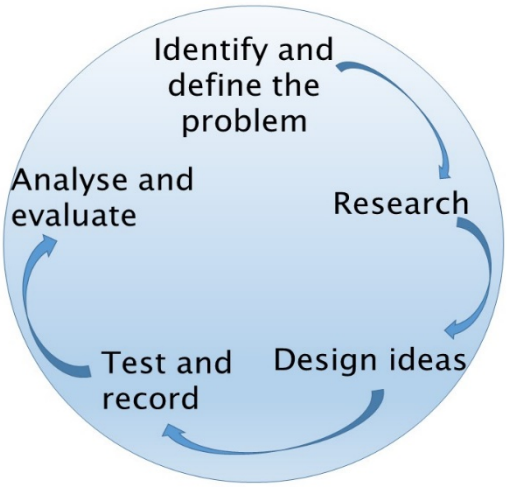
Solar Oven – Student Booklet

The Challenge

Can you cook a meal without using electricity or gas? Is it possible to use just the power of the Sun to cook food?
Your task is to investigate solar ovens and then use your findings to design and make a working oven.



Background Information

Solar ovens are designed to harness energy from the Sun to cook food without the need of gas or electricity, this makes them very environmentally friendly. Solar ovens can be bought in camping stores, but they can also be made using everyday household equipment.

Figure 1. Hot Pot solar cooker with panel reflector (Wikipedia, photograph by Paul Averson, June 27, 2011)

The Sun emits infrared (heat) and light radiation as waves which travel to the Earth through space. It is the infrared waves which a solar cooker uses to heat food. These infrared waves can be focused to a point by using reflective material, like in the image above. By focusing the rays they concentrate the heat and so make the oven more efficient.

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Background Research

1. What are some advantages of using a solar oven to cook food?

2. What are some disadvantages of using a solar oven to cook food?

3. What are some safety precautions that need to be taken when using a solar oven?

4. What are some foods you could cook on a solar oven?

5. Write a definition for the following words:

- Transparent
- Translucent
- Opaque

6. How many hours of sunlight do you get in midsummer and midwinter where you live?

7. What time of day is the Sun at its strongest?

Cooking Pot Colour

Objective

To determine which coloured pot would cook food fastest.

Equipment

- Tin cans painted different colours (or covered in coloured paper). Suggested colours – white, silver, black, red. N.B: all cans must be the same size.
- Thick cardboard (from a cardboard box)
- Scissors
- Thermometer
- Measuring jug

Method

1. First draw around the base of your tins onto the cardboard.
2. Cut about 0.5 cm further around the circle you have drawn, so that your circle is slightly larger than the base of the tin can, this will be your lid.
3. Get your teacher or classroom assistant to poke a hole in the cardboard lid for your thermometer to fit through.
4. Measure out 200 mL of water using the measuring jug and pour this amount into each can.
5. Record the starting temperature in the water of each can.
6. Place the cans in a sunny spot.
7. Check the temperature every 5 minutes for half an hour and record your results in the table below. You should give the water a swirl before checking the temperature.

Hypothesis

Which colour can do you think will have the largest change in temperature?

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Results and Analysis

Colour	Temperature (°C)						
	Start	5 mins	10 mins	15 mins	20 mins	25 mins	30 mins

1. List the colours in order from largest change in temperature to smallest change in temperature?

2. Draw a bar graph with colour along the bottom and change in temperature on the side to present your results clearly.

Evaluation

1. Which variables did you keep the same?

2. Which variable did you change in this experiment?'

3. Why was it important to swirl the water in the can before measuring the temperature?

4. Why was it important that all cans were the same size?

5. Was this a fair test? Explain your answer.

6. What colour will be best for the cooking pot in our solar oven if we want to cook the food quickest?

Investigating Reflection

You may have been to a house of mirrors at a fair or in a theme park before. The mirrors are not flat, like the ones you have at home, but have bends in them which can make you look very funny; some might stretch you while others squash you. You might also have looked at your reflection in a spoon and noticed that you appear upside down. This is all because of the path that the reflected light rays take.
Some houses have satellite dishes on their roofs, these help to reflect the radio and television waves to one point so that the signal becomes stronger, giving you better reception.

Objective

To investigate how light is reflected to draw ray diagrams and consider how this could be useful in the design of a solar oven.

