Superposition – 2023 June AS Physics 9702

1. June/2023/Paper_ 9702/11/No.25

Two progressive waves meet at a point.

Which condition must be met for superposition of the waves to occur?

A The waves must be coherent.

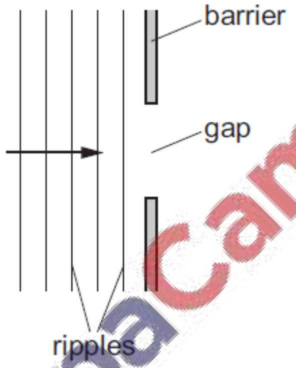
B The waves must be of the same type.

C The waves must be travelling in opposite directions.

D The waves must meet in phase.

2. June/2023/Paper_ 9702/11/No.27

A ripple tank and a barrier with a single gap are used to demonstrate the diffraction of surface ripples on water. Initially, the wavelength of the ripples is five times smaller than the gap in the barrier.



Which change increases the amount of diffraction observed?

A double the amplitude of the ripples

B double the width of the gap

C halve the frequency of the ripples

D halve the wavelength of the ripples

3. June/2023/Paper_ 9702/11/No.28

A laser produces a beam of light of wavelength 650 nm. The beam is incident normally on two slits that are a distance of 0.12 mm apart.

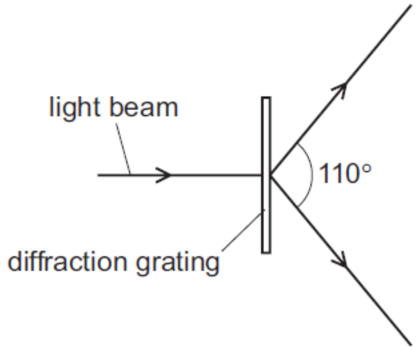
A screen is placed parallel to the slits. The bright interference fringes on the screen have a separation of 7.5 cm.

What is the distance between the screen and the two slits?

A 1.4 m **B** 2.8 m **C** 7.0 m **D** 14 m

4. June/2023/Paper_ 9702/11/No.29

A beam of light from a laser is incident normally on a diffraction grating.



The diagram shows only the **second**-order maxima that are produced.

The grating has a line spacing of 1.0×10^{-6} m. The angle between the two second-order maxima is 110°.

What is the wavelength of the light?

A 4.1×10^{-7} m

B 4.7×10^{-7} m

C 8.2×10^{-7} m

D 9.4×10^{-7} m

5. June/2023/Paper_ 9702/12/No.27

A continuous progressive water wave in a ripple tank passes through a gap in a barrier and diffracts.

The width of the gap is greater than the wavelength of the wave.

Which change causes the wave to spread over a larger angle as it passes through the gap?

A a small decrease in the wavelength of the wave

B a small decrease in the width of the gap

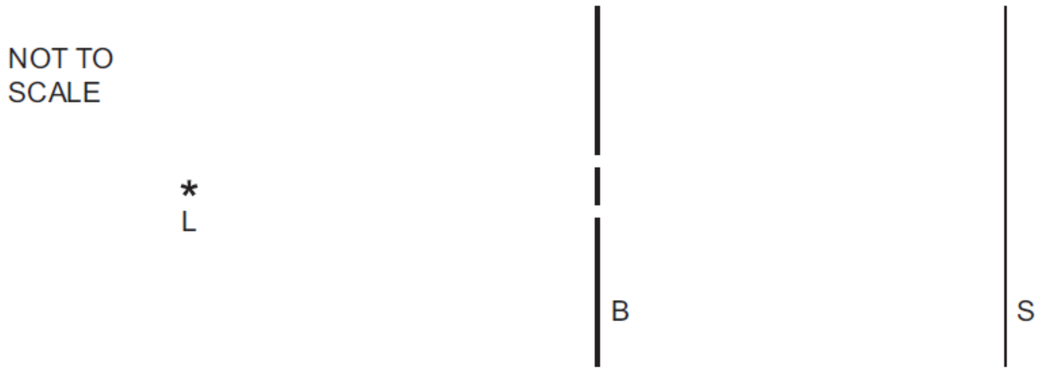
C a small increase in the frequency of the wave

D a small increase in the height of the barrier

6. June/2023/Paper_ 9702/12/No.28

The diagram shows a view from above of a double-slit interference demonstration.

L is a monochromatic light source with a vertical filament. B is a barrier with two narrow vertical slits and S is a screen upon which interference fringes form.



