4.2 Detecting invisible radiation

Investigation

Apart from your eyes you also have another built in EMR detector; the heat detecting nerves in your skin. Your hands have a high concentration of these nerves and it is these nerves that control how close you get to hot objects.

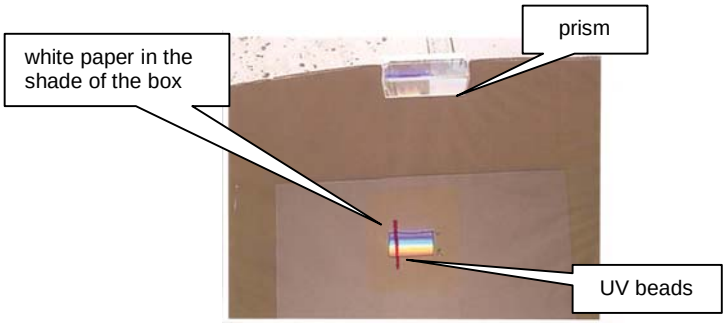
1. Put the palms of your hands very close to your face without touching it. What do you feel?

2. Attempt to explain what might be happening?

Experimenting

Materials

- prism (this can be rectangular or triangular)
- light source (use the sun)
- three thermometers
- pencil and felt-tip pen
- string of UV sensitive beads
- cardboard box



Method

A. William Herschel's infrared experiment

1. Set the prism into a cardboard box that you can tilt to get a bright, well spread spectrum in the shade.
2. Place white paper on the bottom inside the box where the spectrum forms.
3. Place the box in an area where you will do the experiment.
4. Allow the three thermometers to register air temperature.
5. Carefully note the temperatures and record them on the data chart.
6. Place the first thermometer in the violet range of the spectrum.
7. Place the second thermometer in the spectrum's centre
8. Place the third thermometer barely beyond the spectrum's red end.
9. Leave the thermometers in the spectrum for at least five minutes, moving them carefully if the sunlight moves and causes the spectrum to move. Temperature changes may be small, so observe carefully.
10. Record the final temperature readings in the table, and answer **Questions 2, 3 and 4**.

B. Johann Ritter's experiment

1. Using the same setup as you used in the last activity place the UV sensitive beads on the sheet of white paper across the whole of the spectrum including the regions outside the red area and outside the violet area.
2. Outline the area covered by the spectrum with a felt-tip pen and label the red and violet end.
3. Leave for around 60 seconds.
4. On your white paper mark the colour changes that have occurred to the beads.
5. Answer the remaining questions on the worksheet.

Worksheet: Herschel's infrared experiment

1. Record the initial and experiment thermometer readings below.

Thermometer	Reading	Temperature
1	initial in air	
2	initial in air	
3	initial in air	
1	violet range	
2	spectrum centre	
3	infrared range	

2. What do the terms infrared and ultraviolet mean?

3. Why was there an increase in temperature beyond the end of the red end of the spectrum?

4. What can you infer about what exists beyond the red end of the spectrum?

5. When doing the experiment using the UV beads, why do you think you need to use the sunlight from an open window rather than a closed window?

6. On the white paper you should have recorded the spectrum and have made some observations with the UV sensitive beads. Draw a sketch containing all the information and observations you have recorded on the white sheet of paper from these experiments.

7. What does this demonstrate about the area beyond the violet end of the spectrum?

Maths, the language of science

Maths plays a very important part in science and is in fact referred to as 'the language of science'. Now that we have made observations and gathered some quantitative and qualitative data we can use maths to find relationships and patterns that lead to the ability to predict a result. This is known as a scientific law.