Equipment

- Torch
- Pencil
- Paper
- Scissors
- Tape
- Plastic flexible mirror

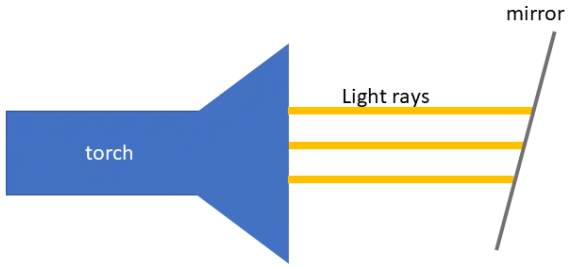
Method

1. Draw around the top of your torch on your piece of paper.
2. Cut out the circle you have drawn and then cut three slits in the circle that are parallel to each other and run about halfway up the circle.

Figure 1. Cut 3 parallel slits in the piece of paper.

3. Stick this onto the front of your torch.
4. Make the room as dark as possible, place the torch on another piece of paper with the slits at the bottom of the torch and turn the torch on.

5. Place the straight mirror in front of the torch about 10 cm away at an angle (as shown by the diagram below). Mark on the paper where you have placed the mirror and draw on the ray paths of the light, and the reflected ray paths.



6. Repeat steps 4 and 5 curving the mirror slightly by pushing in the sides. Use a new piece of paper to draw the ray and reflected paths on.
7. Curve the mirror even more and draw on the ray paths.

Results and Analysis

1. What happened to the reflected light rays when they hit the straight mirror?

_____

2. What happened to the reflected light rays when the mirror was curved?

_____

3. What happened to the reflected light rays as the mirror was curved even more?

_____

4. How could this experiment help you with the design of a solar oven?

_____

Reflecting the Rays

Objective

To determine if using a reflective lining in a solar oven helps it to cook foods more quickly.

Equipment

Use the method below to come up with an equipment list. Show this to your teacher and gain their approval before conducting the experiment.

Method

1. Line one of the boxes with aluminum foil, gluing it down.
2. Using the weighing scales, pour 50 g of chocolate chips into each bowl.
3. Place one bowl, with the chocolate in it, in the middle of each of the boxes and put the boxes in a sunny spot.
4. Watch to see in which box the chocolate melts fastest.

Figure 2. melting chocolate in a solar oven

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Hypothesis

In which box do you think the chocolate will melt fastest, the lined or unlined?

Results and Analysis

1. In which box did the chocolate melt fastest, the aluminum lined or the plain box?

Evaluation

1. Which variable (s) did you keep the same?

2. Which variable did you change in this experiment?

3. Why was it important to weigh the chocolate chips?

4. Was this a fair test? Explain your answer.

5. Was your hypothesis supported?

6. Would you recommend lining your solar oven to make cooking quicker?

Covering the Cooker

Objective

To determine if using a lid on a solar cooker increases how fast it cooks food.

Equipment

- 2 x basic solar ovens the same size (shoe boxes lined with aluminum foil)
- Shoe box lid
- Thick clear malleable plastic (oven bags work well)
- Tape/glue
- Scissors
- Measuring jug
- Two identical bowls/pots.
- Thermometer or infrared thermometer

Method

1. Cut out the inside of one of the shoe box lids, leaving about 2 cm of card from the edge.
2. Stick the plastic over the remainder of the shoe box lid – so that you now have a clear lid, like in the photo below.


3. Pour 100 mL of water into each bowl (or pot) using the measuring jug.

4. Put the boxes in a sunny spot and careful put the bowls of water into the center of each cooker.
5. Place the clear lid on one of the boxes but leave the other box uncovered.
6. Carefully measure the temperature of the water every 5 minutes for half an hour and record your results in the table below.

Hypothesis

In which box do you think the temperature of the water will increase the most, the one with a lid or without?

Results and Analysis

	Temperature (°C)						
	start	**5 mins**	**10 mins**	**15 mins**	**20 mins**	**25 mins**	**30 mins**
Lid							
No lid							

1. In which solar oven did the water temperature increase the most?

Evaluation

1. Which variables did you keep the same?

2. Which variable did you change in this experiment?

3. Was this a fair test? Explain your answer.

4. Was your hypothesis supported?

5. Would you recommend placing a lid on your solar oven or not?

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Increasing Insulation

Objective

To determine if using insulation helps to cook food faster in a solar oven.