The intensity is I at the point on the screen where the centre of the fringe pattern forms.

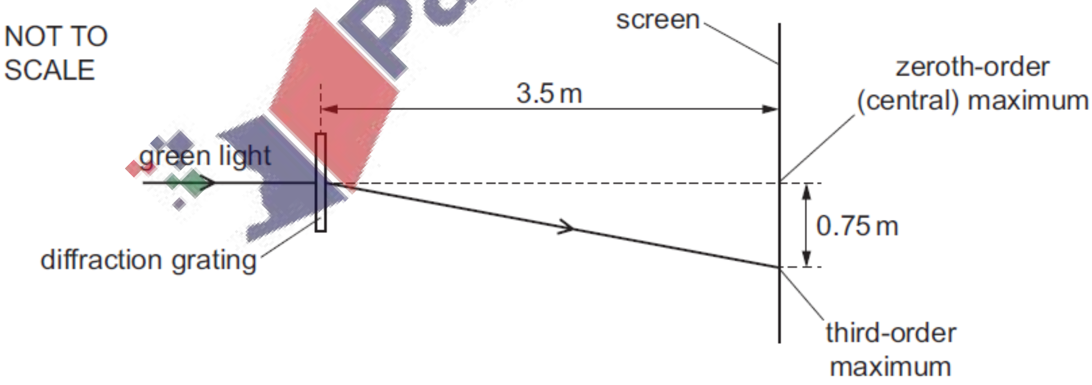
When one of the slits is covered, what is the intensity at the same point on the screen?

A $\frac{I}{\sqrt{2}}$ **B** $\frac{I}{2}$ **C** $\frac{I}{2\sqrt{2}}$ **D** $\frac{I}{4}$

7. June/2023/Paper_ 9702/12/No.29

Green light of wavelength 550 nm is incident normally on a diffraction grating and produces a diffraction pattern on a screen placed 3.5 m from the diffraction grating.

The **third**-order maximum on the screen is a distance of 0.75 m from the zeroth-order (central) maximum.



What is the distance between two adjacent slits in the diffraction grating?

A 2.6×10^{-6} m

B 7.7×10^{-6} m

C 7.9×10^{-6} m

D 1.0×10^{-5} m

8. June/2023/Paper_ 9702/13/No.27

An experiment is set up to demonstrate the diffraction of water waves in a ripple tank.

The waves pass through a gap of width *w* and some diffraction of the waves is observed.

The wavelength of the waves is now doubled.

What is the new gap width needed to cause the same amount of diffraction as before?

A 0.5*w* **B** *w* **C** 2*w* **D** 4*w*

9. June/2023/Paper_ 9702/13/No.28

Two coherent electromagnetic waves are travelling in a vacuum. The two waves meet at a point. At this point, the two waves have different intensities.

Which statement about the waves is **not** correct?

A They have a constant phase difference at the point.

B They have the same amplitude at the point.

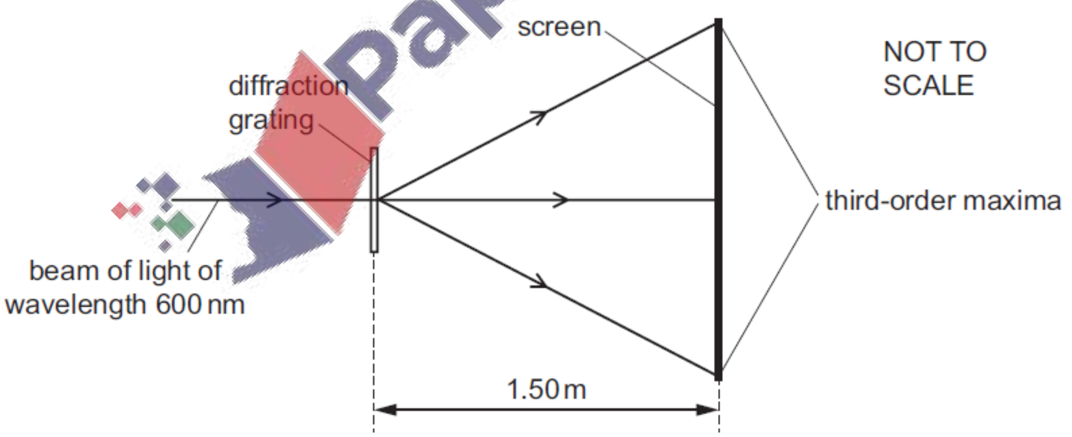
C They have the same frequency.

