CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Units 7 & 8: Progressive Waves and Superposition

Past Papers 2021 – 2025

QUESTION PAPER 46 Questions

Prepared by

Waseem Ahmad

A Level Physics Teacher

Author of ***Practical Mastery: Cambridge 9702 Paper 3***

www.examspath.com

Question 1

(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.

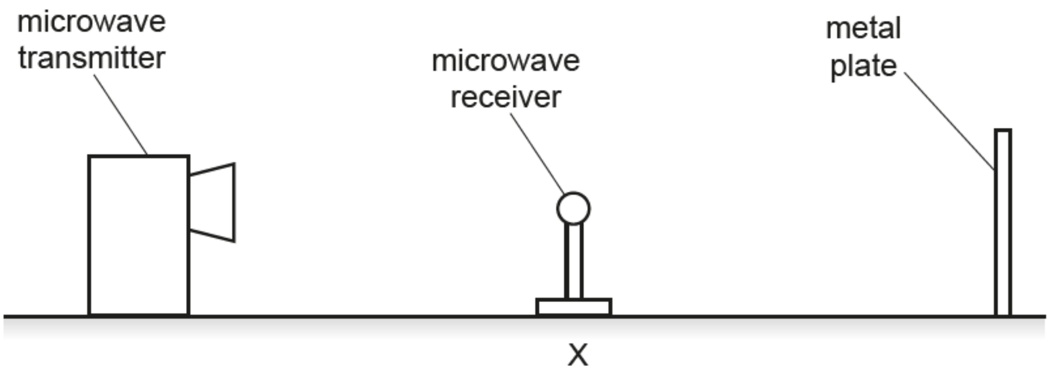


Fig. 4.1

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]

(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]

Question 2

A source of sound is attached to a rope and then swung at a constant speed in a horizontal circle, as illustrated in Fig. 5.1.

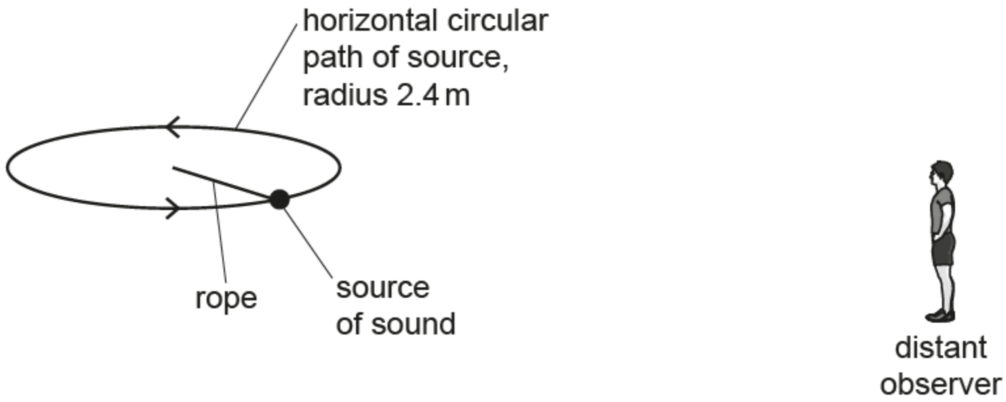


Fig. 5.1 (not to scale)

The source moves with a speed of $12.0\,\mathrm{m\,s^{-1}}$ and emits sound of frequency 951 Hz. The speed of the sound in the air is $330\,\mathrm{m\,s^{-1}}$. An observer, standing a very long distance away from the source, hears the sound.

(a) Calculate the minimum frequency, to three significant figures, of the sound heard by the observer.

minimum frequency = ... Hz [2]

(b) The circular path of the source has a radius of 2.4 m.

Determine the shortest time interval between the observer hearing sound of minimum frequency and the observer hearing sound of maximum frequency.

time interval = ... s [2]

[Total: 4]

Question 3

(a) For a progressive wave, state what is meant by *wavelength*.

....

.... [1]

(b) A light wave from a laser has a wavelength of 460 nm in a vacuum.

Calculate the period of the wave.

period = ... s [3]

(c) The light from the laser is incident normally on a diffraction grating.

Describe the diffraction of the light waves at the grating.

....

....

.... [2]

(d) A diffraction grating is used with different wavelengths of visible light. The angle θ of the **fourth**-order maximum from the zero-order (central) maximum is measured for each wavelength. The variation with wavelength λ of $\sin\theta$ is shown in Fig. 4.1.

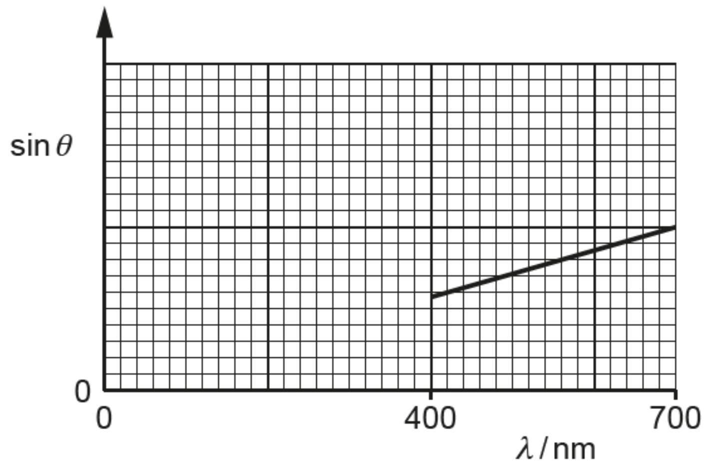


Fig. 4.1

(i) The gradient of the graph is G.

Determine an expression, in terms of G, for the distance d between the centres of two adjacent slits in the diffraction grating.

d = ... [2]

(ii) On Fig. 4.1, sketch a graph to show the results that would be obtained for the **second**-order maxima. [2]

[Total: 10]

Question 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.

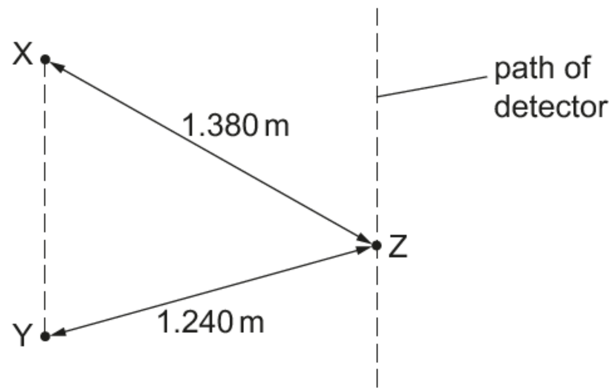


Fig. 4.1 (not to scale)

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]

(iii) Show that the path difference at point Z between the waves from X and Y is 3.5 λ, 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]

Question 5

(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)

(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]

Question 6

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

....

.... **[1]**

(b) A vehicle travels at constant speed around a wide circular track. It continuously sounds its horn, which emits a single note of frequency 1.2 kHz. An observer is a large distance away from the track, as shown in the view from above in Fig. 4.1.

Fig. 4.1 (not to scale)

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

....

.... **[1]**

(b) A vehicle travels at constant speed around a wide circular track. It continuously sounds its horn, which emits a single note of frequency 1.2 kHz. An observer is a large distance away from the track, as shown in the view from above in Fig. 4.1.

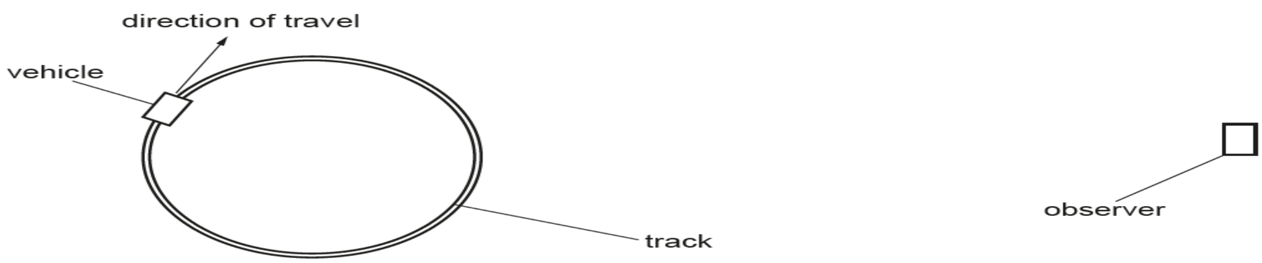


Fig. 4.1 (not to scale)

Fig. 4.2 shows the variation with time of the frequency f of the sound of the horn that is detected by the observer. The time taken for the vehicle to travel once around the track is T.

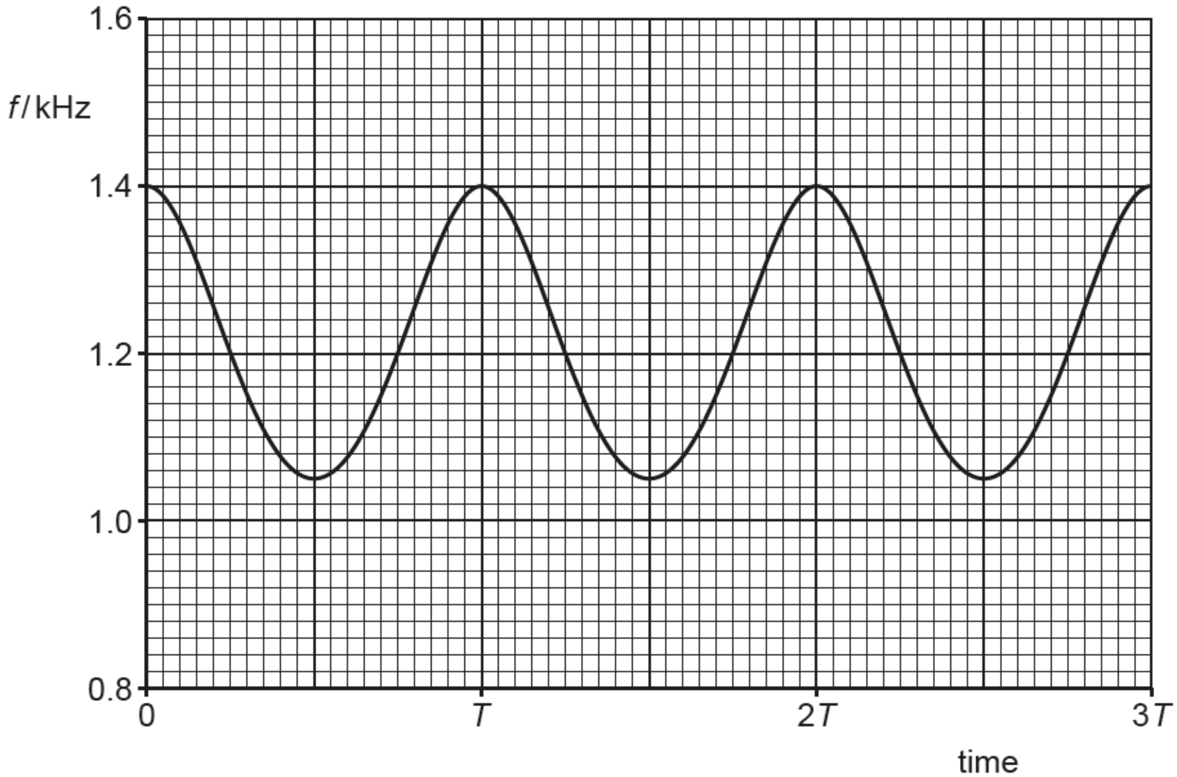


Fig. 4.2

(i) Explain why the frequency of the sound detected by the observer is sometimes above and sometimes below 1.2 kHz.

....

....

....

.... [2]

(ii) State the name of the phenomenon in **(b)(i)**.

.... [1]

(iii) On Fig. 4.1, mark with a letter X the position of the vehicle when it emitted the sound that is detected at time T. [1]

(iv) On Fig. 4.1, mark with a letter Y the position of the vehicle when it emitted the sound that is detected at time $\frac{9T}{4}$. [1]

(c) The speed of the sound in the air is $320\,\mathrm{m\,s^{-1}}$.

Use Fig. 4.2 to determine the speed of the vehicle in **(b)**.

speed = ... $\mathrm{m\,s^{-1}}$ [3]

[Total: 9]

Question 7

A tube is initially fully submerged in water. The axis of the tube is kept vertical as the tube is slowly raised out of the water, as shown in Fig. 5.1.

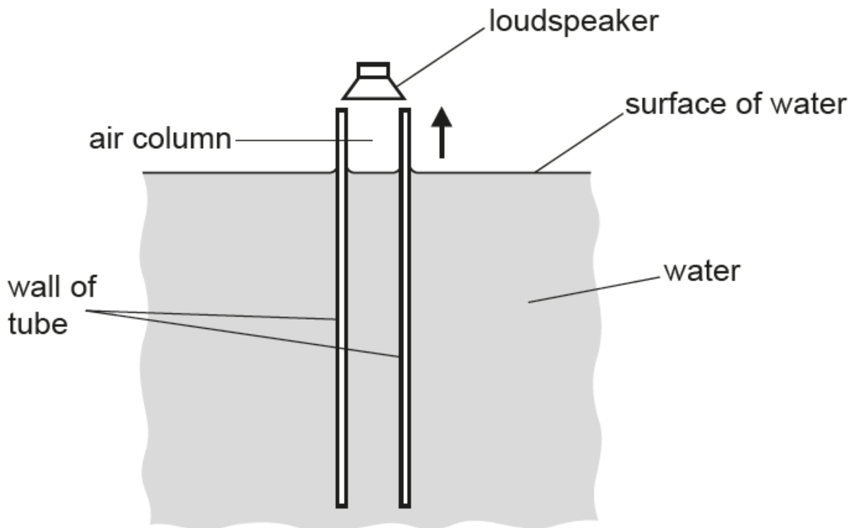


Fig. 5.1

A loudspeaker producing sound of frequency 530 Hz is positioned at the open top end of the tube as it is raised. The water surface inside the tube is always level with the water surface outside the tube. The speed of the sound in the air column in the tube is $340\,\text{m s}^{-1}$.

(a) Describe a simple way that a student, without requiring any additional equipment, can detect when a stationary wave is formed in the air column as the tube is being raised.

....

