OCR A Physics A-Level

PAG 6.2

Experiments with light

All electromagnetic waves travel at the same speed in a vacuum, hence in this experiment we can find the speed of light using a microwave as both visible light and microwaves are EM waves.

Equipment
- Microwave oven
- Ruler
- Chocolate bar

Method
1. Remove the turntable wheels from the microwave so that the plate is stationary.
2. Place the chocolate on the turntable and turn the microwave on for 30 seconds.
3. Take the chocolate out and observe the pattern of melted and solid strips.
4. Using the ruler, measure the distance between 4 melted strips and divide by 3 to find the distance between adjacent melted strips.

Calculations
- The microwaves in the oven reflect off the walls and interfere to form standing waves with nodes and antinodes, the antinodes are where the chocolate melts as the wave is at maximum amplitude. The nodes are where it stays solid, as these are the points of minimum displacement.

- The distance between 2 adjacent melted strips is the distance between 2 antinodes, however this is only half a wavelength (see diagram below).
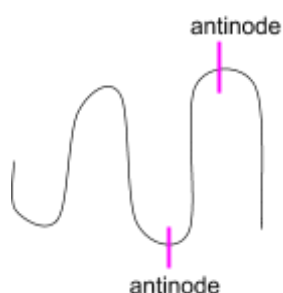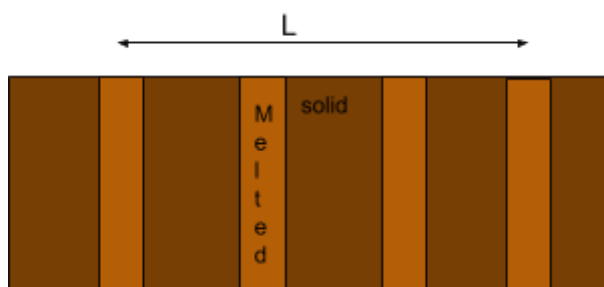
- Multiply the distance between the 2 adjacent strips by 2 to find the wavelength of the microwaves, make sure this value is in m.
- The frequency of the microwaves is shown on the microwave oven, make sure this value is in Hz.
- Multiply the frequency by the wavelength to find the speed of microwaves as $c = f\lambda$.

Notes
- EM waves will travel slightly slower in air than in a vacuum, the speed of light in air is 299,700,000m/s whereas it is 299,792,458m/s in a vacuum.
- Using a longer bar of chocolate reduces the uncertainty in the measurements and using one of uniform thickness makes it easier to discern where the antinodes are (as the thinner parts will melt faster in a non-uniform bar).

Safety
- Microwaves can cause burns, make sure the protective mesh in the inner screen is present.

Investigating refraction and total internal reflection of light using ray boxes, including transparent rectangular and semi-circular blocks

Equipment
- Ray box
- Semi circular pyrex/glass block
- Rectangular pyrex/glass block
- White paper sheets with protractor printed on
- Plain white paper
- Pencil and ruler

Method (semi-circular block)
1. To investigate refraction, place the semi-circular block on top of the protractor with the centre of its diameter aligned with 0° on the protractor.
2. Direct the ray towards this 0° point from a point at nearly 180° and using the pencil and ruler trace the ray entering the block and leaving.
3. Repeat this, moving the ray around every 10°.
4. Record the angle at which the angle of refraction is 90°, (the ray leaves along the straight boundary of the block). This is the critical angle.
5. Increase the angle further and observe that it does not leave the block, it is being totally internally reflected.

Method (rectangular block)
1. Place the block on white paper and draw in pencil around it to mark its position
2. Mark a point on the longer edge approximately 1-2 cm from the corner, this is the target for the incident ray.
3. Aim the beam normal to the block and trace the entry and exit ray, the straight part of the protractor should be against the long side of the block.
4. Rotate the beam 10° each time, still entering the block at the same marking and record each path.
5. For each position, measure the angle of incidence (angle between the incident ray and normal) and the angle of refraction (angle between the refracted ray and normal).

Calculations

- The refractive index of the rectangular block, $n = \frac{\sin i}{\sin r}$ where i is the angle of incidence and r is the angle of refraction. To derive this formula replace n_1 in Snell's law with 1 as this is the refractive index of air.
- The refractive index of the semi circular block is found by, $n = \frac{1}{\sin c}$ where c is the critical angle.

Notes

- The printed protractor will have a large error and a real protractor underneath tracing paper may give more accurate results.
- Using a laser gives more defined rays so there is less uncertainty about where to trace the line (as the light is monochromatic so all light rays are refracted by the same amount).

Safety

- Do not shine the light from the ray box in eyes as it can damage the retina.
- Lasers can permanently damage your eyesight therefore, when using lasers there are several safety precautions, which must be followed:
  - Wear laser safety goggles
  - Don't shine the laser at reflective surfaces
  - Display a warning sign
  - Never shine the laser at a person

Young's Double Slit Experiment

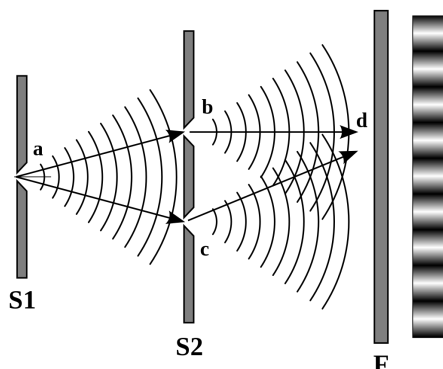**Equipment**

- Laser
- Double slit
- Screen
- Ruler

Method

Image source: Stannered, CC BY-SA 3.0

1. Shine the laser through the double slit so each slit acts as coherent point source.

2. Observe the pattern of light and dark bands on the screen, mark the centre of each bright spot then turn the laser off and measure the distance of at least 4 fringe spacings.

3. Measure the distance from the slits to the screen (D) and record the distance between the slits, s (should be given by manufacturer).

Calculations
- Find the fringe spacing by dividing the distance across 4 adjacent fringes by 3 to find fringe spacing (w).
- Rearrange the double slit equation to make λ the subject, $\lambda = \frac{ws}{D}$, and substitute the other values, making sure all units are in m, to calculate wavelength.

Safety
- Lasers can permanently damage your eyesight therefore, when using lasers there are several safety precautions, which must be followed:
    - Wear laser safety goggles
    - Don't shine the laser at reflective surfaces
    - Display a warning sign
    - Never shine the laser at a person

Notes
- Vary wavelength by changing the colour of the laser and see how this affects the fringe spacing, varying different values can show how they are related.
- Use white light to see a less intense diffraction pattern with a bright white central fringe and spectral adjacent fringes.