Task

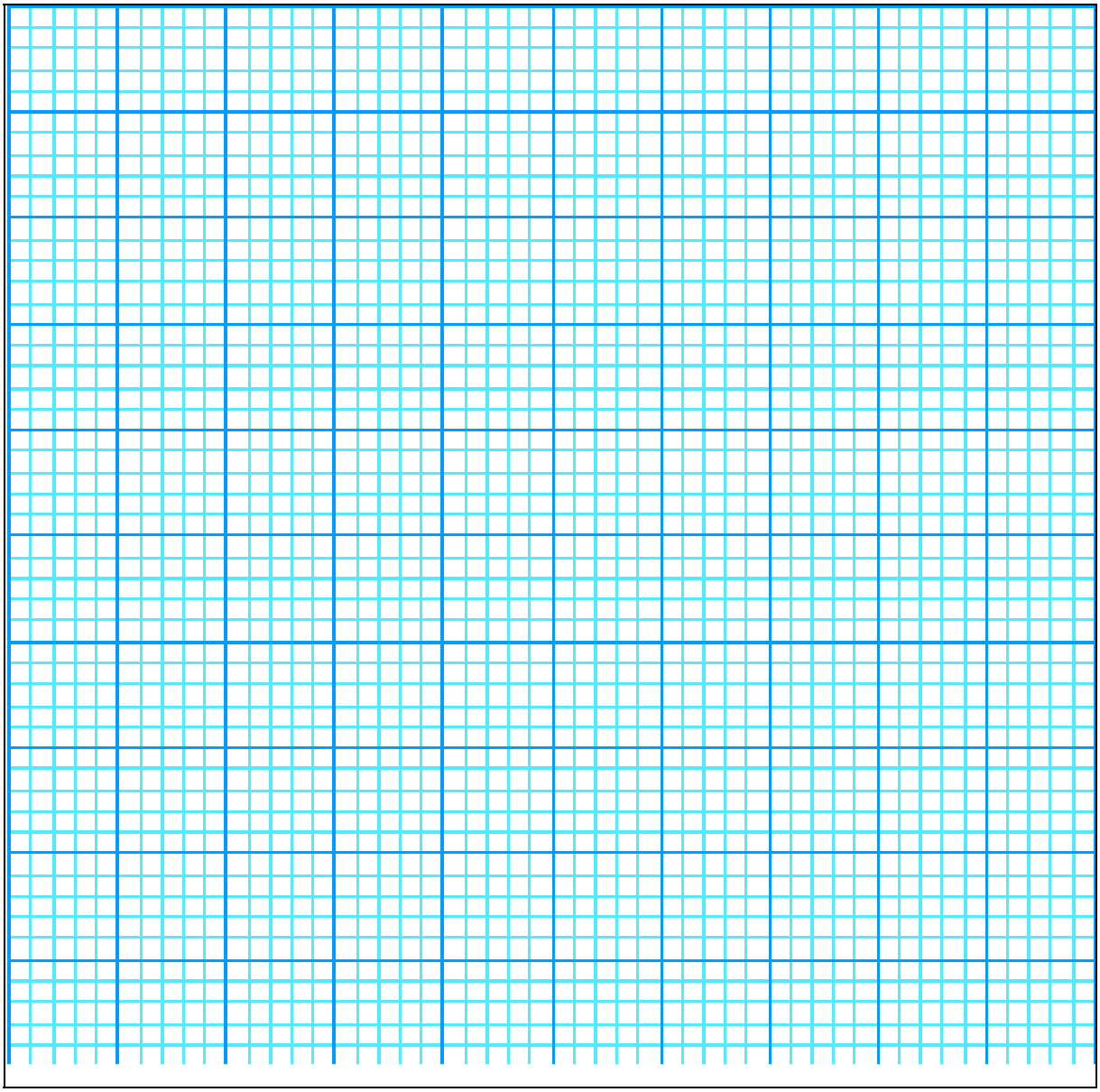
Research the top and bottom range of the visible spectrum both in frequency and wavelength. Use this information to find the frequency and the wavelength scale of each from your UV bead plan.

1. Complete the table below.

	Frequency (Hz)	Wavelength (m)
Beginning of the infrared		
Beginning of the ultraviolet		

2. Transfer your UV bead range to graph paper and write in the values of the wavelength and the frequency and establish a scale for the frequency in Hz per mm.