.... [1]

(b) Determine the height of the top end of the tube above the surface of the water when a stationary wave is first produced in the tube. Assume that an antinode is formed level with the top of the tube.

height = ... m [3]

(c) Determine the distance moved by the tube between the positions at which the first and second stationary waves are formed.

distance = ... m [1]

[Total: 5]

Question 8

A child sits on the ground next to a remote-controlled toy car. At time $t = 0$, the car begins to move in a straight line directly away from the child. The variation with time t of the velocity of the car along this line is shown in Fig. 4.1.

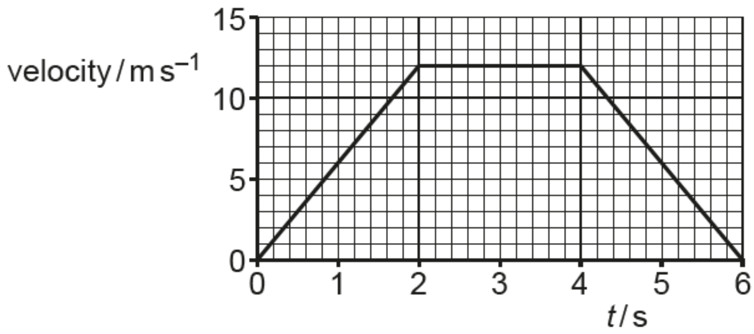


Fig. 4.1

The car's horn continually emits sound of frequency 925 Hz between time $t = 0$ and time $t = 6.0$ s. The speed of the sound in the air is 338 m s^{-1}.

(a) Describe qualitatively the variation, if any, in the frequency of the sound heard, by the child, that was emitted from the car horn:

(i) from time $t = 0$ to time $t = 2.0$ s

.... [1]

(ii) from time $t = 4.0$ s to time $t = 6.0$ s.

.... [1]

(b) Determine the frequency, to three significant figures, of the sound heard, by the child, that was emitted from the car horn at time $t = 3.0$ s.

frequency = ... Hz [2]

(c) Determine the time taken for the sound emitted at time t = 4.0 s to travel to the child.

time taken = ... s [2]

[Total: 6]

Question 9

(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.

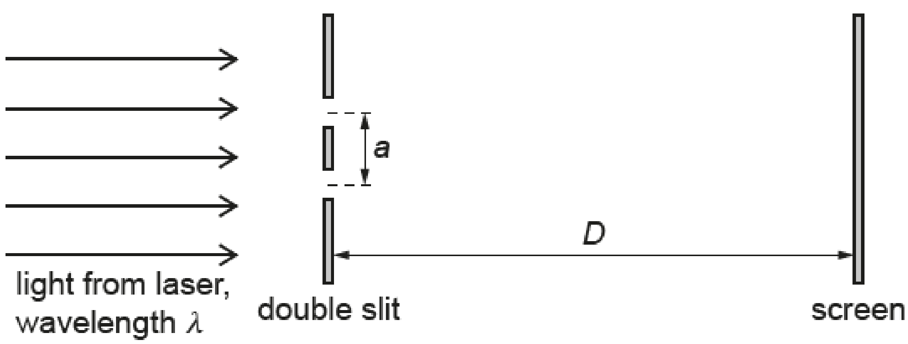


Fig. 5.1 (not to scale)

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.

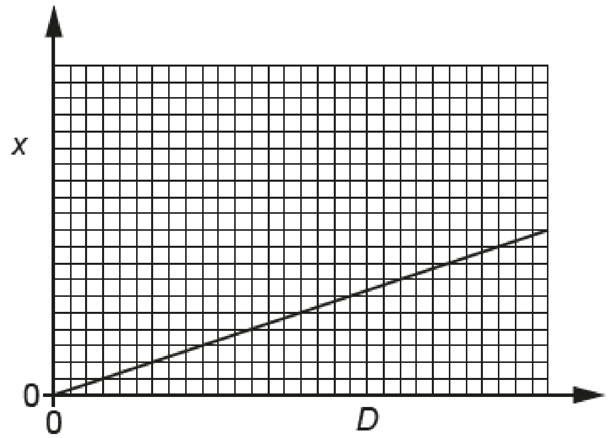


Fig. 5.2

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 = ... [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]

Question 10

(a) **(i)** State the conditions required for the formation of a stationary wave.

....

....

....

.... [2]

(ii) State the phase difference between any two vibrating particles in a stationary wave between two adjacent nodes.

phase difference = ...° [1]

(b) A motorcycle is travelling at 13.0 m s^{-1} along a straight road. The rider of the motorcycle sees a pedestrian standing in the road directly ahead and operates a horn to emit a warning sound. The pedestrian hears the warning sound from the horn at a frequency of 543 Hz. The speed of the sound in the air is 334 m s^{-1}.

(i) Calculate the frequency, to three significant figures, of the sound emitted by the horn.

frequency = ... Hz [2]

(ii) The motorcycle rider passes the stationary pedestrian and then moves directly away from her. As the rider moves away, he operates the horn for a second time. The pedestrian now hears sound that is increasing in frequency.

State the variation, if any, in the speed of the motorcycle when the rider operates the horn for the second time.

.... [1]

(c) A beam of vertically polarised monochromatic light is incident normally on a polarising filter, as shown in Fig. 5.1.

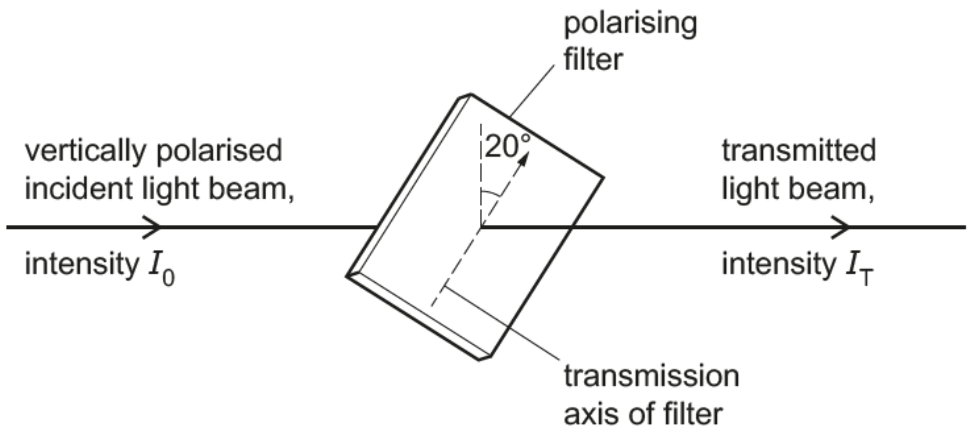


Fig. 5.1

The filter is positioned with its transmission axis at an angle of 20° to the vertical.
The incident light has intensity I_0 and the transmitted light has intensity I_T.

(i) By considering the ratio $\dfrac{I_T}{I_0}$, calculate the ratio

$$\frac{\text{amplitude of transmitted light}}{\text{amplitude of incident light}}.$$

Show your working.

ratio = ... [3]

(ii) The filter is now rotated, about the direction of the light beam, from its starting position shown in Fig. 5.1. The direction of rotation is such that the angle of the transmission axis to the vertical initially increases.

Calculate the minimum angle through which the filter must be rotated so that the intensity of the transmitted light returns to the value that it had when the filter was at its starting position.

angle = ... ° [1]

[Total: 10]

Question 11

A horizontal string is stretched between two fixed points A and B. A vibrator is used to oscillate the string and produce an observable stationary wave.

At one instant, the moving string is straight, as shown in Fig. 5.1.

Fig. 5.1

The dots in the diagram represent the positions of the nodes on the string. Point P on the string is moving downwards.

The wave on the string has a speed of $35\,\text{m}\,\text{s}^{-1}$ and a period of 0.040 s.

(a) Explain how the stationary wave is formed on the string.

....

....

....

.... [2]

(b) On Fig. 5.1, sketch a line to show a possible position of the string a quarter of a cycle later than the position shown in the diagram. [1]

(c) Determine the horizontal distance from A to B.

distance = ... m [3]

(d) A particle on the string has zero displacement at time $t = 0$. From time $t = 0$ to time $t = 0.060$ s, the particle moves through a total distance of 72 mm.

Calculate the amplitude of oscillation of the particle.

amplitude = ... mm [2]

[Total: 8]

Question 12

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

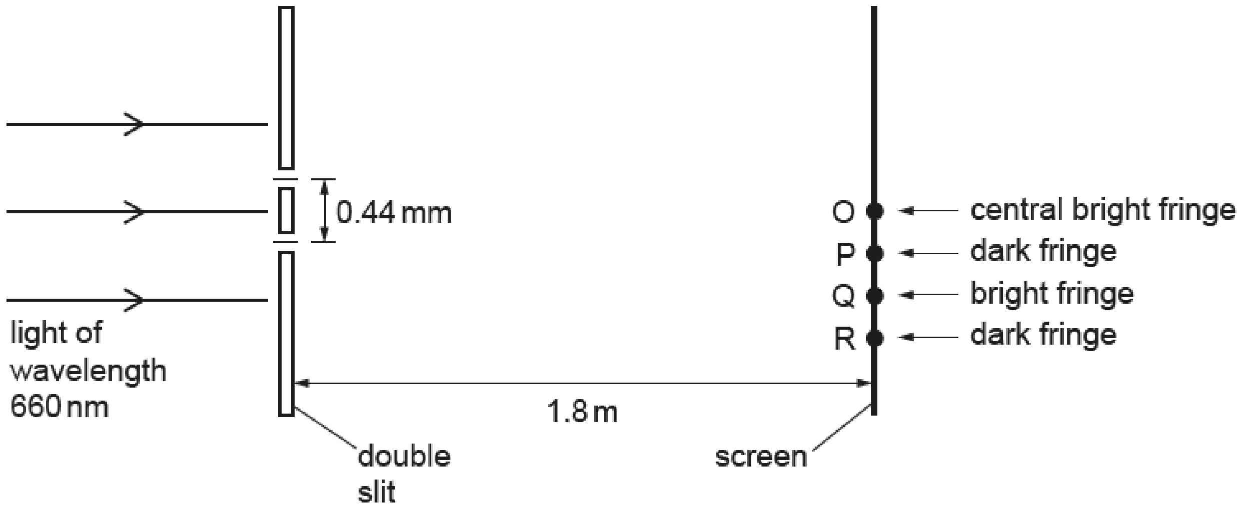


Fig. 5.1 (not to scale)

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]

(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]

Question 13

(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.

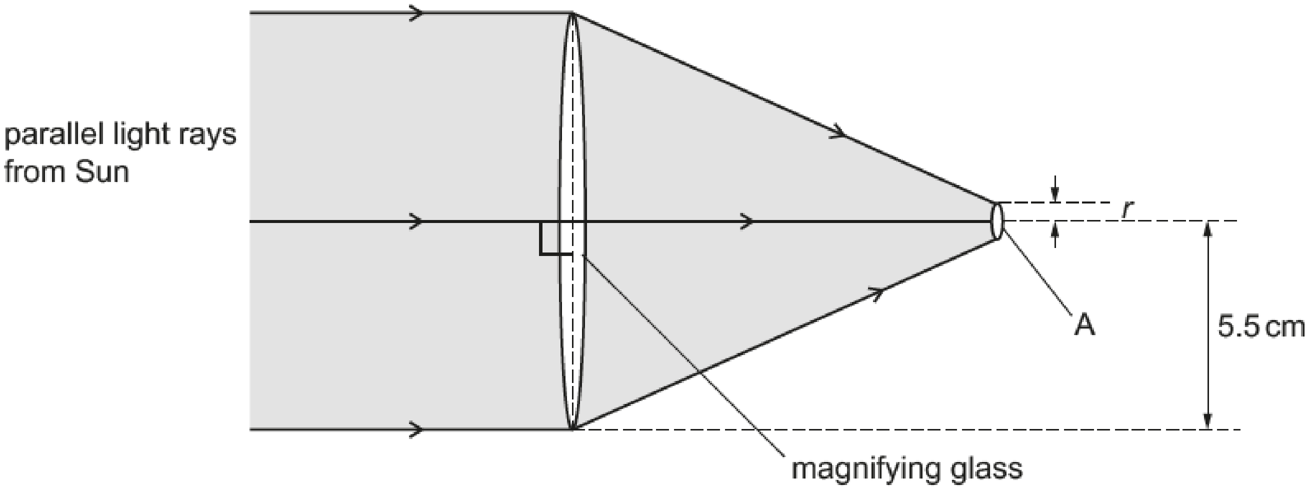


Fig. 5.1 (not to scale)

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 $1.3\,\text{kW}\,\text{m}^{-2}$.

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 3.7×10^{15} Hz in a vacuum.

(i) Show that the wavelength of the waves is 8.1×10^{-8} 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.

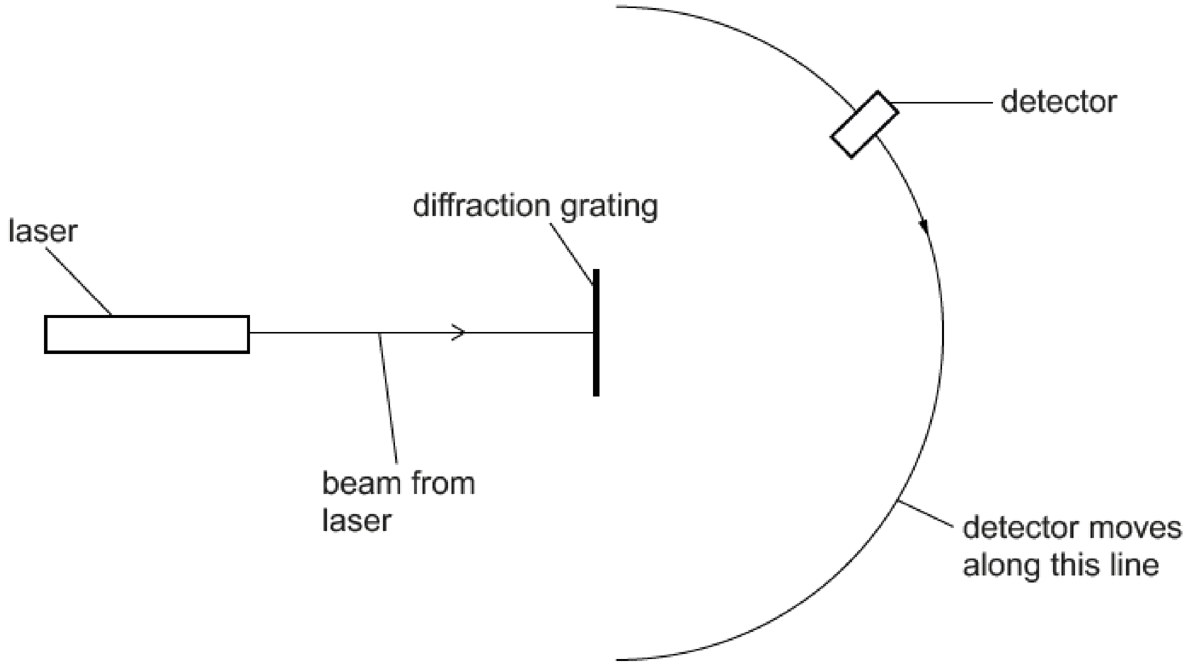


Fig. 5.2

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]

Question 14

(a) Two progressive sound waves meet to form a stationary wave. The two waves have the same amplitude, wavelength, frequency and speed.

