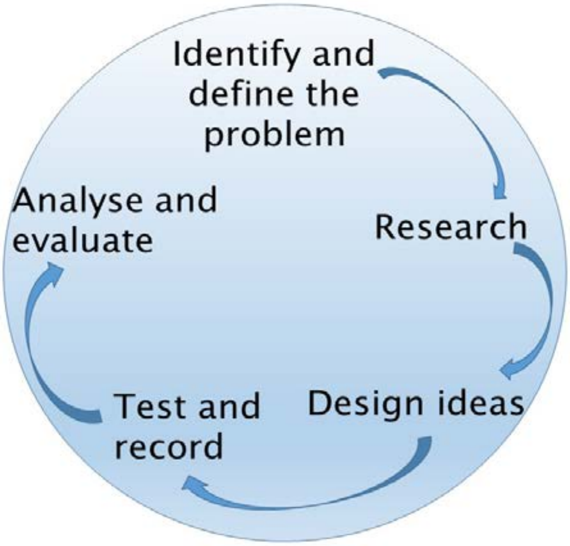
The Challenge

Every two years the World Solar Challenge takes place in Australia. This is a solar powered car race which starts in Darwin and finishes in Adelaide (3,022 km). It runs through the Australian outback and was created to foster the development of experimental, solar-powered vehicles. The race attracts teams from all across the globe, most of which are made of people from large corporations or universities. Sometimes high schools also enter teams.
Your challenge is to investigate the factors which effect the efficiency of a solar car and to use your findings to design a solar car.



Background Information

It is well known that transport that uses petrol or diesel produces carbon dioxide and other gases (and particulates) which have a negative impact on the environment and people's health. As scientists become more aware of the causes and impacts of global warming there has been more focus on designing more environmentally friendly cars – solar cars being one of them.

Figure 1. Solar car - with solar panels on the top of it. (Hideki Kimura, 2009)

Solar panels work by absorbing light energy from the Sun and converting it into electrical energy. This electrical energy is then used to turn the motor and make the car run. There are different types of solar panels, some are more efficient than others. This means they turn more of the light energy into electrical energy. Most solar panels are between 15 – 20 % efficient, with the top of the range being around 23% efficient. This means they convert 23% of the light energy hitting them into electrical energy (that's just less than a quarter).

There are several factors which will effect the efficiency of a solar panel:

- the material used in the solar panel,
- the wiring – how the panels are wired up and what the wires are made of, and
- the amount of reflection (this will depend on the type of glass used) – the more light that is absorbed the more efficient the panel will be.

There have been massive improvements in solar car designs since the first World Solar Challenge took place in 1987. The Dutch Nun team were the first to beat an average speed of 100 km/h in 2005. This has brought about a change to the race rules and class entries. For example, the introduction of the Cruiser category, which focuses on designing solar cars that can fit multiple occupants and carry larger loads. The aim is for solar cars to become more like commercial cars and to be more practical for the everyday user.

Background Research

1. Define what is meant by renewable energy?

2. What are some of the positives of using solar panels to power a car?

3. What are some of the negatives of using solar panels to power a car?

4. What are the three different types of solar panels? Outline the advantages and disadvantages of each.

Type of panel	Advantage	Disadvantage

5. What does the word photovoltaic mean?

6. Where do electric cars get most of their energy from?

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7. What generates most electricity in Australia?

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8. Why are solar cars better for the environment than electric cars at present?

