Student Sheet

In this practical I will be:

- Repeatedly measuring the temperature of thermometers placed throughout the spectrum of light, and beyond.
- Calculating the mean change in temperature for colours in the light spectrum and beyond
- Interpreting trends in the class' data for the experiment.
- Using my knowledge of electromagnetic radiation to explain trends found in the class data.

Introduction:

You change your white robes for black robes and you are suddenly aware that just this change of colour has increased the temperature of your body. Why is this the sun is still the same sun as a short time ago when you were wearing the white robes. A little later you notice that the same effect occurs when you go into two different tents one white one black. You decide to find out why there is this effect....

Equipment:

- 1 glass prism
- 1 prism stand
- 3 sensitive heat sensors connected to a data logger (Or thermometers with the bulbs painted black)
- Thermometers
- Matt black paint or a permanent black marker
- 1 pair of scissors
- Cardboard box (about 210 mm x 297 mm x 250 mm) with a white inside (An empty A4 copier paper box is ideal.)
- 1 blank sheet of white paper

Method:

First the detecting end of the temperature sensor will need to be blackened with matt black paint.

Why do think you need to do this?

(Clue: Try holding a sheet of white paper on the palm of your hand in the sun. Now repeat with a piece of matt black paper.)

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Would the thickness of paint be something you need to control?

Let the paint or marker ink completely dry.

1. On one of the short ends of the cardboard box, cut out a gap just big enough to take the prism long ways across the length of the side of the box (see Fig 1).

   To start with cut a section smaller than the prism and adjust it as necessary. The prism should be held in place but be able to rotate on its axis.

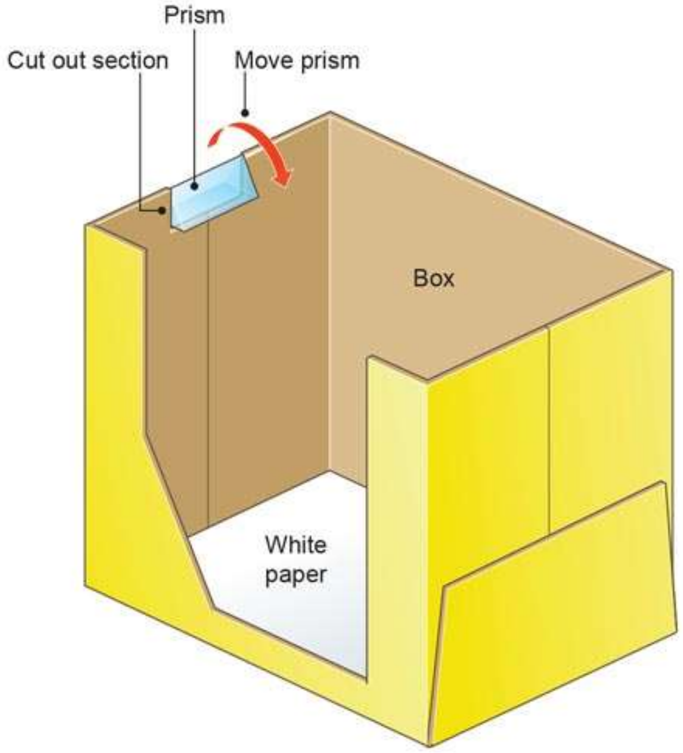

Figure 1: Prism-box set up. Peter Bull

2. Use a prism stand, or use the cut out section of the box, to hold the prism in position and face the prism towards the Sun.
3. With the Sun's rays going through the prism carefully rotate the prism in the direction of the arrow (see Fig 1) until you get a wide and strong spectrum projected on the bottom of the box. You might also have to tilt the box by placing the edge of the box furthest from the prism on top of a book. Once you have the prism at the correct angle make sure the assembled apparatus is not moved.
4. Tape the 3 temperature sensors or thermometers together so that when placed inside the box they are each in one of the colours of the spectrum starting from the violet end first.
5. Connect the taped temperature sensors to the data logger.

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6. First you will need a control temperature. Place the 3 taped temperature sensors inside the box in the shade, well away from the spectrum. Using the 'snapshot' option on the data logger, take the air temperature and record the results in table 1.

