SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Models & Inventions

Year 9-10

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Brighton Secondary School

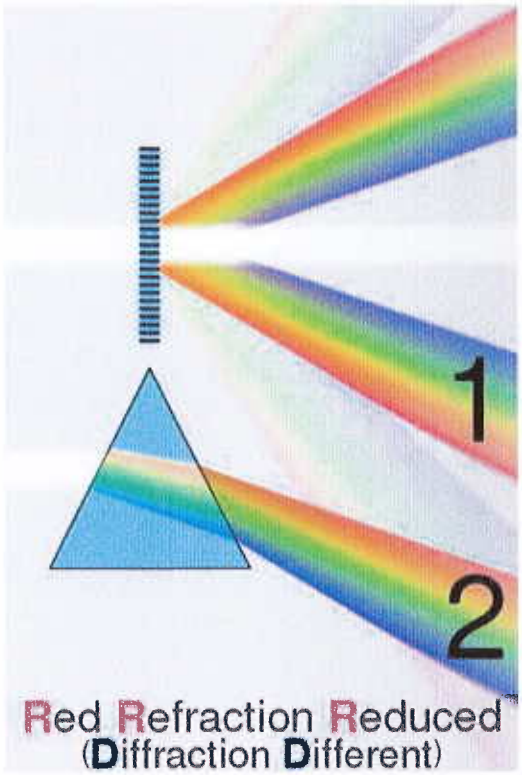
SPECTROSCOPY

Simran Bruce & Kostya Szarszewski

Scientific principle

DIFFRACTION GRATING:

Diffraction grating is an optical component which splits light into multiple beams which travel in different directions. The beams produce colour from microscopically fine surfaces which are small enough to interfere with visible light.



Comparison of the spectra obtained from a diffraction grating by diffraction (1), and a prism by refraction (2). Longer wavelengths (red) are diffracted more but refracted less than shorter wavelengths (violet). Hence: Red Refraction Reduced.

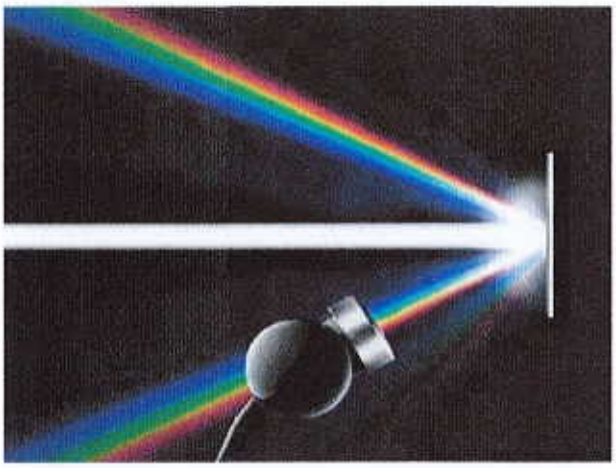
It is important to understand the difference between **refraction** and **diffraction**. **Refraction** is the change of direction (bending) when waves travel from one medium to another. **Diffraction** is the bending and spreading of waves as a beam of light passes through a narrow opening. Because of how the light refracts from a prism, only a singular spectrum is formed but gratings diffract in both directions.

DVD and CD are composed of a thin layer of transparent plastic. When separated from other layers of the disc, it can act just like a diffraction grating.

When the discs are written, the lines are broken into smaller lines, making it unusable for diffraction.

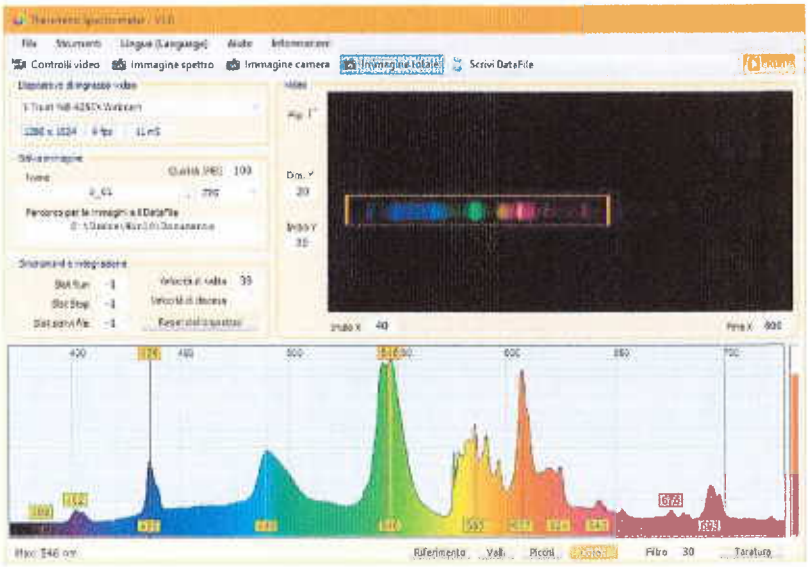
SOFTWARE & HARDWARE

By placing a webcam with a diffraction grating ahead (tilted at an angle from the beam of light to produce a wide spectrum), we get the blue, ultraviolet and violet components hitting the leftmost pixels and the infrared and red colours to the rightmost. Most webcams include an infrared filter to capture the clearest images. Our webcam has this, and it is irremovable so we can only show minor components of infrared.