State the other condition that must be fulfilled by the two waves in order for them to produce the stationary wave.

.... [1]

(b) A stationary wave is formed on a string that is stretched between two fixed points A and B. Fig. 5.1 shows the string at time $t = 0$ when each point is at its maximum displacement.

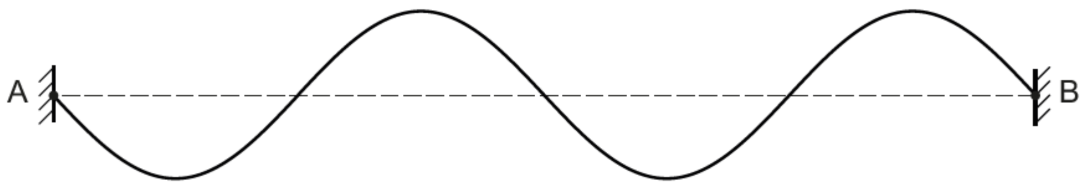


Fig. 5.1

Distance AB is 0.80 m. The period of the stationary wave is 0.016 s.

(i) On Fig. 5.1, sketch a solid line to show the position of the string:

- at time $t = 0.004$ s (label this line P)
- at time $t = 0.024$ s (label this line Q).

[2]

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

speed = ... m s^{-1} [3]

(c) A beam of vertically polarised light of intensity I_0 is incident normally on a polarising filter that has its transmission axis at 30° to the vertical, as shown in Fig. 5.2.

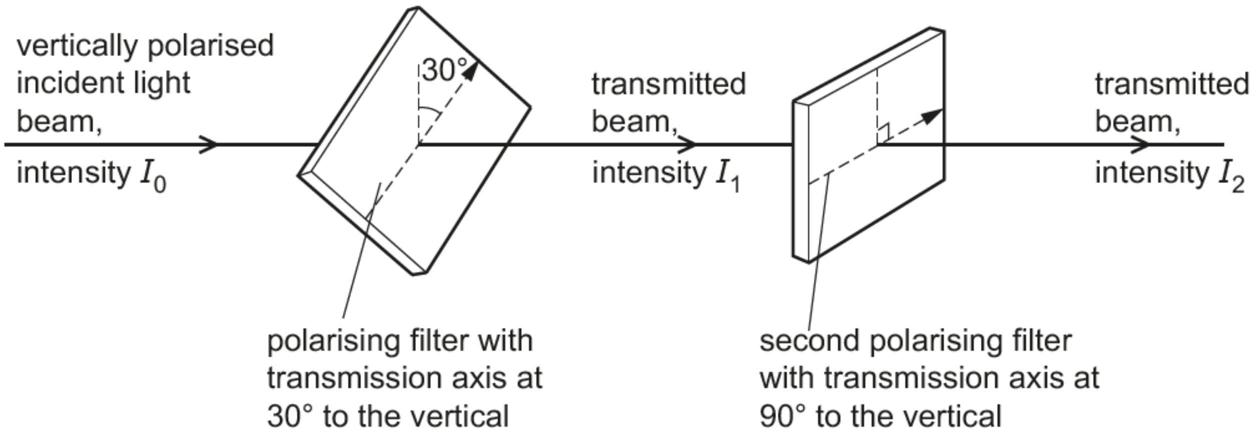


Fig. 5.2

The transmitted light from the first polarising filter has intensity I_1. This light is then incident normally on a second polarising filter that has its transmission axis at 90° to the vertical. The transmitted light from the second filter has intensity I_2.

Calculate:

(i) the ratio $\dfrac{I_1}{I_0}$

$\dfrac{I_1}{I_0}$ = ... [2]

(ii) the ratio $\dfrac{I_2}{I_0}$.

$\dfrac{I_2}{I_0}$ = ... [2]

[Total: 10]

Question 15

(a) A progressive longitudinal wave travels through a medium from left to right. Fig. 4.1 shows the positions of some of the particles of the medium at time t_0 and a graph showing the particle displacements at the same time t_0.

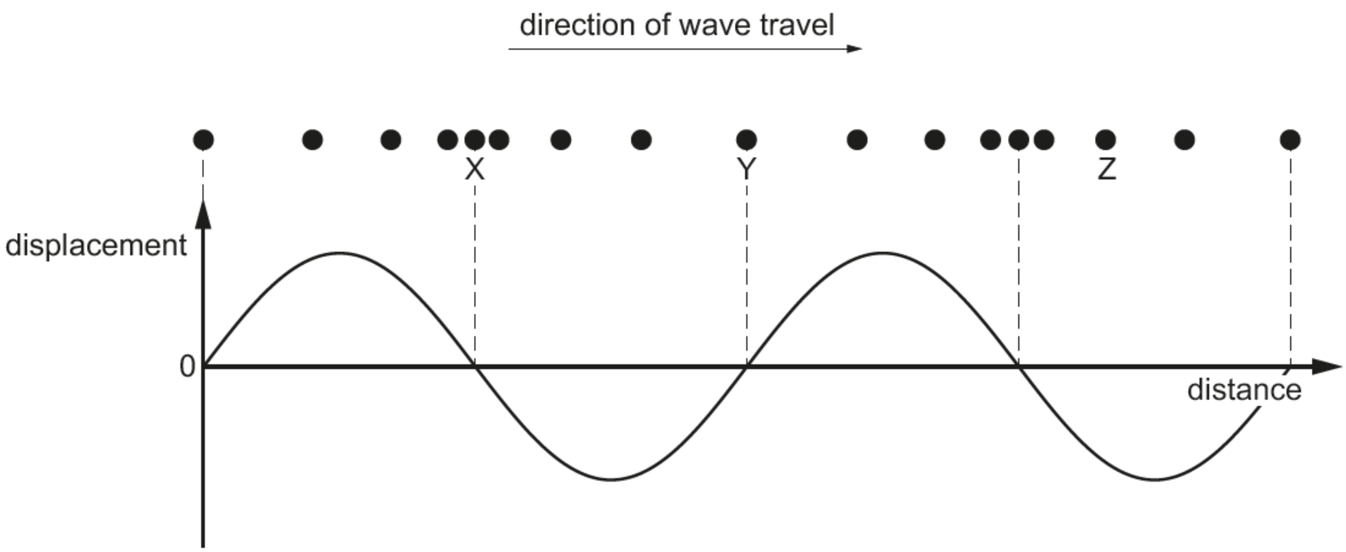


Fig. 4.1

Particle displacements to the right of their equilibrium positions are shown as positive on the graph and particle displacements to the left are shown as negative on the graph.

The period of the wave is T.

(i) On Fig. 4.1, draw circles around two particles which are exactly one wavelength apart. [1]

(ii) On Fig. 4.1, sketch a line on the graph to represent the displacements of the particles for the longitudinal wave at time $t_0 + \dfrac{T}{4}$. [3]

(iii) State the direction of motion of particle Z at time $t_0 + \dfrac{T}{4}$.

.... [1]

(b) The frequency of the wave in **(a)** is 16 kHz. The distance between particles X and Y is 0.19 m.

Calculate the speed of the wave as it travels through the medium.

speed = ... $m s^{-1}$ [3]

(c) A longitudinal sound wave is travelling through a solid. The initial intensity of the wave is I_0. The frequency of the wave remains constant and the amplitude falls to half of its original value.

Determine, in terms of I_0, the final intensity of the wave.

intensity = ... I_0 [2]

(d) The sound wave in **(c)** now meets another sound wave travelling in the opposite direction.

(i) State a condition necessary for these two waves to form a stationary wave.

.... [1]

(ii) State **two** ways in which a stationary wave differs from a progressive wave.

1 ....

....

2 ....

....
[2]

[Total: 13]

Question 16

(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.

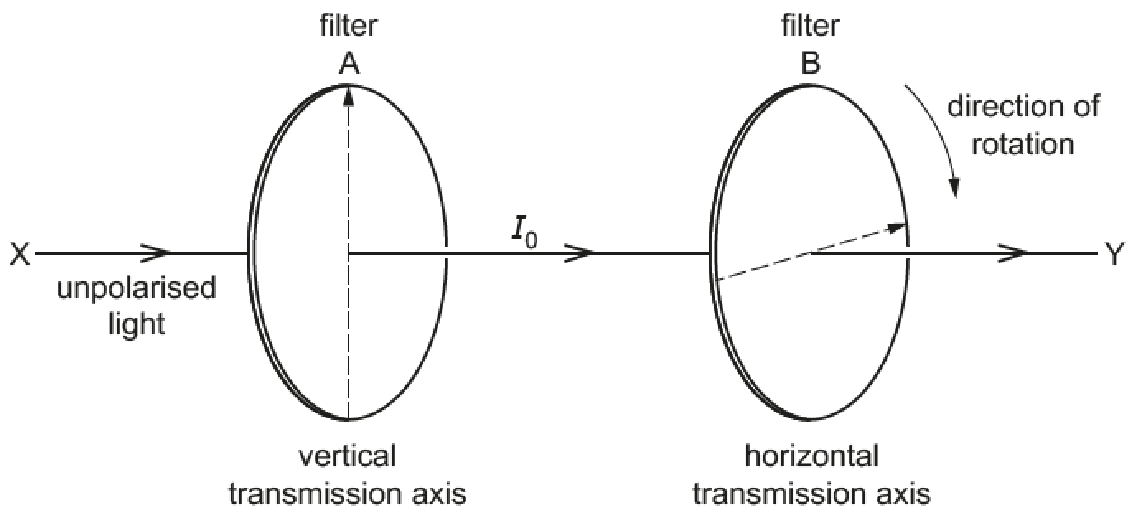


Fig. 4.1

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]

Question 17

(a) Two progressive sound waves meet to form a stationary wave. The two waves have the same amplitude, wavelength, frequency and speed.

State the other condition that must be fulfilled by the two waves in order for them to produce the stationary wave.

.... [1]

(b) A stationary wave is formed on a string that is stretched between two fixed points A and B. Fig. 5.1 shows the string at time $t = 0$ when each point is at its maximum displacement.

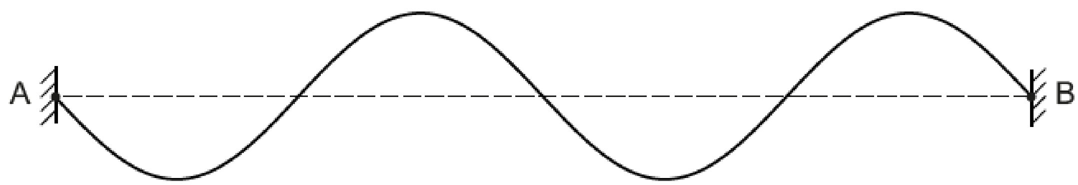


Fig. 5.1

Distance AB is 0.80 m. The period of the stationary wave is 0.016 s.

(i) On Fig. 5.1, sketch a solid line to show the position of the string:

- at time $t = 0.004$ s (label this line P)
- at time $t = 0.024$ s (label this line Q).

[2]

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

speed = ... m s^{-1} [3]

(c) A beam of vertically polarised light of intensity I_0 is incident normally on a polarising filter that has its transmission axis at 30° to the vertical, as shown in Fig. 5.2.

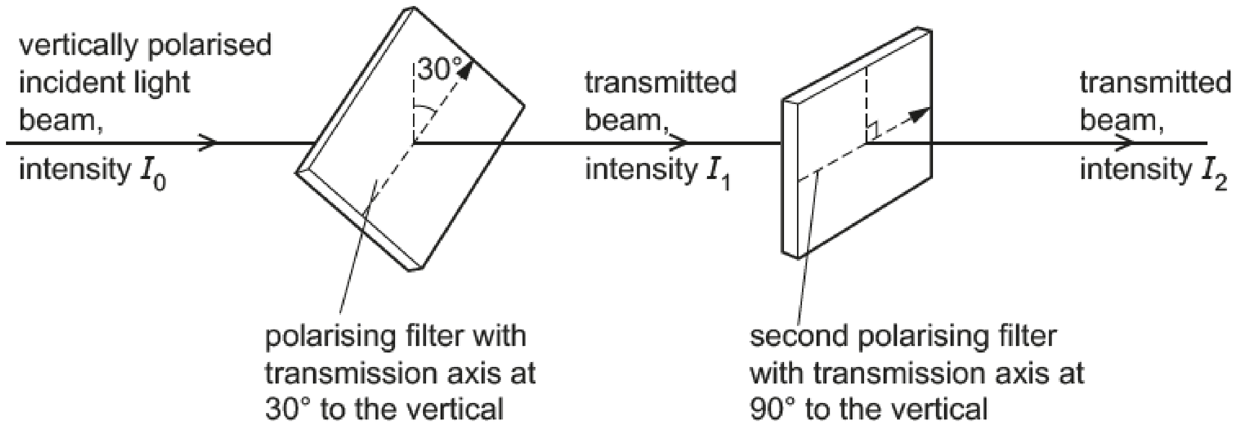


Fig. 5.2

The transmitted light from the first polarising filter has intensity I_1. This light is then incident normally on a second polarising filter that has its transmission axis at 90° to the vertical. The transmitted light from the second filter has intensity I_2.

Calculate:

(i) the ratio $\dfrac{I_1}{I_0}$

$\dfrac{I_1}{I_0}$ = ... [2]

(ii) the ratio $\dfrac{I_2}{I_0}$.