D They travel at the same speed.

10. June/2023/Paper_ 9702/13/No.29

A parallel beam of light of wavelength 600 nm is incident normally on a diffraction grating.

The distance between adjacent slits in the grating is 2.0×10^{-6} m. A screen is placed parallel to the grating, at a distance of 1.50 m from the grating. **Third**-order diffraction maxima are observed at the two ends of the screen, as shown.



What is the distance between the two ends of the screen?

A 1.4 m **B** 2.7 m **C** 3.1 m **D** 6.2 m

11. June/2023/Paper_ 9702/21/No.5(b, c)

(b) An arrangement that uses a double slit to demonstrate the interference of light from a laser is shown in Fig. 5.1.

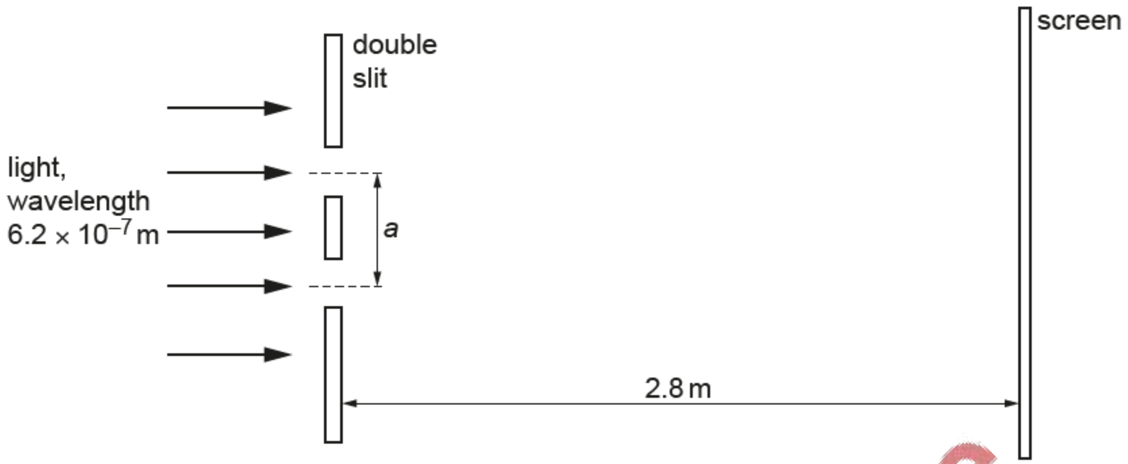


Fig. 5.1 (not to scale)

The light from the laser has a wavelength of 6.2×10^{-7} m and is incident normally on the slits. The separation of the two slits is *a*. The slits and screen are parallel and separated by a distance of 2.8 m.

An interference pattern of bright fringes and dark fringes is formed on the screen. The distance on the screen across 8 bright fringes is 22 mm, as illustrated in Fig. 5.2.

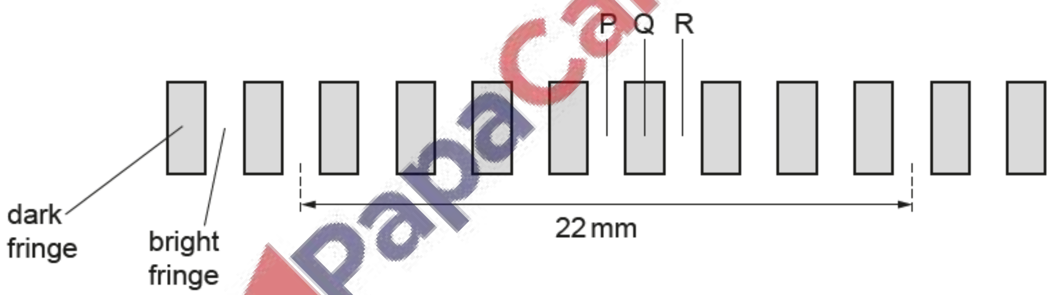


Fig. 5.2

(i) The light waves emerging from the two slits are coherent.

State what is meant by coherent.

....

.... [1]

(ii) Calculate the separation *a* of the slits.

a = ... m [3]

(c) Fringe P is the central bright fringe of the interference pattern in **(b)**. Fringe Q and fringe R are the nearest dark fringe and the nearest bright fringe respectively to the right of fringe P, as shown in Fig. 5.2.