Equipment

Use the method below to come up with an equipment list. Show this to your teacher and gain their approval before conducting the experiment.

Method

1. Place a layer of insulating material at the bottom of your large box and put one solar oven inside the box, on top of the insulation.
2. Pack around the edges of your solar oven with the insulating material, filling in the gap. You may need to cut down the outer cardboard box, so that it is the same height as your inner solar oven box.
3. Put both solar ovens outside in a sunny spot (the one with insulation and the other without).
4. Place a bowl/pot into the center of each oven.
5. Carefully pour 100 mL of water into each oven using the measuring jug.
6. Measure the temperature of the water in each oven and record it in the table below. Do this every 5 minutes for half an hour.

Hypothesis

In which solar oven do you think the temperature will increase the most, the one with or without insulation?

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Results and Analysis

	Temperature (°C)					
	5 mins	**10 mins**	**15 mins**	**20 mins**	**25 mins**	**30 mins**
Insulation						
No insulation						

1. In which solar oven did the water temperature increase the most?

2. Plot a bar chart to present your results, with “insulation” and “no insulation” on the bottom and the overall change in temperature on the side.

Evaluation

1. Which variables did you keep the same?

2. Which variable did you change in this experiment?

3. Was this a fair test? Explain your answer.

4. How could you improve this investigation?

5. Would you recommend placing an insulating layer around your solar oven or not?

Focusing the Sunlight

Background

Some solar ovens are very simple boxes with silver lining, others may have one flap on them – like those found in pizza boxes, where the lid is covered with aluminium foil to reflect light into the box. Just as curving a mirror can help focus light, it might be the case that if a solar oven has flaps on it they can also help to focus light into the box, meaning that the food will cook faster.

Figure 3. Solar oven with two flaps angles at ~ 45 degrees

Objective

To determine if using focusing flaps help to speed up cooking times.

Equipment

- 1 x basic solar oven (shoe box lined with aluminum)
- 1 x bowl/cooking pot
- Thick cardboard (from a cardboard box would be best)
- Aluminum foil
- Scissors
- Glue
- Hole punch
- String
- Sticky tape
- Chocolate chips
- Weighing scales
- Stopwatch

Method

1. Cut out four pieces of cardboard which are the same size as the four sides of the solar oven and cover one side of each with aluminum foil.

2. Use the hole punch to make a hole at the top and center of each side of the oven.
3. Use the sticky tape to stick the flaps on to the top edges of the solar oven, then use the hole punch to make a hole in the top center of each flap.
4. Put the string through one hole in the flap and connect it to the hole in the opposite side of the oven, tighten the string so the flap is at an angle of roughly 45 degrees. Do this for each flap, so that the oven looks a bit like a flower with open petals – as in the picture below.
5. Place the solar oven in a sunny spot.
6. Weigh out 50 g of chocolate chips into the bowl and place the bowl in the center of the oven.
7. Time how long it takes for the chocolate to melt and record your results in the table below.
8. Repeat steps 6 and 7 taking a flap off the oven for each trial.

Figure 4. Chocolate melting in a solar oven with four flaps

Hypothesis

Do you think the number of flaps on the oven will affect the melting time?

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Results and Analysis

Number of focusing flaps	Time taken to melt chocolate (minutes)
0	
1	
2	
3	
4	

1. In which test did the chocolate melt the fastest?

2. Plot your results as a bar graph

Evaluation

1. Which variables did you keep the same?

2. Which variable did you change in this experiment?

3. Was this a fair test? Explain your answer.

4. Was your hypothesis supported?

5. How could you improve the investigation?

6. Would you recommend adding focusing flaps to your solar oven or not? Explain your answer.

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Designing a Solar Oven

Objective

To design and build a solar oven that can bake cookies in it.

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

Using your research and what you have learned from your experiments draw a labelled diagram of your solar oven design, highlighting any important features.

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Equipment

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

Method

Write a step-by-step method of how you will make and test your solar oven. Ensure your have listed any safety precautions you will take to minimise risks when making the product. Show this to your teacher and make any necessary changes before making the oven.

Evaluation

1. Were you able to bake some cookies in your oven?

2. How efficient was your solar oven compared to a normal oven?

3. How did your finished oven compare to your original design you drew? What changes did you have to make?

4. What improvements could you make to your solar oven?