and plywood or balsa wood
- You may wish to incorporate forward / reverse operation.
- A selection of spur and pinion gears is 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.



TOP VIEW

- How do these various ratios translate into actual speed? Take into account wheel size and motor speed (how fast does the motor spin under full sunlight? On an overcast day?).
- 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).

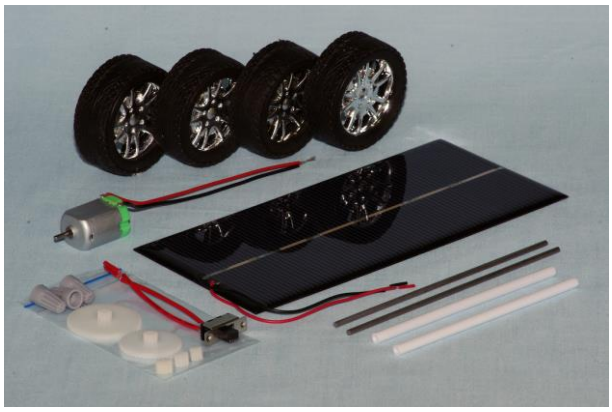
NOTE: The maximum motor speed, at maximum efficiency, is approximately 4,500 rpm.

NOTE: To investigate gearing further, we have more information in our DRAGSTER teaching unit (downloadable from our website). Also, the program "Crocodile Clips" is useful for simulating the operation of gears, and investigating their operation.

SECTION 2: COMPONENTS & MATERIAL REQUIRED

2.1 COMPONENTS SUPPLIED

The following components are supplied in the kit:



2.2 ADDITIONAL REQUIREMENTS

The following material is to be supplied by the student / designer:

- Hot glue or double-sided foam tape
- Material for the platform (PVC or acrylic sheet, plywood, etc.)

- NOTE: Plastic materials can be purchased from plastics suppliers (in the Yellow Pages under the heading "Plastics Fabricators" or search the Internet.)

2.3 TOOLS REQUIRED

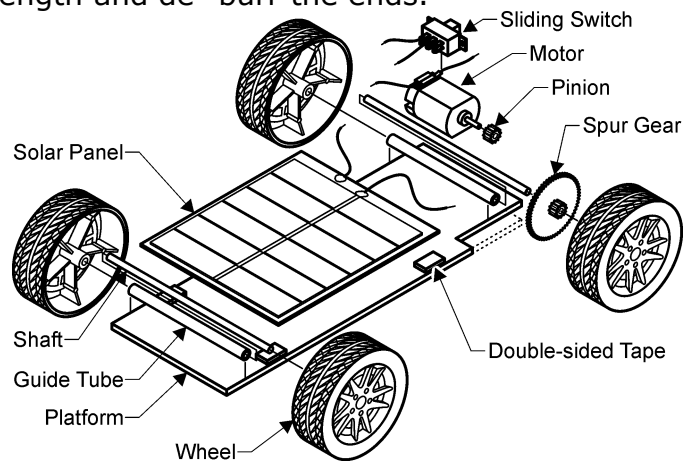
The following tools are required:

- Assorted hand tools

SECTION 3: CONSTRUCTION

3.1 FABRICATION AND PREPARATION FOR ASSEMBLY

- 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 (see Hint below).



EXPLODED VIEW

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

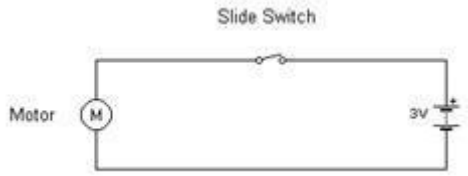
NOTE: the best methods for attaching items to the chassis are either hot glue of double sided tape.

WARNING: If using hot glue be very careful as it can burn you, if you get it on yourself.

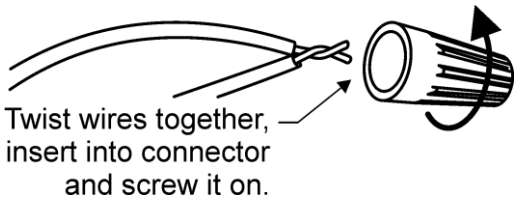
- Attach the solar panel to the platform, in the position chosen, using double-sided foam tape.
- Attach the pre-assembled front axle (guide tube, shaft and wheels) to the platform with hot glue.
  NOTE: Ensure that the shaft guide tube is at right angles to the car's platform and both guide tubes are 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.

SECTION 4: WIRING

The electrical wiring should be wired as shown in the "Circuit Diagram".



- Connect the solar panel's red wire to one of the red wires from the switch. Twist the ends together, and finish by screwing on the screw-on connector.
- Connect the switches other red wire to the motor's red wire. Twist the ends together and finish by screwing on the screw-on connector.
- Twist the black wires from the motor and solar panel holder together and finish by screwing on the screw-on connector.
- Insert the batteries, and turn the switch on:
  - If the vehicle moves forward, your wiring is correct.
- You will need to test the vehicle's function.