   If thermometers are being used, record the initial temperatures.

Table 1:

Control readings	**Sensor 1**	**Sensor 2**	**Sensor 3**
Temperature in the non-spectrum side of the box T_B			

7. Calculate the mean value of the box temperature.
8. Carefully place the temperature sensors or thermometers in the box so that each black end of the temperature sensor is in one of the colours starting from just beyond the violet end first ie the first sensor is not in a colour, the second will be in the violet section, and the third will be in the blue section.
9. Let them stay in the coloured light without touching them for 5 minutes. Do not block the Sun's rays or move the box.
10. Record the temperature on the temperature sensor using the colour of the light group in the spectrum you have selected. Using the 'snapshot' option on the data logger, take a series of five readings for this group of colours. (Or record the temperatures on the thermometers.)
11. Record your results in table 2.

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Table 2:

Reading	Sensor beyond violet end	Sensor in blue	Sensor in yellow	Sensor in orange	Sensor in red	Sensor beyond the red end
1						
2						
3						
4						
5						

12. Calculate the mean temperature for the portion of the spectrum being measured.
13. Now carefully move the temperature sensors to the next three colours: yellow, red and just beyond the red end of the spectrum.
14. Using the 'snapshot' option on the data logger take a series of five readings for this group of colours. Record your results in table 2 and calculate the mean temperature for the portion of the spectrum being measured.
15. Use table 3 to calculate the difference between **final** temperature measured in the spectrum and the temperature measured in the shade for the three sensors.

Table 3:

	Sensor beyond violet end	Sensor in blue	Sensor in yellow	Sensor in orange	Sensor in red	Sensor beyond the red end
Mean Temperature T_S						
T_B						
$T_S - T_B$						

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16. Calculate the class averages for the differences in temperature.

Questions:

- What did you notice about the temperature readings?
- Are there any patterns or trends?
- Where was the lowest and the highest temperatures?
- What do you think is just beyond the red part of the spectrum?
- Discuss any other observations and prepare a poster presentation of your work.

Going further:

Try doing the experiment at different times of the day.

What do you think the results will look like?

Theory:

Herschel discovered the existence of infrared light by passing sunlight through a glass prism in an experiment similar to this one.

As sunlight passes through a prism, it is spread out or is **dispersed** into a rainbow of colours called a **spectrum**.

A spectrum contains all visible colours and invisible colours like Ultra Violet and Infra-red that makes up sunlight.

Herschel measured the temperature in each colour and used thermometers with blackened bulbs (the blackened bulbs absorb more heat than a plain glass bulb) to measure the various colour temperatures.

He noticed the temperature increased from the blue to the red part of the visible spectrum. Placing a thermometer just beyond the red part of the spectrum in a region where there was no visible light showed a temperature that was even higher.

Herschel realised that there must be another form of light beyond the red and he called it ’calorific rays’ (from the Latin word for *heat*). We now call this type of light **infrared** (*infra* from the Latin word for *below*).

Herschel's experiment was important because it led to the discovery of infrared light, and because it was the first time it was shown that there were forms of light we cannot see with our eyes.

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Herschel continued to investigate the infrared radiation and he found it could be reflected, refracted, absorbed and transmitted in a similar way to visible light.

Recent developments have led to many useful applications using infrared radiation.

- Infrared imaging has been used in art to discover details about paintings that we cannot see.
- Infrared imaging has also been used in archaeology to reveal hundreds of miles of ancient towns, roads and settlements, providing valuable information about vanished civilisations.
- Medical infrared technology is used for the non-invasive analysis of body tissues and fluids.
- Infrared cameras are used in military, police and security work.
- In firefighting, infrared cameras are used to locate people and animals caught in heavy smoke and for detecting hot spots in forest fires.
- Infrared satellites are routinely used to measure ocean temperatures and to monitor convection within clouds to identify destructive storms.
- Airborne and space-based cameras use infrared light to study vegetation patterns and to study the distribution of rocks, minerals and soil.
- Infrared imaging is used to detect heat loss in buildings, test for stress and faults in mechanical and electrical systems, and to monitor pollution.