$\dfrac{I_2}{I_0}$ = ... [2]

[Total: 10]

Question 18

(a) A progressive longitudinal wave travels through a medium from left to right. Fig. 4.1 shows the positions of some of the particles of the medium at time t_0 and a graph showing the particle displacements at the same time t_0.

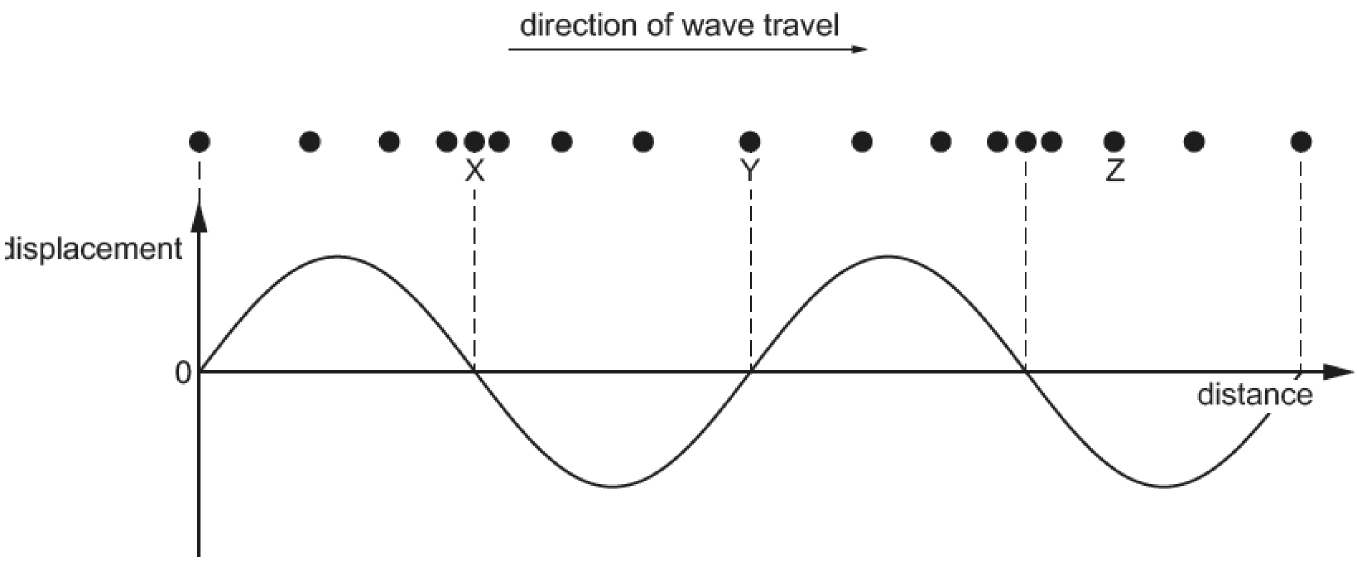


Fig. 4.1

Particle displacements to the right of their equilibrium positions are shown as positive on the graph and particle displacements to the left are shown as negative on the graph.

The period of the wave is T.

(i) On Fig. 4.1, draw circles around two particles which are exactly one wavelength apart.

[1]

(ii) On Fig. 4.1, sketch a line on the graph to represent the displacements of the particles for the longitudinal wave at time $t_0 + \frac{T}{4}$. [3]

(iii) State the direction of motion of particle Z at time $t_0 + \frac{T}{4}$.

.... [1]

(b) The frequency of the wave in **(a)** is 16 kHz. The distance between particles X and Y is 0.19 m.

Calculate the speed of the wave as it travels through the medium.

speed = ... $m\,s^{-1}$ [3]

(c) A longitudinal sound wave is travelling through a solid. The initial intensity of the wave is I_0. The frequency of the wave remains constant and the amplitude falls to half of its original value.

Determine, in terms of I_0, the final intensity of the wave.

intensity = ... I_0 [2]

(d) The sound wave in **(c)** now meets another sound wave travelling in the opposite direction.

(i) State a condition necessary for these two waves to form a stationary wave.

.... [1]

(ii) State **two** ways in which a stationary wave differs from a progressive wave.

1 ....

....

2 ....

....

[2]

[Total: 13]

Question 19

(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.

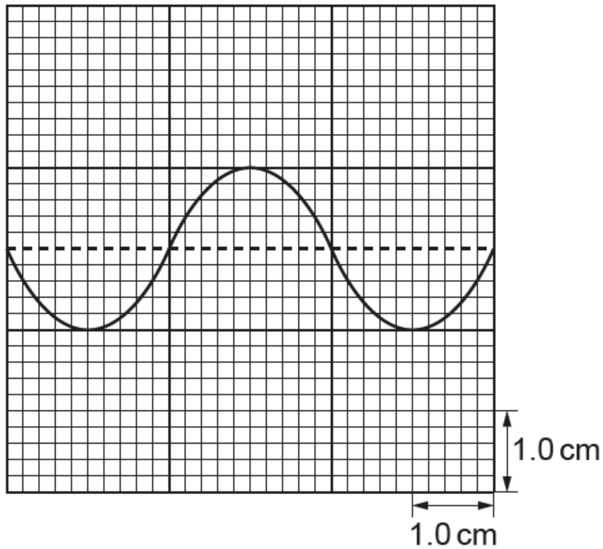


Fig. 5.1

(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.

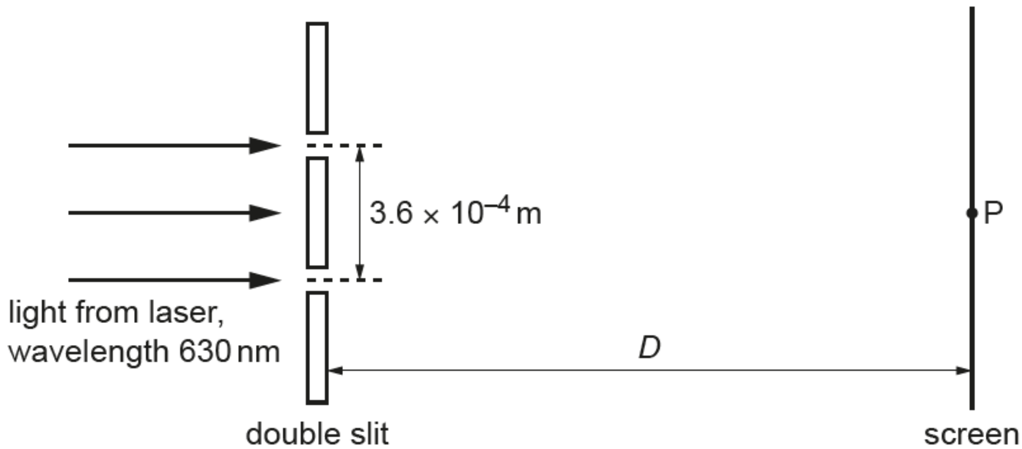


Fig. 5.2 (not to scale)

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]

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.

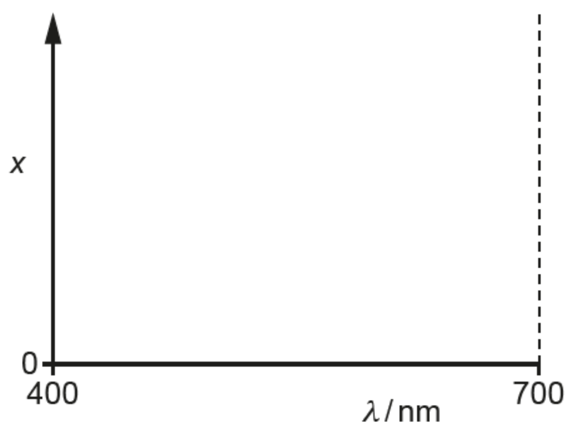


Fig. 5.3

[1]

[Total: 10]

Question 20

(a) An electromagnetic wave in a vacuum has a wavelength of 8.4×10^{-6} 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.

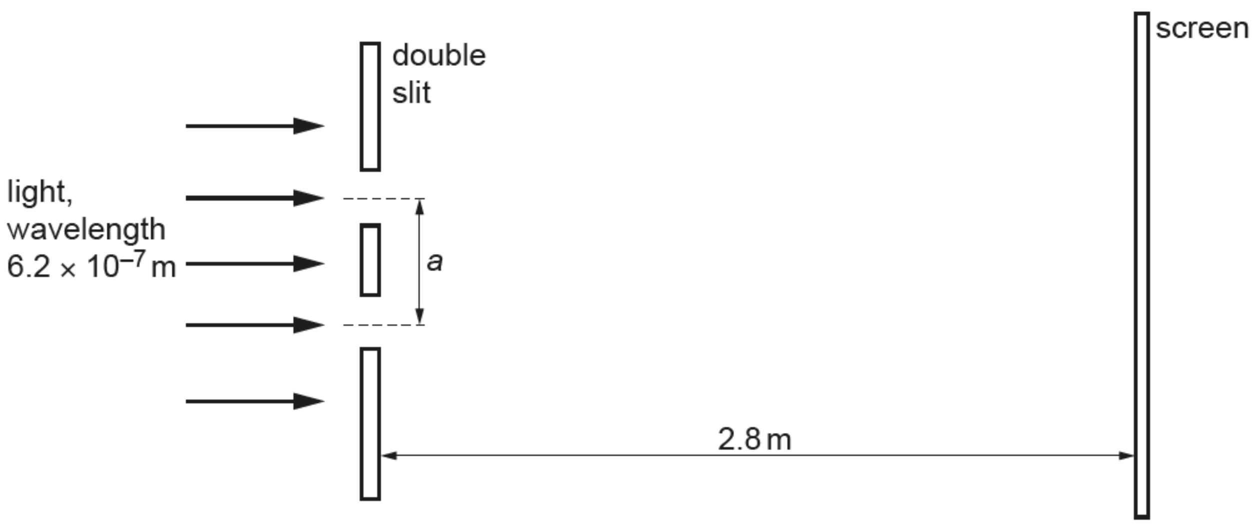


Fig. 5.1 (not to scale)

The light from the laser has a wavelength of 6.2×10^{-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.

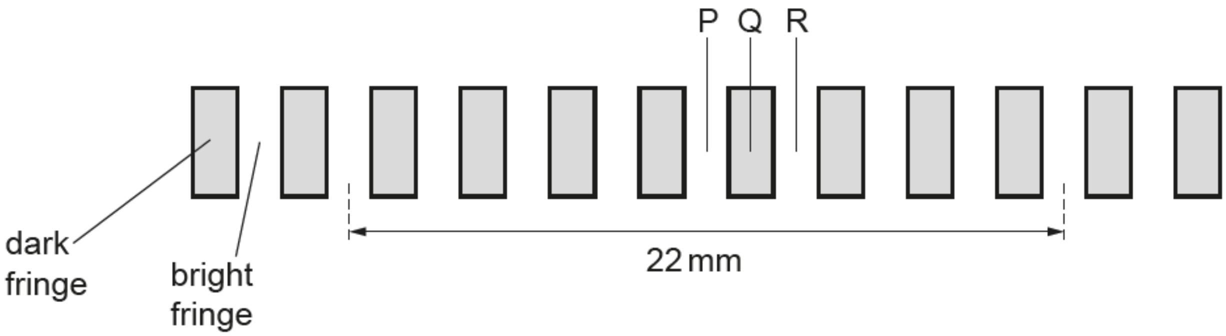


Fig. 5.2

(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]

[Total: 9]

Question 21

(a) A progressive wave travels through a medium. The wave causes a particle of the medium to vibrate along a line P. The energy of the wave propagates along a line Q.

Compare the directions of lines P and Q if the wave is:

(i) a transverse wave

.... [1]

(ii) a longitudinal wave.

.... [1]

(b) A tube is closed at one end. A loudspeaker is placed near the other end of the tube, as shown in Fig. 5.1.

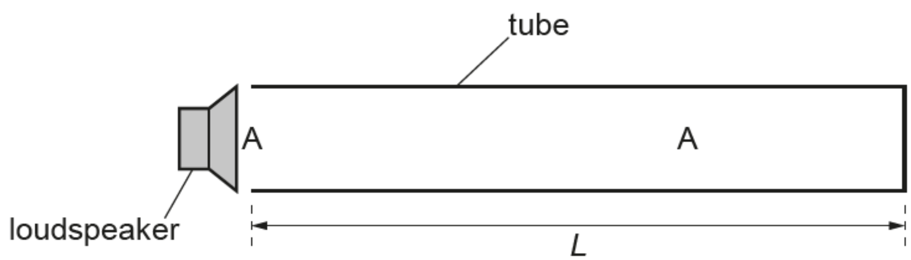


Fig. 5.1 (not to scale)

The loudspeaker emits sound of frequency 1.7 kHz. The speed of sound in the air in the tube is 340 m s^{-1}. A stationary wave is formed with an antinode A at the open end of the tube. There is only one other antinode A inside the tube, as shown in Fig. 5.1.

Determine:

(i) the wavelength of the sound

wavelength = ... m [2]

(ii) the length L of the tube

L = ... m [1]

(iii) the maximum wavelength of the sound from the loudspeaker that can produce a stationary wave in the tube.

maximum wavelength = ... m [1]

(c) Two polarising filters are arranged so that their planes are vertical and parallel. The first filter has its transmission axis at an angle of 35° to the vertical and the second filter has its transmission axis at angle α to the vertical, as shown in Fig. 5.2.

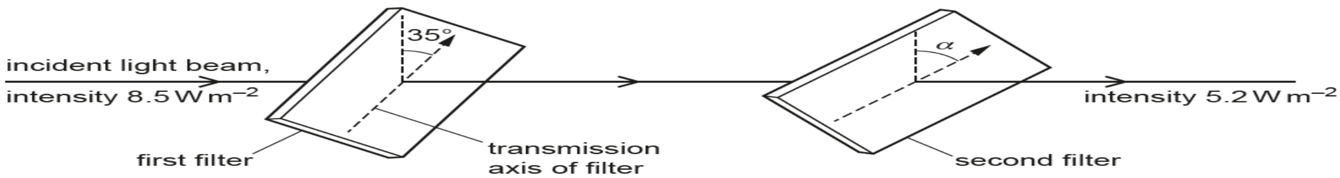


Fig. 5.2

(iii) the maximum wavelength of the sound from the loudspeaker that can produce a stationary wave in the tube.

maximum wavelength = ... m [1]

(c) Two polarising filters are arranged so that their planes are vertical and parallel. The first filter has its transmission axis at an angle of 35° to the vertical and the second filter has its transmission axis at angle α to the vertical, as shown in Fig. 5.2.