This is similar to how our spectrometer is set up

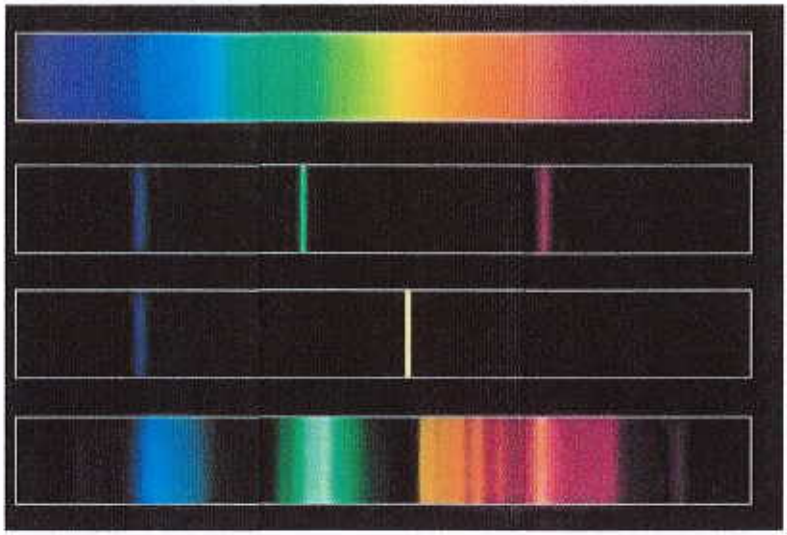
The webcam feeds live video into the Theremino spectrometer software. The software then calculates the amount of light striking each pixel and is able to measure the dispersion of each colour.



The Theremino Spectrometer Software

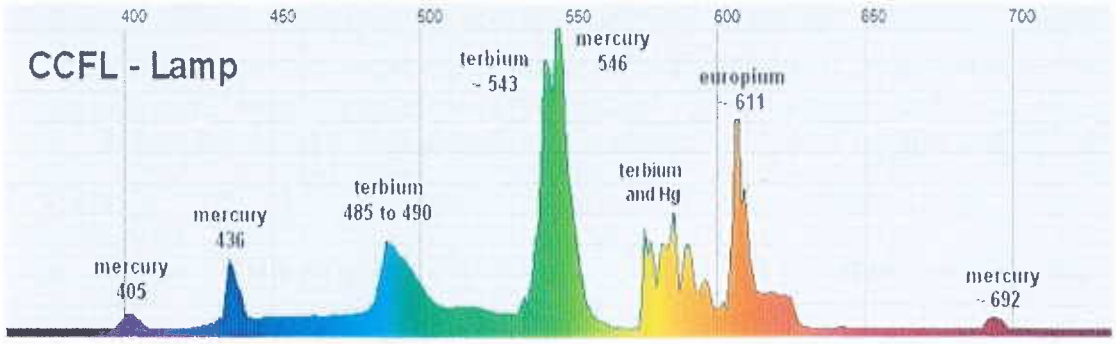
A spectrometer detects and analyses wavelengths of electromagnetic radiation and they are made commercially available but are often very expensive. Our spectrometer is cheap to produce, is fairly accurate and the only external medium it requires is a computer. They are useful pieces of equipment, because they allow us to identify and analyse the atoms in a sample, or measure changes in a reaction.

Different globes produce different spectrums depending on what they are made of. Solar light from the sun emits all wavelengths and others concentrate their energy in some areas called characteristic emission lines.



Above: (Each of these light sources produce the colour 'white')

A fluorescent lamp produces a spectrum containing two lines useful for calibrating the spectrometer because they are stable. These lines are produced by mercury at **436 nm** and **546 nm**.



The lines at 436 and 546 nm are accurate. The position of the other rows is not stable and can change from one lamp to another.