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Weight and Speed

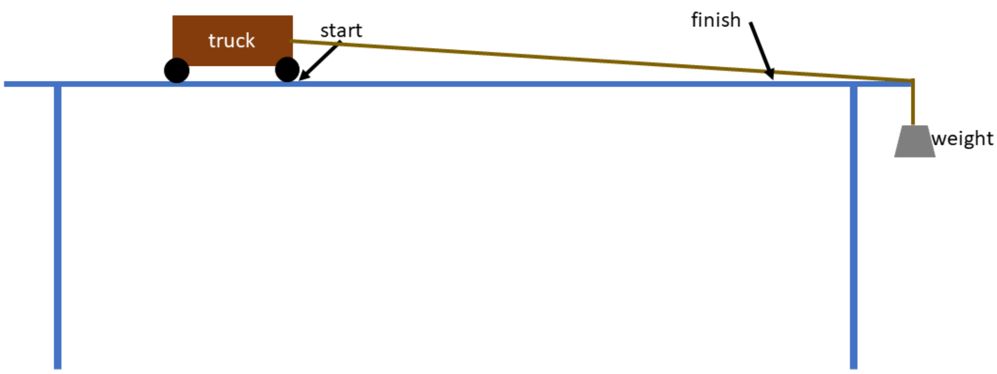
Objective

To make solar cars more feasible and desirable it is important that they can be used by the average person and family. This means they have to be able to perform like a regular car. This includes carrying many people, shopping etc. in them. This experiment is designed to find out if there is any relationship between the load of a truck and how fast it goes. Then relate this to the design of a solar car.

Equipment

- 1 wooden truck
- 1 x 1 m long length of string
- Slotted mass or weight
- Meter rule
- Stopwatch
- Whiteboard marker or masking tape
- Blocks/weights or plasticine.
- Scales

Method



1. Weigh your truck and record it into your results table.
2. Measure out a 1 metre track on your table and use the whiteboard marker or masking tape to mark where the start and finish line are.
3. Tie the slotted mass to one end of the string and then the truck to the other end.
4. Place the front of the truck on the start line and hang the slotted mass over the table edge.
5. Let go of the slotted mass and immediately start the stopwatch. Time how long it takes the truck to cross the finish line. Record your results in the table below.
6. Add blocks/weights or plasticine to your truck, weigh it and record the results into your table. Repeat steps 4-5.

7. Repeat the experiment adding more weight to the truck each time, recording your results in the table.

Results and Analysis

Weight (kg)	Time taken (s)

1. Plot your results in your table as a column graph.

2. Is there a relationship between the weight of the truck and the time taken to move the distance?

3. Is the truck faster when it is heavier or lighter?

Evaluation

1. What variable(s) did you keep the same in this investigation?

2. What variable did you change in this investigation?

3. Was this a fair test?

4. How could you improve this experiment?

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5. What do your results mean in terms of designing a solar car?

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6. The more solar panels a solar car has the more energy it will generate, but what will having lots of panels mean for the weight of the car?

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Streamlining

Objective

To observe the effect of streamlining and relate this to solar car design.

Research

1. What is the definition of streamline?

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2. Why is a streamlined car desirable?

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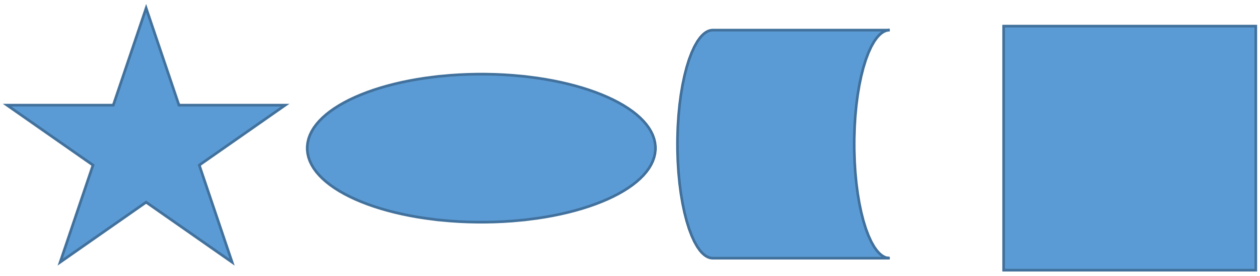
3. Put these shapes in order of most streamlined to least streamlined



Equipment

- Plasticine (about a walnut/ honkey nut sized amount)
- Fish tank or large cylindrical tube
- Thin wallpaper paste
- Stopwatch

Method

1. Ask your teacher to fill the fish tank with wallpaper paste.
2. Mould the plasticine into a shape that is not very streamlined.
3. Draw a picture of your shape in the results table below.
4. Drop the plasticine into the fish tank and immediately start the stopwatch.
5. Time how long it takes to reach the bottom and record your results in the table below.