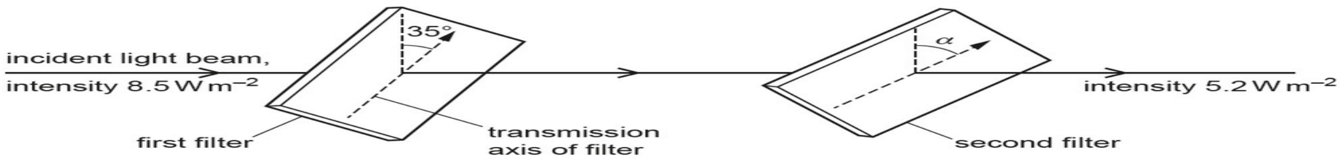


Fig. 5.2

Angle α is greater than 35° and less than 90°. A beam of vertically polarised light of intensity 8.5 W m^{-2} is incident normally on the first filter.

(i) Show that the intensity of the light transmitted by the first filter is 5.7 W m^{-2}.

[1]

(ii) The intensity of the light transmitted by the second filter is 5.2 W m^{-2}.

Calculate angle α.

α = ... ° [2]

[Total: 9]

Question 22

(a) For a progressive wave, state what is meant by the frequency.

....

.... [1]

(b) A loudspeaker, microphone and cathode-ray oscilloscope (CRO) are arranged as shown in Fig. 4.1.

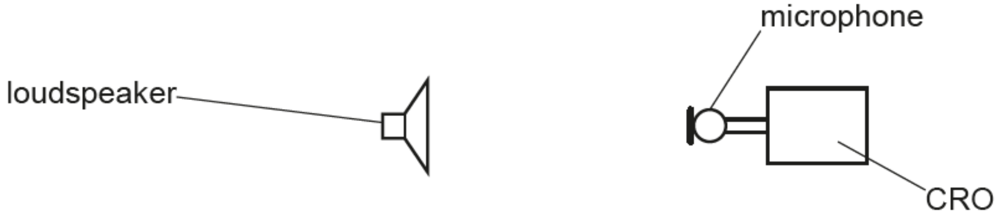


Fig. 4.1

The loudspeaker is emitting a sound wave which is detected by the microphone and displayed on the screen of the CRO as shown in Fig. 4.2.

The loudspeaker is emitting a sound wave which is detected by the microphone and displayed on the screen of the CRO as shown in Fig. 4.2.

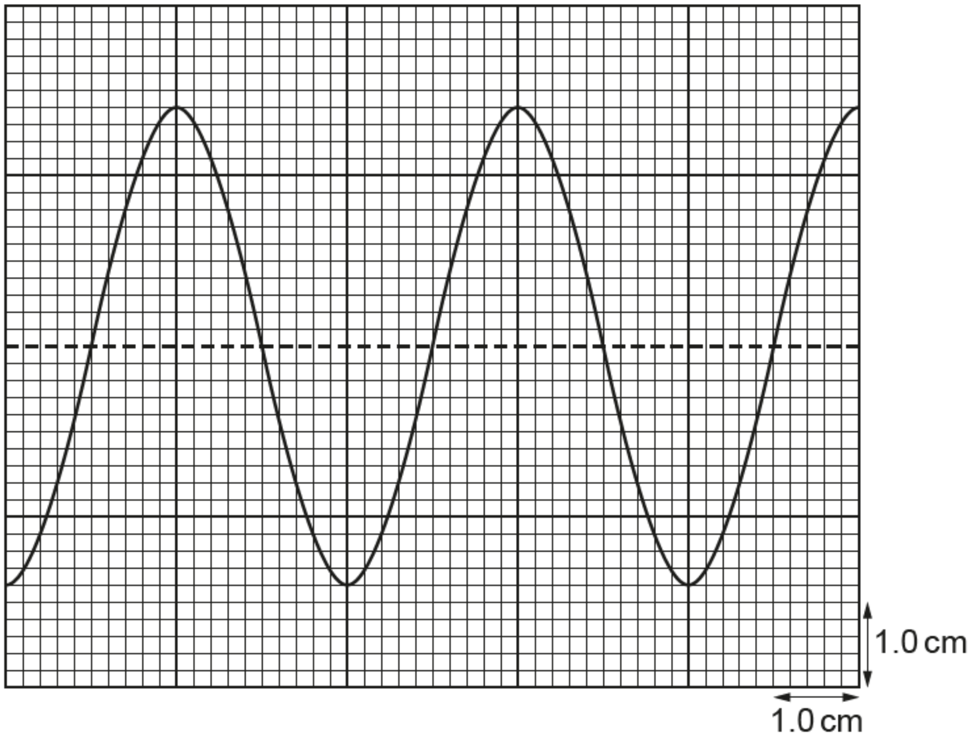


Fig. 4.2

The time-base on the CRO is set to $0.50\,\text{ms}\,\text{cm}^{-1}$ and the *y*-gain is set to $0.20\,\text{V}\,\text{cm}^{-1}$.

Calculate:

(i) the frequency of the sound wave

frequency = ... Hz [2]

(ii) the amplitude of the signal received by the CRO.

amplitude = ... V [1]

(c) The intensity of the sound wave in **(b)** is reduced to a quarter of its original intensity without a change in frequency. Assume that the amplitude of the signal received by the CRO is proportional to the amplitude of the sound wave.

On Fig. 4.2, sketch the trace that is now seen on the screen of the CRO. [3]

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

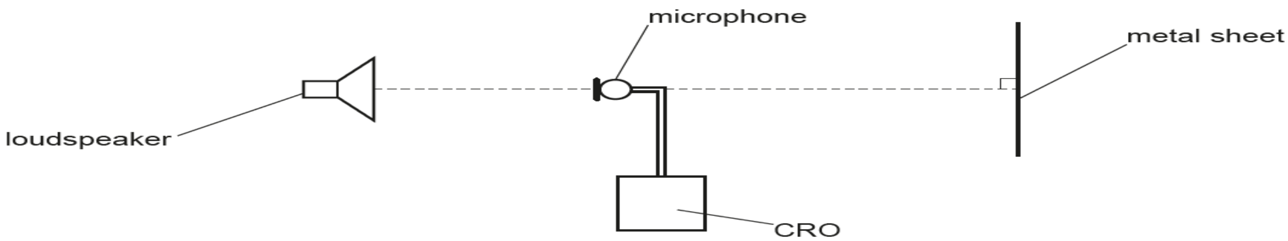


Fig. 4.3

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

(i) State the principle of superposition.

....

....

.... [2]

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

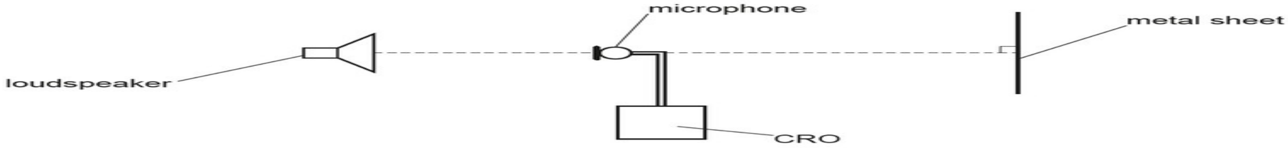


Fig. 4.3

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]

[Total: 13]

Question 23

(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.

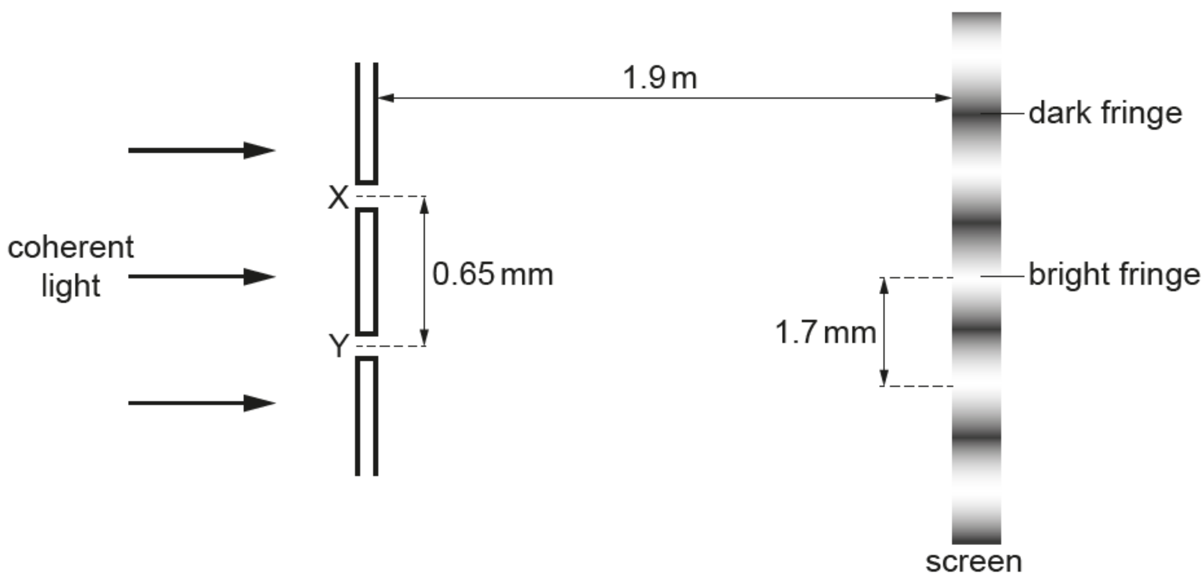


Fig. 4.1 (not to scale)

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.

λ = ... 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.

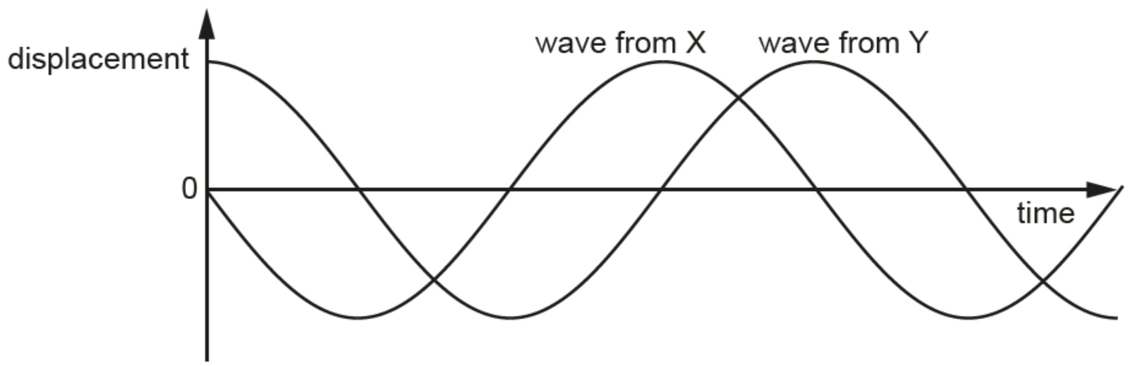


Fig. 4.2

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]

Question 24

A train travels at a constant high speed along a straight horizontal track towards an observer standing adjacent to the track, as shown in Fig. 5.1.

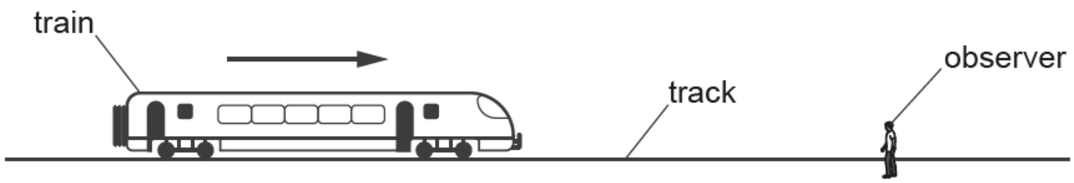


Fig. 5.1

The train sounds its horn continuously as it approaches the observer, from time $t = 0$ until it is well past the observer at time $t = t_2$. The train passes the observer at time $t = t_1$.
The horn emits a sound wave of constant frequency f_S.

(a) On Fig. 5.2, sketch the variation of the frequency of sound heard by the observer with time t, from time $t = 0$ to $t = t_2$.

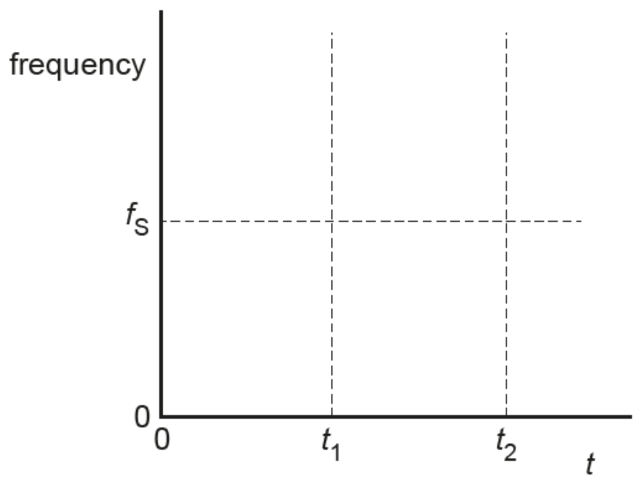


Fig. 5.2

[1]

(b) At a particular time, the sound waves at the observer have an intensity of $4.7 \times 10^{-3}\,\mathrm{W\,m^{-2}}$. The waves at the observer are incident at right angles on a circular detector of radius 2.8 cm.

Calculate the power *P* of the waves incident on the detector.

P = ... W [3]

[Total: 4]

Question 25

(a) A beam of vertically polarised light is incident normally on a polarising filter, as shown in Fig. 5.1.