CONSTRUCTION

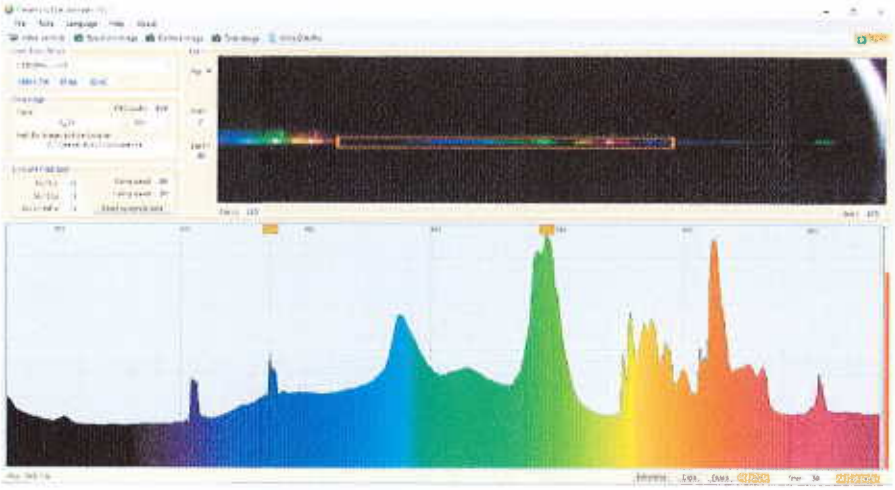
To construct the spectrometer, we got a wooden box and cut a slit for the beam of light to shine through. A filter was made to make the light coming through more focused. The diffraction grating was positioned with the webcam inside the box and that was majority of the spectrometer completed.

PROBLEMS

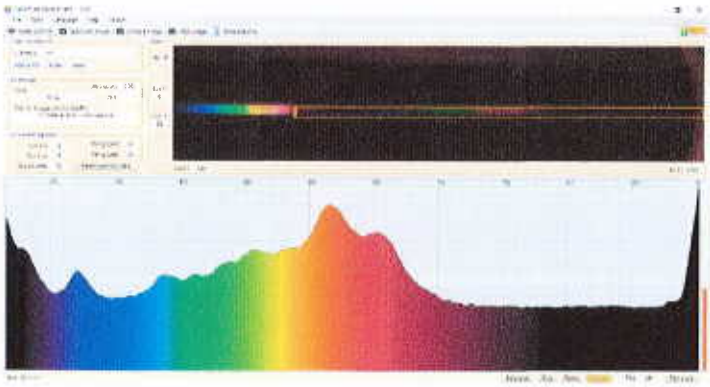
There were no real hurdles with the creation of the spectrometer. One thing we did need to account for was stray light reflecting inside the box. To work around this the box was spray painted in matte black.

RESULTS

White Fluorescent Bulb (CFL) Spectrum:

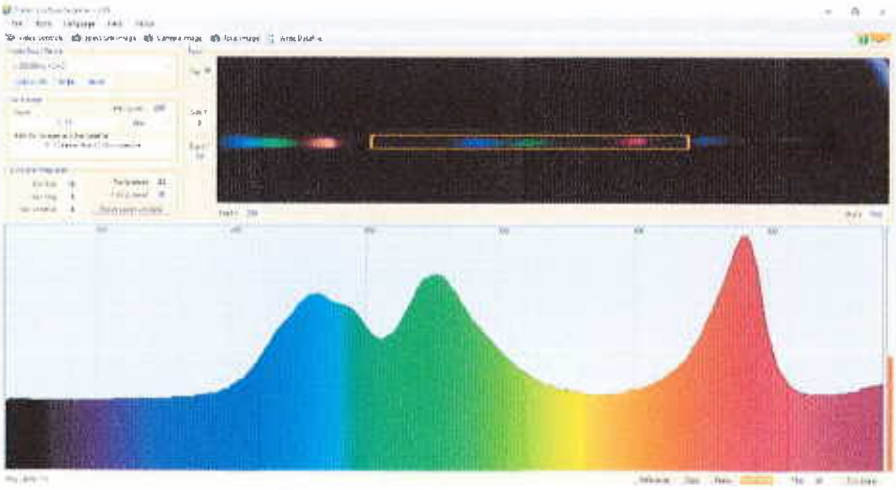


Incandescent Bulb Spectrum:

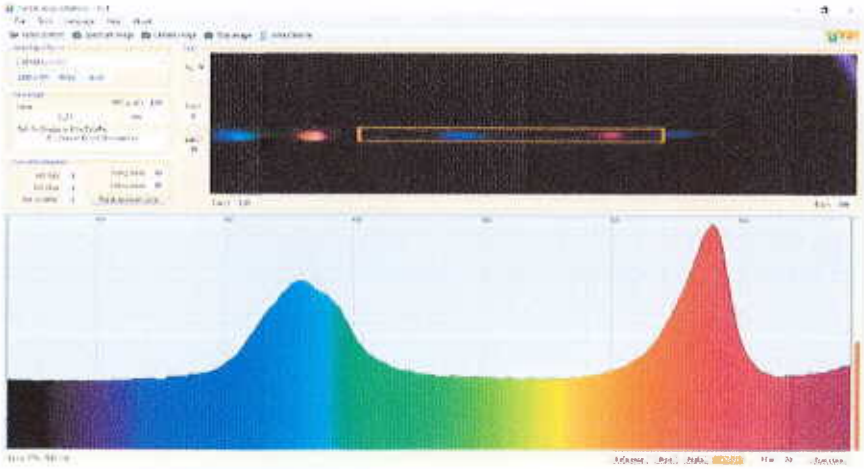


The large plateau after the red wavelength is due to the infrared filter. You can tell it is very stable which shows that something artificial must blocks out the infrared. Without the filter there would negative skewness into the infrared range.

