Measuring Wavelengths of Light

OBJECTIVES

1. Use diffraction grating and diffraction angle to calculate wavelengths of light.
2. Recognise differing wavelengths in the light spectrum to predict calculations.

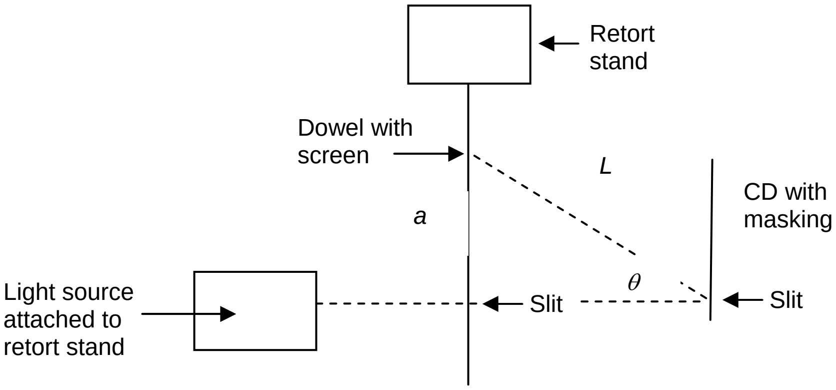

Figure 1: Set-up for measuring wavelengths of light

WHAT YOU NEED

- 2 x Retort stands with clamps
- Flashlight/light source
- CD
- Black card
- A4 white paper
- Scissors/scalpel
- Blutack and clear tape
- Shoe box
- Wooden dowel (5mm diameter)
- Tape measure
- Darkened room

WHAT TO DO

Setting up the CD

1. Make a mask for the disc using the black card. Trace a circle around the CD onto the black cardboard and cut out.
2. Make a slit on one edge of the cardboard (1cm long x .05cm high).
3. Using blutack attach the mask to the CD.
4. In the lid of the shoe box make a slit 7cm wide, 3cm from the front of the box.
5. Position the masked CD in the shoebox so that the slit it sitting parallel to the box lid and table surface.

The Torch/light source

6. Attach the torch to the retort stand. Position the torch ~40cm from the screen.
7. Adjust the height of the torch so that the light shines directly through the slit on the mask to hit the CD.

The Screen

8. Fold the A4 paper in half length-ways.
9. Measure and cut a piece of black card board to attach to one half of the folded white paper using clear tape.
10. Make a small slit ~0.02cm x 1cm in the screen midway ~3cm from the outer edge.
11. Thread the folded paper/cardboard over the dowel and attach the dowel to the retort stand.
12. Position the screen on the retort stand ~17cm from the CD. Make sure that the screen is parallel to the CD to ensure correct measurements are made.
13. Adjust the height of the screen so that the light source shines through the slit and onto the exposed section of the CD.

Measuring the wavelength

14. Turn the light source on and you should see a light spectrum projected from the CD onto your screen. You should also see a white light reflecting straight back to the slit in the screen.
15. This white light is *the zero order image* and the spectrum should be the *first order image*.
16. Measure the distance between the zero order image and the middle of the coloured image you are measuring (eg.red) (*a* on the diagram). Record this measurement in the table below.
17. Measure the distance between the 1^{st} order image colour (eg.red) and the slit in front of the CD (*L* on the diagram). Record this measurement in the table below.

CALCULATIONS

18. Using these measurements to calculate the wavelength of each colour in the spectrum. The formula to calculate wavelength of light is:

$$\lambda = d \sin\theta$$

Since $\sin\theta = \frac{opposite}{hypotenuse}$ for the set-up you are using $\sin\theta = \frac{a}{L}$

so $$\lambda = d\frac{a}{L}$$

where d = the diffraction grating (1600nm)

OBSERVATIONS

	a	*L*
Red		
Orange		
Yellow		
Green		
Blue		
Violet		

Measuring Wavelengths of Light

QUESTIONS

1. How would the wavelengths differ when measuring from a second order image?
2. Which colour diffracts the most? Which colour diffracts the least? Explain.
3. Astronomers use diffraction to determine the composition of stars. Explain how this would work.
4. The distance between the diffraction gratings determines the spacing of the spectral lines. How might droplets in mist alter the spectral lines?

REAL WORLD APPLICATIONS OF USING A SPECTROMETER

Astronomy. Astronomers use spectrometry to learn about different objects in space. By studying its spectrum they can determine an objects composition (what it's made of), temperature, density and motion.

Medical research. A research group in America has recently used a mass spectrometry technique to identify cancerous liver cells. Article at http://www.purdue.edu/UNS/html4ever/2005/051109.Cooks.tissue.html