

1. Question part 1/2 | 9702 Feb-March 2016 P2 V2 Q4

4 (a) (i) By reference to the direction of propagation of energy, state what is meant by a *transverse* wave.

.....
..... [1]

(ii) State the principle of superposition.

.....
.....
..... [2]

(b) Circular water waves may be produced by vibrating dippers at points P and Q, as illustrated in Fig. 4.1.

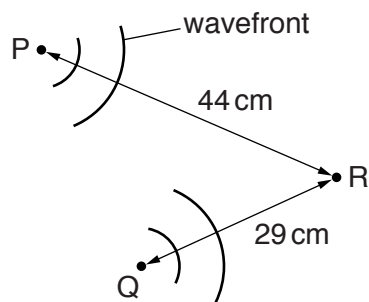


Fig. 4.1 (not to scale)

The waves from P alone have the same amplitude at point R as the waves from Q alone. Distance PR is 44 cm and distance QR is 29 cm.

The dippers vibrate in phase with a period of 1.5 s to produce waves of speed 4.0 cm s⁻¹.

(i) Determine the wavelength of the waves.

wavelength = ...cm [2]

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(ii) By reference to the distances PR and QR, explain why the water particles are at rest at point R.

.....

.....

.....

.....

..... [3]

(c) A wave is produced on the surface of a different liquid. At one particular time, the variation of the vertical displacement y with distance x along the surface of the liquid is shown in Fig. 4.2.

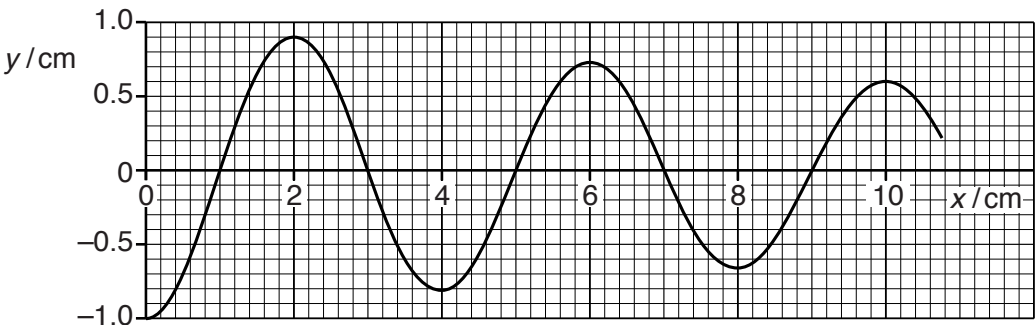


Fig. 4.2

(i) The wave has intensity I_1 at distance $x = 2.0\text{ cm}$ and intensity I_2 at $x = 10.0\text{ cm}$.

Determine the ratio

$$\frac{\text{intensity } I_2}{\text{intensity } I_1} .$$

ratio = ... [2]

(ii) State the phase difference, with its unit, between the oscillations of the liquid particles at distances $x = 3.0\text{ cm}$ and $x = 4.0\text{ cm}$.

phase difference = ... [1]

2. Question part 1/2 | 9702 May-June 2016 P2 V2 Q5

- 5 (a) Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction:
.....
interference:
.....
.....

[3]

- (b) The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

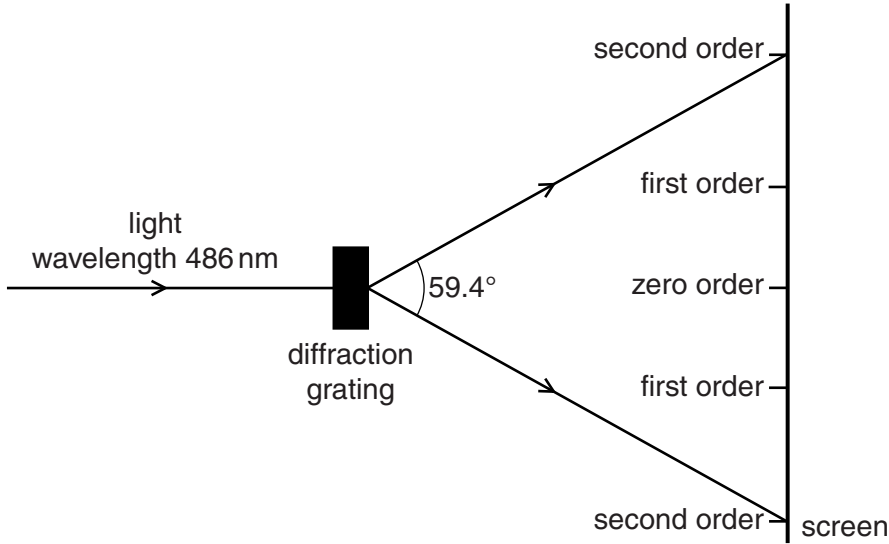


Fig. 5.1 (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating.

number of lines per millimetre = ... mm⁻¹ [3]

[Total: 6]

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3. Question part 1/2 | 9702 May-June 2016 P2 V3 Q7

- 7 (a) Apparatus used to produce stationary waves on a stretched string is shown in Fig. 7.1.

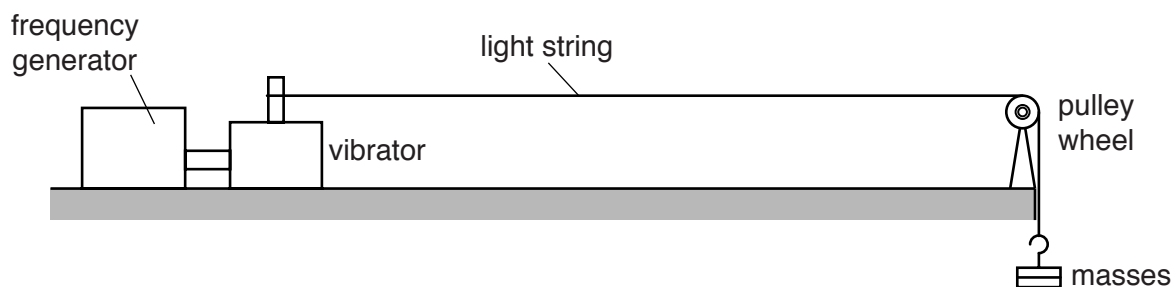


Fig. 7.1

The frequency generator is switched on.

- (i) Describe two adjustments that can be made to the apparatus to produce stationary waves on the string.

1.

.....

2.

.....

[2]

- (ii) Describe the features that are seen on the stretched string that indicate stationary waves have been produced.

..... [1]

- (b) The variation with time t of the displacement x of a particle caused by a progressive wave R is shown in Fig. 7.2. For the same particle, the variation with time t of the displacement x caused by a second wave S is also shown in Fig. 7.2.

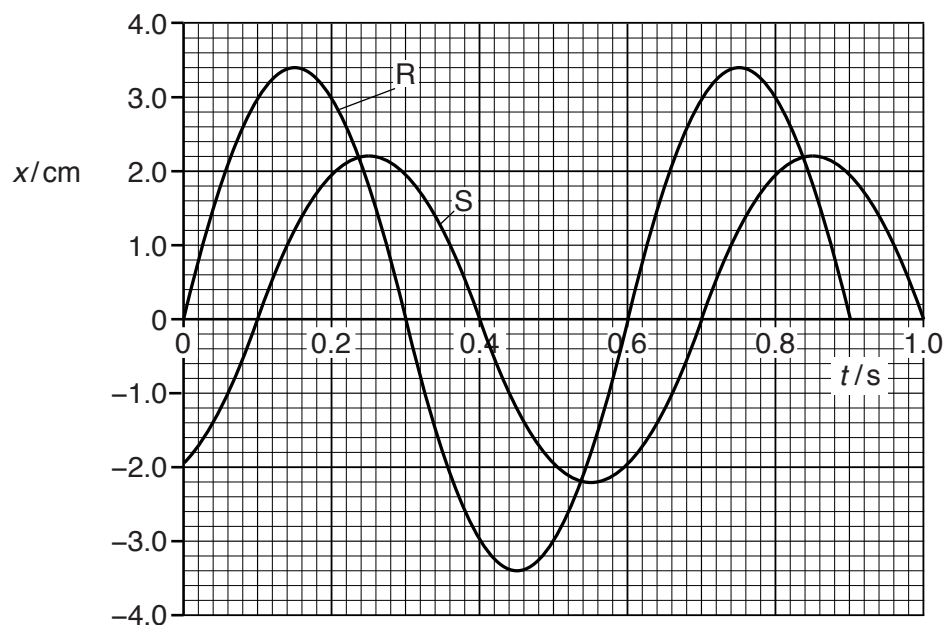


Fig. 7.2

- (i) Determine the phase difference between wave R and wave S. Include an appropriate unit.

phase difference = ... [1]

- (ii) Calculate the ratio

$$\frac{\text{intensity of wave R}}{\text{intensity of wave S}}$$

ratio = ... [2]

[Total: 6]

5 (a) State what is meant by the *diffraction* of a wave.

.....
.....[2]

(b) Laser light of wavelength 500nm is incident normally on a diffraction grating. The resulting diffraction pattern has diffraction maxima up to and including the fourth-order maximum.

Calculate, for the diffraction grating, the minimum possible line spacing.

line spacing = ... m [3]

(c) The light in (b) is now replaced with red light. State and explain whether this is likely to result in the formation of a fifth-order diffraction maximum.

.....
.....
.....
.....[2]

[Total: 7]

- 4 (a) State what is meant by the *diffraction* of a wave.

.....
[2]

- (b) An arrangement for demonstrating the interference of light is shown in Fig. 4.1.

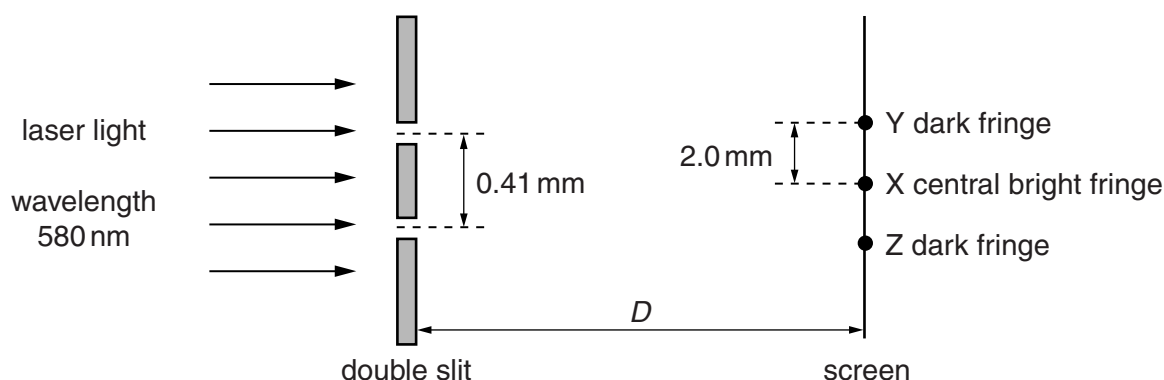


Fig. 4.1 (not to scale)

The wavelength of the light from the laser is 580 nm. The separation of the slits is 0.41 mm. The perpendicular distance between the double slit and the screen is D .

Coherent light emerges from the slits and an interference pattern is observed on the screen. The central bright fringe is produced at point X. The closest dark fringes to point X are produced at points Y and Z. The distance XY is 2.0 mm.

- (i) Explain why a bright fringe is produced at point X.

.....

[2]

- (ii) State the difference in the distances, in nm, from each slit to point Y.

distance = ... nm [1]

(iii) Calculate the distance D .

$D = \dots\dots\dots$ m [3]

(iv) The intensity of the light passing through the two slits was initially the same. The intensity of the light through **one** of the slits is now reduced. Compare the appearance of the fringes before and after the change of intensity.

.....

.....

.....

.....[2]

[Total: 10]

5 (a) State what is meant by the *diffraction* of a wave.

.....
.....[2]

(b) Laser light of wavelength 500nm is incident normally on a diffraction grating. The resulting diffraction pattern has diffraction maxima up to and including the fourth-order maximum.

Calculate, for the diffraction grating, the minimum possible line spacing.

line spacing = ... m [3]

(c) The light in (b) is now replaced with red light. State and explain whether this is likely to result in the formation of a fifth-order diffraction maximum.

.....
.....
.....
.....[2]

[Total: 7]

4 (a) State the conditions required for the formation of stationary waves.

.....

.....

.....[2]

(b) One end of a string is attached to a vibrator. The string is stretched by passing the other end over a pulley and attaching a load, as illustrated in Fig. 4.1.

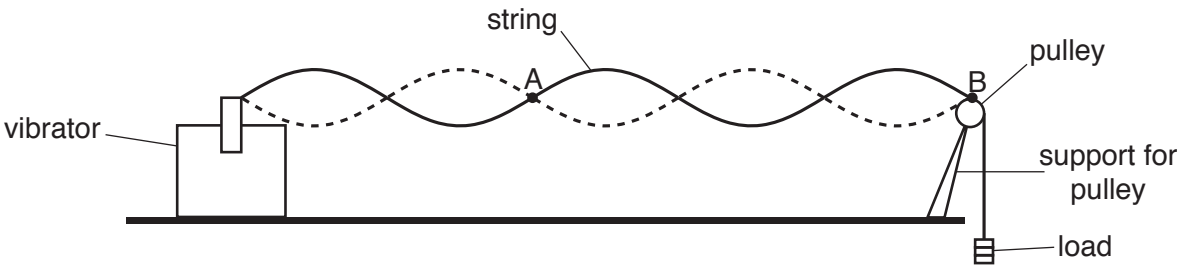


Fig. 4.1

The frequency of vibration of the vibrator is adjusted to 250 Hz and a transverse wave travels along the string with a speed of 12 m s^{-1} . The wave is reflected at the pulley and a stationary wave forms on the string.

Fig. 4.2 shows the string between points A and B at time $t = t_1$.

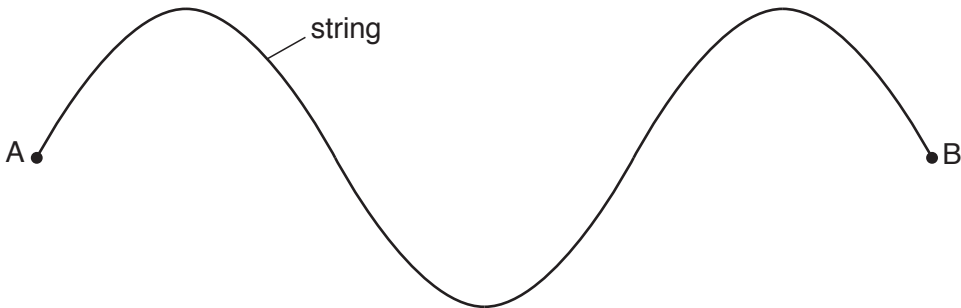


Fig. 4.2

At time $t = t_1$ the string has maximum displacement.

(i) Calculate the distance AB.

distance = ...m [2]

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(ii) On Fig. 4.2, sketch the position of the string between A and B at times

1. $t = t_1 + 2.0 \text{ ms}$ (label this line P),
2. $t = t_1 + 5.0 \text{ ms}$ (label this line Q).

[3]

[Total: 7]

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- 6 (a)** Interference fringes may be observed using a light-emitting laser to illuminate a double slit. The double slit acts as two sources of light.

Explain

- (i)** the part played by diffraction in the production of the fringes,

.....

.....

.....[2]

- (ii)** the reason why a double slit is used rather than two separate sources of light.

.....

.....

.....[1]

- (b) A laser emitting light of a single wavelength is used to illuminate slits S_1 and S_2 , as shown in Fig. 6.1.

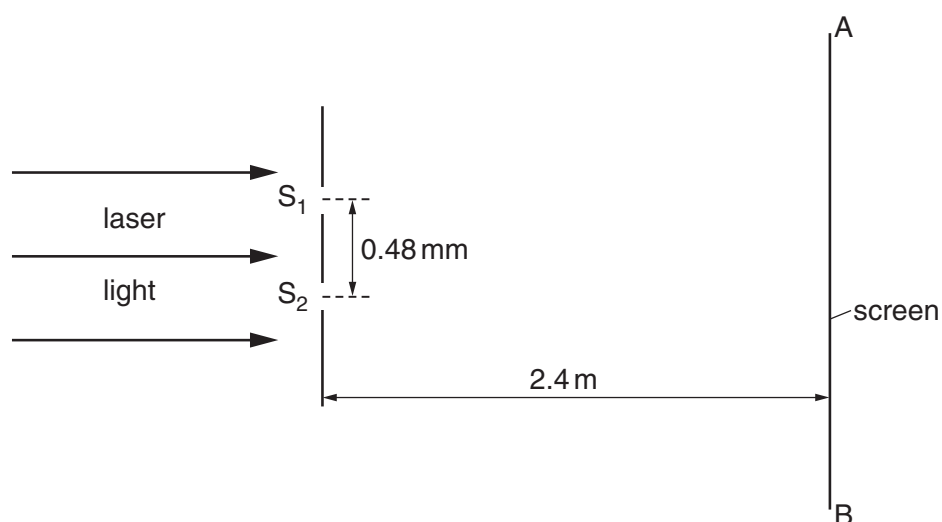


Fig. 6.1 (not to scale)

An interference pattern is observed on the screen AB. The separation of the slits is 0.48 mm . The slits are 2.4 m from AB. The distance on the screen across 16 fringes is 36 mm , as illustrated in Fig. 6.2.