White RGB LED Bulb Spectrum:

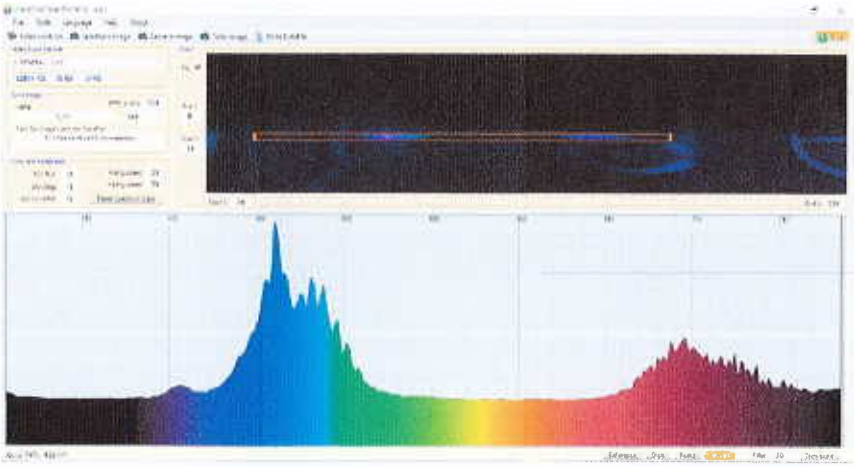


Purple LED Spectrum:

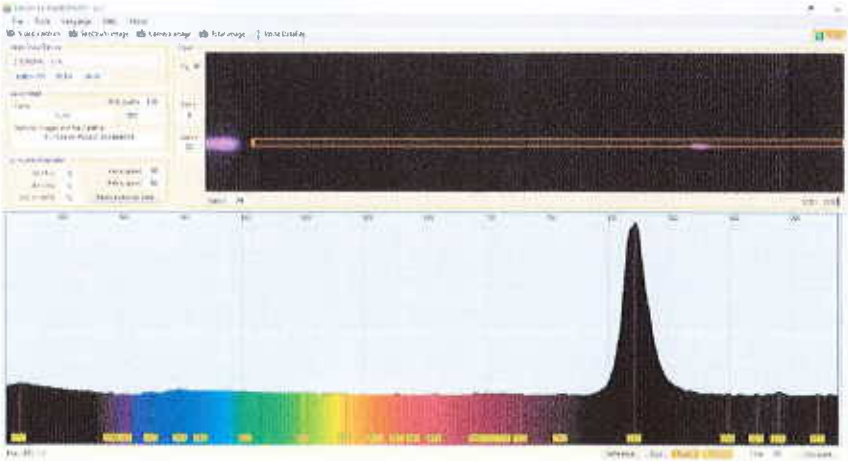


There is a red and blue peak for a purple light, as there no wavelength which corresponds to purple. We make out the colour purple because our eyes can't tell what is going on.

Near-Ultraviolet light:

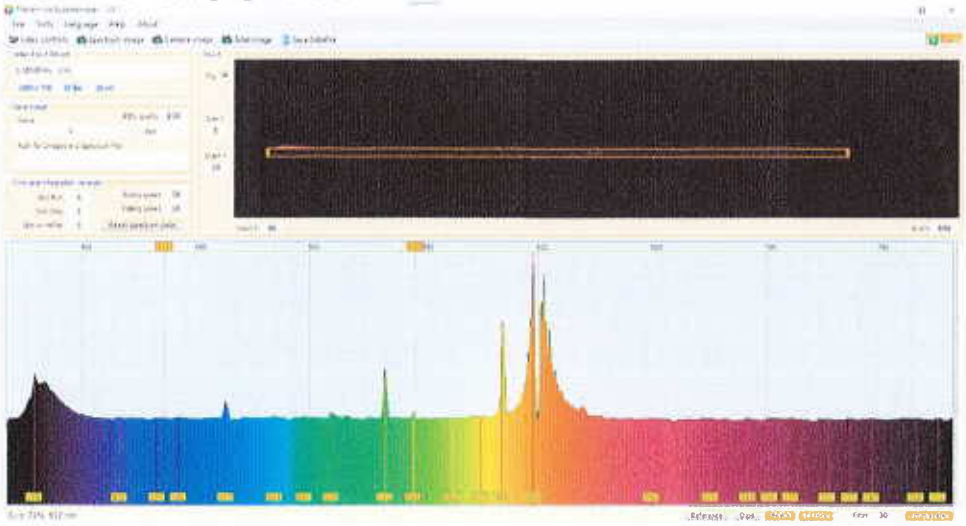


TV remote (Infrared LED):