6. Repeat the investigation changing the shape of the plasticine to be more streamlined.

Results and Analysis

Shape (drawing)	Time taken to reach the bottom (s)

1. Which dropped faster, the shapes that were not very streamlined or the more streamlined shapes?

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2. How could making a car streamlined effect how fast it can go?

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Evaluation

1. What variable(s) did you keep the same in this investigation?

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2. What variable did you change in this investigation?

3. Was this a fair test?

4. How could you improve this experiment?

5. How practical was your most streamlined shape for the design of a car? Explain your answer.

Temperature and Efficiency

Objective

To find out if there is any relationship between the temperature of a solar panel and how efficient it is.

Equipment

Write an equipment list which will allow you to conduct this experiment. Show this to our teacher and gain their approval before conducting the experiment.

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Method

1. Measure out a one metre track on a flat area of ground in a sunny spot.
2. Place the solar car on the start line and time how long it takes to reach the finish line. Record your results in the table.
3. Heat the panel up for two minutes.
4. Repeat step 2
5. Cool the panel down for two minutes, then repeat step 2.

Hypothesis

Do you think the car will be faster when the panel is hot, cold or at room temperature?

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Results and Analysis

Temperature	Time taken (s)
Room temperature	
Hot	
Cold	

1. Draw a bar chart with the temperature on the bottom and the time on the side.
2. Was the car faster when the solar panel was hotter or colder?

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Evaluation

1. What variable(s) did you keep the same in this investigation?

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2. What variable did you change in this investigation?

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3. Was this a fair test?

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4. How could you improve this experiment?

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5. Will a solar panel work better on a hot summer day or a cool, clear winter day? Explain your answer.

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Time of Day

The Sun rises in the East and sets in the West. Over the course of the day the movement of the Earth, relative to the Sun, will lead to shadows also moving and changing in size.