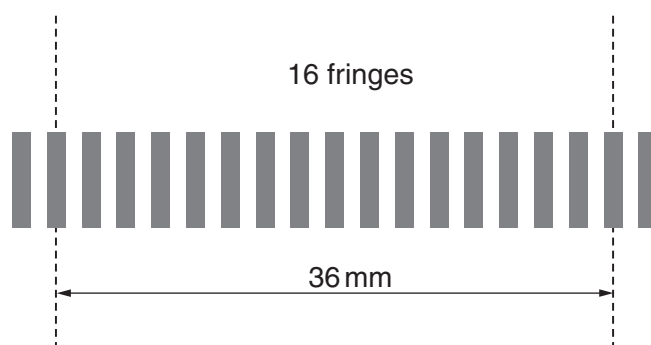


Fig. 6.2

Calculate the wavelength of the light emitted by the laser.

wavelength = ...m [3]

- (c) Two dippers D_1 and D_2 are used to produce identical waves on the surface of water, as illustrated in Fig. 6.3.

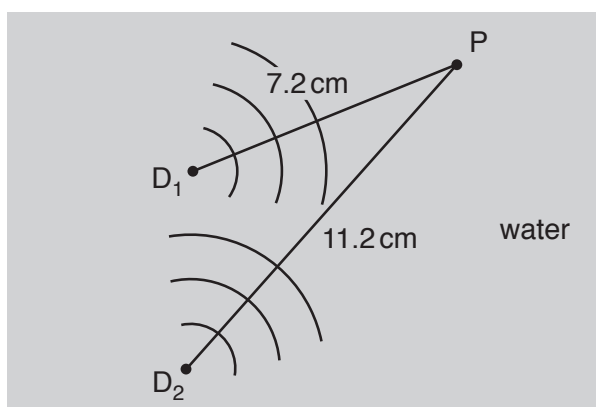


Fig. 6.3 (not to scale)

Point P is 7.2 cm from D_1 and 11.2 cm from D_2 .

The wavelength of the waves is 1.6 cm. The phase difference between the waves produced at D_1 and D_2 is zero.

- (i) State and explain what is observed at P.

.....

[2]

- (ii) State and explain the effect on the answer to (c)(i) if the apparatus is changed so that, separately,

1. the phase difference between the waves at D_1 and at D_2 is 180° ,

.....

2. the intensity of the wave from D_1 is less than the intensity of that from D_2 .

.....

[2]

[Total: 10]

5 (a) A diffraction grating is used to determine the wavelength of light.

(i) Describe the diffraction of light at a diffraction grating.

.....
.....
.....[2]

(ii) By reference to interference, explain

1. the zero order maximum,

.....
.....
.....

2. the first order maximum.

.....
.....
[3]

(b) A diffraction grating is used with different wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of $\sin \theta$ is shown in Fig. 5.1.

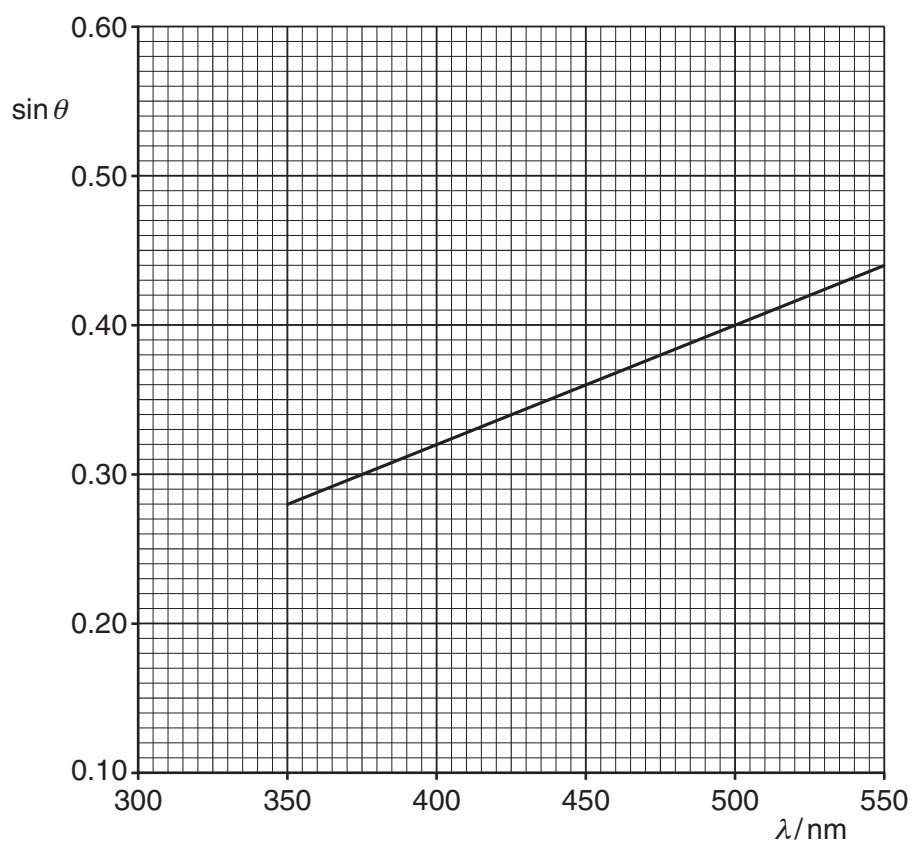


Fig. 5.1

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- (i) Determine the gradient of the line shown in Fig. 5.1.

gradient = ...[2]

- (ii) Use the gradient determined in (i) to calculate the slit separation d of the diffraction grating.

$d = \dots\dots\dots$ m [2]

- (iii) On Fig. 5.1, sketch a line to show the results that would be obtained for the first order maxima. [1]

[Total: 10]

- 4 (a) State the conditions required for the formation of a stationary wave.

.....

.....

.....

.....[2]

- (b) A horizontal string is stretched between two fixed points X and Y. The string is made to vibrate vertically so that a stationary wave is formed. At one instant, each particle of the string is at its maximum displacement, as shown in Fig. 4.1.

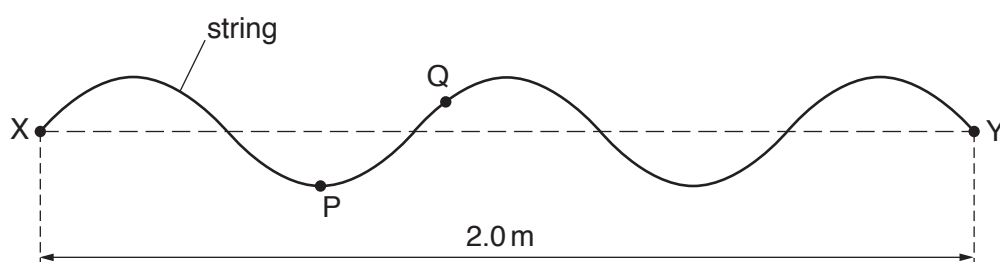


Fig. 4.1

P and Q are two particles of the string. The string vibrates with a frequency of 40 Hz. Distance XY is 2.0 m.

- (i) State the number of antinodes in the stationary wave.

number = ...[1]

- (ii) Determine the minimum time taken for the particle P to travel from its lowest point to its highest point.

time taken = ... s [2]

- (iii) State the phase difference, with its unit, between the vibrations of particle P and of particle Q.

phase difference = ...[1]

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(iv) Determine the speed of a progressive wave along the string.

speed = ...ms⁻¹ [2]

[Total: 8]

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- 4 (a) State the conditions required for the formation of a stationary wave.

.....

.....

.....

.....[2]

- (b) The sound from a loudspeaker is detected by a microphone that is connected to a cathode-ray oscilloscope (c.r.o.). Fig. 4.1 shows the trace on the screen of the c.r.o.

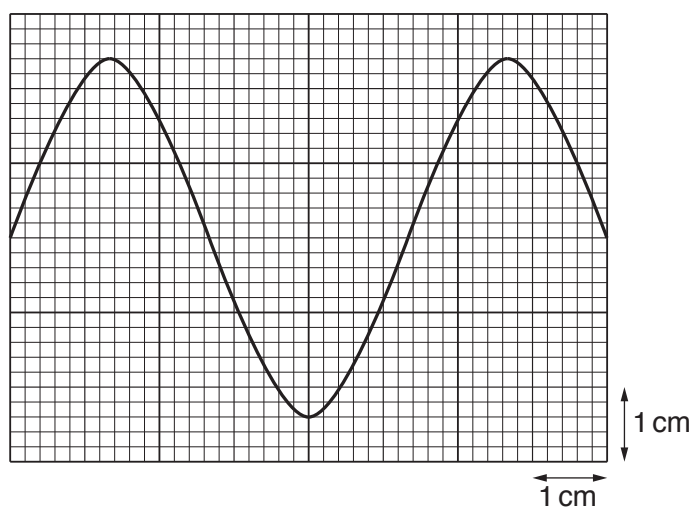


Fig. 4.1

In air, the sound wave has a speed of 330 ms^{-1} and a wavelength of 0.18 m .

- (i) Calculate the frequency of the sound wave.

frequency = ... Hz [2]

- (ii) Determine the time-base setting, in s cm^{-1} , of the c.r.o.

time-base setting = ... s cm^{-1} [2]

- (iii) The intensity of the sound from the loudspeaker is now halved. The wavelength of the sound is unchanged. Assume that the amplitude of the trace is proportional to the amplitude of the sound wave.

On Fig. 4.1, sketch the new trace shown on the screen of the c.r.o. [2]

- (c) The loudspeaker in (b) is held above a vertical tube of liquid, as shown in Fig. 4.2.

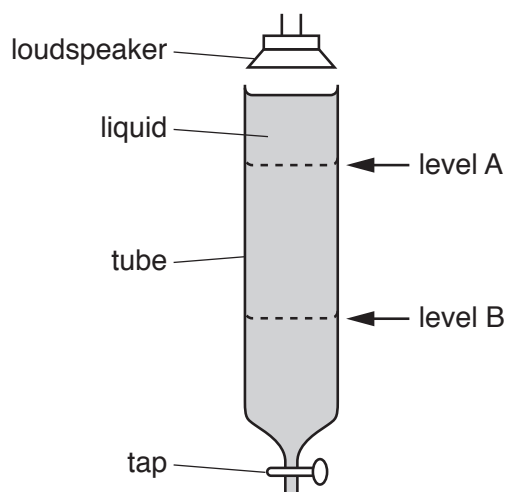


Fig. 4.2

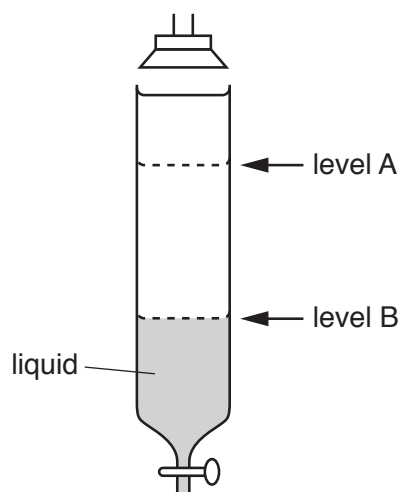


Fig. 4.3

A tap at the bottom of the tube is opened so that liquid drains out at a constant rate. The wavelength of the sound from the loudspeaker is 0.18m. The sound that is heard first becomes much louder when the liquid surface reaches level A. The next time that the sound becomes much louder is when the liquid surface reaches level B, as shown in Fig. 4.3.

- (i) Calculate the vertical distance between level A and level B.

distance = ... m [1]

- (ii) On Fig. 4.3, label with the letter N the positions of the nodes of the stationary wave that is formed in the air column when the liquid surface is at level B. [1]
- (iii) The mass of liquid leaving the tube per unit time is 6.7 g s^{-1} . The tube has an internal cross-sectional area of 13 cm^2 . The density of the liquid is 0.79 g cm^{-3} .

Calculate the time taken for the liquid to move from level A to level B.

time = ... s [2]

[Total: 12]

4 (a) For a progressive wave, state what is meant by

(i) the *period*,

.....
.....[1]

(ii) the *wavelength*.

.....
.....[1]

(b) Fig. 4.1 shows the variation with time t of the displacement x of two progressive waves P and Q passing the same point.

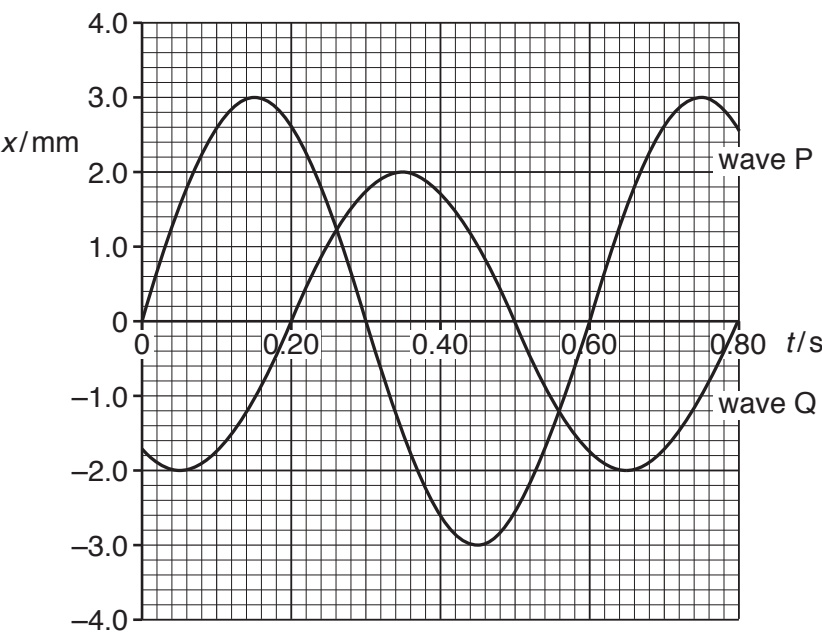


Fig. 4.1

The speed of the waves is 20 cm s^{-1} .

(i) Calculate the wavelength of the waves.

wavelength = ... cm [2]

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(ii) Determine the phase difference between the two waves.

(iii) Calculate the ratio $\frac{\text{phase difference}}{\text{intensity of wave Q}}$ [1]

$\frac{\text{intensity of wave Q}}{\text{intensity of wave P}}$

ratio = ... [2]

(iv) The two waves superpose as they pass the same point. Use Fig. 4.1 to determine the resultant displacement at time $t = 0.45\text{ s}$.

displacement = ... mm [1]

[Total: 8]

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- 5 (a) When monochromatic light is incident normally on a diffraction grating, the emergent light waves have been diffracted and are coherent.

Explain what is meant by

- (i) *diffracted* waves,

.....
.....[1]

- (ii) *coherent* waves.

.....
.....[1]

- (b) Light consisting of only two wavelengths λ_1 and λ_2 is incident normally on a diffraction grating.

The third order diffraction maximum of the light of wavelength λ_1 and the fourth order diffraction maximum of the light of wavelength λ_2 are at the same angle θ to the direction of the incident light.

- (i) Show that the ratio $\frac{\lambda_2}{\lambda_1}$ is 0.75.

Explain your working.

[2]

- (ii) The difference between the two wavelengths is 170 nm.

Determine wavelength λ_1 .

$\lambda_1 =$ nm [1]

[Total: 5]

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5 (a) State the relationship between the intensity and the amplitude of a wave.

.....
.....[1]

(b) Microwaves of the same amplitude and wavelength are emitted in phase from two sources P and Q. The sources are arranged as shown in Fig. 5.1.

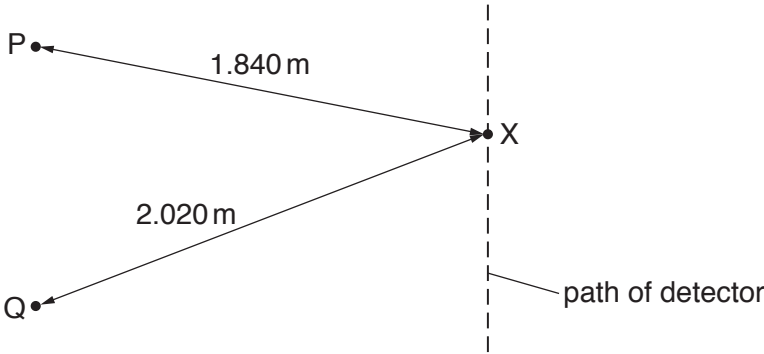


Fig. 5.1

A microwave detector is moved along a path that is parallel to the line joining P and Q. A series of intensity maxima and intensity minima are detected.

When the detector is at a point X, the distance PX is 1.840 m and the distance QX is 2.020 m. The microwaves have a wavelength of 6.0 cm.

(i) Calculate the frequency of the microwaves.

frequency = ... Hz [2]

(ii) Describe and explain the intensity of the microwaves detected at X.

.....
.....
.....
.....
.....[3]

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(iii) Describe the effect on the interference pattern along the path of the detector due to each of the following separate changes.

1. The wavelength of the microwaves decreases.

.....

.....

2. The phase difference between the microwaves emitted from the sources changes to 180° .

.....

.....

[2]

[Total: 8]

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4 (a) State the principle of superposition.

.....

 [2]

(b) An arrangement for demonstrating the interference of light is shown in Fig. 4.1.