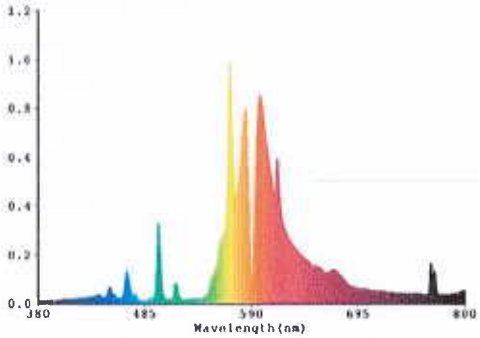


The infrared here showed up at 820nm even though the camera has an infrared filter. We will need to look into this further to find out why.

Sodium street lamp spectrum:

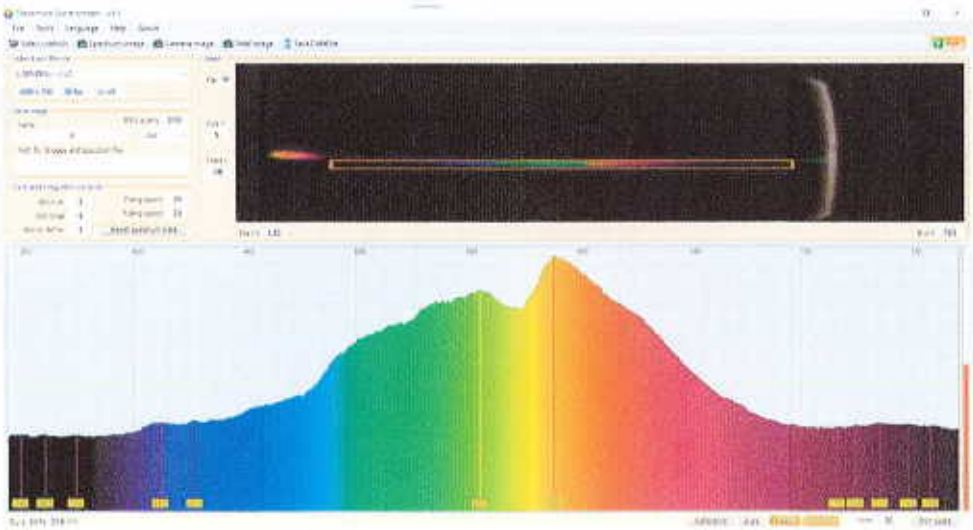


To achieve this spectrum I walked with the spectrometer and laptop down to a nearby streetlamp because I noticed its orange light compared top the newer lamps. When I pointed the spectrometer at it, it produced the spectrum of a sodium vapour lamp, because this is what old street lamps used. It produces a yellowish orange glow because of the light emmited by sodium electrons.



High pressure sodium streetlamp (HPS) comparison

Broad daylight spectrum:



Spectrometer Operation

Simran Bruce and Kostya Szarszewski

KEY (labelled parts):

1: Spectrometer Box

2: Laptop

3: Micro-USB Cable

4: Webcam

5: Diffraction Grating

6: Edison Lamp

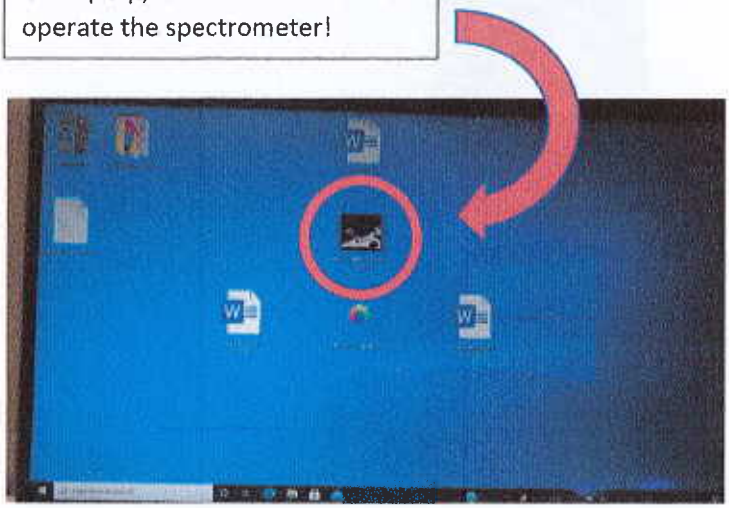
7: Fluorescent Bulb

8: Filament Bulb (incandescent) cannot be labelled due to limitations

9: Near-UV light

Laptop password: 1901

Please watch the 10m Video on the laptop, to understand how to operate the spectrometer!