NOTE: This kit has components that allow this to be assembled without soldering. However, the connections will be more effective and permanent if they are soldered.

SECTION 5: TESTING

5.1 ELECTRICAL TEST

Once the car has been constructed, you need to test it.

- To test the operation of your SOLAR CAR, place the SOLAR CAR in direct sunlight or under a strong lamp (refer the explanation below).
- If the vehicle goes in reverse, you will need to swap the motor's wires:
  - Remove the motor's red wire from the switch and untwist the black wires from the motor and solar panel.
  - Twist the red wire from the motor to the black wire from the solar panel.
  - Connect the motor's black wire to the remaining red wire on the switch.
  - Twist the ends together and finish by screwing on the screw-on connectors.

5.2 SUNLIGHT VERSUS ARTIFICIAL LIGHT

For testing your car a good substitute for sunlight is a powerful halogen lamp. Mains powered halogen flood lamps are readily available from lighting shops or hardware suppliers.

A 500 watt lamp directly facing the panel and about 300mm away, will produce a light level equivalent to about 50% Sun.

CAUTION: The lamp puts out more heat than the sun, so to avoid panel damage only illuminate the panel for about 40 seconds – then allow the panel to cool down.

A safer option is a low voltage 100 watt handheld halogen spotlight. This type of lamp is available from automotive accessory stores and is usually 12 volt rated. You will need a suitable battery or power supply. This lamp is suitable to demonstrate power generation but is not sufficient to run a vehicle.

NOTE: In the classroom, the light may appear very bright to our eyes, but the car does not run as the light level is far too low for the solar panel to produce useful quantities of power. Fluorescent lights are a poor substitute for Sunlight, as the

frequency of light they produce is very different from the sun. Incandescent lamps are much better, however remember that full sunlight is around 1000 Watts per square metre. In a typical room at home you might have 500 Watts of light in a room of 15 square metres, this is only about 3% of the energy provided by full Sunlight, so it is no wonder solar panels do not work well inside.

SECTION 6: THEORY

Silicon solar cells (photovoltaic cells) generate electricity when exposed to sunlight, but a halogen lamp can also be used. These cells can be likened to a generator using sunlight as fuel. The electricity generated from the photovoltaic cells can be used immediately or stored in a rechargeable battery.

6.1 THE SOLAR CELL

Solar cells are silicon based and typically in the order of 0.3mm thick. They are a glass like material, which is very brittle. Consequently they must be mounted in a way that offers protection. The front side of the cell exposed to the sunlight is negative (-ve) and the underside is positive (+ve).

A single solar cell, when exposed to sunlight generates electricity at a voltage of just over 0.5 volts and a current which varies with the area of the cell and the light intensity. The power generated by the cell at 25 Degrees Centigrade when exposed to light having the same frequency spectrum as the Sun with an energy density of 1000 watts per square metre is its rated power.

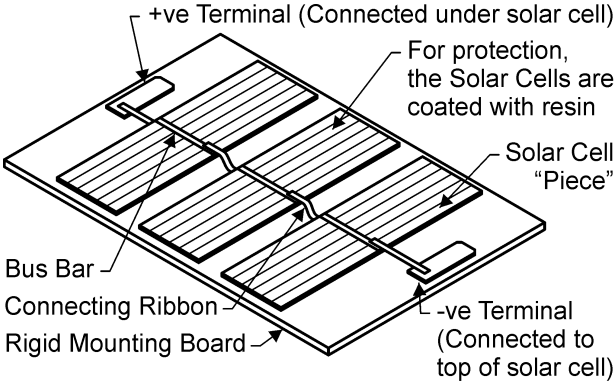
Typically high quality cells have a conversion efficiency of around 20%. That is they produce electrical energy equal to 20% of the light power falling on them. As the cell temperature increases the power produced falls, predominantly due to dropping voltage. As a rule of thumb power falls by about 0.45% per Degree Centigrade increase in cell temperature.

6.2 THE SOLAR PANEL

The solar cells are manufactured in different sizes. Standard sizes include 100 x 100mm, 125 x 125mm and 156 x 156mm. For hobby purposes, they are far too large, with too many amperes.

Depending on the Amps (current) required, the cells are cut to the required sizes and connected in series, to give the required voltage. Thus, for example, if three (3) cells 100 x 100 mm are connected in series you will have 1.5 Volts and about 2.8 amps.

Consider our Solar Panel No. 11, as supplied in our Solar Car Kit (version 2). The panel consists of two arrays, each being 1.5Volts, 0.3 amps. When using it in full sunlight, one array is enough to drive the car. However, if the sky is overcast the car will not run, as the amps generated are too low.



Construction of a "hobby" solar panel - 1.5 volts

ILLUSTRATION ONLY

A TYPICAL HOBBY SOLAR PANEL

If the two arrays are connected in parallel, the amps will be doubled, your car will run.

In full sunlight, if you connect the two arrays in series, the voltage generated will be doubled allowing the car to run twice as fast

Excellent in depth technical information on solar cells and panels can be found at http:www.pveducation.org/