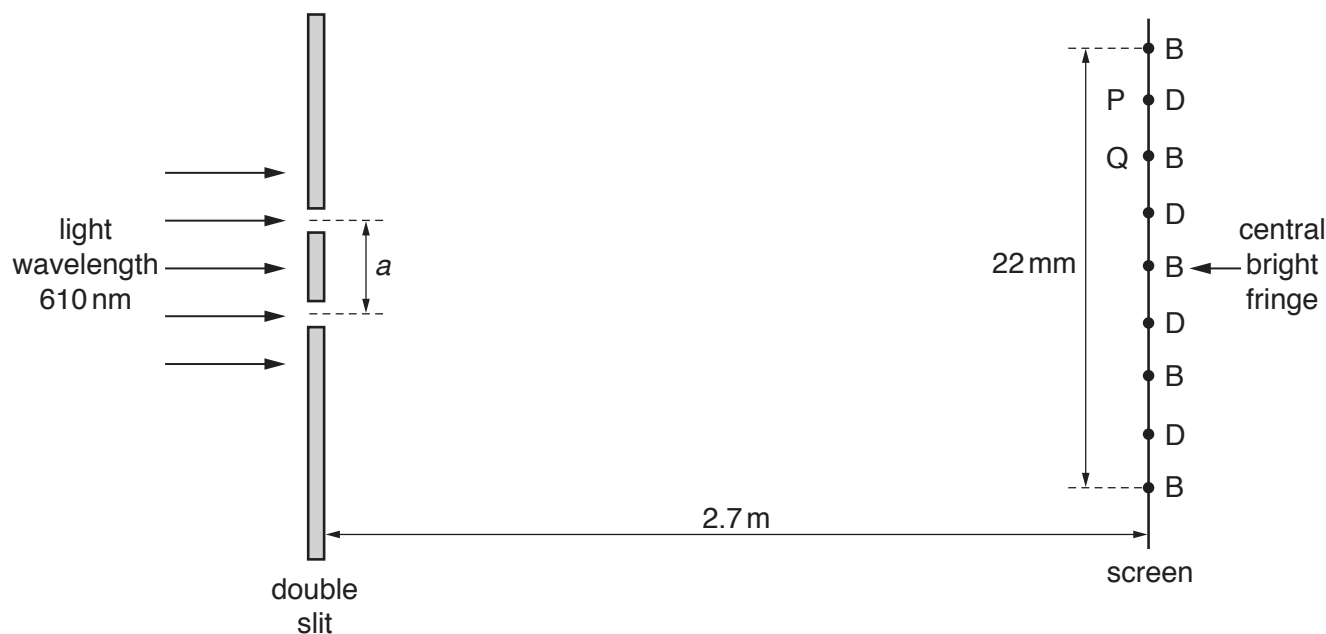


Fig. 4.1 (not to scale)

The wavelength of the light is 610 nm. The distance between the double slit and the screen is 2.7 m.

An interference pattern of bright fringes and dark fringes is observed on the screen. The centres of the bright fringes are labelled B and centres of the dark fringes are labelled D. Point P is the centre of a particular dark fringe and point Q is the centre of a particular bright fringe, as shown in Fig. 4.1. The distance across five bright fringes is 22 mm.

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

State what is meant by *coherent*.

.....
 [1]

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- (ii) 1. State the phase difference between the waves meeting at Q.

phase difference = ... °

2. Calculate the path difference, in nm, of the waves meeting at P.

path difference = ... nm
[2]

- (iii) Determine the distance a between the two slits.

a = ... m [3]

- (iv) A higher frequency of visible light is now used. State and explain the change to the separation of the fringes.

.....
..... [1]

- (v) The intensity of the light incident on the double slit is now increased without altering its frequency. Compare the appearance of the fringes after this change with their appearance before this change.

.....
.....
.....
..... [2]

[Total: 11]

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- 5 Red light of wavelength 640 nm is incident normally on a diffraction grating having a line spacing of 1.7×10^{-6} m, as shown in Fig. 5.1.

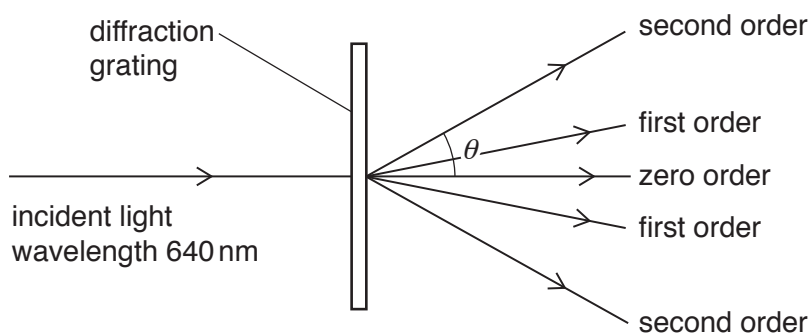


Fig. 5.1 (not to scale)

The second order diffraction maximum of the light is at an angle θ to the direction of the incident light.

- (a) Show that angle θ is 49° .

[3]

- (b) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 49° .

wavelength = ... m [2]

[Total: 5]

5 (a) By reference to two waves, state:

(i) the principle of superposition

.....

.....

.....

.....[2]

(ii) what is meant by *coherence*.

.....

.....[1]

(b) Two coherent waves P and Q meet at a point in phase and superpose. Wave P has an amplitude of 1.5 cm and intensity I . The resultant intensity at the point where the waves meet is $3I$.

Calculate the amplitude of wave Q.

amplitude = ... cm [2]

(c) The apparatus shown in Fig. 5.1 is used to produce an interference pattern on a screen.

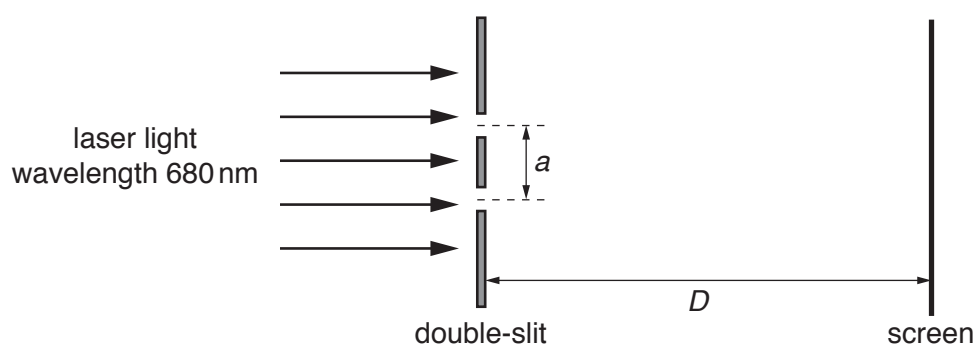


Fig. 5.1 (not to scale)

Light of wavelength 680 nm is incident on a double-slit. The slit separation is a . The separation between adjacent fringes is x . Fringes are viewed on a screen at distance D from the double-slit.

Distance D is varied from 2.0 m to 3.5 m. The variation with D of x is shown in Fig. 5.2.

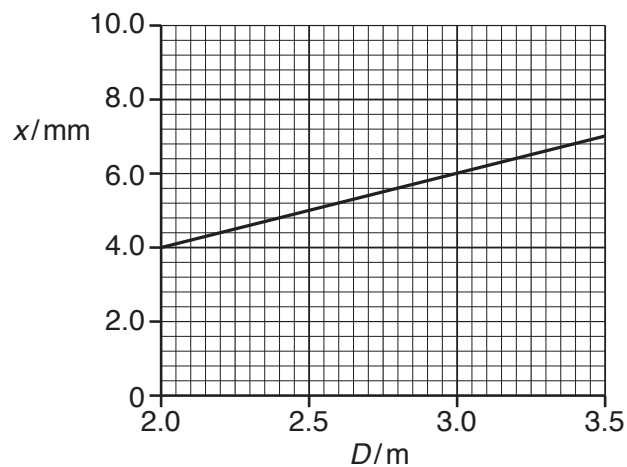


Fig. 5.2

- (i) Use Fig. 5.2 to determine the slit separation a .

$a = \dots\dots\dots \text{ m [3]}$

- (ii) The laser is now replaced by another laser that emits light of a shorter wavelength.

On Fig. 5.2, sketch a possible line to show the variation with D of x for the fringes that are now produced. [2]

[Total: 10]

- 5 (a)** A loudspeaker oscillates with frequency f to produce sound waves of wavelength λ . The loudspeaker makes N oscillations in time t .

(i) State expressions, in terms of some or all of the symbols f , λ and N , for:

- 1.** the distance moved by a wavefront in time t

distance = ...

- 2.** time t .

time t = ...

[2]

- (ii)** Use your answers in **(i)** to deduce the equation relating the speed v of the sound wave to f and λ .

[1]

- (b)** The waveform of a sound wave is displayed on the screen of a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 5.1.

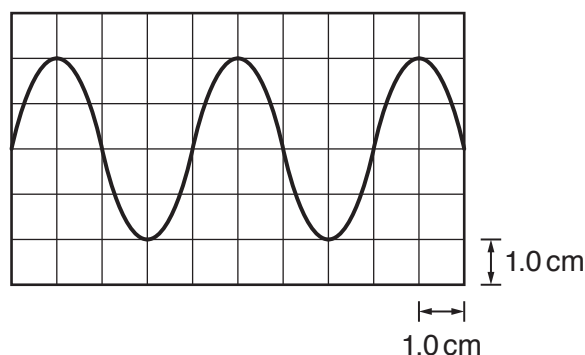


Fig. 5.1

The time-base setting is 0.20 ms cm^{-1} .

Determine the frequency of the sound wave.

frequency = ... Hz [2]

(c) Two sources S_1 and S_2 of sound waves are positioned as shown in Fig. 5.2.

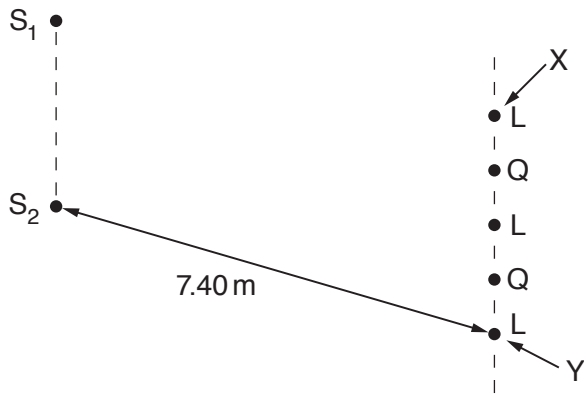


Fig. 5.2 (not to scale)

The sources emit coherent sound waves of wavelength 0.85 m. A sound detector is moved parallel to the line S_1S_2 from a point X to a point Y. Alternate positions of maximum loudness L and minimum loudness Q are detected, as illustrated in Fig. 5.2.

Distance S_1X is equal to distance S_2X . Distance S_2Y is 7.40 m.

(i) Explain what is meant by *coherent* waves.

.....
.....[1]

(ii) State the phase difference between the two waves arriving at the position of minimum loudness Q that is closest to point X.

phase difference = ... ° [1]

(iii) Determine the distance S_1Y .

distance = ... m [2]

[Total: 9]

4 (a) For a progressive water wave, state what is meant by:

(i) *displacement*

.....
.....[1]

(ii) *amplitude*.

.....
.....[1]

(b) Two coherent waves X and Y meet at a point and superpose. The phase difference between the waves at the point is 180°. Wave X has an amplitude of 1.2cm and intensity *I*. Wave Y has an amplitude of 3.6 cm.

Calculate, in terms of *I*, the resultant intensity at the meeting point.

intensity = ... [2]

(c) (i) Monochromatic light is incident on a diffraction grating. Describe the diffraction of the light waves as they pass through the grating.

.....
.....
.....[2]

- (ii) A parallel beam of light consists of two wavelengths 540nm and 630nm. The light is incident normally on a diffraction grating. Third-order diffraction maxima are produced for each of the two wavelengths. No higher orders are produced for either wavelength.

Determine the smallest possible line spacing d of the diffraction grating.

$d = \dots\dots\dots \text{ m [3]}$

- (iii) The beam of light in (c)(ii) is replaced by a beam of blue light incident on the same diffraction grating.

State and explain whether a third-order diffraction maximum is produced for this blue light.

.....

.....

.....[2]

[Total: 11]

- 5 A ripple tank is used to demonstrate the interference of water waves. Two dippers D1 and D2 produce coherent waves that have circular wavefronts, as illustrated in Fig. 5.1.

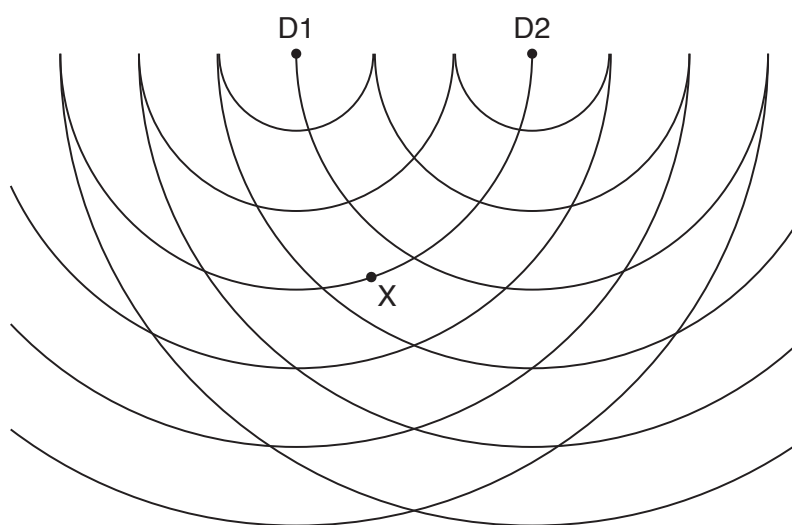


Fig. 5.1

The lines in the diagram represent crests. The waves have a wavelength of 6.0 cm.

- (a) One condition that is required for an observable interference pattern is that the waves must be coherent.

- (i) Describe how the apparatus is arranged to ensure that the waves from the dippers are coherent.

.....
..... [1]

- (ii) State one other condition that must be satisfied by the waves in order for the interference pattern to be observable.

.....
..... [1]

- (b) Light from a lamp above the ripple tank shines through the water onto a screen below the tank. Describe one way of seeing the illuminated pattern more clearly.

.....
..... [1]

- (c) The speed of the waves is 0.40 m s^{-1} . Calculate the period of the waves.

period = ... s [2]

- (d) Fig. 5.1 shows a point X that lies on a crest of the wave from D1 and midway between two adjacent crests of the wave from D2.

For the waves at point X, state:

- (i) the path difference, in cm

path difference = ... cm [1]

- (ii) the phase difference.

phase difference = ... ° [1]

- (e) On Fig. 5.1, draw **one** line, at least 4 cm long, which joins points where only maxima of the interference pattern are observed. [1]

[Total: 8]

- 5 (a) State what is meant by the *wavelength* of a progressive wave.

.....

..... [1]

- (b) A cathode-ray oscilloscope (CRO) is used to analyse a sound wave. The screen of the CRO is shown in Fig. 5.1.

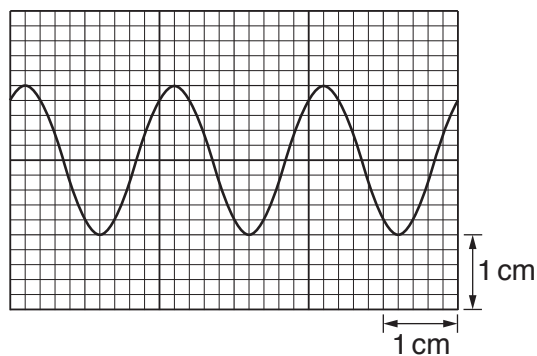


Fig. 5.1

The time-base setting of the CRO is 2.5 ms cm^{-1} .

Determine the frequency of the sound wave.

frequency = ... Hz [2]

- (c) The source emitting the sound in (b) is at point A. Waves travel from the source to point C along two different paths, AC and ABC, as shown in Fig. 5.2.

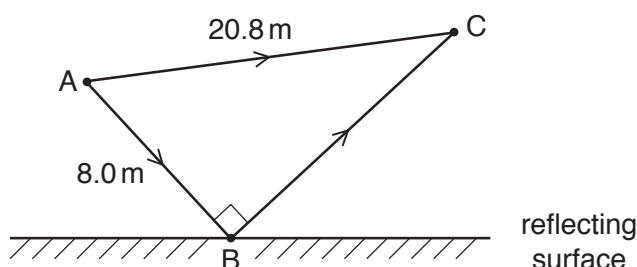


Fig. 5.2 (not to scale)

Distance AB is 8.0 m and distance AC is 20.8 m. Angle ABC is 90° . Assume that there is no phase change of the sound wave due to the reflection at point B. The wavelength of the waves is 1.6 m.

- (i) Show that the waves meeting at C have a path difference of 6.4 m.

[1]

- (ii) Explain why an intensity maximum is detected at point C.

.....

 [2]

- (iii) Determine the difference between the times taken for the sound to travel from the source to point C along the two different paths.

time difference = ... s [2]

- (iv) The wavelength of the sound is gradually increased. Calculate the wavelength of the sound when an intensity maximum is next detected at point C.

wavelength = ... m [1]

[Total: 9]

- 5 (a) Light waves emerging from the slits of a diffraction grating are coherent and produce an interference pattern.

Explain what is meant by:

- (i) *coherence*

.....
 [1]

- (ii) *interference*.

.....
 [1]

- (b) A narrow beam of light from a laser is incident normally on a diffraction grating, as shown in Fig. 5.1.