Step 1:

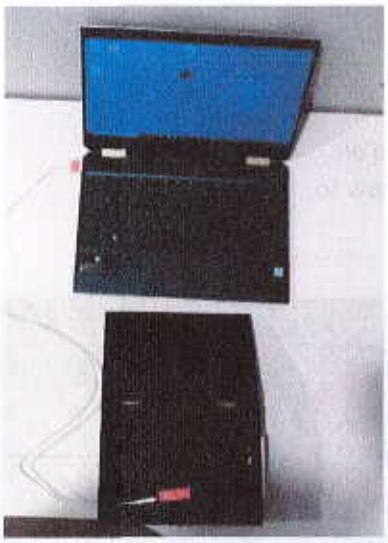
Place the Laptop and the box (1) side by side, with the slit in the box on your right-hand side.

Step 2:

Turn on the laptop using the button on the left-hand side and sign into the account **Spectrometer Entry** using the password.

Step 3:

Grab the **cable** (3) and plug the USB-A side of the cable into the left-hand side of the **laptop** and route the other end through the hole in the left side of spectrometer box.

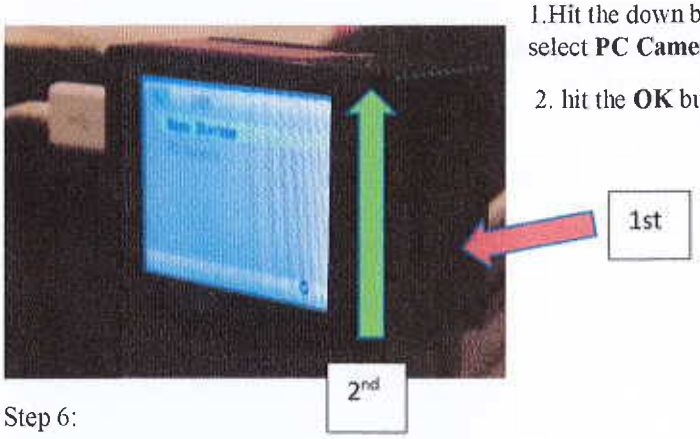


Step 4:

Take the **webcam** (4) and place it in the cut-out inside the box, then plug the cable (3) into the left side of the camera.

Step 5:

The **web camera** should turn on when it receives power from the cable.

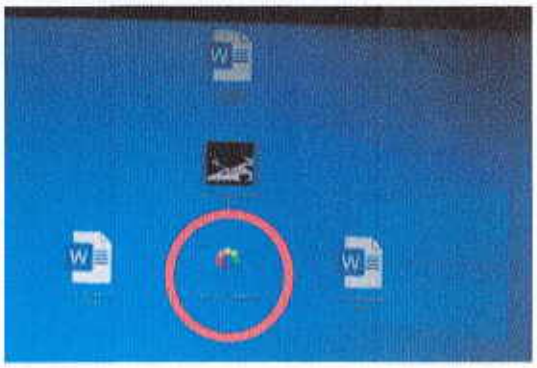


1.Hit the down button (located on the side of the webcam) to select **PC Camera.**

2. hit the **OK** button (located on the top of the webcam).

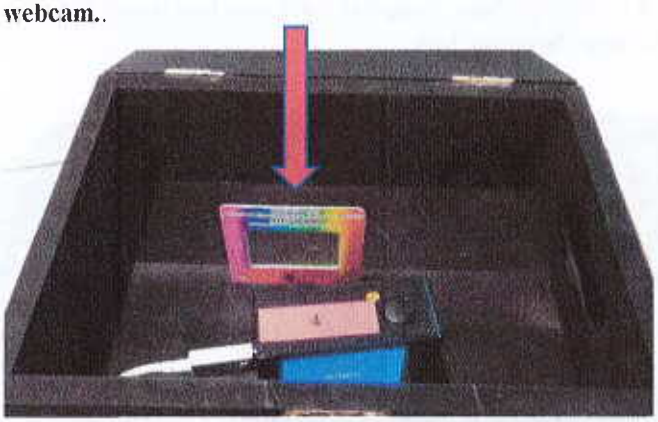
Step 6:

Open up the **Theremino spectrometer** software, then the **webcam** should start feeding video to the screen (see video for explanation).



Step 7:

Take the **Diffraction Grating** (5) and place it in the slit cut-out, inside the box **with the 5 facing towards the webcam.**.