(i) Calculate the difference in the distances (the path difference) from each slit to the centre of fringe Q.

difference in the distances = ... m [1]

(ii) State the phase difference between the light waves meeting at the centre of fringe R.

phase difference = ...° [1]

12. June/2023/Paper_ 9702/23/No.4(d)

(d) A metal sheet is now placed in front of the loudspeaker in **(b)**, as shown in Fig. 4.3.

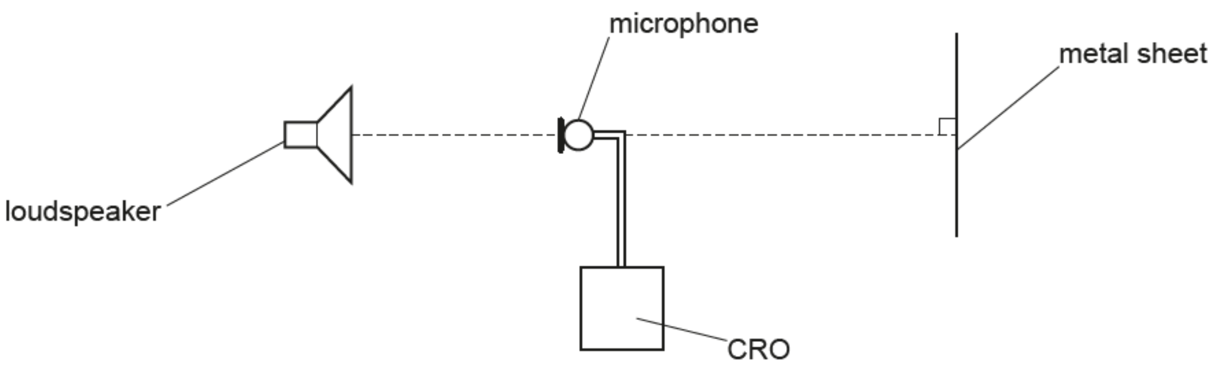


Fig. 4.3

A stationary wave is formed between the loudspeaker and the metal sheet.

(i) State the principle of superposition.

....

....

.... [2]

(ii) The initial position of the microphone is such that the trace on the CRO has an amplitude minimum. It is now moved a distance of 1.05 m away from the loudspeaker along the line joining the loudspeaker and metal sheet.

As the microphone moves, it passes through three positions where the trace has an amplitude maximum before ending at a position where the trace has an amplitude minimum.

Determine the wavelength of the sound wave.

wavelength = ... m [2]

(iii) Use your answers in **(b)(i)** and **(d)(ii)** to determine the speed of the sound in the air.

speed = ... $m\,s^{-1}$ [2]

13. March/2023/Paper_ 9702/12/No.25

A musical instrument is made using a long tube with a mouthpiece at one end. The other end is open and flared, as shown.

A musician maintains stationary sound waves with a node at the mouthpiece and an antinode at the other end. The lowest frequency of sound that the instrument can produce is 92 Hz.

Which different frequencies of sound can be produced by the instrument?

A 92 Hz, 138 Hz, 184 Hz, 230 Hz

B 92 Hz, 184 Hz, 276 Hz, 368 Hz

C 92 Hz, 276 Hz, 460 Hz, 644 Hz

D 92 Hz, 276 Hz, 828 Hz, 1288 Hz

14. March/2023/Paper_ 9702/12/No.26

Two waves of equal frequency and amplitude are travelling in opposite directions along a stretched string. When they meet, they form a stationary wave with three nodes and two antinodes.

The frequency of both waves is doubled and a new stationary wave is formed.

How many antinodes are there in the new stationary wave?

A 1 **B** 2 **C** 3 **D** 4

15. March/2023/Paper_ 9702/12/No.28

Waves are emitted from two coherent sources.

Which statement about the waves must be correct?

A They are in phase.