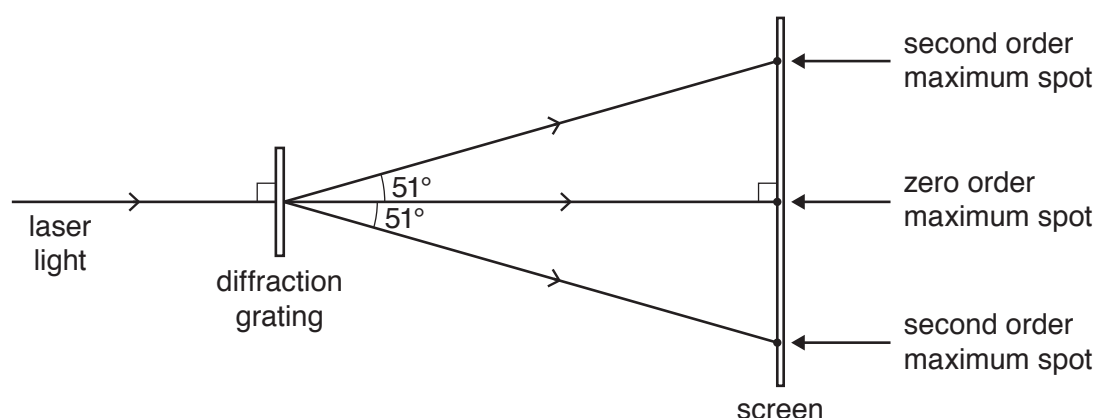


Fig. 5.1 (not to scale)

Spots of light are seen on a screen positioned parallel to the grating. The angle corresponding to each of the **second** order maxima is 51° . The number of lines per unit length on the diffraction grating is $6.7 \times 10^5 \text{ m}^{-1}$.

- (i) Determine the wavelength of the light.

wavelength = ... m [2]

(ii) State and explain the change, if any, to the distance between the second order maximum spots on the screen when the light from the laser is replaced by light of a shorter wavelength.

.....

.....

.....[1]

[Total: 5]

- 4 (a) (i) By reference to the direction of propagation of energy, state what is meant by a *longitudinal wave*.

.....
 [1]

- (ii) State the principle of superposition.

.....

 [2]

- (b) The wavelength of light from a laser is determined using the apparatus shown in Fig. 4.1.

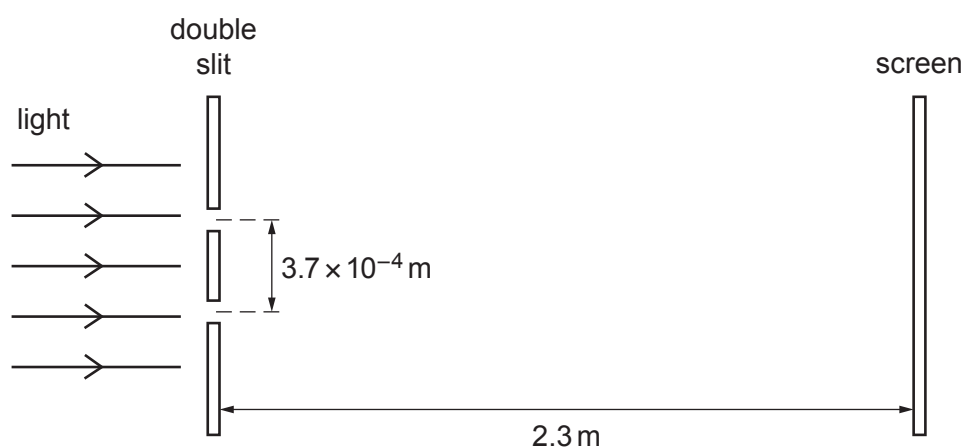


Fig. 4.1 (not to scale)

The light from the laser is incident normally on the plane of the double slit.

The separation of the two slits is $3.7 \times 10^{-4} \text{ m}$. The screen is parallel to the plane of the double slit. The distance between the screen and the double slit is 2.3 m .

A pattern of bright fringes and dark fringes is seen on the screen. The separation of adjacent bright fringes on the screen is $4.3 \times 10^{-3} \text{ m}$.

- (i) Calculate the wavelength, in nm, of the light.

wavelength = ... nm [3]

- (ii) The intensity of the light passing through each slit was initially the same. The intensity of the light through **one** of the slits is now reduced.

Compare the appearance of the fringes before and after the change of intensity.

.....

.....

.....

..... [2]

[Total: 8]

9702 Physics Paper 2 - Superposition

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24. Question | 9702 Oct-Nov 2020 P2 V1 Q6

- 6 (a)** Describe the conditions required for two waves to be able to form a stationary wave.

.....
.....
.....
..... [2]

- (b)** A stationary wave on a string has nodes and antinodes. The distance between a node and an adjacent antinode is 6.0 cm.

- (i)** State what is meant by a *node*.

..... [1]

- (ii)** Calculate the wavelength of the two waves forming the stationary wave.

wavelength = ... cm [1]

- (iii)** State the phase difference between the particles at two adjacent antinodes of the stationary wave.

phase difference = ... ° [1]

[Total: 5]

25. Question part 1/2 | 9702 Oct-Nov 2020 P2 V2 Q5

- 5 Microwaves with the same wavelength and amplitude are emitted in phase from two sources X and Y, as shown in Fig. 5.1.

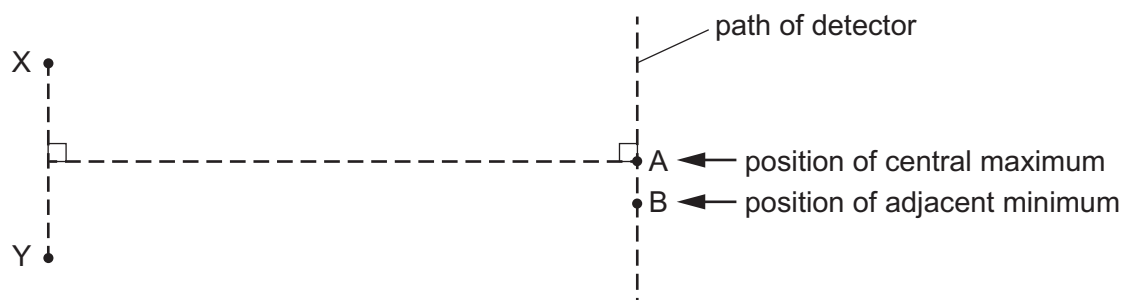


Fig. 5.1 (not to scale)

A microwave detector is moved along a path parallel to the line joining X and Y. An interference pattern is detected. A central intensity maximum is located at point A and there is an adjacent intensity minimum at point B. The microwaves have a wavelength of 0.040 m.

- (a) Calculate the frequency, in GHz, of the microwaves.

frequency = ... GHz [3]

- (b) For the waves arriving at point B, determine:

- (i) the path difference

path difference = ... m [1]

- (ii) the phase difference.

phase difference = ...° [1]

- (c) The amplitudes of the waves from the sources are changed. This causes a change in the amplitude of the waves arriving at point A. At this point, the amplitude of the wave arriving from source X is doubled and the amplitude of the wave arriving from source Y is also doubled.

Describe the effect, if any, on the intensity of the central maximum at point A.

.....

.....

..... [2]

- (d) Describe the effect, if any, on the positions of the central intensity maximum and the adjacent intensity minimum due to the following separate changes.

- (i) The separation of the sources X and Y is increased.

.....

..... [1]

- (ii) The phase difference between the microwaves emitted by the sources X and Y changes to 180°.

.....

..... [1]

[Total: 9]

- 5 (a)** A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.

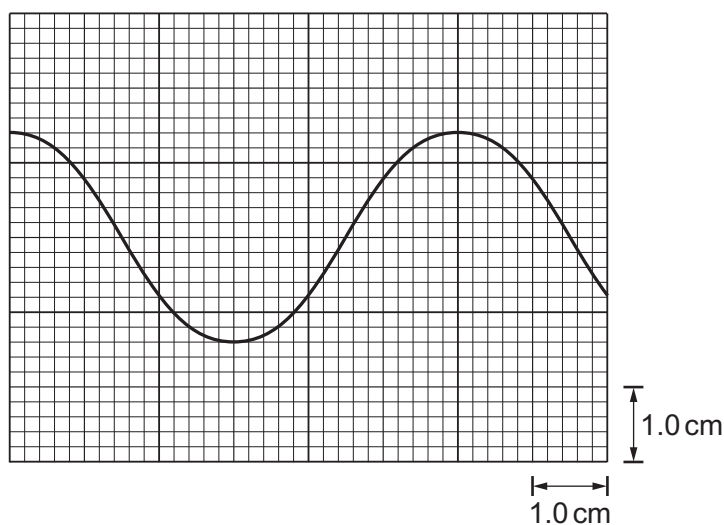


Fig. 5.1

The time-base setting of the CRO is $2.0 \times 10^{-5} \text{ s cm}^{-1}$.

- (i)** Determine the frequency of the sound wave.

frequency = ... Hz [2]

- (ii)** The intensity of the sound wave is now doubled. The frequency is unchanged. Assume that the amplitude of the trace is proportional to the amplitude of the sound wave.

On Fig. 5.1, sketch the new trace shown on the screen. [2]

- (iii)** The time-base is now switched off.

Describe the trace seen on the screen.

.....

..... [1]

- (b) A beam of light of a single wavelength is incident normally on a diffraction grating, as illustrated in Fig. 5.2.

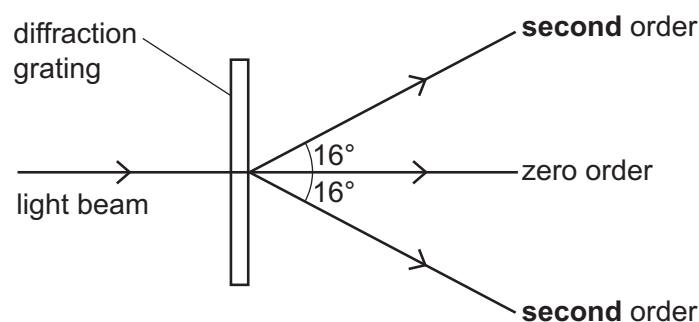


Fig. 5.2 (not to scale)

Fig. 5.2 does not show all of the emerging beams from the grating. The angle between the **second**-order emerging beam and the central zero-order beam is 16° . The grating has a line spacing of $3.4 \times 10^{-6}\text{ m}$.

- (i) Calculate the wavelength of the light.

wavelength = ... m [2]

- (ii) Determine the highest order of emerging beam from the grating.

highest order = ... [2]

[Total: 9]

4 (a) State the principle of superposition.

.....

.....

..... [2]

(b) A transmitter produces microwaves that travel in air towards a metal plate, as shown in Fig. 4.1.

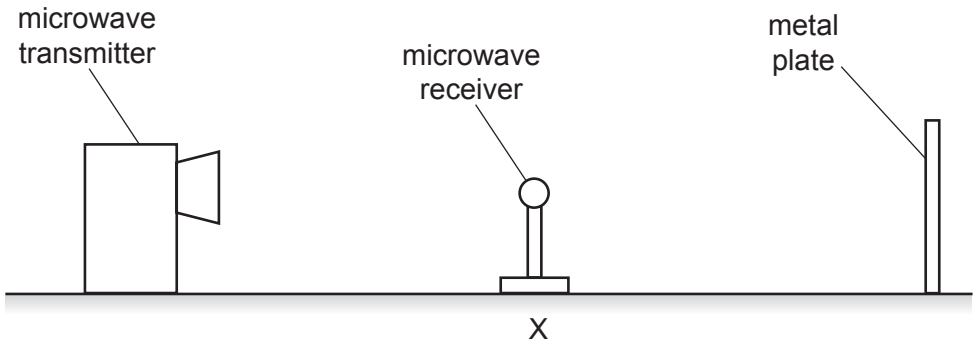


Fig. 4.1

The microwaves have a wavelength of 0.040 m. A stationary wave is formed between the transmitter and the plate.

(i) Explain the function of the metal plate.

.....

..... [1]

(ii) Calculate the frequency, in GHz, of the microwaves.

frequency = ... GHz [3]

9702 Physics Paper 2 - Superposition

Topical questions | 49 questions

27. Question part 2/2 | 9702 Feb-March 2021 P2 V2 Q4

(iii) A microwave receiver is initially placed at position X where it detects an intensity minimum. The receiver is then slowly moved away from X directly towards the plate.

1. Determine the shortest distance from X of the receiver when it detects another intensity minimum.

distance = ... m

2. Determine the number of intensity maxima that are detected by the receiver as it moves from X to a position that is 9.1 cm away from X.

number = ...
[2]

[Total: 8]

- 4 (a) For a progressive wave, state what is meant by its *period*.

.....
 [1]

- (b) State the principle of superposition.

.....

 [2]

- (c) Electromagnetic waves of wavelength 0.040 m are emitted in phase from two sources X and Y and travel in a vacuum. The arrangement of the sources is shown in Fig. 4.1.

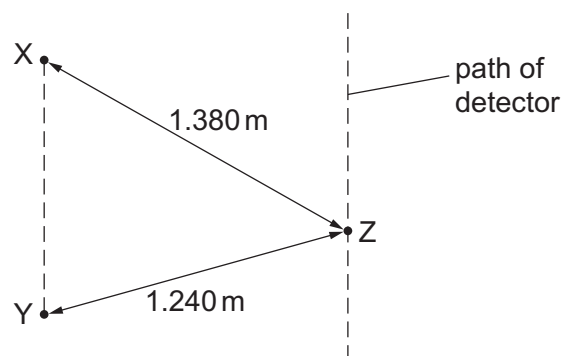


Fig. 4.1 (not to scale)

A detector moves along a path that is parallel to the line XY. A pattern of intensity maxima and minima is detected.

Distance XZ is 1.380 m and distance YZ is 1.240 m .

- (i) State the name of the region of the electromagnetic spectrum that contains the waves from X and Y.

..... [1]

- (ii) Calculate the period, in ps, of the waves.

period = ... ps [3]

9702 Physics Paper 2 - Superposition

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28. Question part 2/2 | 9702 May-June 2021 P2 V2 Q4

- (iii) Show that the path difference at point Z between the waves from X and Y is 3.5λ , where λ is the wavelength of the waves.

[1]

- (iv) Calculate the phase difference between the waves at point Z.

phase difference = ...° [1]

- (v) The waves from X alone have the same amplitude at point Z as the waves from Y alone.

State the intensity of the waves at point Z.

..... [1]

- (vi) The frequencies of the waves from X and Y are both decreased to the same lower value. The waves stay within the same region of the electromagnetic spectrum.

Describe the effect of this change on the pattern of intensity maxima and minima along the path of the detector.

.....
..... [1]

[Total: 11]

- 4 (a) State the principle of superposition.

.....
.....
..... [2]

- (b) Two waves, with intensities I and $4I$, superpose. The waves have the same frequency.

Determine, in terms of I , the maximum possible intensity of the resulting wave.

maximum intensity = ... I [2]

- (c) Coherent light of wavelength 550 nm is incident normally on a double slit of slit separation 0.35 mm. A series of bright and dark fringes forms on a screen placed a distance of 1.2 m from the double slit, as shown in Fig. 4.1. The screen is parallel to the double slit.

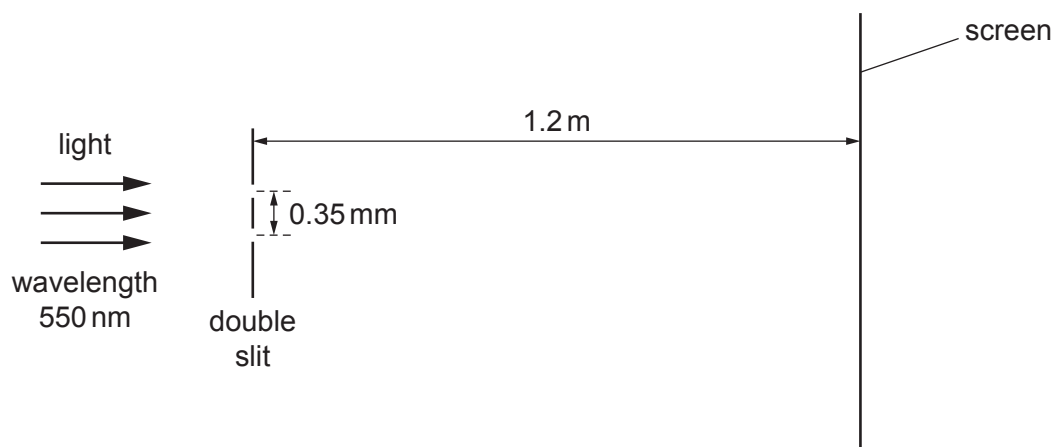


Fig. 4.1 (not to scale)

9702 Physics Paper 2 - Superposition

Topical questions | 49 questions

29. Question part 2/2 | 9702 May-June 2021 P2 V3 Q4

- (i) Determine the distance between the centres of adjacent bright fringes on the screen.

distance = ... m [3]

- (ii) The light of wavelength 550 nm is replaced with red light of a single frequency.

State and explain the change, if any, in the distance between the centres of adjacent bright fringes.

.....
.....
..... [1]

[Total: 8]

- 5 (a) For a progressive wave on a stretched string, state what is meant by *amplitude*.

.....
 [1]

- (b) Light from a laser has a wavelength of 690 nm in a vacuum.

Calculate the period of the light wave.

period = ... s [3]

- (c) A two-source interference experiment uses the arrangement shown in Fig. 5.1.

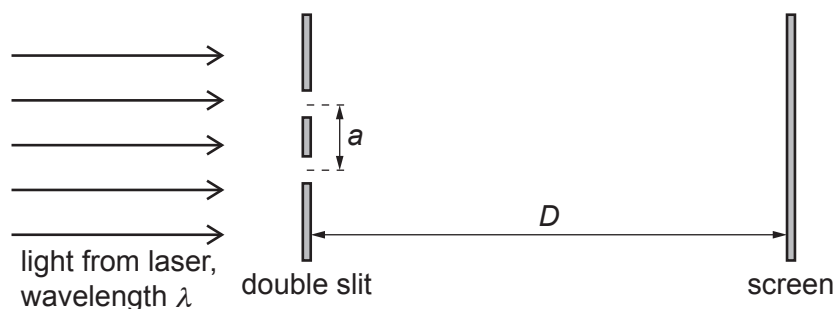


Fig. 5.1 (not to scale)

Light from a laser is incident normally on a double slit. A screen is parallel to the double slit.