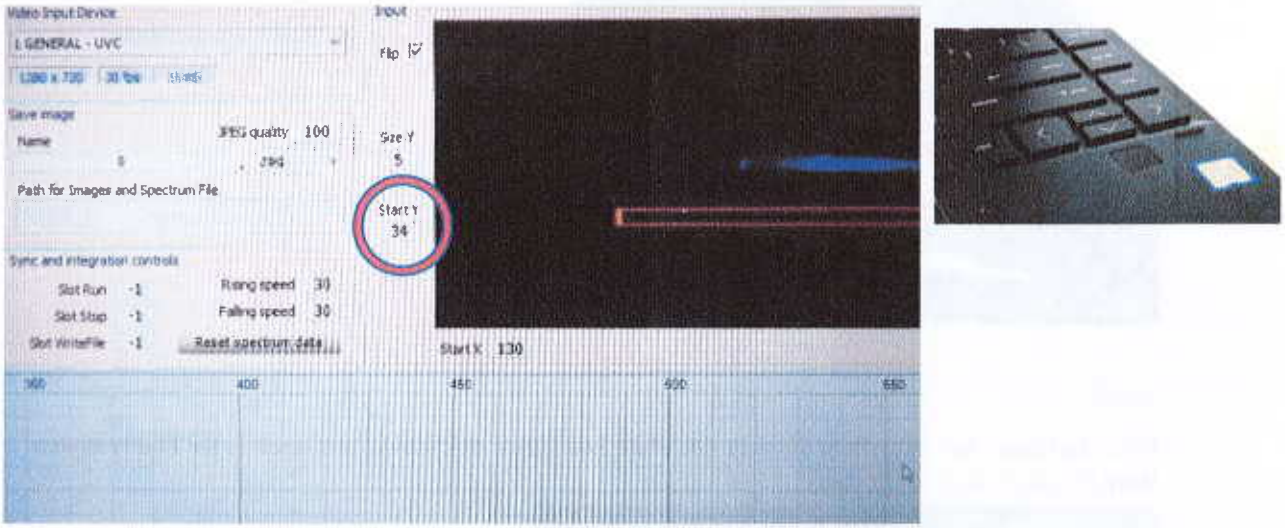


Step 8:

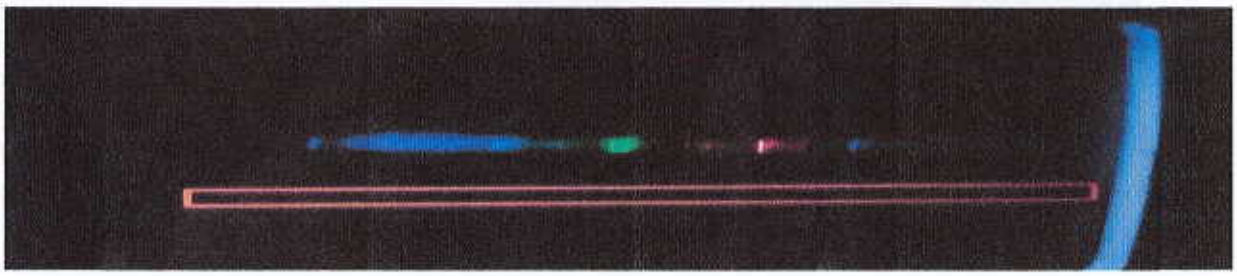
Place the **lamp** 15cm away from the right side of the box (black stand down) and screw in the **Fluorescent lamp** (7) clockwise into the lamp.

Step 9:

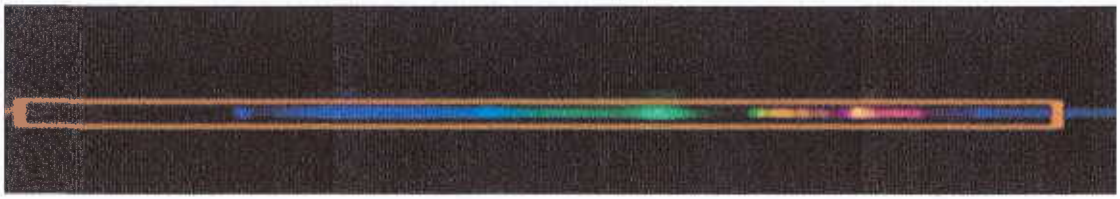
Flick on the **lamp** and observe for a spectrum. The spectrum will not always be inside where it is analysing, so you must move the bars, so the spectrum produced is inside the bars. To do this, click on where it says **Start Y** and use the **Arrow Keys** to make the spectrum fit inside the orange bars.



Incorrect analysis of spectrum:

