A Level H2 Physics Tutorial 12: Superposition

Syllabus :
(a) explain and use the principle of superposition in simple applications

(b) show an understanding of the terms interference, coherence, phase difference and path difference

(c) show an understanding of experiments which demonstrate stationary waves using microwaves, stretched strings and air columns

(d) explain the formation of a stationary wave using a graphical method, and identify nodes and antinodes

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1.

(a) Using diagrams, show that when two waves travelling in opposite direction meet, a stationary wave is formed. Explain using the diagrams of two overlapping waves at times t = 0, T/2, T and 3T/2, where T is the period.

(b) The displacements are clearly changing. In what sense is the wave stationary?

(c) label the nodes and antinodes on the diagrams.

(e) explain the meaning of the term diffraction

(f) show an understanding of experiments which demonstrate diffraction including the diffraction of water waves in a ripple tank with both a wide gap and a narrow gap

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2. Sketch the diffraction of water wave through :

(a) a gap much wider than the wavelength,

(b) a gap of similar size to to the wavelength.

(g) show an understanding of experiments which demonstrate two-source interference using water waves, sound waves, light waves and microwaves

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(h) show an understanding of the conditions required for two-source interference fringes to be observed

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(i) recall and solve problems using the equation $\lambda = ax / D$ for double-slit interference

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3. This is the top view of a ripple tank (of water). A plane wave on the water surface is diffracted through two slits.

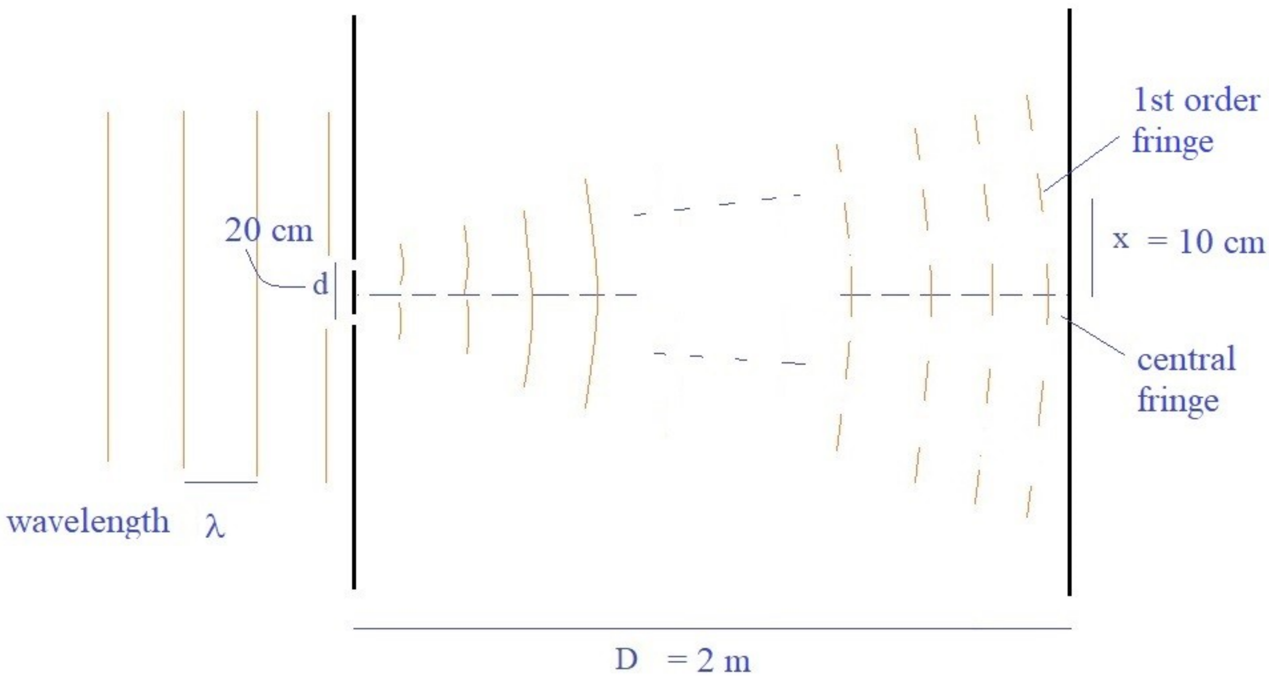

Figure 12-1

Using the distances of d, D and x show above, calculate the wavelength λ of the ripple.

(j) recall and use the equation $\sin\theta = \lambda / b$ to locate the position of the first minima for single slit diffraction

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4. Plane wave on a water surface is diffracted through a single slit 20 cm wide.