Interference fringes are seen on the screen at distance D from the double slit. The separation of the centres of the slits is a . The light has wavelength λ .

The separation x of the centres of adjacent bright fringes is measured for different values of distance D .

The variation with D of x is shown in Fig. 5.2.

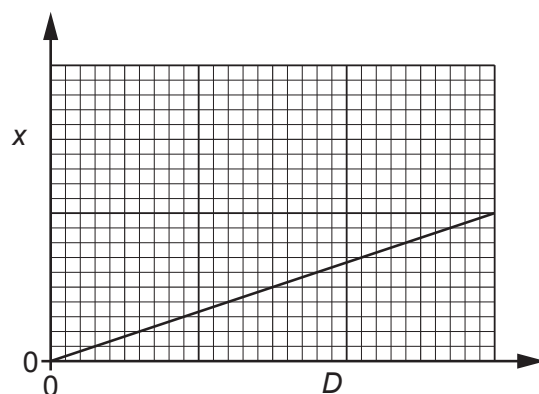


Fig. 5.2

The gradient of the graph is G .

- (i) Determine an expression, in terms of G and λ , for the separation a of the slits.

$$a = \dots\dots\dots [2]$$

- (ii) The experiment is repeated with slits of separation $2a$. The wavelength of the light is unchanged.

On Fig. 5.2, sketch a graph to show the results of this experiment. [2]

[Total: 8]

31. Question part 1/2 | 9702 May-June 2022 P2 V2 Q5

- 5 Light from a laser is used to produce an interference pattern on a screen, as shown in Fig. 5.1.

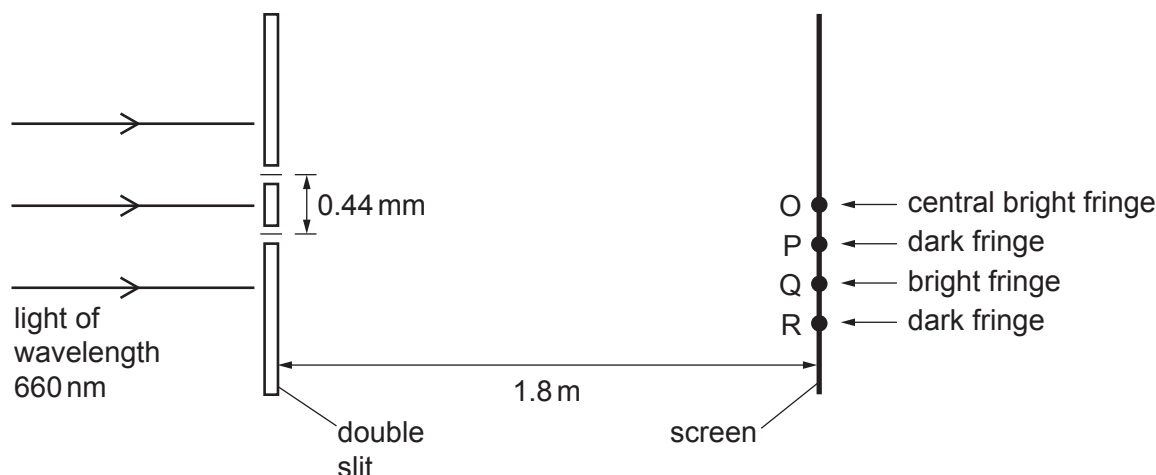


Fig. 5.1 (not to scale)

The light of wavelength 660 nm is incident normally on two slits that have a separation of 0.44 mm. The double slit is parallel to the screen. The perpendicular distance between the double slit and the screen is 1.8 m.

The central bright fringe on the screen is formed at point O. The next dark fringe below point O is formed at point P. The next bright fringe and the next dark fringe below point P are formed at points Q and R respectively.

- (a) The light waves from the two slits are coherent.

State what is meant by coherent.

.....
 [1]

- (b) For the two light waves superposing at R, calculate:

- (i) the difference in their path lengths, in nm, from the slits

path difference = ... nm [1]

- (ii) their phase difference.

phase difference = ... ° [1]

(c) Calculate the distance OQ.

distance OQ = ... m [3]

(d) The intensity of the light incident on the double slit is increased without changing the frequency.

Describe how the appearance of the fringes after this change is different from, and similar to, their appearance before the change.

.....

.....

.....

.....

..... [3]

(e) The light of wavelength 660 nm is now replaced by blue light from a laser.

State and explain the change, if any, that must be made to the separation of the two slits so that the fringe separation on the screen is the same as it was for light of wavelength 660 nm.

.....

.....

.....

..... [2]

[Total: 11]

- 5 (a) Parallel light rays from the Sun are incident normally on a magnifying glass. The magnifying glass directs the light to an area A of radius r , as shown in Fig. 5.1.

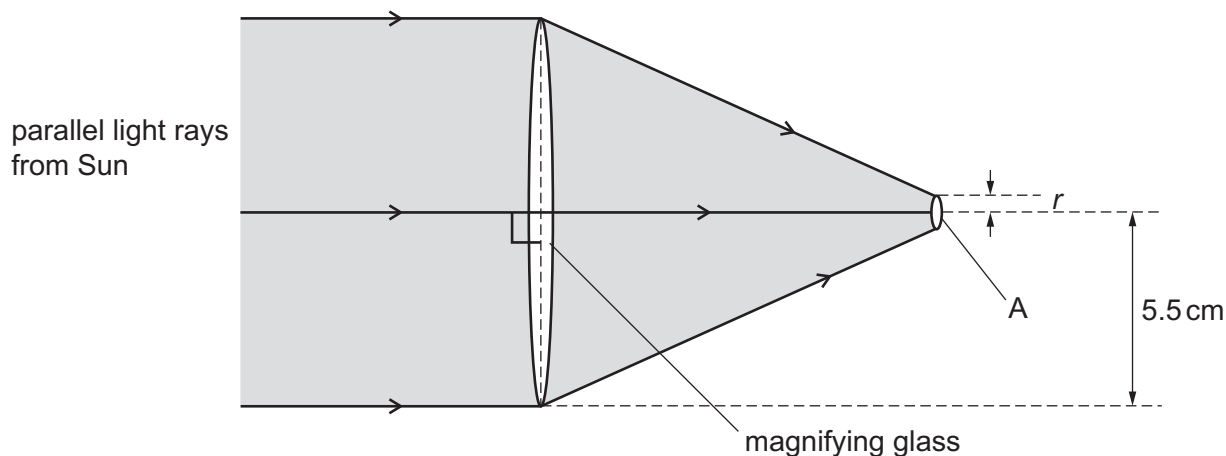


Fig. 5.1 (not to scale)

The magnifying glass is circular in cross-section with a radius of 5.5 cm. The intensity of the light from the Sun incident on the magnifying glass is 1.3 kW m^{-2} .

Assume that all of the light incident on the magnifying glass is transmitted through it.

- (i) Calculate the power of the light from the Sun incident on the magnifying glass.

power = ... W [2]

- (ii) The value of r is 1.5 mm.

Calculate the intensity of the light on area A.

intensity = ... W m^{-2} [1]

(b) A laser emits a beam of electromagnetic waves of frequency $3.7 \times 10^{15} \text{ Hz}$ in a vacuum.

(i) Show that the wavelength of the waves is $8.1 \times 10^{-8} \text{ m}$.

[2]

(ii) State the region of the electromagnetic spectrum to which these waves belong.

..... [1]

(iii) The beam from the laser now passes through a diffraction grating with 2400 lines per millimetre. A detector sensitive to the waves emitted by the laser is moved through an arc of 180° in order to detect the maxima produced by the waves passing through the grating, as shown in Fig. 5.2.

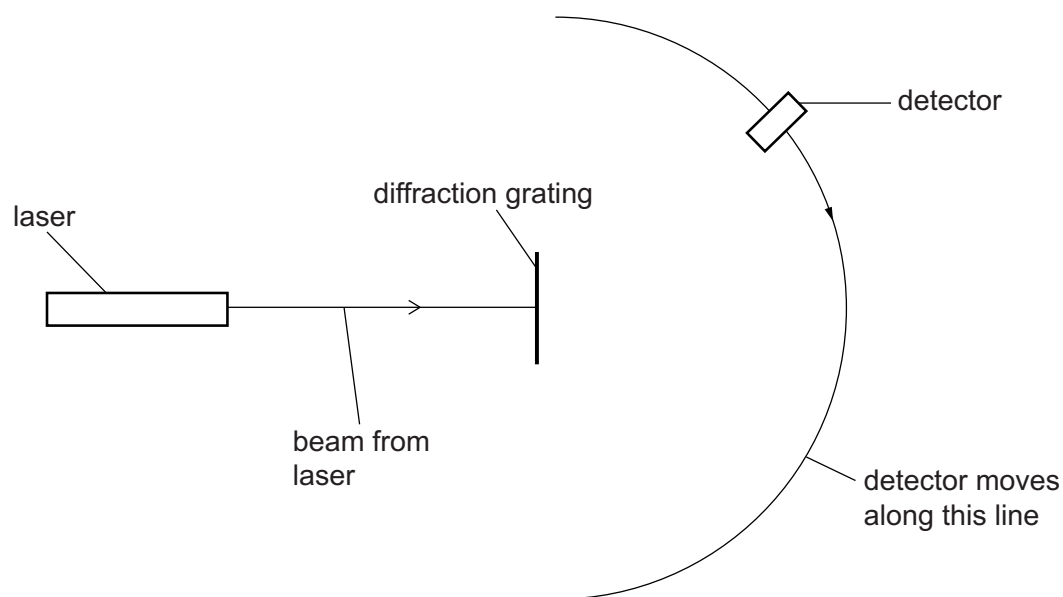


Fig. 5.2

Calculate the number of maxima detected as the detector moves through 180° along the line shown in Fig. 5.2. Show your working.

number of maxima detected = ... [4]

(iv) The laser is now replaced with one that emits electromagnetic waves with a wavelength of 300 nm.

Explain, without calculation, what happens to the number of maxima now detected. Assume that the detector is also sensitive to this wavelength of electromagnetic waves.

.....
.....
..... [2]

[Total: 12]

4 (a) Polarisation is a phenomenon associated with light waves but not with sound waves.

(i) State the meaning of polarisation.

.....

 [1]

(ii) State why light waves can be plane polarised but sound waves cannot.

.....

 [1]

(b) Two polarising filters A and B are positioned so that their planes are parallel to each other and perpendicular to a central axis line XY, as shown in Fig. 4.1.

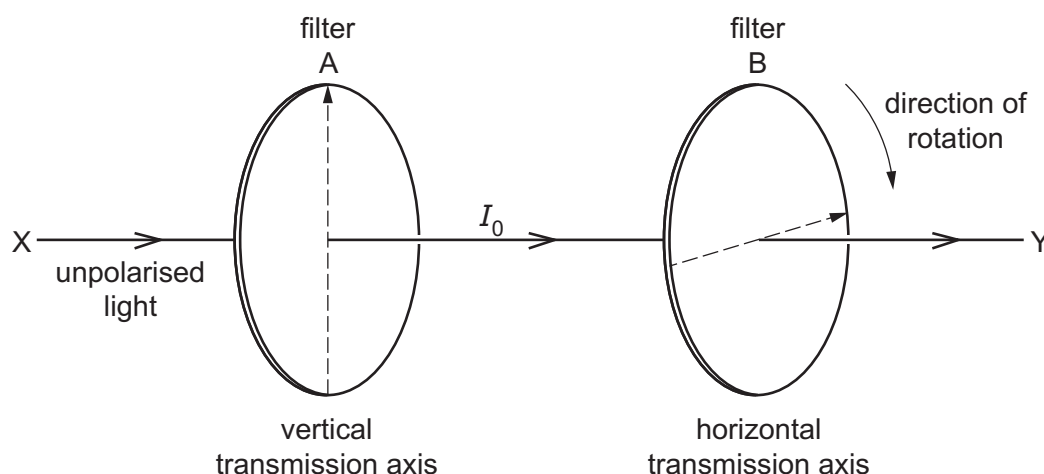


Fig. 4.1

The transmission axis of filter A is vertical and the transmission axis of filter B is horizontal.

Unpolarised light of a single frequency is directed along the line XY from a source positioned at X. The light emerging from filter A is vertically plane polarised and has intensity I_0 .

Filter B is rotated from its starting position about the line XY, as shown in Fig. 4.1.

After rotation, the intensity of the light emerging from filter B is $\frac{1}{4} I_0$.

Calculate the angle of rotation of filter B from its starting position.

angle of rotation = ... ° [3]

- (c) A microwave of intensity I_0 and amplitude A_0 meets another microwave of the same frequency and of intensity $\frac{1}{4} I_0$ travelling in the opposite direction. Both microwaves are vertically plane polarised and superpose where they meet.

- (i) Explain, without calculation, why these two waves cannot form a stationary wave with zero amplitude at its nodes.

.....
.....
..... [2]

- (ii) Determine, in terms of A_0 , the maximum amplitude of the wave formed.

maximum amplitude = ... A_0 [3]

[Total: 10]

34. Question part 1/2 | 9702 Specimen 2022 P2 Q4

4 (a) (i) By reference to the direction of transfer of energy, state what is meant by a transverse wave.

.....
..... [1]

(ii) State the principle of superposition.

.....
.....
..... [2]

(b) Circular water waves are produced by vibrating dippers at points P and Q, as illustrated in Fig. 4.1.

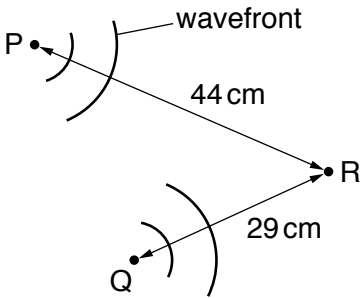


Fig. 4.1 (not to scale)

The waves from P alone have the same amplitude at point R as the waves from Q alone. Distance PR is 44 cm and distance QR is 29 cm.

The dippers vibrate in phase with a period of 1.5 s to produce waves of speed 4.0 cm s⁻¹.

(i) Calculate the wavelength of the waves.

wavelength = ... cm [2]

34. Question part 2/2 | 9702 Specimen 2022 P2 Q4

- (ii) Calculate the path difference at point R of the waves from P and Q.
Give your answer in terms of the wavelength λ of the waves.

path difference = ... λ [1]

- (iii) Describe the motion, if any, of the water particles at point R.
Explain your answer.

.....
.....
..... [2]

[Total: 8]

35. Question part 1/3 | 9702 Feb-March 2023 P2 V2 Q5

- 5 (a) A microphone and cathode-ray oscilloscope (CRO) are used to analyse a sound wave of frequency 5000 Hz. The trace that is displayed on the screen of the CRO is shown in Fig. 5.1.

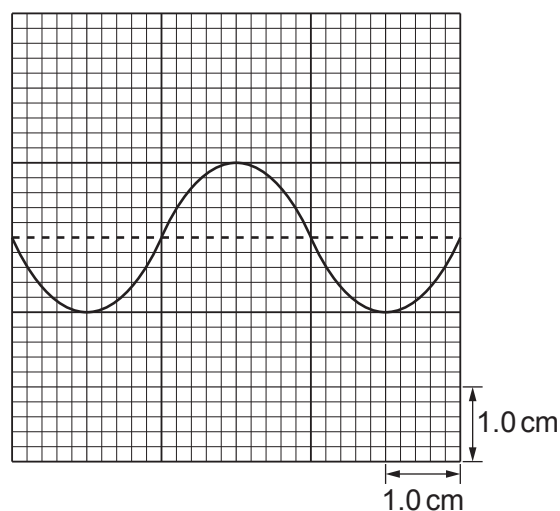


Fig. 5.1

- (i) Determine the time-base setting, in s cm^{-1} , of the CRO.

time-base setting = ... s cm^{-1} [2]

- (ii) The intensity of the sound detected by the microphone is now increased from its initial value of I to a new value of $3I$. The frequency of the sound is unchanged. Assume that the amplitude of the trace on the CRO screen is proportional to the amplitude of the sound wave.

On Fig. 5.1, sketch the new trace shown on the screen of the CRO. [3]

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

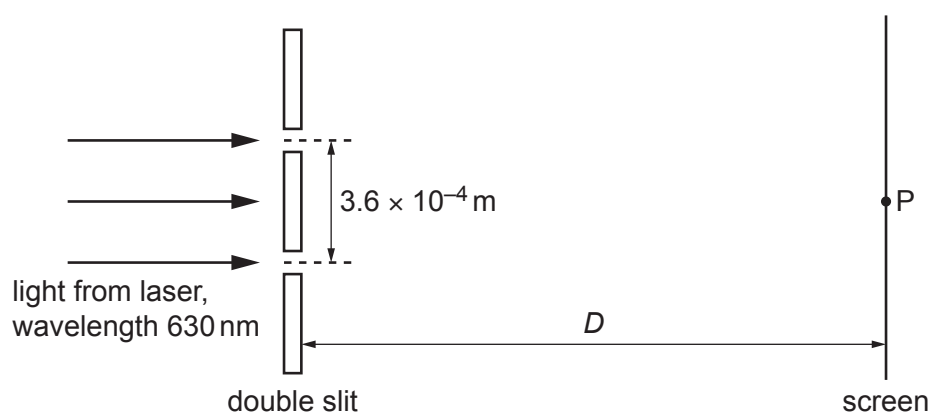


Fig. 5.2 (not to scale)

35. Question part 2/3 | 9702 Feb-March 2023 P2 V2 Q5

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 $\lambda = 400$ nm to $\lambda = 700$ nm. Numerical values of x are not required.