   My scale is: _____



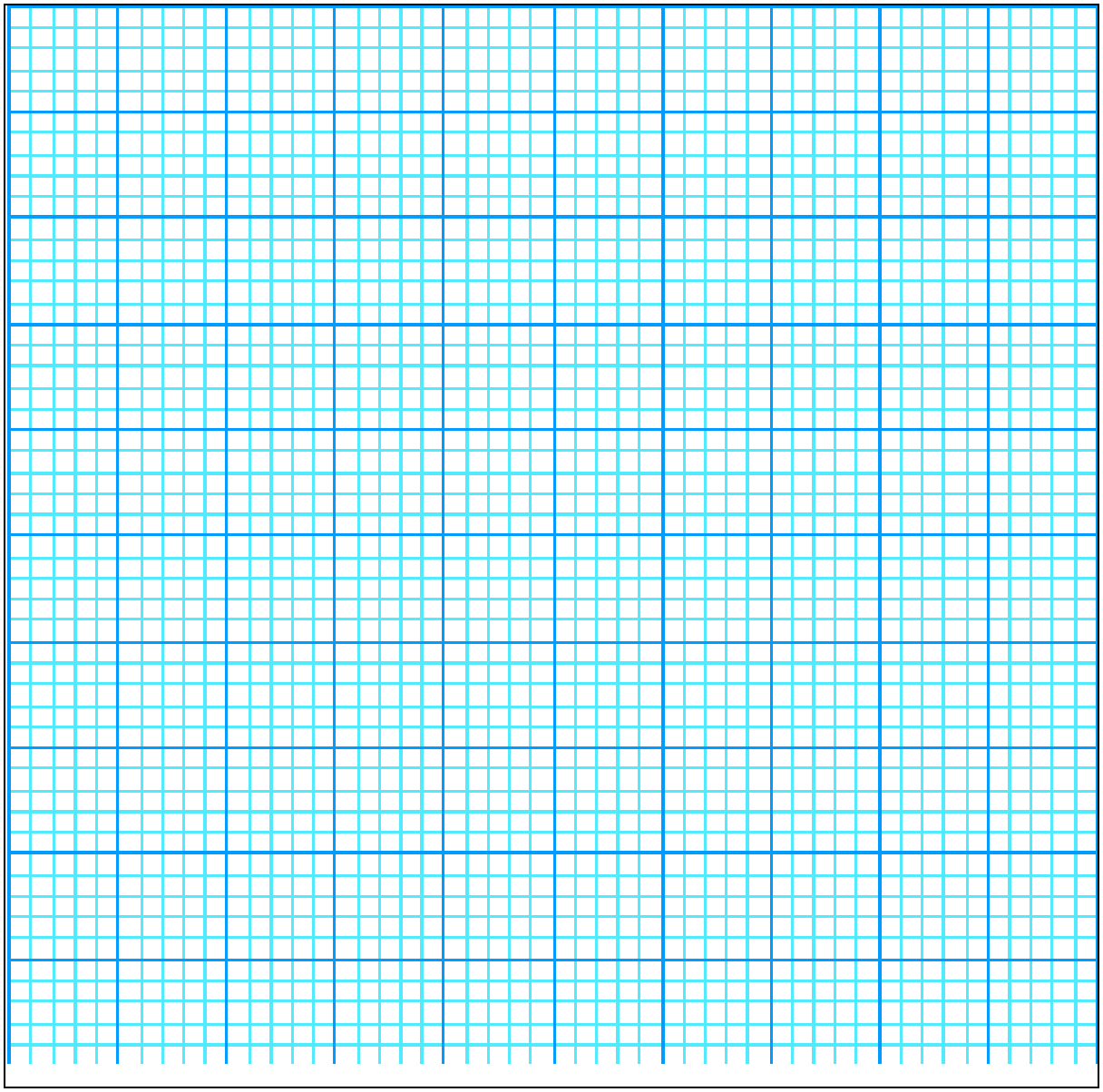
3. Use your scale to find four other value pairs of frequency and wavelength and complete the table below.

