A Guide to Wave Fronts

Teaching Approach

This series presents the phenomenon of diffraction as a problem that exercised the best minds of the 17^{th} to 19^{th} centuries. Nobody really knew what light was and how it travelled, and it was not a simple matter to work it out.

The contest between the ideas of Newton and Huygens is an example of how science develops confidence that it has good explanations for natural phenomena.

Thomas Young showed that light from two sources that are in phase will produce light and dark fringes and this can be explained only by a wave theory of light.

Then we go into the way we can manipulate the light by changing the slit width and the wavelength.

The investigations have useful results such as the ability to detect elements that are in our sun and other stars billions of kilometres away.

The videos have only a few questions in them so make use of the task video to ensure that the students exercise the ideas you are teaching them through the Mindset lesson videos.

Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next day's lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

1. Why Light is a Wave

The lesson sets out the contest of Newton's and Huygens' explanation of what light is, and how it travels away from a source. The double-slit experiment of Thomas Young was decisive in showing that it's best to think of light as a wave.

2. Huygens' Principle

This lesson deals with Huygen's Principle that each point in a wave is a source of secondary waves of the same frequency and wave length. These secondary waves form a new wave front that advances through the medium.

3. Investigating Diffraction

This lesson shows how the degree of diffraction depends on the width of the slit the wave passes through, and shows why the diffraction angle depends on both the slit width and the wavelength.

4. Diffraction and Science Discoveries

This video shows how diffraction phenomena can reveal what stars are made of, and these same phenomena also make it difficult to study very small objects through a microscope.

Resource Material

1. Why Light is a Wave	http://www.physicsclassroom.com/class/light/u12l1b.cfm	This has a good explanation of two-source interference and has two animations to play.
	http://imagine.gsfc.nasa.gov/docs/science/how_l1/spectral_what.html	Article on spectral lines
2. Huygens' Principle	http://physics.about.com/od/mathematicsofwaves/a/huygensprincipl.htm	An introduction to Huygen's principle.
3. Investigating Diffraction	http://www.launc.tased.edu.au/online/sciences/physics/diffrac.html	About diffraction in microscopes. Has nice animations of diffraction and the effect on resolution of decreasing the lens size.
4. Diffraction and Science Discoveries	http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/home_energy/introduction_to_wavesrev6.shtml	Deals with diffraction in microscopes
	http://imagine.gsfc.nasa.gov/docs/science/how_l1/spectral_what.html	Spectra analysis

Task

Question 1

Here is the drawing of the two point sources.

1.1 Where does constructive and destructive interference occur?

1.2 Use a coloured pencil to join the points where constructive interference happens. The lines you draw are called the anti-nodal lines.

1.3 Use a different coloured pencil to join the points where destructive interference happens. The lines you draw are called the nodal lines

Question 2

You want to use the relationship Sin θ = $\frac{\lambda}{w}$ to calculate the wavelength of orange light. You have adjusted the width of the slit to 0.03 mm wide, and carefully measured the angle ɵ to the first bright fringe. You find that the angle is 1.2°. Now work out the wavelength of the orange light.

Question 3

Orange light is diffracted and spreads out as it passes through that narrow slit.

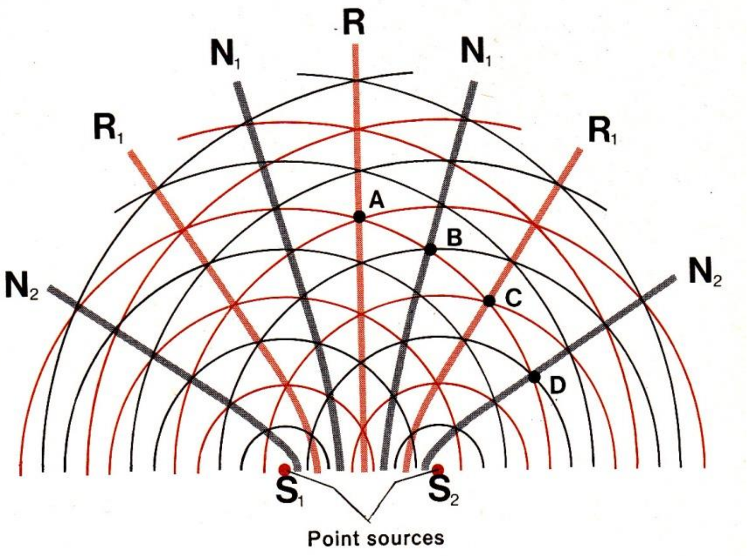
Sketch the diffraction pattern for orange light, as you think it would look. You have seen a diffraction pattern for red light in the videos. Show at least two bright fringes on each side of the central bright line

Question 4

Imagine you kept the slit width the same as in question 3 but used blue light. Right underneath your sketch of the diffraction pattern for orange light, draw a diffraction pattern for <u>blue</u> light. Will the pattern look different to the one for orange light? If so, how will it look different?

Task Answers

Question 1



Question 2

$$\sin\theta = \frac{\lambda}{w}$$

$$\sin 1.2° = \frac{\lambda}{0.03 \times 10^{-3}\, m}$$

$$\lambda = \sin 1.2° \times 0.03 \times 10^{-3}\, m$$

$$\lambda = 6.28 \times 10^{-7} m$$

$$\lambda = 628 nm$$

Question 3

Something like this is adequate. It should show a central maximum, and then thinner bright fringes on either side, getting fainter. The student should colour the pattern orange.

Question 4

Wavelength for blue light is shorter than for orange light, so in the formula $\sin\theta = \frac{\lambda}{w}$, sin ϴ will be smaller, and so the angle ϴ will be smaller, and so the pattern will be spread out less than the pattern for orange light.

The fringes must be narrower and closer together than for the orange light. The student should colour the pattern blue.

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