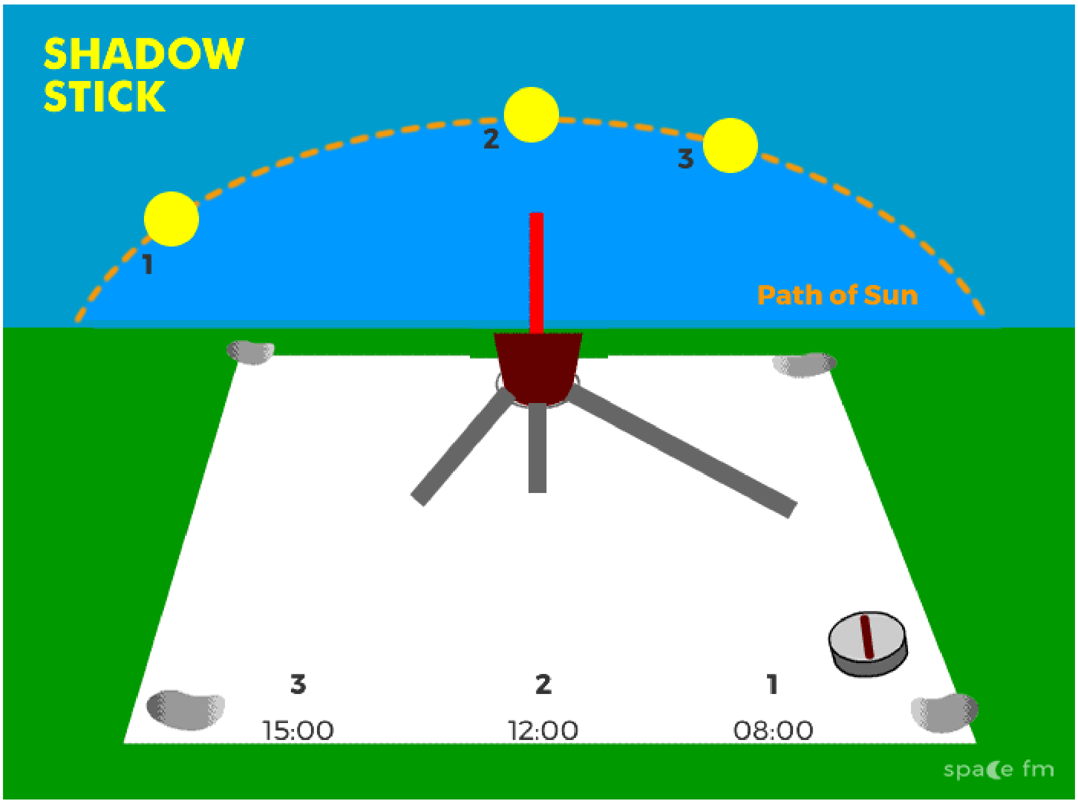

Figure 2. Sun movement throughout the day causes the shadow to also change size and direction. (https://www.space.fm/astronomy/earthmoonsun/shadowstick.html, accessed 11/6/2020)

The angle of the sun can be found by using a shadow stick, a piece of string and a protractor.

Objective

To find out if there is a relationship between the angle of the Sun and how fast a solar car goes.

Equipment

Write an equipment list which will allow you to conduct the experiment below. Show this to our teacher and gain their approval before conducting the experiment.

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Method

1. Determine the angle of the Sun by placing a shadow stick into the ground, making sure it is vertical. Attach a long piece of string to the top of the shadow stick and pull it tight so it touches the ground where the shadow ends. Then use a protractor to measure the angle between the ground and the piece of string.

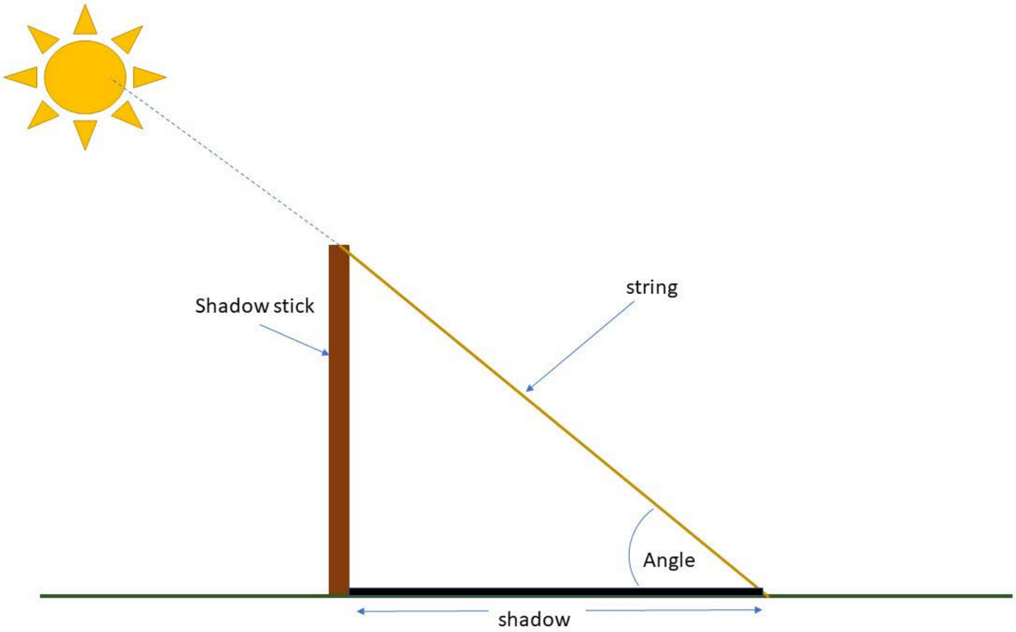


Figure 3. How to use a shadow stick to find the angle of the sun.