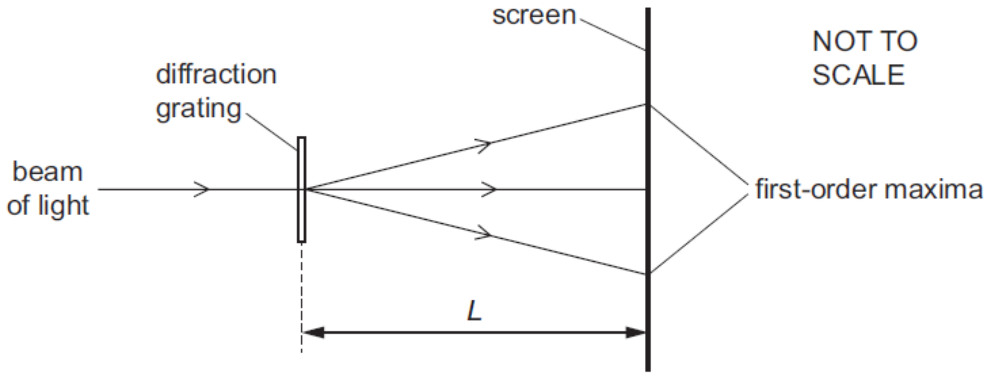
B They are transverse waves.

C They have a constant phase difference.

D They have the same amplitude.

16. March/2023/Paper_ 9702/12/No.29

The diagram shows a screen that is a distance L from a diffraction grating. The grating has a total number of N lines. Any two adjacent lines are a distance d apart. A beam of parallel light of wavelength λ is incident normally on the grating.



Which quantities affect the distance between the first-order diffraction maxima on the screen?

	d	λ	L	N
A	✓	✓	✓	✗
B	✓	✓	✗	✗
C	✓	✗	✓	✓
D	✗	✓	✗	✓

key

✓ = affects the distance

✗ = does not affect the distance

17. March/2023/Paper_ 9702/22/No.5(b),(c)

(b) An arrangement for demonstrating interference using light is shown in Fig. 5.2.

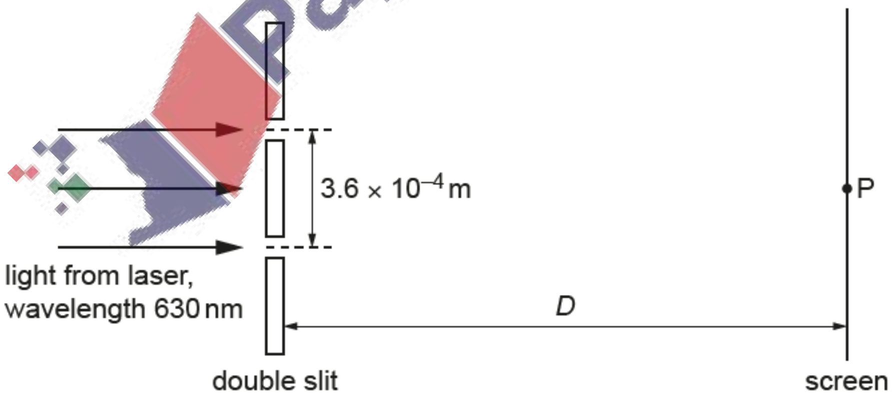


Fig. 5.2 (not to scale)

The wavelength of the light from the laser is 630 nm. The light is incident normally on the double slit. The separation of the two slits is 3.6×10^{-4} m. The perpendicular distance between the double slit and the screen is *D*.

Coherent light waves from the slits form an interference pattern of bright and dark fringes on the screen. The distance between the centres of two adjacent bright fringes is 4.0×10^{-3} m. The central bright fringe is formed at point P.

(i) Explain why a bright fringe is produced by the waves meeting at point P.

....

.... [1]

(ii) Calculate distance *D*.

D = ... m [3]

(c) The wavelength *λ* of the light in **(b)** is now varied. This causes a variation in the distance *x* between the centres of two adjacent bright fringes on the screen. The distance *D* and the separation of the two slits are unchanged.

On Fig. 5.3, sketch a graph to show the variation of *x* with *λ* from *λ* = 400 nm to *λ* = 700 nm. Numerical values of *x* are not required.

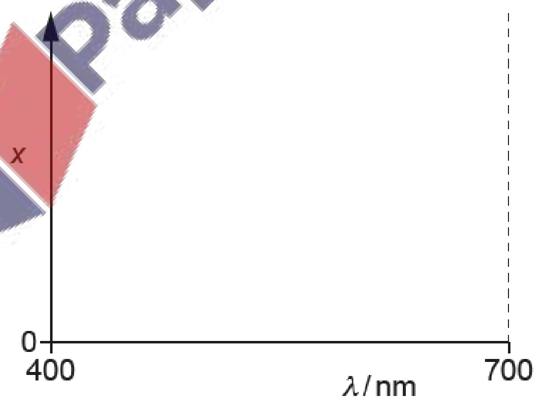


Fig. 5.3

[1]