AQA A-Level Physics

Topic 3.2 Refraction, diffraction and interference

Flashcards

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Define coherence.

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Define coherence.

Coherent waves have a fixed phase difference and the same frequency and wavelength.

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Why is a laser useful in showing interference and diffraction?

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Why is a laser useful in showing interference and diffraction?

It produces monochromatic (same wavelength / colour) light so diffraction and interference patterns are more defined.

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What was Young's double-slit experiment?

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What was Young's double-slit experiment?

A single light source is directed towards two slits, which each act as a coherent light source, the light interferes constructively and destructively to create an interference pattern.

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Describe the interference pattern created using white light.

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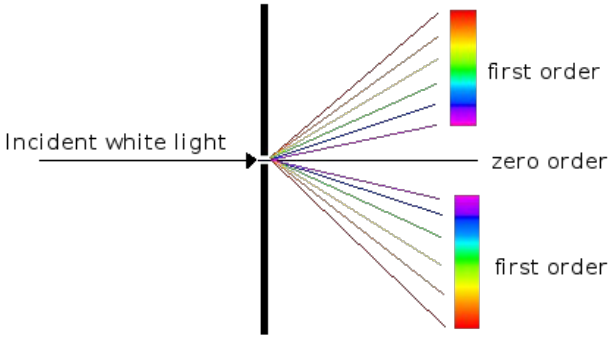
Describe the interference pattern created using white light.

A bright white central maximum flanked by alternating spectral fringes of decreasing intensity with violet closest to the zero order and red furthest

http://gemologyproject.com/wiki/index.php?title=Diffraction



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Why does an interference pattern form when light is passed through a single slit?

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Why does an interference pattern form when light is passed through a single slit?

The light diffracts as it passes through the slit, where the waves are in phase constructive interference occurs making bright fringes and where the waves are completely out of phase destructive interference occurs making a dark fringe.

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Increasing the slit width increases the width of the central diffraction maximum. True or False?

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Increasing the slit width increases the width of the central diffraction maximum. True or False?

False, the slit is not so close to the wavelength in size so less diffraction occurs - the central maximum becomes narrower and more intense.

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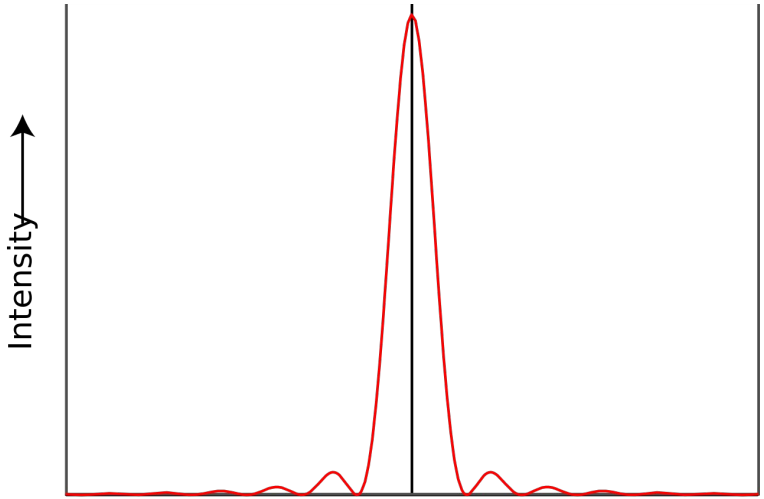
Is the following a double slit pattern, single slit pattern or a diffraction grating pattern?



https://commons.wikimedia.org/wiki/File:Single-slit-diffraction-graph.svg

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Is the following a double slit pattern, single slit pattern or a diffraction grating pattern?

Single Slit.

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What is the approximate refractive index of air?

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What is the approximate refractive index of air?

1

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When light enters a more optically dense medium does it bend towards or away from the normal?

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When light enters a more optically dense medium does it bend towards or away from the normal?