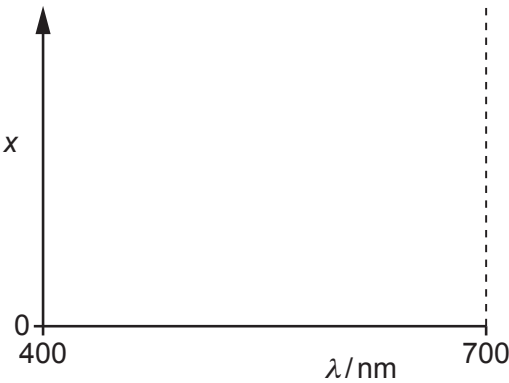


Fig. 5.3

[1]

[Total: 10]

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- 5 (a) An electromagnetic wave in a vacuum has a wavelength of $8.4 \times 10^{-6}\text{m}$.
- (i) State the name of the principal region of the electromagnetic spectrum for the wave.
- [1]
- (ii) Calculate the frequency, in THz, of the wave.

frequency = ... THz [2]

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

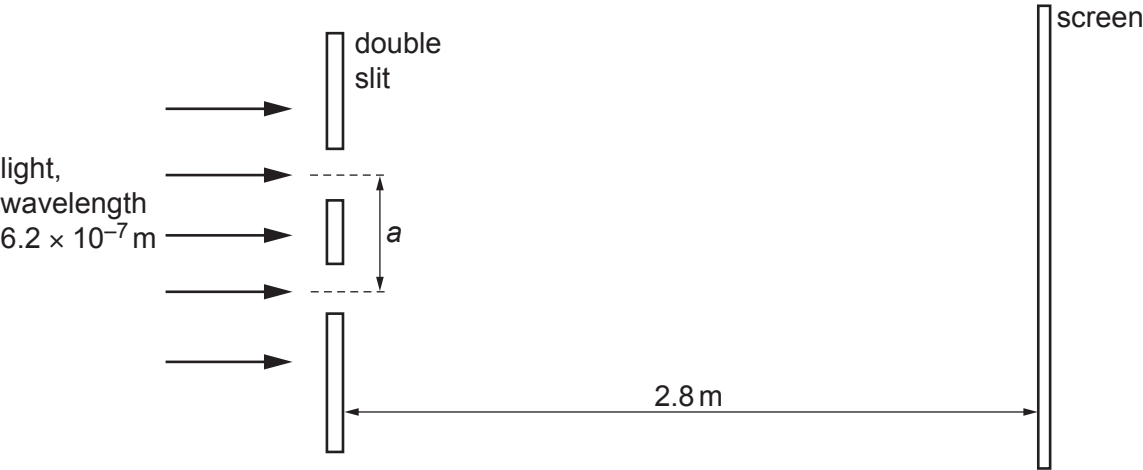


Fig. 5.1 (not to scale)

The light from the laser has a wavelength of $6.2 \times 10^{-7}\text{m}$ 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 2.8m .

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

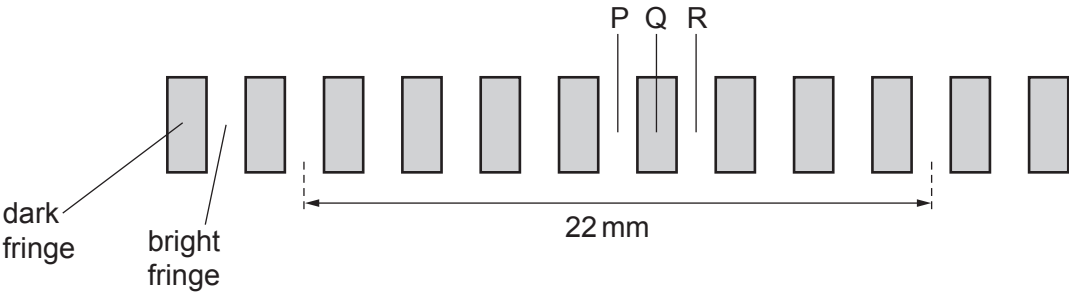


Fig. 5.2

- (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]

[Total: 9]

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- 4 (a) State the principle of superposition.

.....
.....
..... [2]

- (b) Coherent light is incident normally on two identical slits X and Y. The diffracted light emerging from the slits superposes to produce an interference pattern on a screen positioned at a distance of 1.9 m from the slits.

Fig. 4.1 shows the arrangement and the central part of the interference pattern of bright and dark fringes formed on the screen.

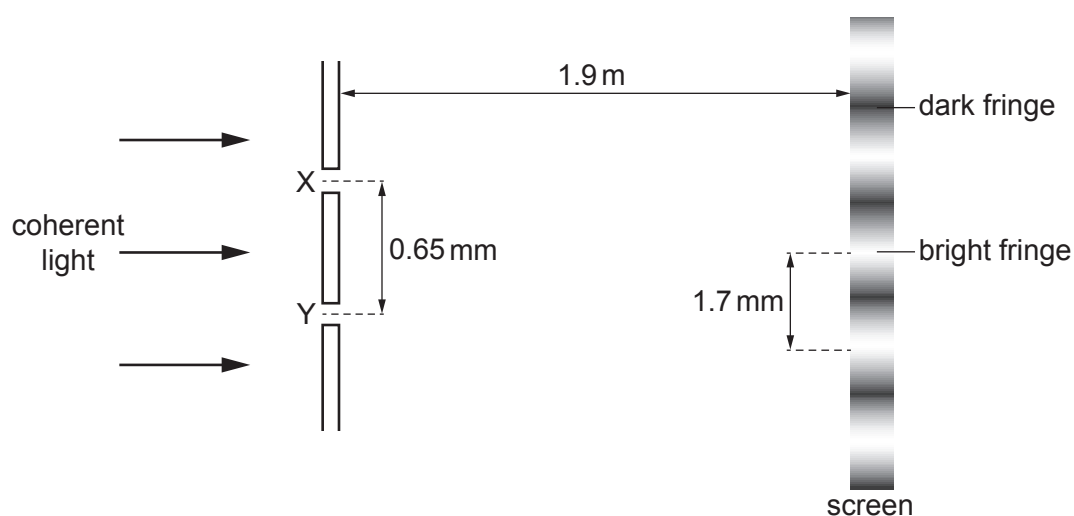


Fig. 4.1 (not to scale)

The separation of the slits is 0.65 mm. The distance between the centres of adjacent bright fringes is 1.7 mm.

Calculate the wavelength λ of the light.

$\lambda =$ m [3]

- (c) Light waves from slits X and Y in (b) arrive at a point between adjacent bright fringes on the screen. Fig. 4.2 shows the variation of displacement with time for the waves arriving at the point where they meet.

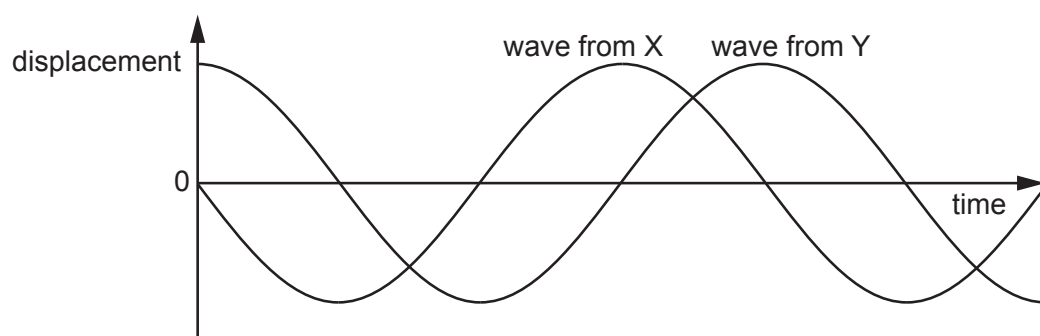


Fig. 4.2

A student makes two statements about the waves at this point:

Statement 1: 'The phase difference between the waves is 90° .'

Statement 2: 'The amplitude of the resultant wave is zero.'

- (i) Explain how statement 1 is correct.

.....
.....
..... [1]

- (ii) State and explain whether statement 2 is correct.

.....
.....
..... [1]

- (d) The width of each slit in (b) is decreased by the same amount. There is no change to the separation of the slits.

Describe and explain the effect, if any, of this change on the appearance of the interference pattern.

.....
.....
..... [2]

[Total: 9]

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38. Question | 9702 Oct-Nov 2023 P2 V3 Q5

- 5 Two point sources, A and B, produce coherent electromagnetic waves. The waves from A and B are emitted in phase and have wavelength λ , as shown in Fig. 5.1.

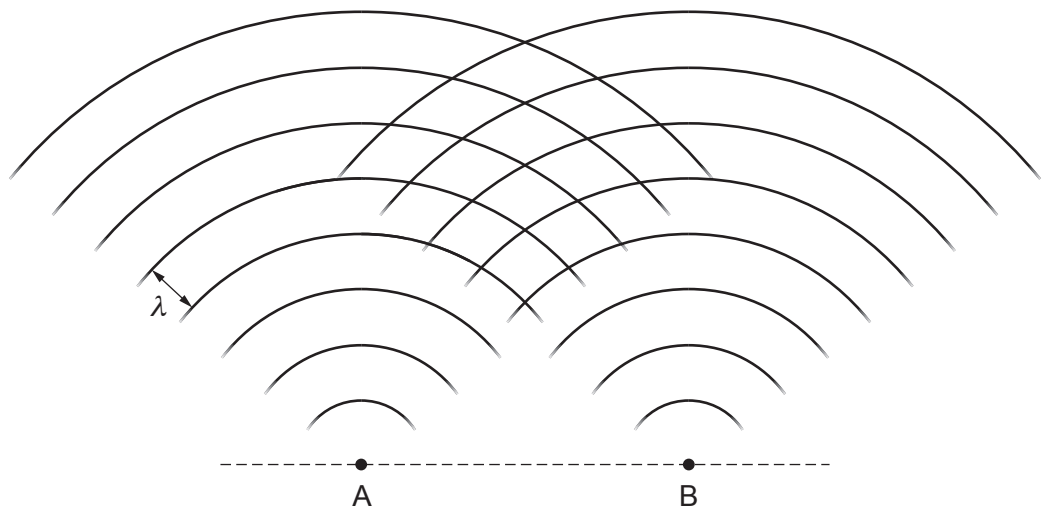


Fig. 5.1 (not to scale)

The lines on Fig. 5.1 represent wavefronts. All the points on a wavefront are in phase.

- (a) On Fig. 5.1, mark with a cross (×):
- (i) the position of an interference maximum (label this cross Y) [1]
 - (ii) the position of an interference minimum (label this cross Z). [1]
- (b) The waves in air have a wavelength of $2.9 \times 10^{-5}\text{m}$.

An interference pattern is detected along a line parallel to AB and at a perpendicular distance of 140 m from AB. The spacing between adjacent interference maxima is 1.2 cm.

- (i) Calculate the separation a of the sources A and B.

$a = \dots\dots\dots\text{m}$ [3]

- (ii) State the principal region of the electromagnetic spectrum to which the waves belong.
- $\dots\dots\dots$ [1]

[Total: 6]

- 6 (a) Coherent visible light of a single frequency is incident normally on a double slit. This produces a pattern of bright and dark interference fringes on a screen, as illustrated in Fig. 6.1.

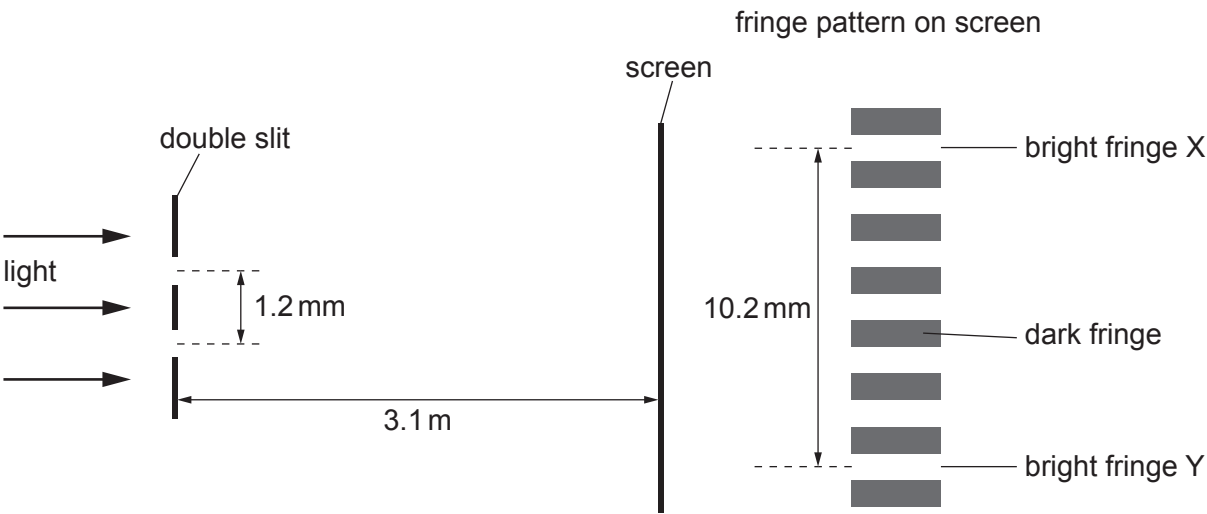


Fig. 6.1 (not to scale)

There are seven bright fringes.

- (i) Explain how the pattern of bright and dark interference fringes is formed.

.....

.....

.....

.....

.....

..... [3]

- (ii) The distance between the centres of bright fringe X and bright fringe Y in the pattern is 10.2 mm. The slit spacing is 1.2 mm. The distance from the slits to the screen is 3.1 m.

Calculate the wavelength of the light incident on the slits.

wavelength = ... m [3]

(iii) The light is replaced by different visible light with a shorter wavelength.

State how the new fringe separation will compare to the original fringe separation.

..... [1]

(b) A stationary wave is formed on a stretched string AB, as shown in Fig. 6.2.

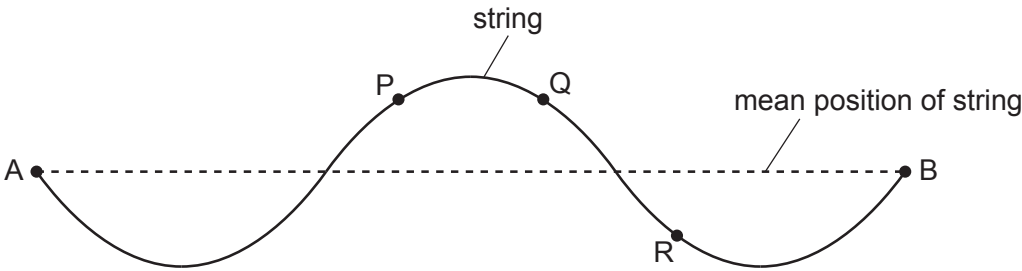


Fig. 6.2

P, Q and R are points on the string.

(i) On Fig. 6.2, draw a cross (×) to show the position of a node. [1]

(ii) State the phase difference between P and Q.

phase difference = ... ° [1]

(iii) State the phase difference between P and R.

phase difference = ... ° [1]

[Total: 10]

- 5 A stretched string PQ has length 1.2 m. One end of the string is attached to a vibration generator and the other end is attached to a wall, as shown in Fig. 5.1.

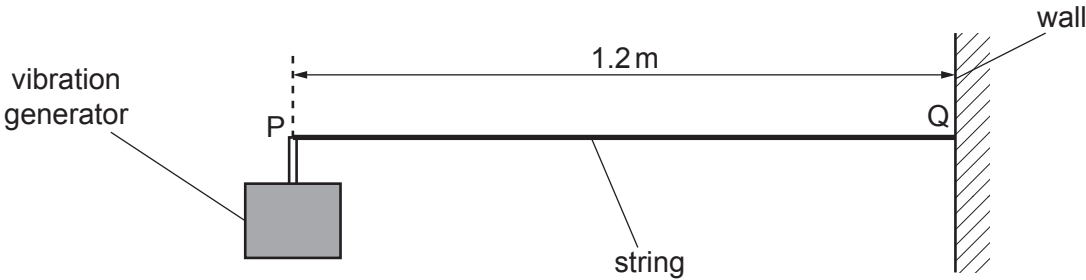


Fig. 5.1

The vibration generator is switched on and a stationary wave is formed on the string. The string is shown at one instant of time in Fig. 5.2.

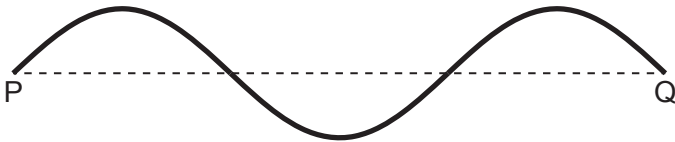


Fig. 5.2

- (a) Explain how a stationary wave is formed between the vibration generator and the wall.

.....

.....

.....

..... [2]

- (b) Calculate the wavelength of the stationary wave shown in Fig. 5.2.

wavelength = ... m [1]

- (c) Fig. 5.3 shows the stationary wave at time $t = 0$ when all points on the wave are at their maximum displacements.

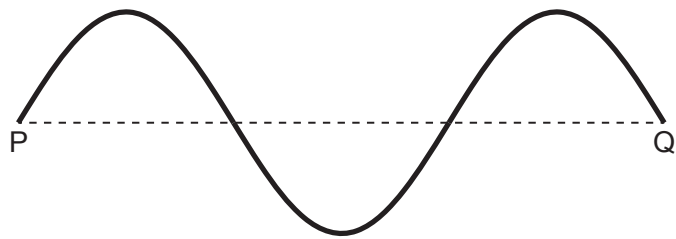


Fig. 5.3

The period of the wave is 0.16 s.