2. Measure out a one metre track on a flat piece of ground in a sunny spot.
3. Place the solar car on the start line and use the stopwatch to time how long it takes to reach the finish line. Record your results in the table.
4. Repeat the investigation at different times of day (suggested times in the table), recording your results.

Hypothesis

When do you predict the car will be the fastest?

Results and Analysis

Time of day	Angle of the Sun (^{0})	Time taken (s)
8 am		
9 am		
10 am		
11 am		
12 pm		
1 pm		
2 pm		
3 pm		

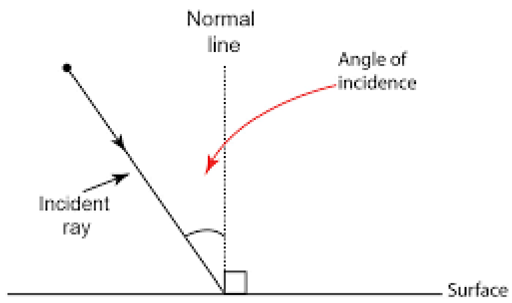
1. Draw a bar chart with the angle of the sun on the bottom and the time taken for your car to travel 1 metre on the side.
2. Which angle was the car fastest at?

Evaluation

1. What variable(s) did you keep the same in this investigation?
2. Was this a fair test?
3. How could you improve this experiment?
4. Why do you think the car went different speeds at different times of day?

Incident Light Angle

Background



Light waves travel in straight lines from the light source, this is known as the incident path/ ray. When light shines directly onto a surface (along the normal line) the angle of incidence is zero. The angle of incidence can be changed by moving where the light source is.

Objective

To find out if there is any relationship between the angle of incidence of light and the amount of energy collected by a solar panel.

Equipment

- Torch with incandescent bulb
- 3 x lever arch files
- Sticky tape/masking tape
- Solar toy (e.g bug, spinning plane)
- Meter rule

Method

1. Measure out 40 cm on your desk and mark this with a piece of masking tape.
2. Make the room as dark as possible.
3. Place the solar toy 40 cm from the torch and lay the torch flat on the table.
4. Turn the torch on and record how active the toy is.
5. Place the torch on top of the lever arch file so that it is angled towards the solar toy and still 40 cm away. Record how active it is in the table.
6. Put another lever arch file on top of the other and place the torch on top, 40 cm from the toy, (the angle should be even steeper). Record how active the toy is in the table.
7. Hold the torch 40 cm directly above the solar toy and record how active it is in the table.

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Hypothesis

Draw a labelled diagram below showing when you think the toy will be the most active.

Results and Analysis

Angle	Activity level (high/ medium/ low)
Horizontal	
Shallow (1 file)	
Steep (2 files)	
Vertical	

1. At which angle was the bug the least active?

2. At which angle was the bug most active?

3. What time of day does the vertical angle relate to?

4. If you completed the "Time of Day" experiment, did you find you had similar results?

Evaluation

1. What variable(s) did you keep the same in this investigation?

2. What variable did you change in this investigation?

3. Was this a fair test?

4. Was your hypothesis supported?

5. How could you improve this experiment?

Designing a Solar Car

Objective

To design and build a solar car toy to enter in a class race.

Design Ideas

Analyse existing products or ideas. What are the pros and cons of each idea? Consider factors such as time taken to build, ease of getting the equipment, cost of the equipment, size of the finished product etc.

Idea **(photo and website link)**	**Pros**	**Cons**

Ideate

Draw a labelled diagram of your design.

Equipment

Write a list of equipment that you will need to make your solar car.

Method

Write a step-by-step method of how you will make and test your solar car. Show this to your teacher and make any necessary changes before making the car.

Evaluation

1. How did your car do in the race?

2. What was the difference between your car and the winning car – or if your car won, what made it stand out from the others?

3. If your car was scaled up to the size of a regular car how many people could you fit in it? How practical would it be for everyday use?

4. How did your finished car compare to your original design? What changes did you have to make?

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5. What improvements could you make to your solar car?

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