CAIE Physics A-level

8 - Superposition

Flashcards

What is the principle of superposition?

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In the context of waves, the principle of superposition means that if multiple waves overlap in space and time, the resultant wave will constitute the sum of the amplitudes of the component waves.

What are the two types of interference?

What are the two types of interference?

Constructive and destructive.

What is constructive interference?

What is constructive interference?

Constructive interference is when waves superpose such that the amplitude of the wave increases i.e. the maxima of the component waves combine.

What is destructive interference?

What is destructive interference?

Destructive interference is when waves superpose such that the amplitude of the wave decreases i.e. maxima and minima of the component waves combine. If this occurs to the maximum extent, oscillations can be nullified completely.

Describe an experiment to investigate the principle of superposition using sound.

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1. Use two speakers, a moderate distance apart, connected to the same signal generator to transmit sound waves.
2. Walk along a line perpendicular to the speakers - you should hear alternating loud and quiet points.
3. This is because in some places the waves from each speaker constructively interfere (loud) and in some places it's destructive.

What is a stationary wave?

What is a stationary wave?

Stationary waves consist of an alternating fixed pattern of nodes (points with zero amplitude) and antinodes (points with maximum amplitude). No energy is transferred by the wave, it is only stored.

What is a node?

What is a node?

A point with no vibrations and at which the resultant amplitude is 0.

What is an antinode?

What is an antinode?

A point with maximum vibration and at which the resultant amplitude is at a maximum.

What are the conditions for a stationary wave to be produced?

What are the conditions for a stationary wave to be produced?

- The waves must be coherent.
- They must be travelling in opposite directions.

These conditions are often met when a wave is reflected back onto itself.

Give an example of an experiment that demonstrates stationary waves.

Give an example of an experiment that demonstrates stationary waves.

Use an oscillator to generate a wave along a string that is fixed at one end.

The stationary wave will form when the progressive wave is reflected off the fixed end.

Give a similarity and a difference between stationary waves and progressive waves.

Give a similarity and a difference between stationary waves and progressive waves.

Similarity: Both have a wavelength, frequency and amplitude.

Difference: Stationary waves don't transmit energy from one place to another.

How could you use the formation of stationary waves in a resonance tube to find the speed of sound?

How could you use the formation of stationary waves in a resonance tube to find the speed of sound?

- Create a closed end pipe using a hollow pipe inside a measuring cylinder containing water.
- Use a tuning fork (which produces a known frequency) and hold it above the tube.
- Move the tube up until you find the first position at which resonance occurs.
- This length will be a quarter of the wavelength.
- Use speed = frequency x wavelength.

What is meant by ‘harmonics’?

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Harmonics are points where the stationary wave form doesn’t change due to the waves in each direction reinforcing each other.

A stationary wave on a string is made to oscillate at its fundamental frequency (1st harmonic) - how many nodes and antinodes would you see?

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Nodes - 2 (1 at either end)

Antinodes - 1 (in the middle)

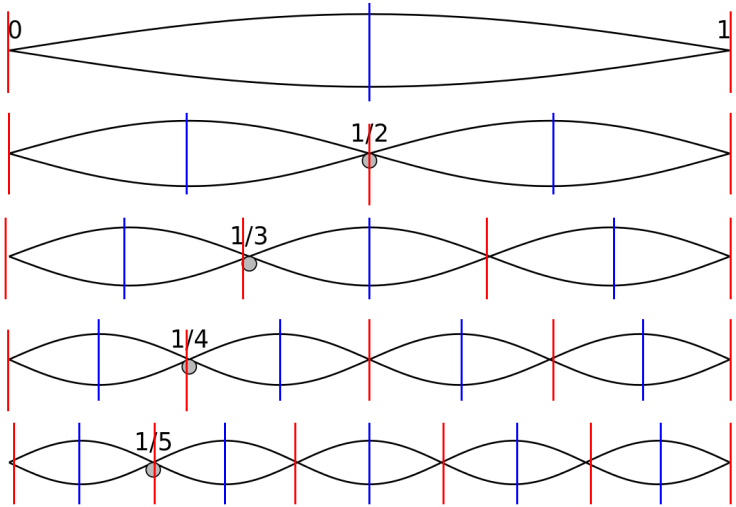
How can stationary microwaves be produced experimentally?

How can stationary microwaves be produced experimentally?

By reflecting a microwave beam. The nodes and antinodes of the reflected wave can be found using a microwave probe.

Identify the nodes and antinodes of these standing waves.

Identify the nodes and antinodes of these standing waves.



Red vertical lines nodes highlight nodes

Blue vertical lines highlight antinodes

How can the wavelength of a stationary wave be determined?

How can the wavelength of a stationary wave be determined?

The wavelength of a stationary wave is equal to twice the distance between adjacent nodes or twice the distance between adjacent antinodes.

Define coherence.

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Coherent waves have the same frequency and wavelength and a fixed phase difference (often zero in exam questions).

If two waves are in phase will they constructively or destructively interfere?

If two waves are in phase will they constructively or destructively interfere?

Waves in phase will constructively interfere.

True or false? Path difference and phase difference are two names for the same thing.

True or false? Path difference and phase difference are two names for the same thing.