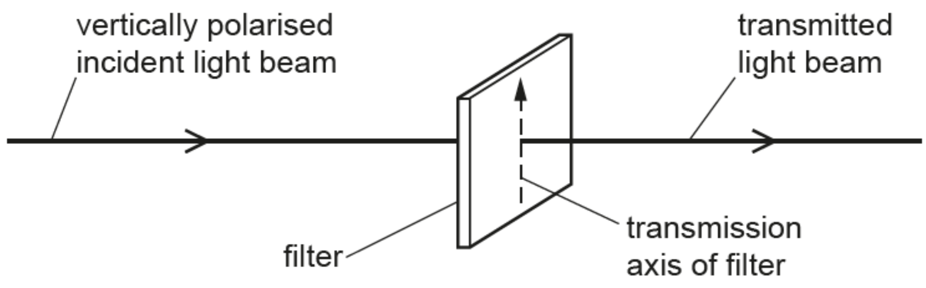


Fig. 5.1

(i) The transmission axis of the filter is initially vertical. The filter is then rotated through an angle of 360° while the plane of the filter remains perpendicular to the beam.

On Fig. 5.2, sketch a graph to show the variation of the intensity of the light in the transmitted beam with the angle through which the transmission axis is rotated.

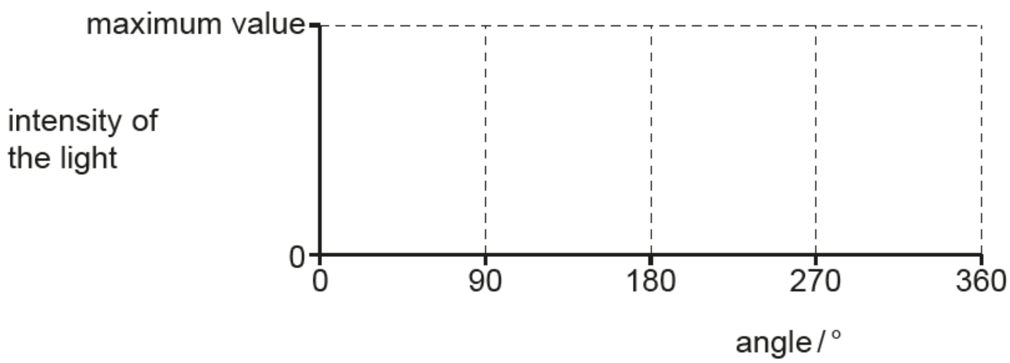


Fig. 5.2

[2]

(ii) The intensity of the light in the incident beam is $7.6\,\text{W m}^{-2}$. When the transmission axis of the filter is at angle θ to the vertical, the light intensity of the transmitted beam is $4.2\,\text{W m}^{-2}$.

Calculate angle θ.

θ = ...° [2]

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

....

....

.... [2]

(c) A beam of light of wavelength $4.3 \times 10^{-7}\,\text{m}$ is incident normally on a diffraction grating in air, as shown in Fig. 5.3.

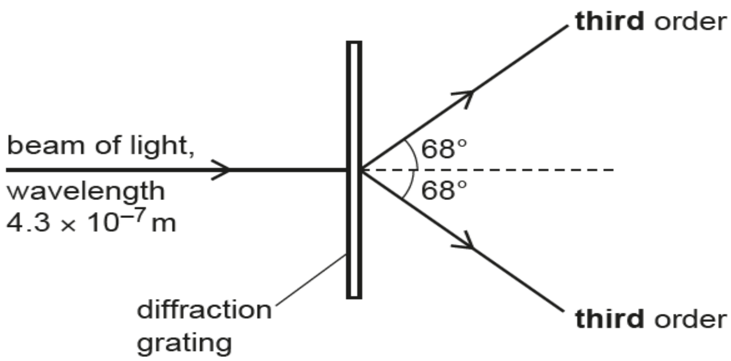


Fig. 5.3 (not to scale)

The **third**-order diffraction maximum of the light is at an angle of 68° to the direction of the incident light beam.

The **third**-order diffraction maximum of the light is at an angle of 68° to the direction of the incident light beam.

(i) Calculate the line spacing d of the diffraction grating.

d = ... m [2]

(ii) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 68°.

wavelength = ... m [2]

[Total: 10]

Question 26

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.

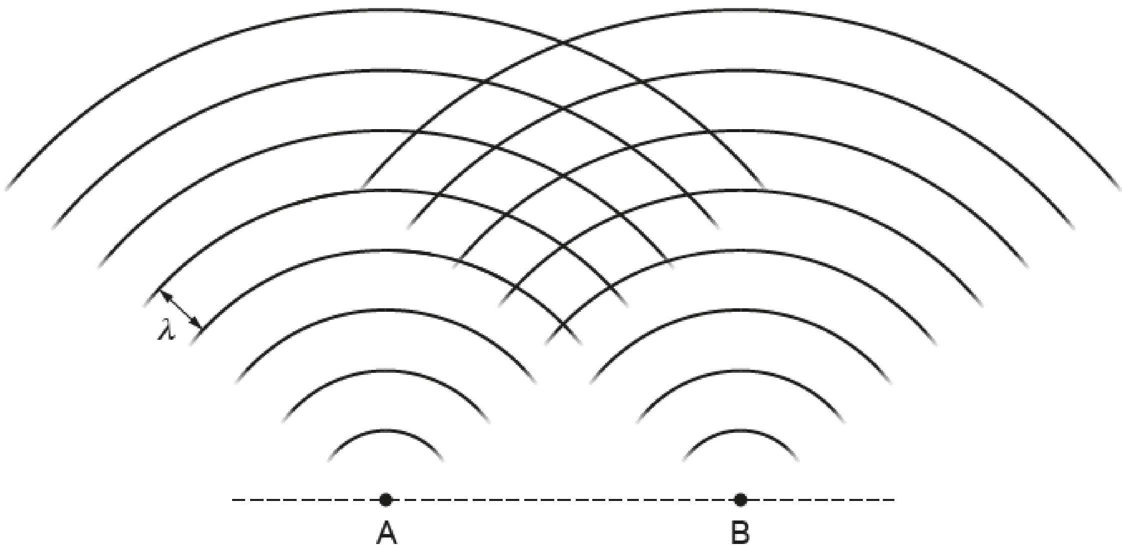


Fig. 5.1 (not to scale)

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 2.9×10^{-5} 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 = ... m [3]

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

.... [1]

[Total: 6]

Question 27

A train travels at constant speed along a straight horizontal track towards an observer standing adjacent to the track, as shown in Fig. 6.1.

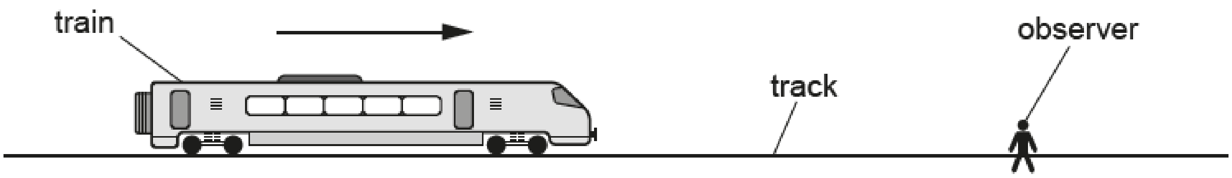


Fig. 6.1

The train sounds its horn continuously as it approaches the observer. The horn emits a sound of constant frequency 251 Hz. The frequency of sound heard by the observer is 291 Hz. The speed of sound in air is 340 $m s^{-1}$.

(a) Calculate the speed of the train.

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

(b) The train approaches and then passes the observer. The intensity I of the sound heard by the observer varies with the distance d of the horn from the observer.

When the horn is at a distance x_0 from the observer, the intensity I of the sound heard is I_0 and the amplitude A of the sound wave at the observer is A_0.

Fig. 6.2 shows the variation with d / x_0 of I / I_0 as the train moves away from the observer.

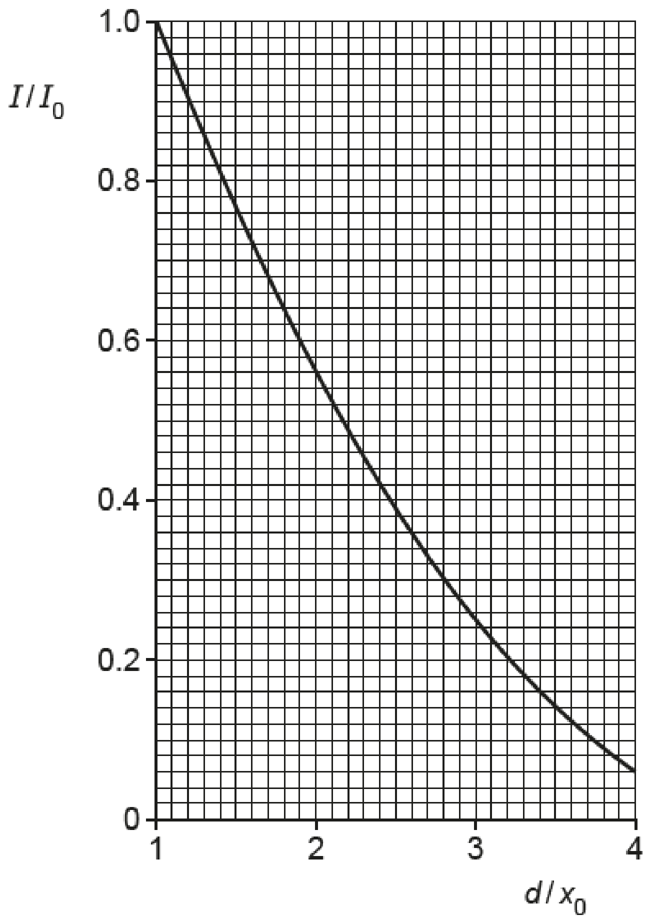


Fig. 6.2

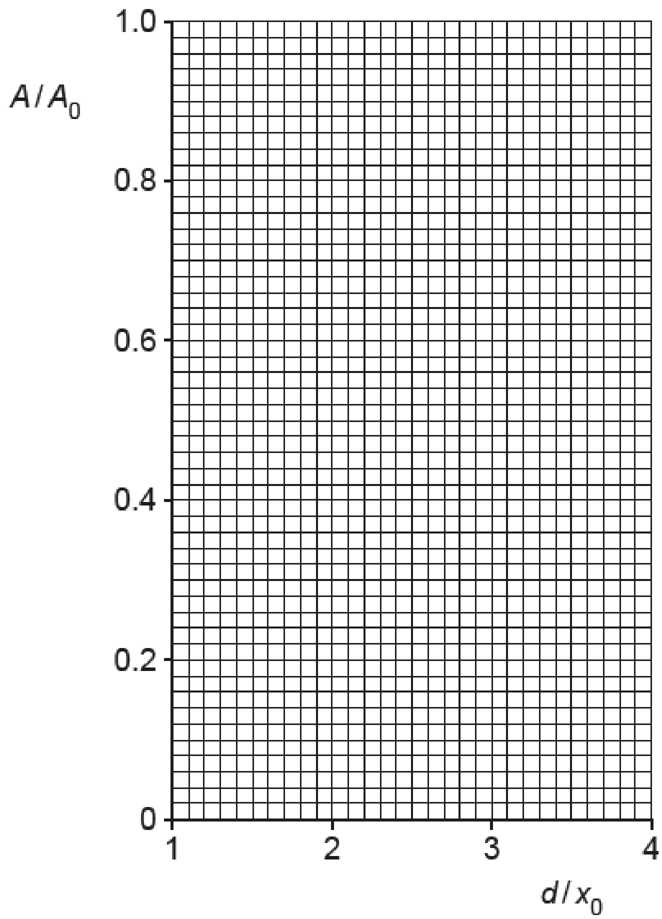


Fig. 6.3

(i) State the relationship between amplitude A and intensity I for a progressive wave.

.... [1]

(ii) On Fig. 6.3, sketch the variation with d / x_0 of A / A_0. [2]

[Total: 5]

Question 28

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

....

.... [1]

(b) A space telescope is designed to detect electromagnetic radiation with wavelengths in the range 12 μm to 28 μm.

State the region of the electromagnetic spectrum for this radiation.

.... [1]

(c) A detector on another space telescope detects an electromagnetic wave. The signal from the detector is transmitted to Earth and displayed on an oscilloscope as shown in Fig. 5.1. The frequency of the signal displayed on the oscilloscope is equal to the frequency of the detected electromagnetic wave.

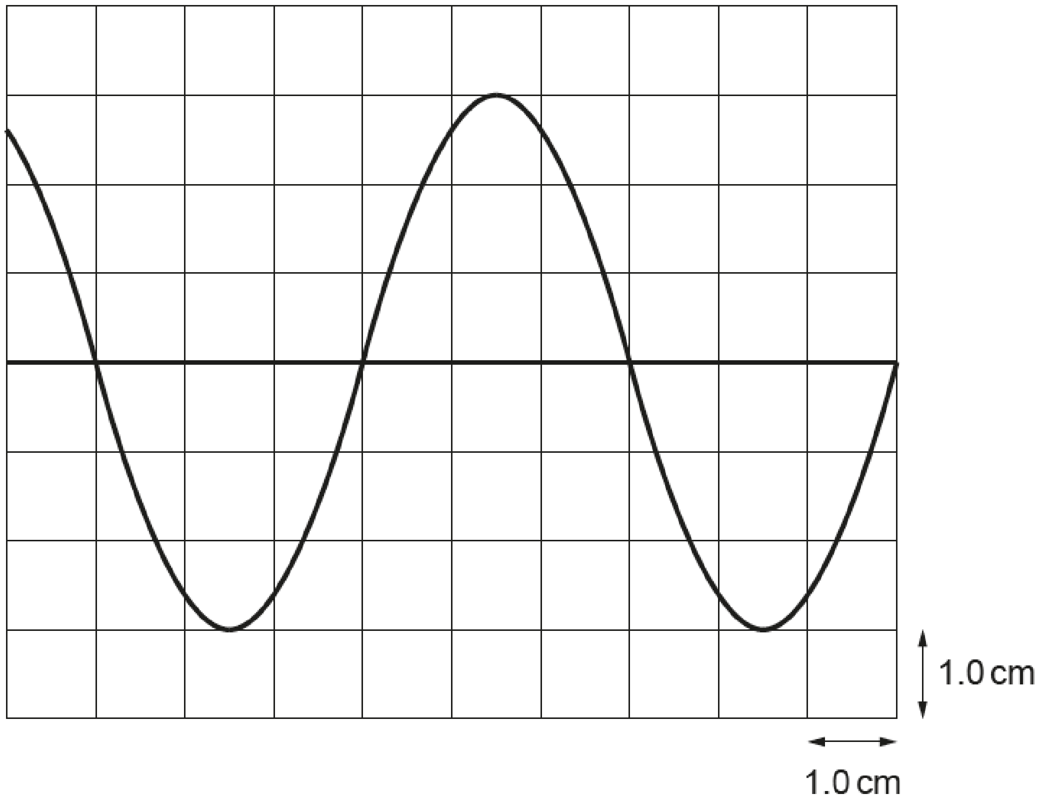


Fig. 5.1

The time-base setting on the oscilloscope is $5.0 \times 10^{-15}\,\mathrm{s\,cm^{-1}}$.