Towards the normal.

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When does total internal reflection occur?

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When does total internal reflection occur?

When light is at a boundary to a **less** optically dense medium and the angle of incidence is greater than the critical angle.

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What is the purpose of the cladding in a step index optical fibre?

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What is the purpose of the cladding in a step index optical fibre?

- Protects core from scratches which would allow light to escape and degrade the signal.
- Allows TIR as it has a lower refractive index than the core.

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How does signal degradation by absorption in an optical fibre affect the received signal?

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How does signal degradation by absorption in an optical fibre affect the received signal?

Part of the signal's energy is absorbed by the fibre so its amplitude is reduced.

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What is pulse broadening?

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What is pulse broadening?

When the received signal is wider than the original, this can cause overlap of signals leading to information loss.

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How does modal dispersion cause pulse broadening?

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How does modal dispersion cause pulse broadening?

Light rays enter the fibre at different angles so they take different paths along it, some may travel down the middle while others are reflected repeatedly, so the rays take different times to travel along the fibre, causing pulse broadening.

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What is material dispersion?

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What is material dispersion?

When light with different wavelengths is used some wavelengths slow down more than others in the fibre so they arrive at different times causing pulse broadening.

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How can modal dispersion be reduced?

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How can modal dispersion be reduced?

Use a single mode fibre (very narrow fibre) so the possible difference in path lengths is smaller.

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How can material dispersion be reduced?

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How can material dispersion be reduced?

Use monochromatic light.

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How can both absorption and dispersion be reduced?

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How can both absorption and dispersion be reduced?

Use a optical fibre repeater to regenerate the signal now and then.

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State the advantages of optical fibres over traditional copper wires.

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State the advantages of optical fibres over traditional copper wires

- Signal can carry more information as light has a high frequency.
- No energy lost as heat.
- No electrical interference.
- Cheaper.
- Very fast.

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What path does a light ray take when the angle of incidence is equal to the critical angle?

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What path does a light ray take when the angle of incidence is equal to the critical angle?

It goes along the boundary ie. the angle of refraction is 90°.

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What formula can be used to find the critical angle for 2 materials whose refractive indices are known?

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What formula can be used to find the critical angle for 2 materials whose refractive indices are known?

$\sin C = n_2 / n_1$ where $n_1 > n_2$

C = critical angle

n_1 = refractive index of material 1

n_2 = refractive index of material 2

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What is the critical angle of a water to air boundary if water has a refractive index of 1.33?

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What is the critical angle of a water to air boundary if water has a refractive index of 1.33?

sinC = n2 / n1 | n2 = air = 1 | n1 = water = 1.33

C = sin^-1 (1 / 1.33)

C = 48.8°

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Using snell's law of refraction, find the angle of refraction in a material with RI = 1.53 when the angle of incidence is 32° from a material with RI = 1.23.

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Using snell's law of refraction, find the angle of refraction in a material with RI = 1.53 when the angle of incidence is 32° from a material with RI = 1.23.

$n1\sin i = n2\sin r$

$1.23\sin 32 = 1.53\sin r$

$\sin r = 1.23\sin 32 / 1.53$

$\sin r = 0.426$

$r = 25.2°$

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Glass has a refractive index of 1.5, water has a refractive index of 1.33, which is more optically dense?

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Glass has a refractive index of 1.5, water has a refractive index of 1.33, which is more optically dense?

Glass.

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What formula is used to determine the refractive index of a material?

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What formula is used to determine the refractive index of a material?

$$n = c / v$$

n = refractive index

c = speed of light in vacuum, 3x 10^8 m/s

v = speed of light in material

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State 2 applications of diffraction gratings.

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State 2 applications of diffraction gratings.

- Splitting up light from stars to make line absorption spectra- used to identify elements present in the star.
- X-ray crystallography, a crystal sheet acts as the diffraction grating the X-rays pass through, used to find the spacing between atoms.