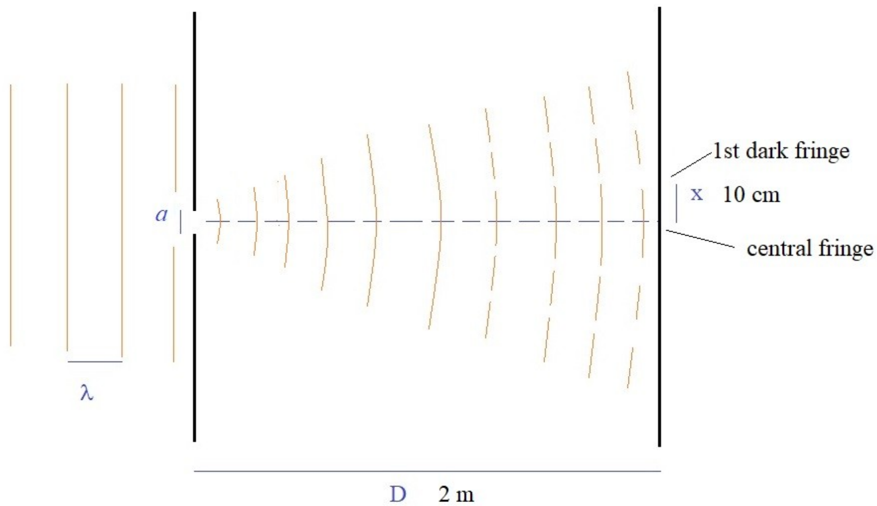

Figure 12-2

Using the distances of a, D and x given above, calculate the wavelength of the ripples.

(k) recall and use the Rayleigh criterion $\theta \approx \lambda / b$ for the resolving power of a single aperture

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5. Referring to the single slit diffraction above, suppose we place a converging lens just after an aperture and enclose it with a tube like this.

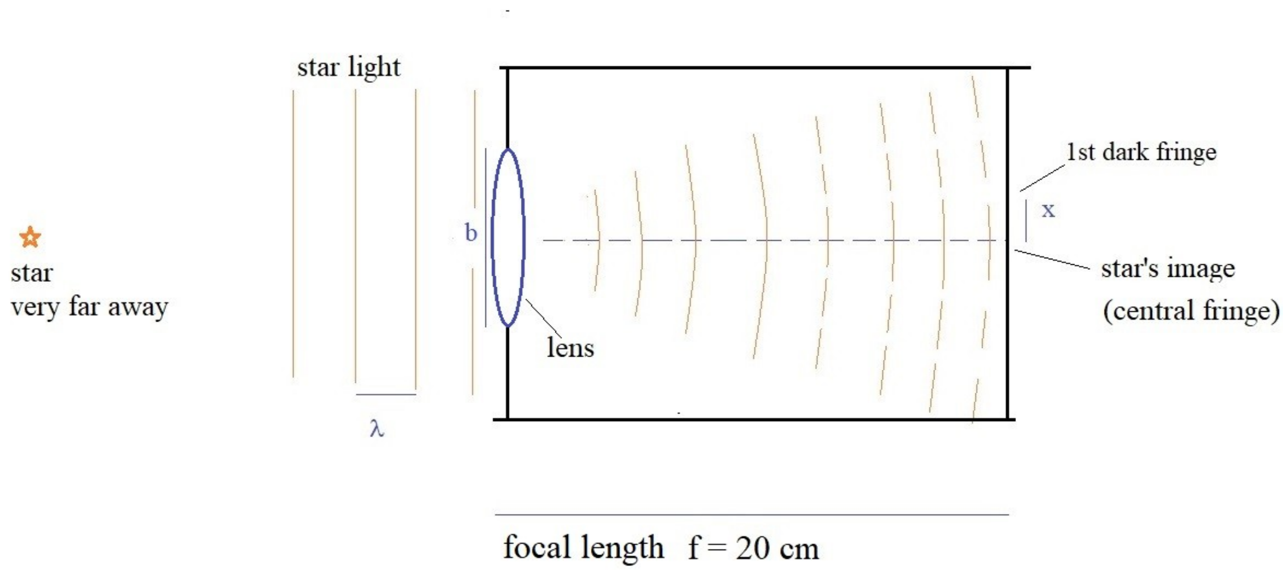

Figure 12-3

Then we can use it to form an image of a star.

The star light would undergo diffraction when it passes through the lens, just as when a wave goes through a slit. The difference is that the fringes would be formed at the focal distance, f.

(i) As the star is so far away, the star's light rays reaching the lens would be parallel. Find the width of the star's image as a result of diffraction. The lens aperture is 10 cm, and wavelength of the star light is 600 nm. The same formula for single slit diffraction may be used here approximately.