Calculate the wavelength of the detected electromagnetic wave.

wavelength = ... m [3]

[Total: 5]

Question 29

(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.

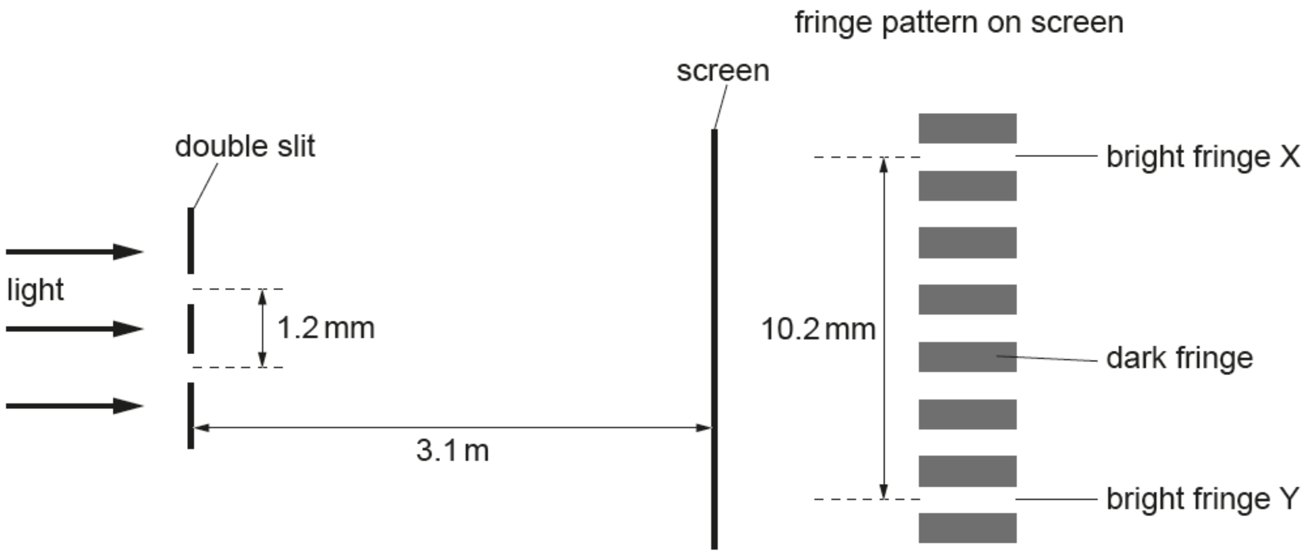


Fig. 6.1 (not to scale)

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.

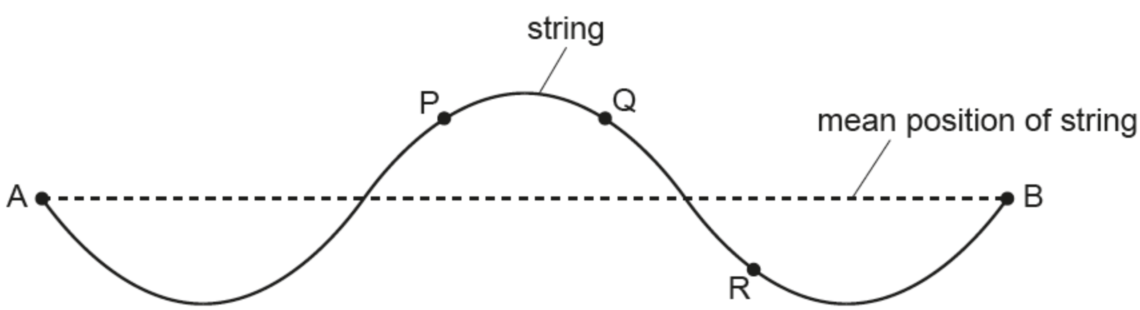


Fig. 6.2

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]

Question 30

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.

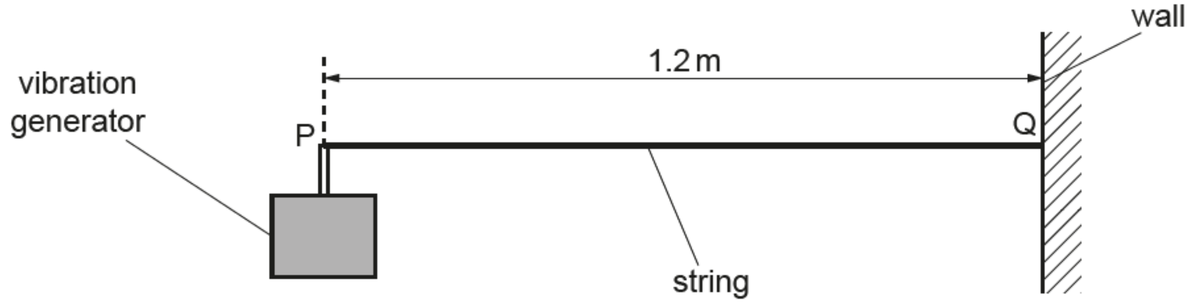


Fig. 5.1

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.

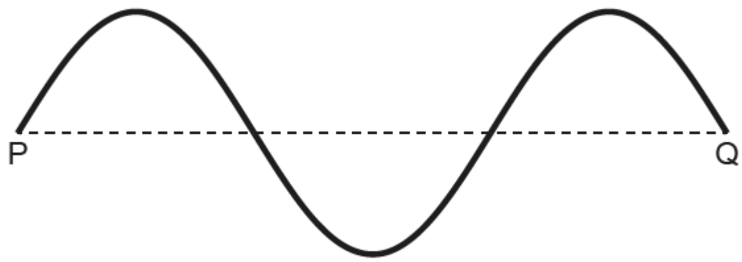


Fig. 5.3

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]

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.

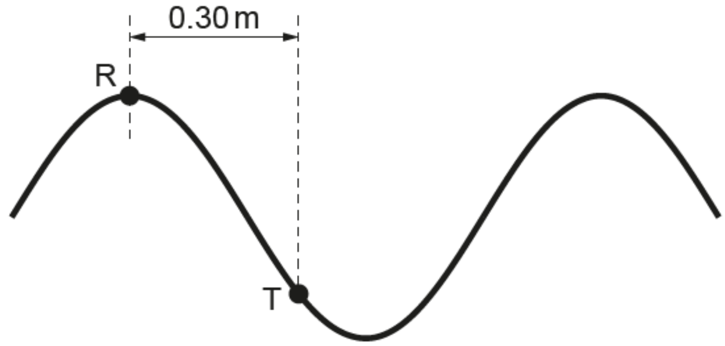


Fig. 5.4

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

[Total: 8]

Question 31

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.

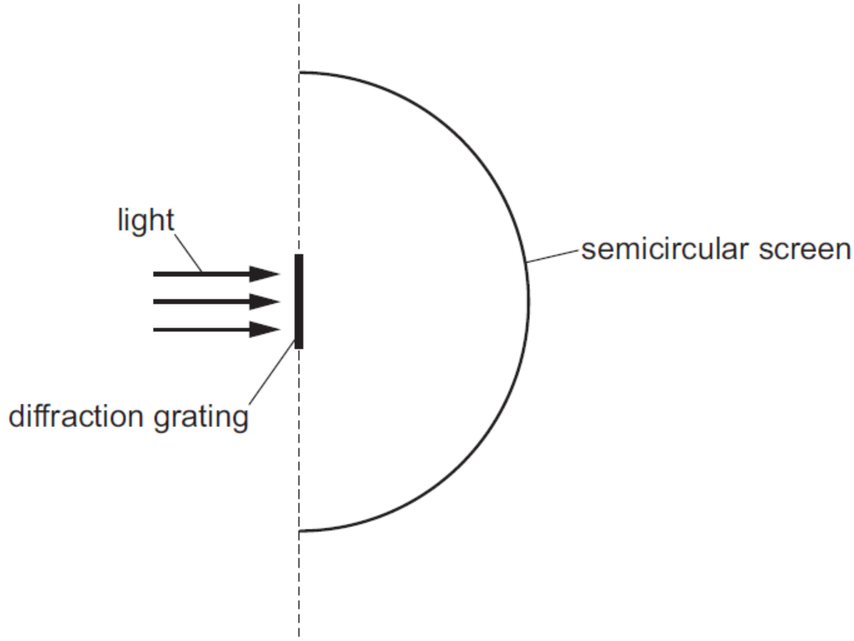


Fig. 6.1 (not to scale)

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]

Question 32

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

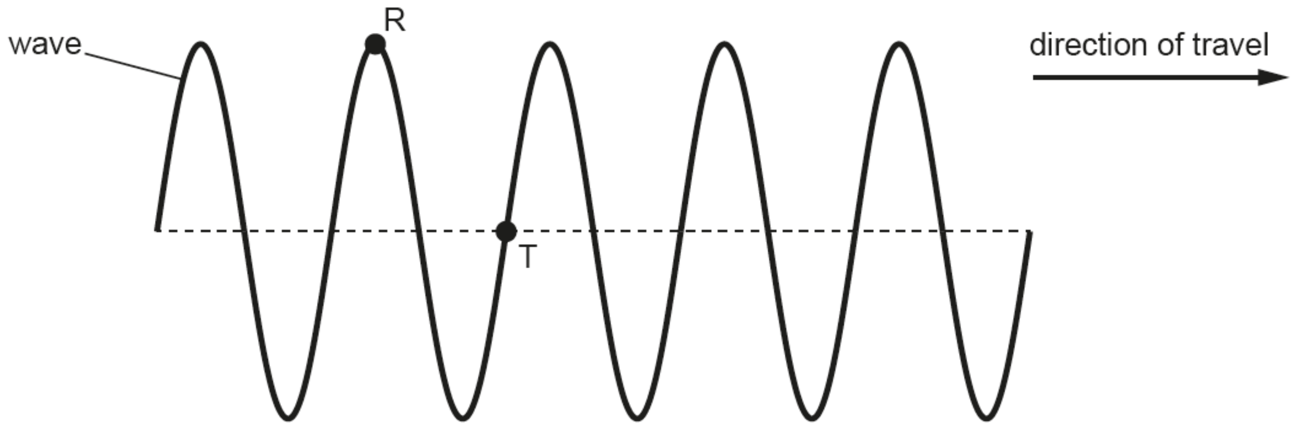


Fig. 4.1

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.

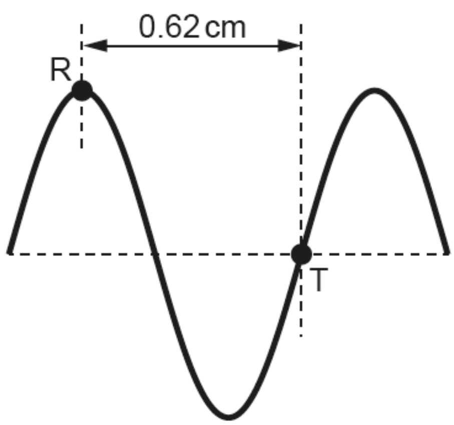


Fig. 4.2 (not to scale)

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.

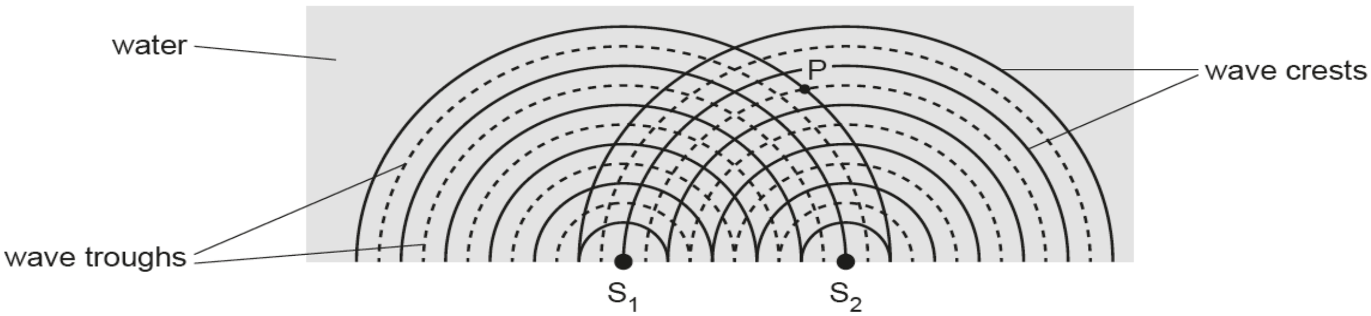


Fig. 4.3 (not to scale)

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

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]

Question 33

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.

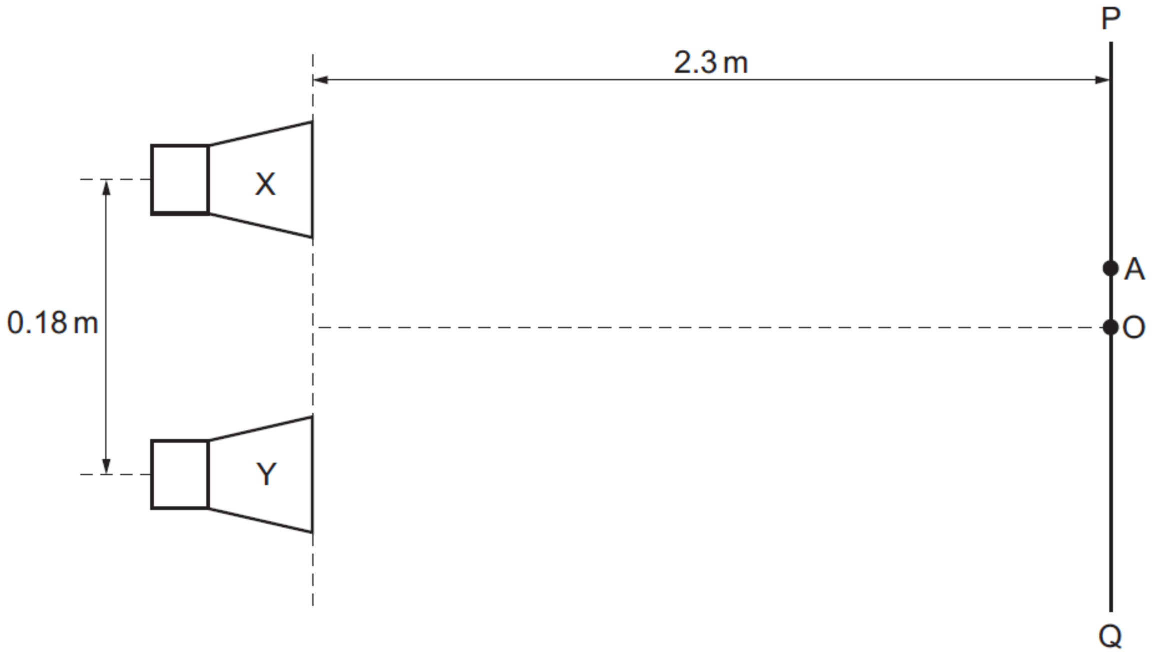


Fig. 6.1 (not to scale)

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 (×) 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]

(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.