False.

Path difference is the difference in distance that two waves have travelled in terms of the wavelength (units of length).

Phase difference is the difference in the point in the cycle of two waves as a proportion of a full wave cycle (units of degrees/radians).

What is diffraction?

What is diffraction?

Diffraction is the bending of waves that occurs as they encounter obstacles. It is obvious when a progressive wave is travelling through a gap, or around a corner.

True or false? Diffraction is most noticeable when the wavelength is much larger than the gap the wave is travelling through.

True or false? Diffraction is most noticeable when the wavelength is much larger than the gap the wave is travelling through.

- False.
- The greatest diffraction is seen when the gap and the wavelength are the same size.
- If the wavelength is much bigger the waves will be mostly reflected.

Describe how a ripple tank might be used to investigate diffraction.

Describe how a ripple tank might be used to investigate diffraction.

- Create water waves in the tank.
- Vary the size of the gap that they pass through.
- Note any changes to the direction of the waves passing through.

Why is a laser useful in showing interference and diffraction?

Why is a laser useful in showing interference and diffraction?

It produces monochromatic (same wavelength/colour) light.

What is Young's double-slit experiment?

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A single source of light is directed towards a double slit, which creates two coherent beams of light. These interfere as they travel towards a screen producing an interference pattern, when reflected off the screen.

Why must a single source be used in the Young's double-slit experiment?

Why must a single source be used in the Young's double-slit experiment?

For complete constructive interference to occur, the source must be coherent and in phase. This is automatically achieved if a single source is used.

Describe the interference pattern created using white light.

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The interference pattern would be a repeating coloured spectrum along the screen, with a bright white point directly in front of the slits.

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

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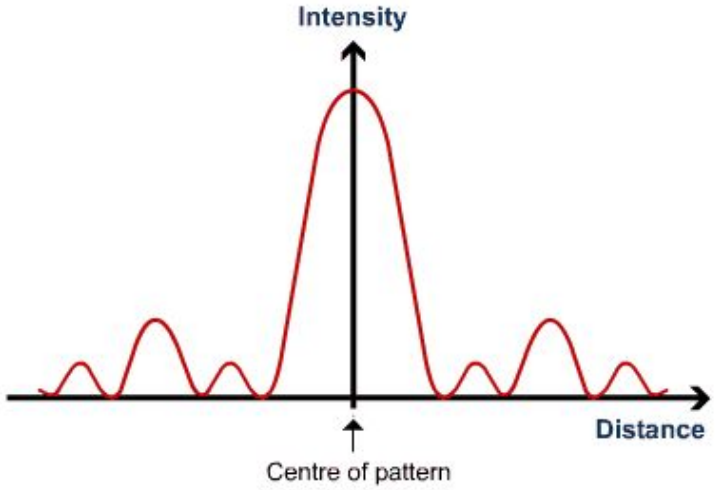
True.

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



https://www.s-cool.co.uk/a-level/physics/diffraction/revise-it/diffraction-interference-and-superposition

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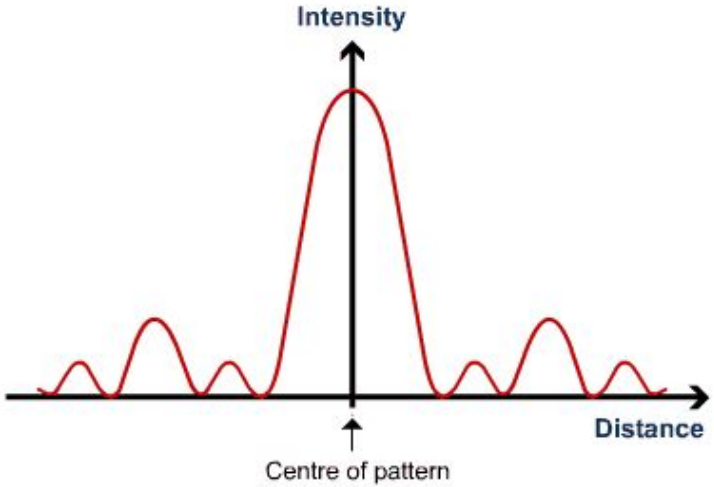

It is a single slit pattern. We know this because the intensity of the antinodes do not get consistently more intense towards the centre, as they would if interference were occurring.

https://www.s-cool.co.uk/a-level/physics/diffraction/revise-it/diffraction-interference-and-superposition

What equation relates the wavelength of light to the slit spacing and the distance to the screen?

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$$\lambda = ax / D$$

Where λ = wavelength, a = slit spacing, x = fringe spacing (on screen), and D = distance to screen

Which two properties of light can only be explained if it is a wave?

Which two properties of light can only be explained if it is a wave?

1. Diffraction.
2. Interference (as seen in Young's experiments).

When shining light through a diffraction grating there is a maximum number of fringes that can be produced. How would you find this maximum number?

When shining light through a diffraction grating there is a maximum number of fringes that can be produced. How would you find this maximum number?

$$n\lambda = D\sin\theta$$

The maximum angle that would produce a fringe would be 89.9999999…. (so call it 90!).

Rearrange the equation for n, using $\theta=90$.