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Derive the formula $d\sin\theta = n\lambda$

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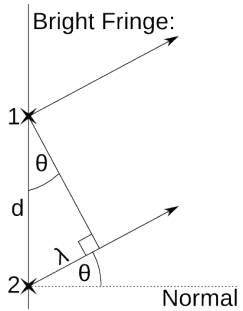
Derive the formula dsinθ = nλ

1. For the first order maximum, the path difference between two adjacent rays of light is 1λ (as shown), the angle between the normal to the grating and the light ray is θ.
2. A right angled triangle is formed, with side lengths d and λ. the upper angle is θ (the lower angle is 90-θ°) .
3. for the first maximum sinθ =λ/d, (sin θ = Opp/Hyp) rearrange to dsin =λ,
4. other maxima occur when the path difference between the two rays of light is nλ, where n is an integer, replace λ with nλ to get: d sin =nλ



https://commons.wikimedia.org/wiki/File:Youngs_slits.png

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When light passing through a diffraction grating is changed from blue to red, do the orders get closer together?

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When light passing through a diffraction grating is changed from blue to red, do the orders get closer together?

The wavelength of light has increased so it will diffract more, the orders will become further apart.

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What is diffraction?

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What is diffraction?

The spreading out of waves when they pass through or around a gap.

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How did Young's double slit experiment provide evidence for the wave nature of light?

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How did Young's double slit experiment provide evidence for the wave nature of light?

Diffraction and interference are wave properties hence the interference pattern of light shows light has wave properties.

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What are 4 safety precautions that must be followed when using a laser?

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What are 4 safety precautions that must be followed when using a laser?

- Wear laser safety goggles
- Don’t shine the laser at reflective surfaces
- Display a warning sign
- Never shine the laser at a person

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What formula is associated with Young's double slit experiment?

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What formula is associated with Young's double slit experiment?

$$w = \lambda D / s$$

w - fringe spacing

λ - wavelength of light used

D - distance from screen to slits

s - slit separation

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The maxima formed by shining a laser through 2 slits are 0.04m apart, the slits are 0.2mm apart and the distance from the slits to the screen is 15m, what is the wavelength of the light?

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The maxima formed by shining a laser through 2 slits are 0.04m apart, the slits are 0.2mm apart and the distance from the slits to the screen is 15m, what is the wavelength of the light?

$\lambda = ws / D$

$= (0.04 \times 0.2 \times 10^{-3}) / 15$

$= 5.3 \times 10^{-7}$ m

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What is path difference?

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What is path difference?

The difference in distance travelled by 2 waves.

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How could you investigate stationary sound waves?

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How could you investigate stationary sound waves?

Place a speaker at one end of a closed glass tube, lay powder across the bottom of the tube, it will be shaken from the antinodes and settle at the nodes. The distance between each node is half a wavelength.

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What is the frequency of the first harmonic of a string length 2m, mass 0.03kg with a mass of 2kg hanging off it?

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What is the frequency of the first harmonic of a string length 2m, mass 0.03kg with a mass of 2kg hanging off it?

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

T = tension = 2 x 9.81 = 19.62N

μ = mass / unit length = 0.03 / 2 = 0.015 kg/m

f = (¼) x (sq.rt: 19.62/0.015)

F =9.0 Hz

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What is the speed of a wave with frequency 10GHz and wavelength 6cm?

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What is the speed of a wave with frequency 10GHz and wavelength 6cm?

$$c = f\lambda$$

c = (10x10^9) x (6x10^-2)

c = 6x10^8 m/s

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What is ‘phase’?

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What is ‘phase’?

The position of a certain point on a wave cycle, (units are radians, degrees or fractions of a cycle).

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True or False:
‘Only light can produce interference patterns’.

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True or False: ‘Only light can produce interference patterns’.

False: interference patterns can be formed by sound waves and all EM waves too.

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