On Fig. 5.3, sketch the shape of the stationary wave at time $t = 0.24$ s. [2]

- (d) Points R and T on the string are a horizontal distance of 0.30 m apart and in the positions shown in Fig. 5.4.

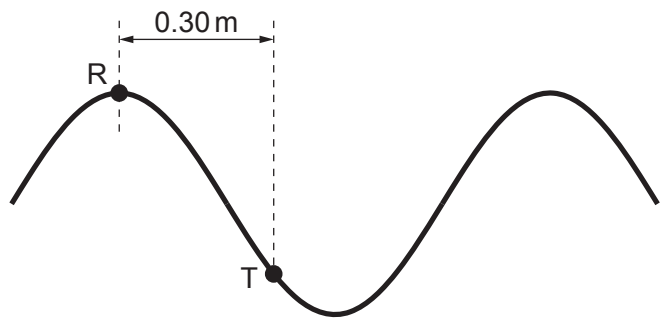


Fig. 5.4

State the phase difference between the oscillations of points R and T.

phase difference = ... ° [1]

- (e) Calculate the speed of the progressive waves on the stretched string.

speed = ... ms⁻¹ [2]

[Total: 8]

41. Question part 1/2 | 9702 May-June 2024 P2 V2 Q6

- 6 Light of a single frequency is incident normally on a diffraction grating. An interference pattern of bright and dark fringes forms on the semicircular screen shown in Fig. 6.1.

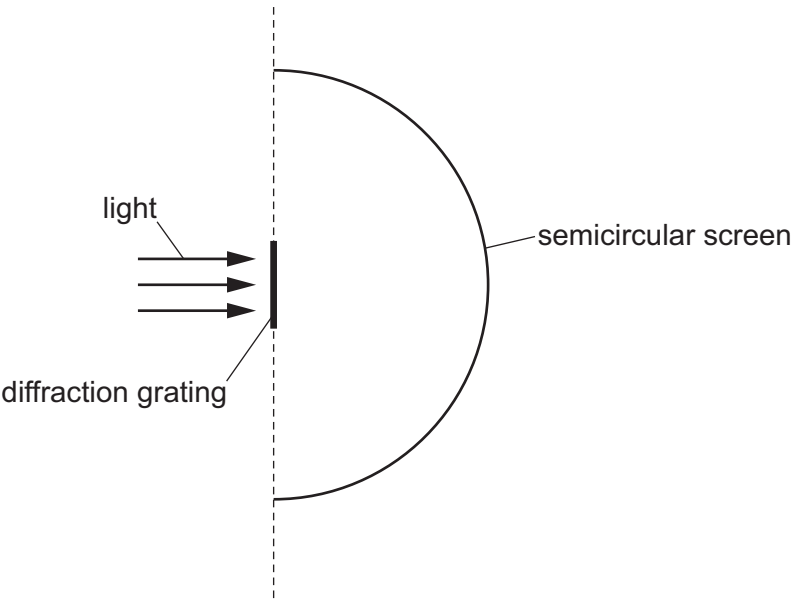


Fig. 6.1 (not to scale)

The light has wavelength 520 nm.
The separation of the lines in the grating is 3.8×10^{-6} m.

- (a) Determine the total number of bright fringes formed on the screen.

number of bright fringes = ... [3]



(b) The light is replaced with red light of a single frequency.

(i) State whether the frequency of the red light is greater than, less than or the same as the frequency of the original light.

..... [1]

(ii) State and explain the effect of this change on the number of bright fringes formed on the screen. A calculation is not required.

.....
.....
.....
..... [2]

[Total: 6]

4 A progressive transverse wave travelling from left to right is shown at an instant in time in Fig. 4.1.

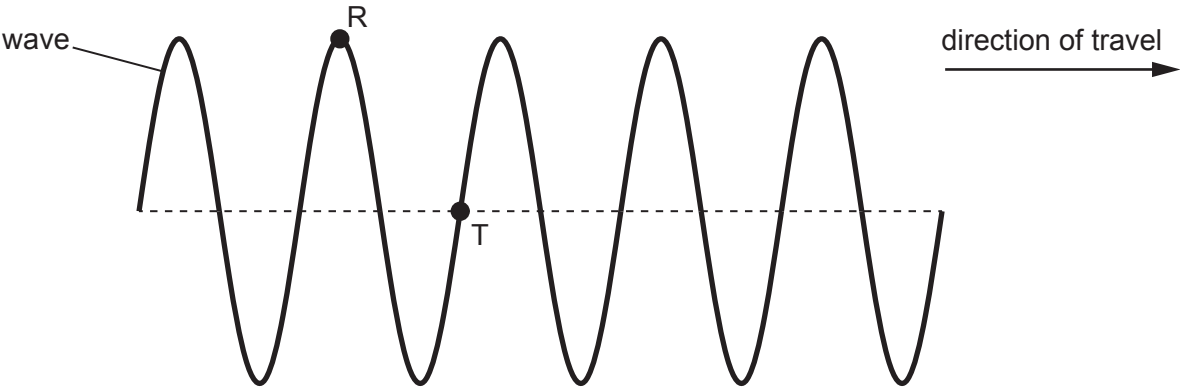


Fig. 4.1

R and T are points on the wave.

(a) State the phase difference between the points R and T.

phase difference = ... ° [1]

(b) On Fig. 4.1, draw an arrow at point T to show the direction of movement of point T at the instant shown. [1]

(c) The horizontal distance between R and T is 0.62 cm, as shown in Fig. 4.2.

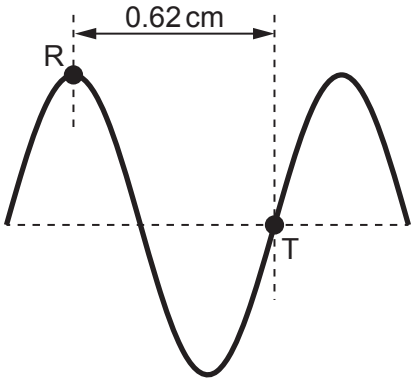


Fig. 4.2 (not to scale)

The speed of the wave is 0.27 m s^{-1} .

Calculate the frequency of the wave.

frequency = ... Hz [3]

(d) The wave is a water wave produced by a dipper S_1 attached to a vibrator in a ripple tank.

An identical dipper S_2 is attached to the same vibrator. The two dippers produce an interference pattern on the water in the tank, as shown in Fig. 4.3.

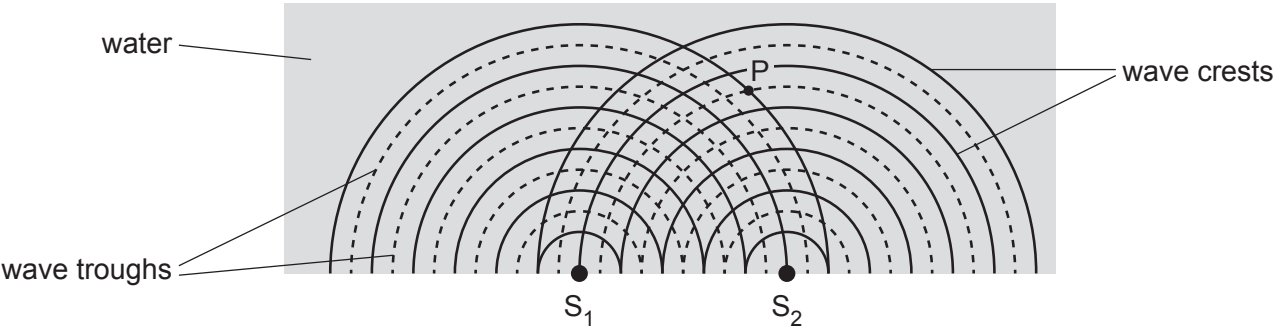


Fig. 4.3 (not to scale)

The wave crests from each source are represented by solid lines on Fig. 4.3 and the wave troughs are represented by dashed lines.

At point P in Fig. 4.3, the wave from S_1 has the same amplitude A as the wave from S_2 .

Describe and explain the amplitude of the resultant wave at point P.

.....

.....

.....

..... [3]

[Total: 8]

43. Question part 1/2 | 9702 Oct-Nov 2024 P2 V1 Q6

- 6 Two coherent sources X and Y of microwaves of frequency 2.5×10^{10} Hz are a distance of 0.18 m apart in a vacuum, as shown in Fig. 6.1.

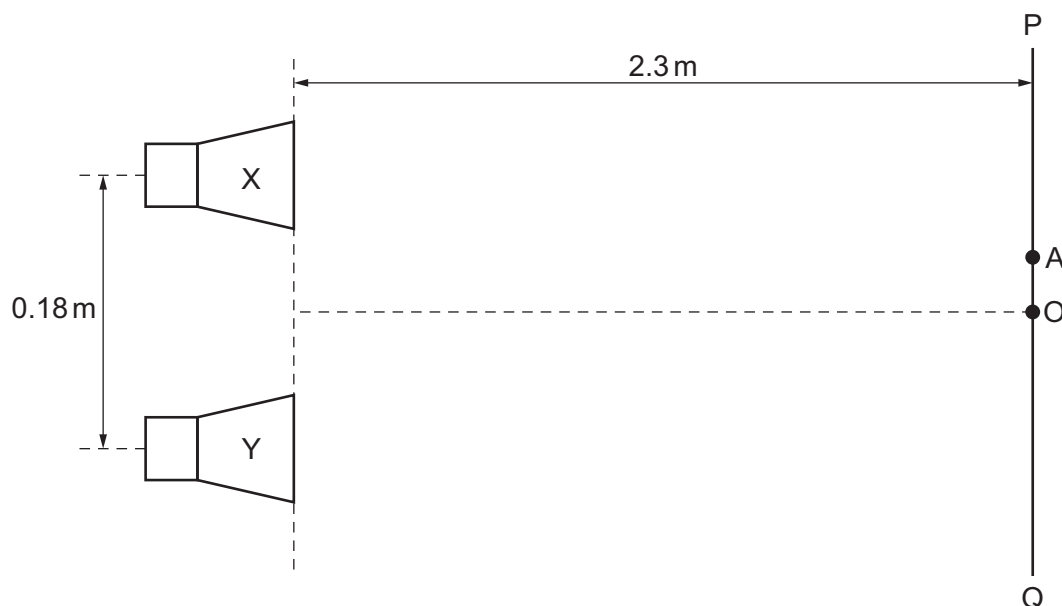


Fig. 6.1 (not to scale)

There is a phase difference of 90° between the waves emitted at the two sources.

A microwave detector moves along the line PQ, which is parallel to the line joining the two sources and 2.3 m away from it.

Point O is on the line PQ at a position that is equidistant from the two sources.

Point A is the position on line PQ where the intensity of the microwaves is the greatest.

- (a) (i) Explain why the position of greatest intensity is **not** at point O.

.....

.....

.....

..... [2]

- (ii) On Fig. 6.1, draw a cross (x) to show the position of the point on line PQ where the intensity minimum that is the closest to point O occurs. Label this point B. [2]

43. Question part 2/2 | 9702 Oct-Nov 2024 P2 V1 Q6



(b) (i) Show that the wavelength of the microwaves is 0.012 m.

[2]

(ii) For point A on line PQ, determine the difference in the distances Δx travelled by the microwaves from X and the microwaves from Y.

$\Delta x = \dots\dots\dots$ m [1]

(iii) Use the formula for the double-slit interference of light to calculate the distance between adjacent intensity maxima on line PQ.

distance = $\dots\dots\dots$ m [2]

[Total: 9]

44. Question part 1/2 | 9702 May-June 2025 P2 V1 Q4

- 4 (a) State the principle of superposition.

.....

.....

..... [2]

- (b) Light of wavelength $7.2 \times 10^{-7} \text{ m}$ is incident normally on a double slit, as shown in Fig. 4.1.

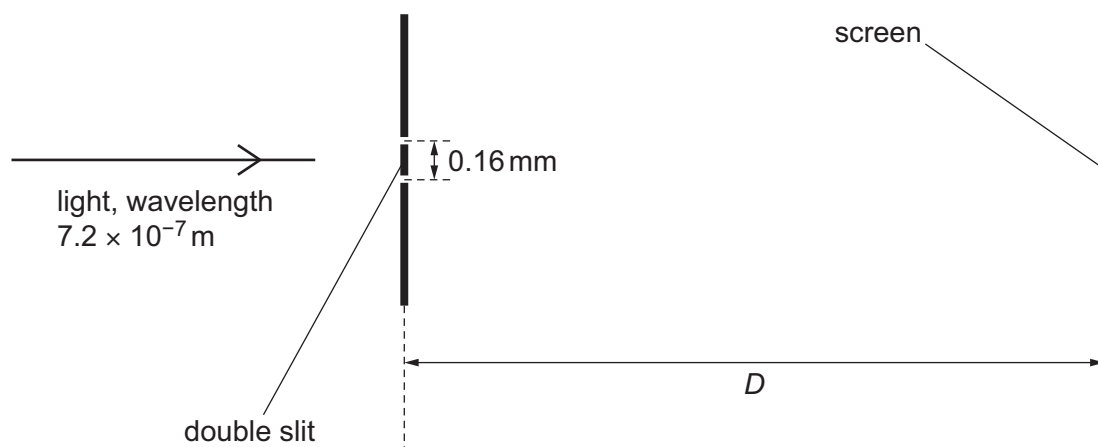


Fig. 4.1 (not to scale)

A screen is at a distance D from the double slit. The double slit and the screen are parallel.

The separation of the slits in the double-slit arrangement is 0.16 mm. The resulting interference pattern on the screen contains nine dark fringes, as shown in Fig. 4.2.

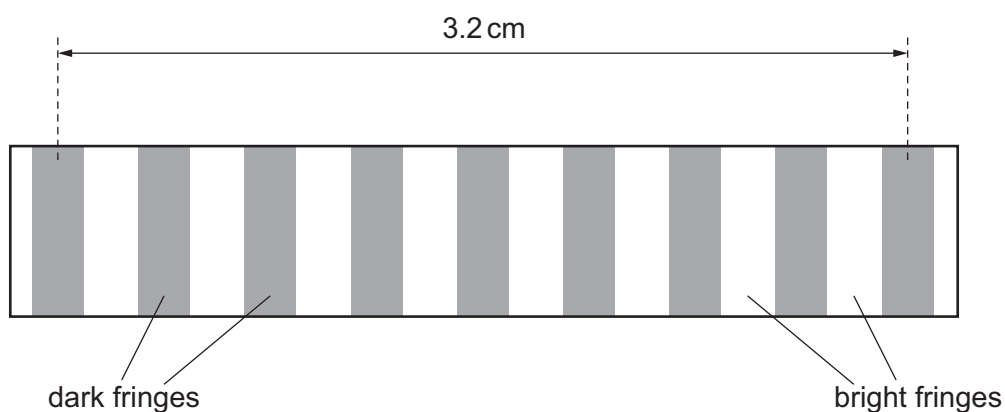


Fig. 4.2 (not to scale)

44. Question part 2/2 | 9702 May-June 2025 P2 V1 Q4



The distance between the centres of the first and ninth dark fringes is 3.2 cm.

(i) Calculate D .

$D = \dots\dots\dots\text{m}$ [3]

(ii) The slit separation is now gradually decreased from 0.16 mm to 0.04 mm. The distance between the centres of adjacent dark fringes is x .

On Fig. 4.3, sketch the variation of x with slit separation.

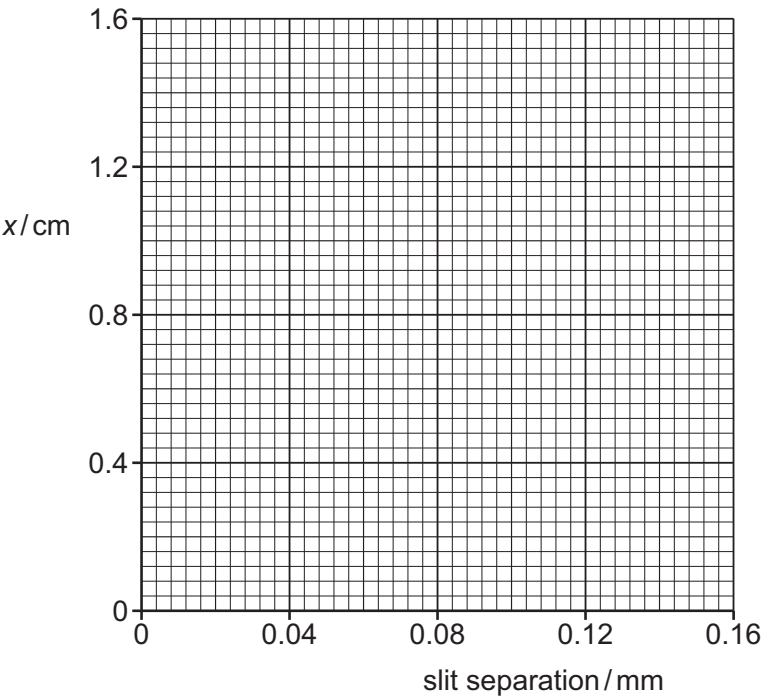


Fig. 4.3

[3]

[Total: 8]

45. Question part 1/2 | 9702 May-June 2025 P2 V2 Q3

- 3 Two progressive water waves X and Y travel along a straight line from point A to point B. The variation of displacement of the waves with distance from A at an instant in time is shown in Fig. 3.1.