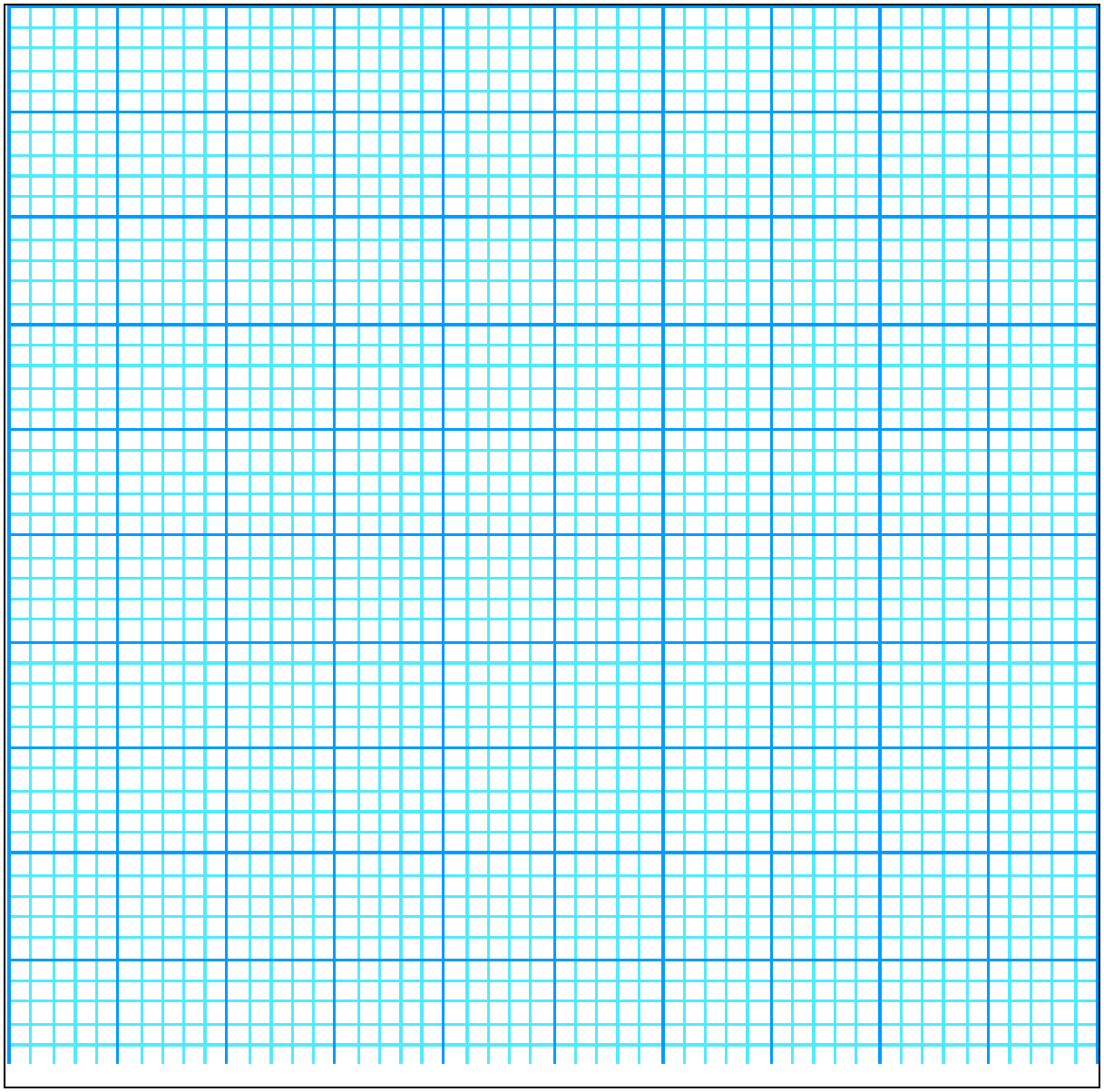
Range	Frequency (Hz)	Wavelength (m)	Inverse of wavelength $\frac{1}{\text{Wavelength}}$ (m^{-1})
Beginning of the infrared			
Value 2			
Value 3			
Value 4			
Value 5			
Beginning of the ultraviolet			

4. Plot two graphs:

   frequency vs. wavelength,

   frequency vs. the inverse of the wavelength





5. What information does the shape of the graphs tell you about the relationship between the frequency and the wavelength?

6. What is the gradient on the graph of the *frequency vs. the inverse of the wavelength* and what are the units of the gradient?

7. These are the units of what quantity in science?

8. Write a formula for the relationship between this quantity, frequency and wavelength in words and then in symbols.

9. Compare your gradient with the speed of light to calculate your percentage experimental error.

You have just established a science law — well done!