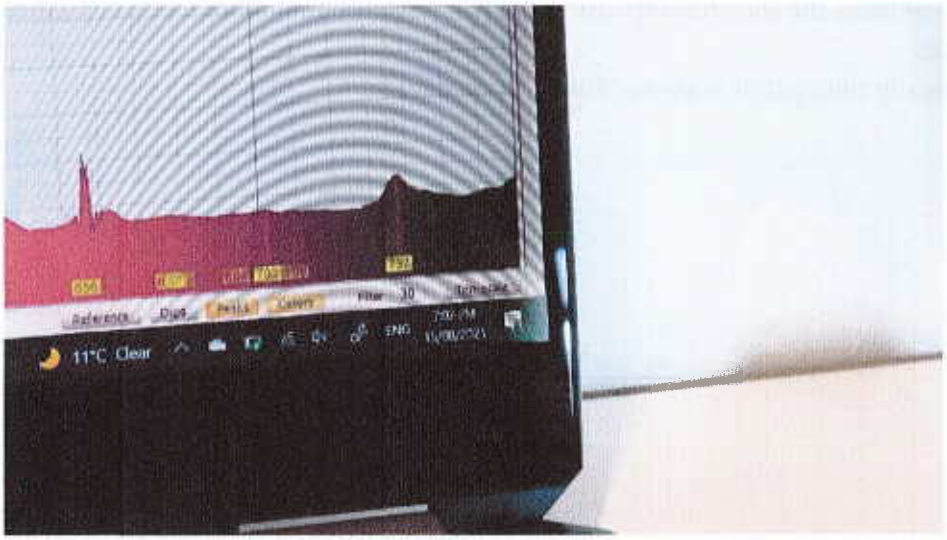


Correct analysis of spectrum (inside orange bars):



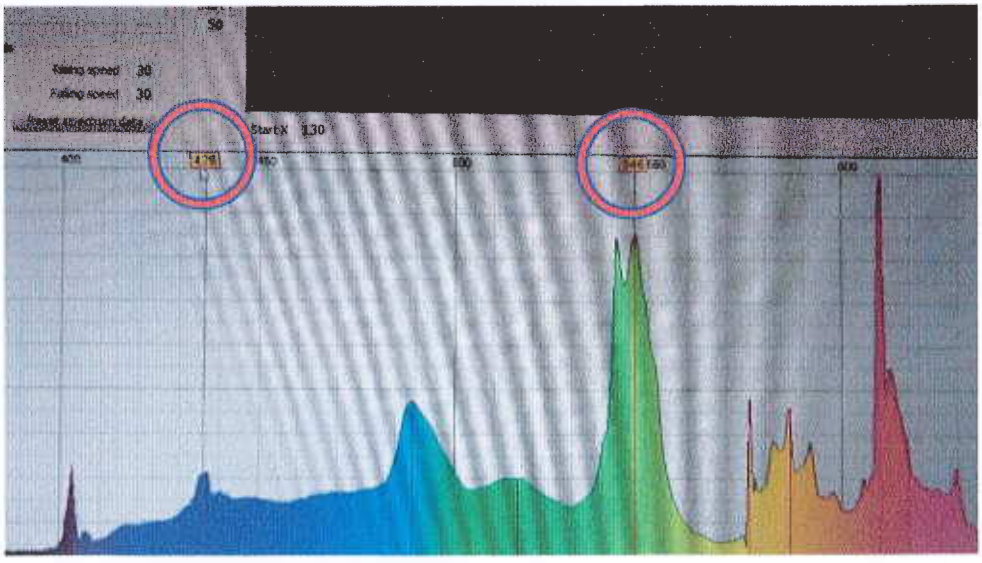
Step 10:

You are required to calibrate the spectrometer to receive an accurate spectrum. To do this hit the **trim point** button in the bottom right corner and adjust the spectrum to the characteristic peaks to 546 nm and 436nm by clicking and dragging.



A correct calibration should look something like this:

(Note: you will not achieve the exact spectrum)



Step 11:

Repeat steps 9 and 10 with the **Incandescent Bulb** (8) and **Near-UV light** (9).

NOTES:

- Do not unplug the cable from the webcam when in use.
- Do not use the laptop for anything else other than an external medium
- You must calibrate the spectrometer using the fluorescent bulb before using any other light sources.
- Keep the laptop plugged in to power during open day.

RISK ASSESSMENT FORM
Models & Inventions

This must be included with your report, log book or entry

NAME: Simran Bruce, Kostya Szarszewski ID: 0068-003

SCHOOL: Brighton Secondary school

Activity: Give a brief outline of what you are planning to do.

We are aiming to create an instrument which can analyse different light sources to produce different spectrums. Using a Web camera, we can use live video of the spectrum and plot it into wavelengths (nm).

Are there possible risks? Consider the following:

- Chemical Risks: are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal Risks: are you heating things? Could you be burnt?
- Biological Risks: are you working with micro-organisms such as mould and bacteria?
- Sharps Risks: are you cutting things, and is there a risk of injury from sharp objects?
- Electrical Risks: are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation Risks: does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
Thermal - Hot Globes Electrial - lamp isolation	Thermal: When filament globes are turned on they can get quite hot. to avoid mild burns, wait for the filament to cool down. Electrical: To make sure nothing goes wrong electrically, we can isolate the lamp from its power supply when changing globes.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Simran Bruce, Kostya Szarszewski

SIGNATURE(S): Simran.S Kostya.S

☑ **by ticking this box, I / we state that my / our project adheres to the listed criteria for this Category.**

TEACHER'S NAME: MARIA GALOUZIS SIGNATURE: M Galouzis

DATE: 12/8/21