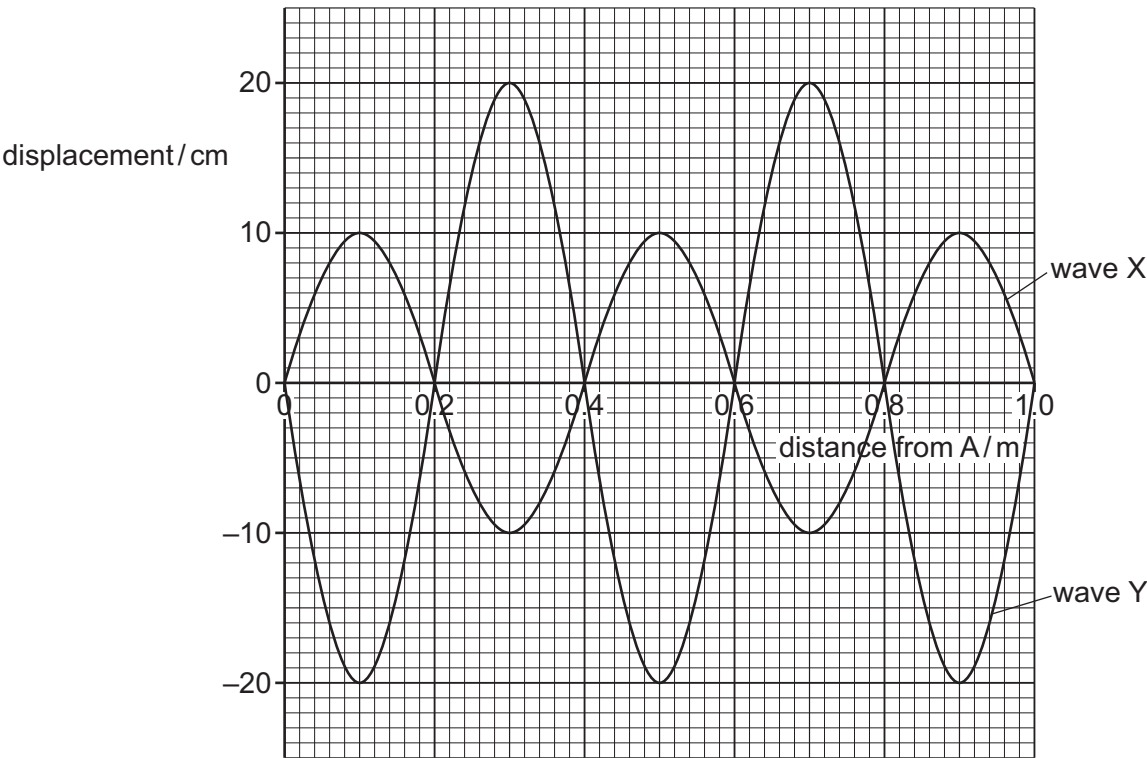


Fig. 3.1

- (a) State the amplitude of wave X.

amplitude = ... cm [1]

- (b) Both waves have frequency 16 Hz.

- (i) Determine the speed of wave X.

speed = ... ms⁻¹ [2]

- (ii) State and explain whether X and Y are coherent.

.....
.....
..... [1]

45. Question part 2/2 | 9702 May-June 2025 P2 V2 Q3



(c) Wave X and wave Y superpose to form a resultant wave.

On Fig. 3.2, sketch the variation of displacement of the resultant wave with distance from A at the instant of time shown in Fig. 3.1.

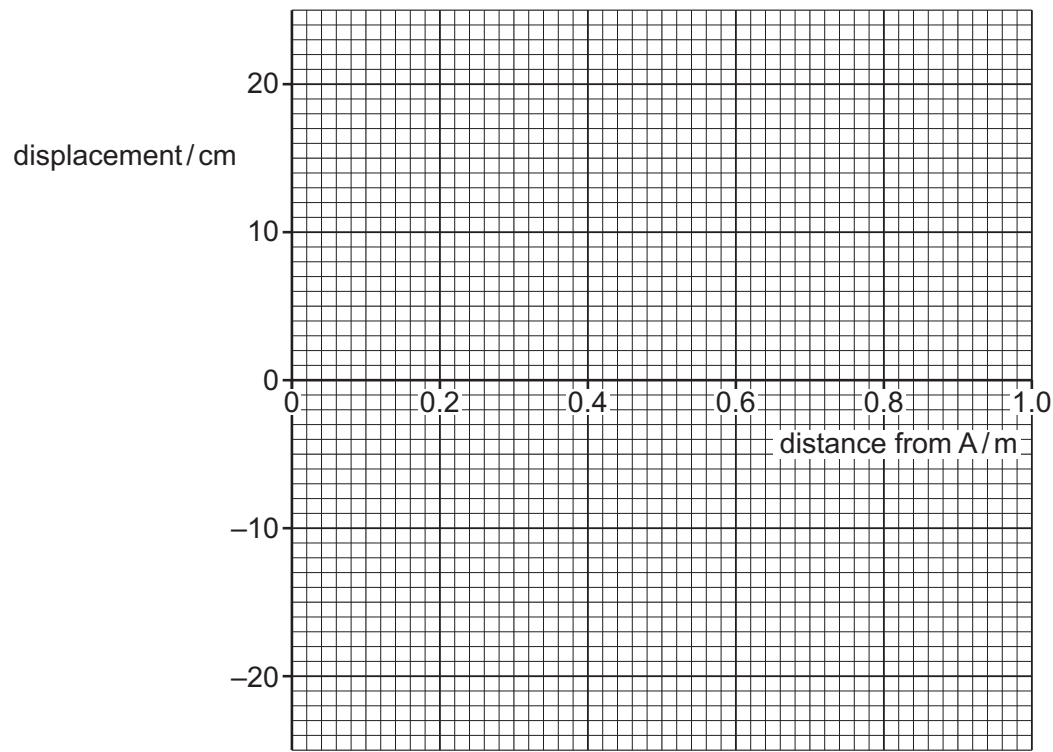


Fig. 3.2

[2]

(d) The intensity of wave X is I_X . The intensity of wave Y is I_Y .

Use Fig. 3.1 to determine the ratio $\frac{I_X}{I_Y}$.

ratio = ... [2]

[Total: 8]

46. Question part 1/2 | 9702 May-June 2025 P2 V3 Q6

6 (a) State what is meant by diffraction.

.....
..... [1]

(b) Light of wavelength 720 nm in a vacuum is incident normally on a diffraction grating as shown in Fig. 6.1.

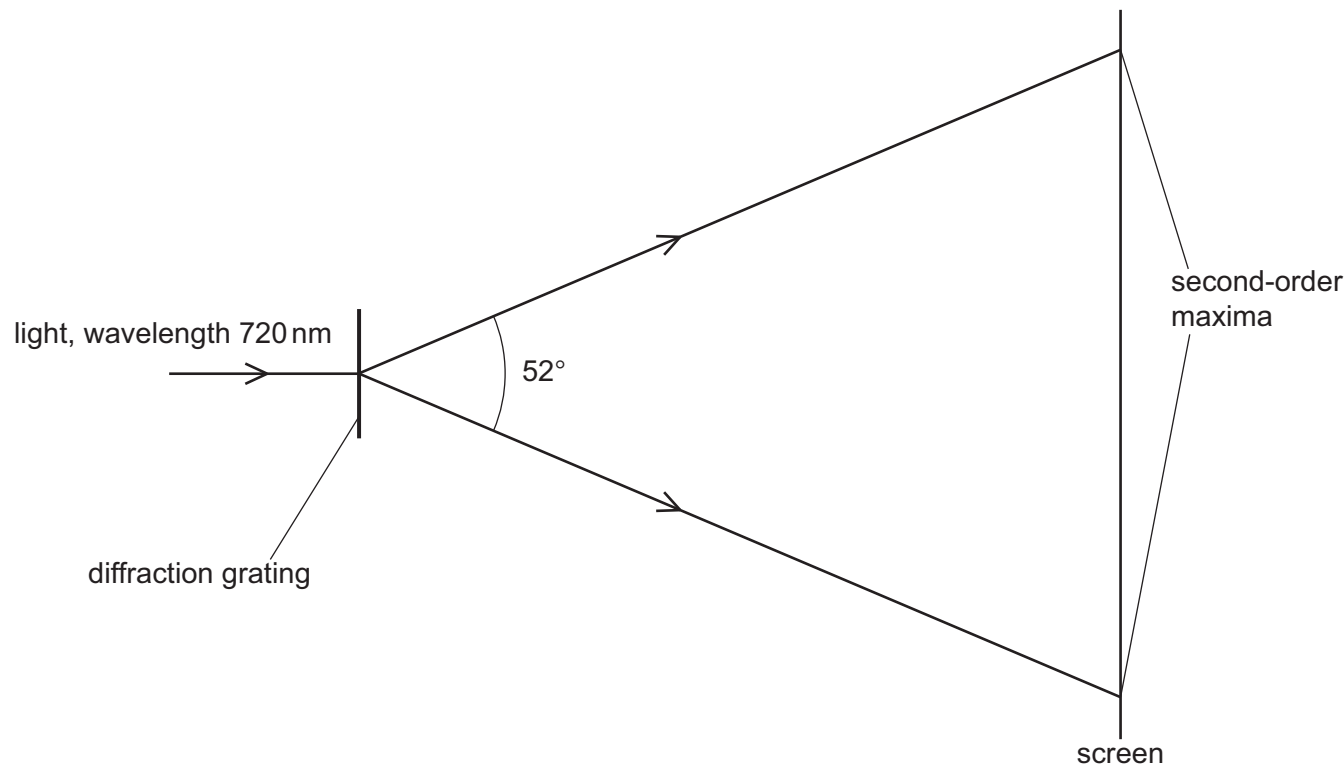


Fig. 6.1 (not to scale)

A screen is parallel to the grating. An interference pattern is seen on the screen and the angle between the **second**-order maxima is 52° .

(i) Calculate the frequency of the light.

frequency = ... Hz [2]

9702 Physics Paper 2 - Superposition

Topical questions | 49 questions

46. Question part 2/2 | 9702 May-June 2025 P2 V3 Q6



- (ii) Calculate the number of lines per unit length in the diffraction grating.

number per unit length = ... m^{-1} [3]

- (iii) The light in Fig. 6.1 is now replaced with light of a different wavelength λ . It is observed that the third-order maxima of this light are at the same positions as the second-order maxima of the light in Fig. 6.1.

Calculate, in nm, the wavelength λ .

$\lambda =$ nm [2]

[Total: 8]

47. Question part 1/2 | 9702 May-June 2025 P2 V4 Q4

4 (a) A source oscillates with frequency f to produce a progressive wave of wavelength λ . The source takes time t to produce n complete oscillations.

(i) State what is meant by a progressive wave.

.....
..... [1]

(ii) State expressions, in terms of some or all of f , λ and n , for:

- the distance moved by a wavefront in time t

distance = ...

- time t .

time t = ... [2]

(iii) Use your answers in (ii) to determine an expression for the speed v of the wave in terms of f and λ .

[1]

(b) Two identical microwave sources X and Y emit waves in phase. The sources are separated by a distance of 30 cm, as shown in Fig. 4.1.

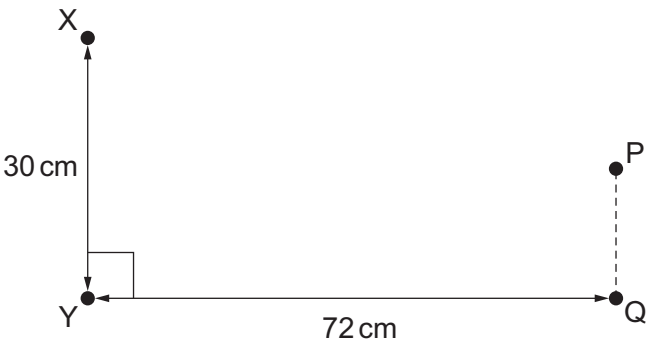


Fig. 4.1 (not to scale)

The intensity of the microwaves is to be investigated at points P and Q.
Line PQ is parallel to line XY. Distance XP is equal to distance YP. Distance YQ is 72 cm and angle XYQ is 90°.
The wavelength of the microwaves is 4.0 cm.

47. Question part 2/2 | 9702 May-June 2025 P2 V4 Q4



(i) Calculate the frequency, in GHz, of the microwaves.

frequency = ... GHz [2]

(ii) Show that the difference between the path lengths XQ and YQ is 6 cm.

[1]

(iii) State and explain what may be deduced about the intensity of the microwaves at point Q.

.....
.....
.....
.....
..... [3]

(iv) A microwave detector is positioned at P and connected to a cathode-ray oscilloscope (CRO). The controls of the CRO are adjusted so that a waveform is shown on the screen.

Describe the changes to the amplitude of the waveform as the detector is moved from P to Q.

.....
.....
.....
..... [2]

[Total: 12]

48. Question part 1/2 | 9702 Oct-Nov 2025 P2 V2 Q4

- 4 A laser emits visible light of a single frequency in a vacuum. The light is incident normally on a double slit and then forms a pattern of bright and dark fringes on a screen, as shown in Fig. 4.1.

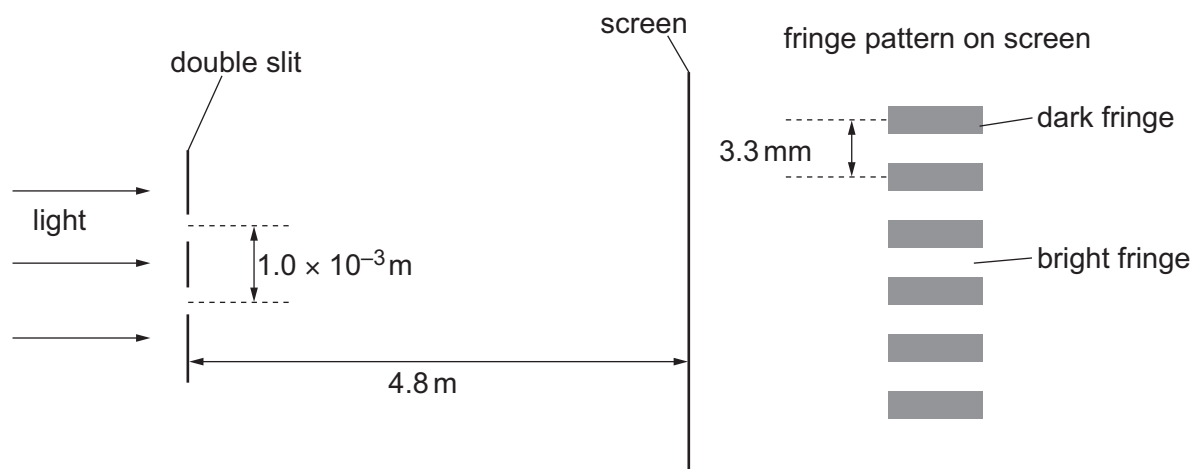


Fig. 4.1 (not to scale)

The separation of the slits is $1.0 \times 10^{-3} \text{ m}$. The distance from the slits to the screen is 4.8 m . The distance between the centres of adjacent dark fringes on the screen is 3.3 mm .

- (a) Explain how the pattern of bright and dark fringes is formed.

.....

.....

.....

.....

..... [3]

- (b) Calculate the frequency of the light emitted by the laser.

frequency = ... Hz [4]

48. Question part 2/2 | 9702 Oct-Nov 2025 P2 V2 Q4



- (c) The double slit is removed. A second laser is placed beside the first laser. The second laser produces visible light of a different frequency from that of the first laser. The beams of light from the two lasers overlap on the screen.

Explain why a steady pattern of bright and dark fringes is **not** formed on the screen.

.....

..... [1]

[Total: 8]

49. Question part 1/2 | 9702 Oct-Nov 2025 P2 V4 Q4

4 (a) State the principle of superposition.

.....

.....

..... [2]

(b) An electromagnetic wave of wavelength 0.026 m in free space is incident normally on an aluminium sheet, as shown in Fig. 4.1.

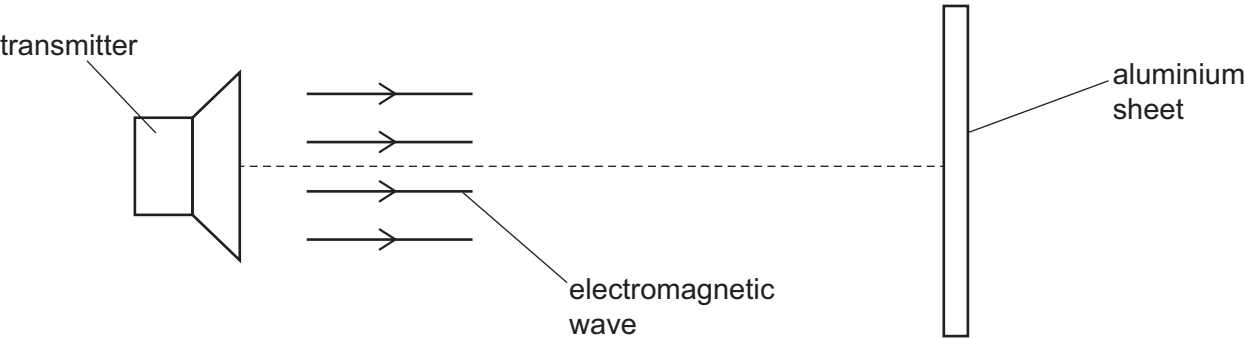


Fig. 4.1

The wave reflects at the aluminium sheet and a stationary wave is formed in the region between the transmitter and the sheet.

(i) Explain how the stationary wave, including its nodes and antinodes, is formed.

.....

.....

.....

.....

..... [3]

(ii) Calculate the frequency of the electromagnetic wave.

frequency = ... Hz [2]

(iii) State the principal region of the electromagnetic spectrum to which the wave belongs.

..... [1]

49. Question part 2/2 | 9702 Oct-Nov 2025 P2 V4 Q4



(iv) Determine the distance between a node and an adjacent antinode.

distance = ... m [1]

[Total: 9]