(ii)

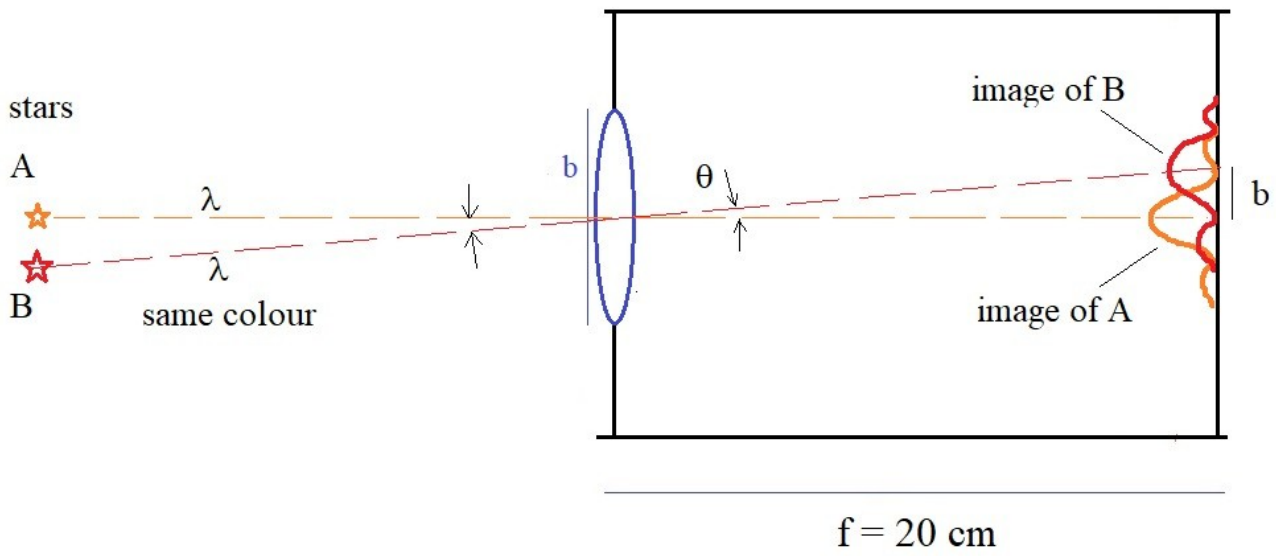

Figure 12-4

State Rayleigh's criterion for the smallest angle θ in the above diagram for which we can resolve the images of the two stars (that is, for which we can tell them apart).

(iii) For wavelength λ = 600 nm and lens aperture b = 10 cm, find this angle θ.

(l) recall and use the equation $d \sin\theta = n\lambda$ to locate the positions of the principal maxima produced by a diffraction grating

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(m) describe the use of a diffraction grating to determine the wavelength of light (the structure and use of a spectrometer are not required)

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6. A diffraction grating has many slits. This produces very narrow fringes. The slits are also very close together, which gives much wider spacing between fringes. So the fringe spacing can be measured accurately, which means that the wavelength can be calculated accurately.

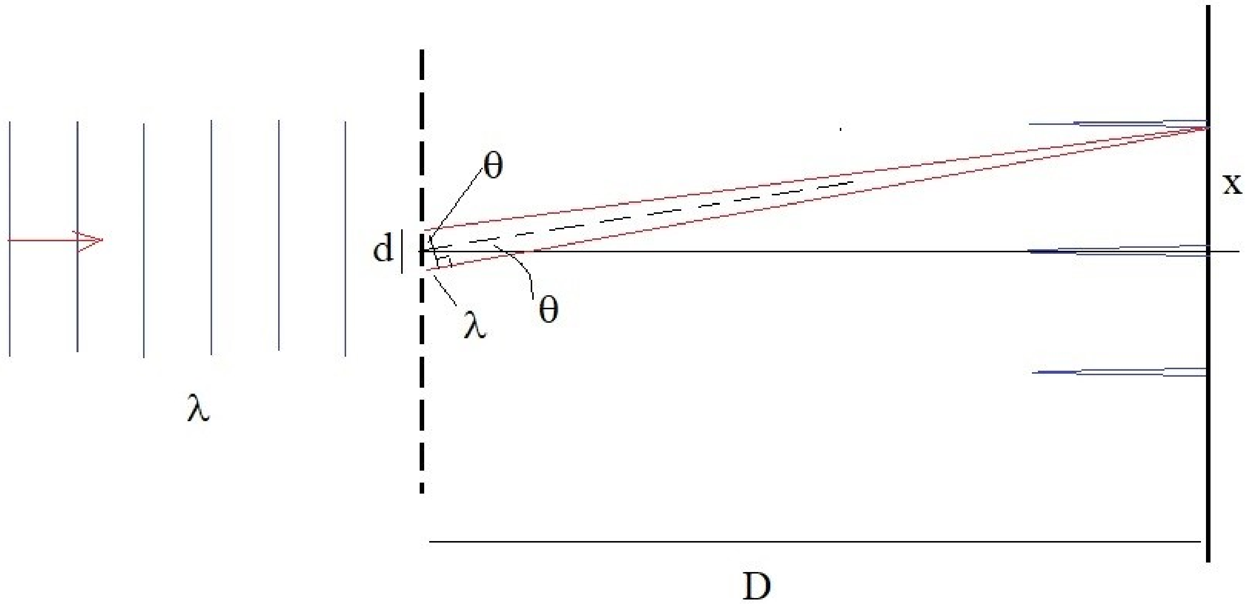

Figure 12-5

A diffraction grating has 10000 lines per cm. A light of wavelength 500 nm falls on the grating. Sharp fringes are see on a screen 1 m away. Find the spacing between the 0^{th} and 1^{st} order fringes.