Δx = ... 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 = ... m [2]

[Total: 9]

Question 34

(a) With reference to the direction of transfer of energy, compare the oscillations of transverse and longitudinal progressive waves.

....

....

....

.... [2]

(b) A pipe is open at one end and closed at the other with a piston. The piston can slide freely and is at a distance of 4.5×10^{-2} m from the open end of the pipe.

A loudspeaker is positioned near the open end of the pipe and emits a sound wave of a single constant frequency. A stationary wave is formed in the pipe, as illustrated in Fig. 4.1.

A loudspeaker is positioned near the open end of the pipe and emits a sound wave of a single constant frequency. A stationary wave is formed in the pipe, as illustrated in Fig. 4.1.

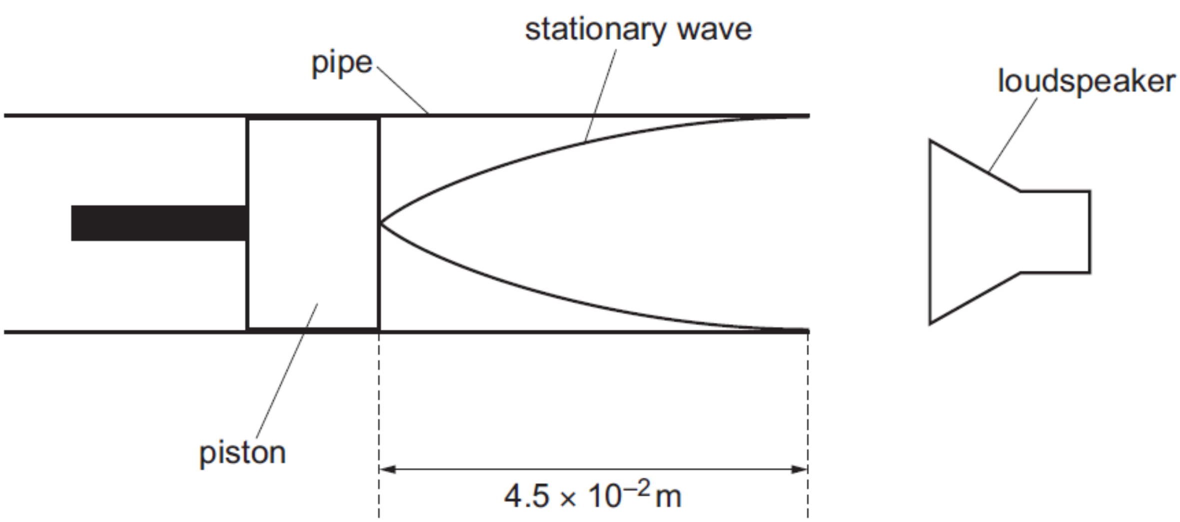


Fig. 4.1

(i) On Fig. 4.1, draw a letter A at the position of an antinode. [1]

(ii) The speed of sound in air is $340\,m\,s^{-1}$.

Determine the frequency of the sound wave.

frequency = ... Hz [3]

(iii) The piston is moved to the left. The frequency of the sound wave emitted by the loudspeaker is then changed so that a stationary wave is formed with same number of antinodes as in Fig. 4.1.

State and explain the change that is made to the frequency of the sound wave.

....

....

....

.... [2]

[Total: 8]

Question 35

(a) A stationary wave is formed on a string XY that has a length of 0.48 m. Fig. 5.1 shows the string at one instant in time.

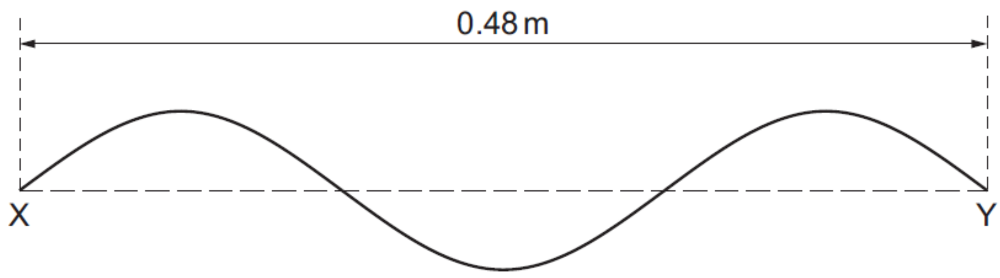


Fig. 5.1

The speed of the wave on the string is $1400\,m\,s^{-1}$.

(i) On Fig. 5.1, draw a cross (×) at **one** position that is a node and another cross at **one** position that is an antinode. Label the node N and the antinode A. [1]

(ii) Show that the wavelength of the wave produced is 0.32 m. Explain your reasoning.

[1]

(iii) Calculate the frequency of the wave.

frequency = ... Hz [2]

(b) A source of sound waves of frequency 780 Hz is on a rotating platform. The speed of the source is $39\,\mathrm{m\,s^{-1}}$.

The sound is detected by an observer that is a large distance from the rotating platform, as shown in Fig. 5.2.

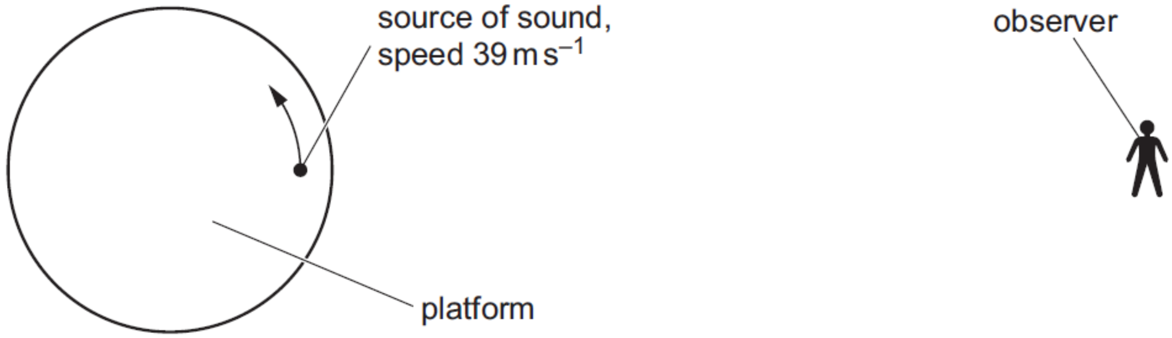


Fig. 5.2 (not to scale)

(i) The speed of sound in air is $320\,\mathrm{m\,s^{-1}}$.

(i) The speed of sound in air is $320\,\mathrm{m\,s^{-1}}$.

Calculate the maximum frequency of the sound detected by the observer.

maximum frequency = ... Hz [2]

(ii) At time t = 0, the observer detects the sound emitted by the source when it was in the position shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with t of the frequency f of the sound detected by the observer for one complete rotation of the platform. Calculations are not required.

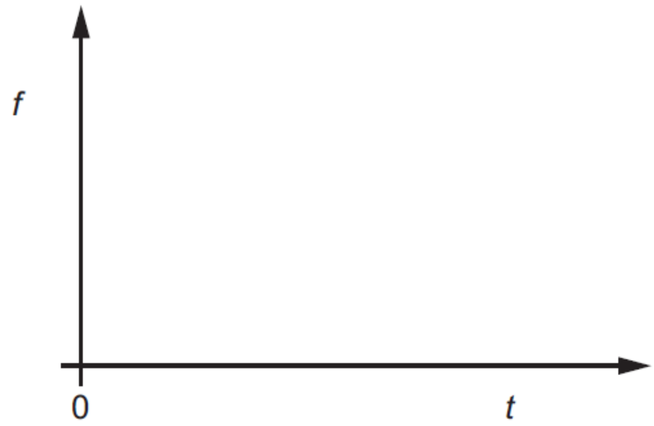


Fig. 5.3

[2]

[Total: 8]

Question 36

A device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

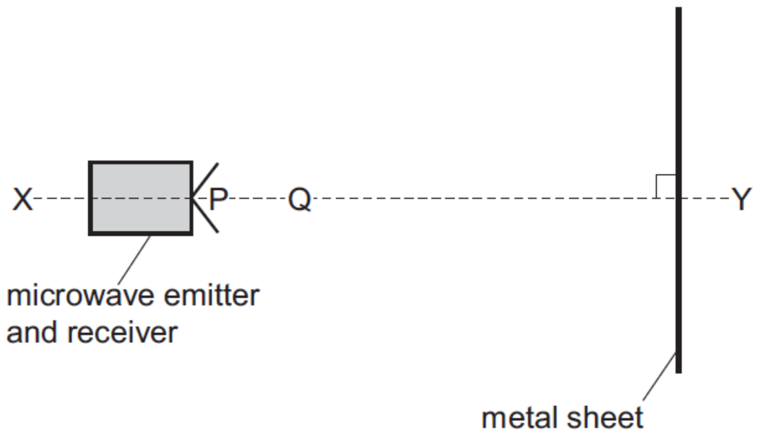


Fig. 4.1 (not to scale)

The line XY is perpendicular to the metal sheet. The device emits microwaves of frequency 6.3 GHz.

(a) When the device is at position P, a stationary wave is formed between the device and the sheet.

Explain how the stationary wave, including the nodes and the antinodes, is formed.

....

....

....

....

....

....

....

....

.... [4]

(b) (i) Calculate the wavelength of the microwaves.

wavelength = ... m [2]

(ii) At point P the receiver detects a maximum amplitude of the stationary wave.

The device is moved slowly from point P along the line XY and the receiver detects a series of minimum and maximum amplitudes. The first time a minimum amplitude is detected by the receiver is when the device is at point Q.

Determine the distance between P and Q.

distance = ... m [1]

(iii) The intensity of the microwaves emitted by the device is increased. The frequency of the microwaves is unchanged. The device is moved slowly along the line XY from point Q until the next maximum amplitude is detected at point R.

State and explain whether the distance QR is greater than, less than or the same as distance PQ.

....

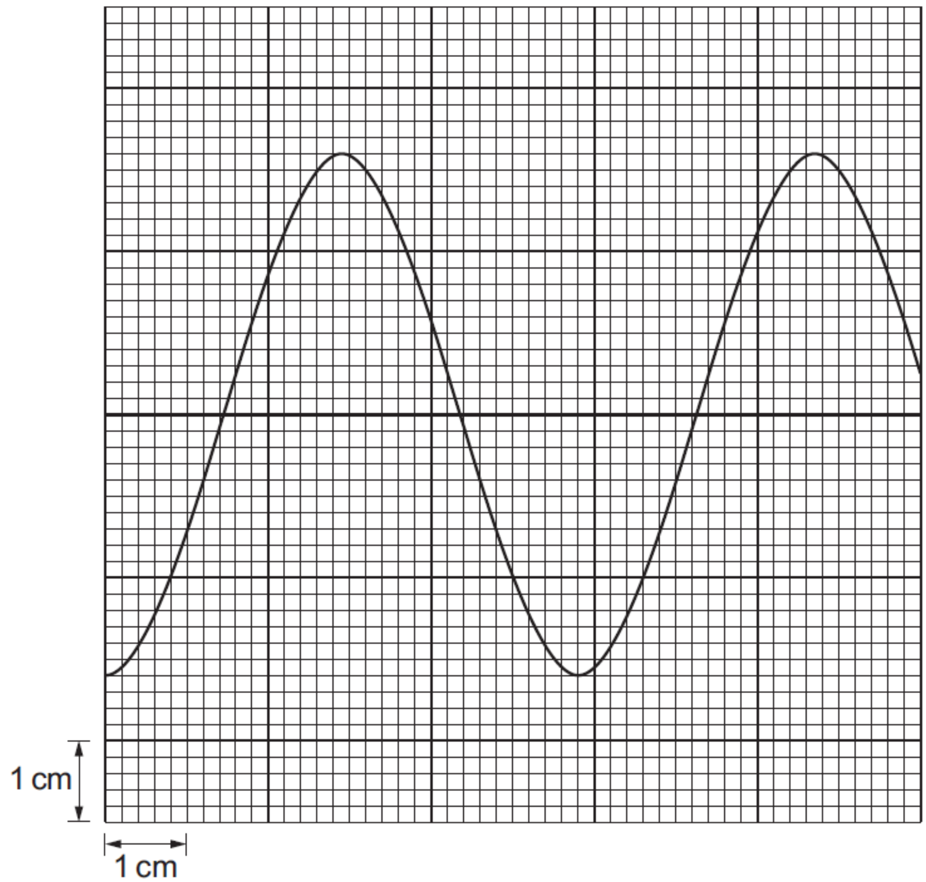
....

.... [1]

[Total: 8]

Question 37

A stationary loudspeaker emits sound of constant frequency. A microphone is placed near to the loudspeaker and connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.



The time-base of the CRO is set to $5.0 \times 10^{-4}\,\mathrm{s\,cm^{-1}}$.

(a) The speed of the sound emitted by the loudspeaker is $330\,\mathrm{m\,s^{-1}}$.

Determine the wavelength of the sound.

wavelength = ... m [3]

(b) The loudspeaker now moves in a straight line while emitting the same sound of constant frequency. The period of the trace on the CRO increases continuously.

Describe the motion of the loudspeaker.

....

....

.... [2]

[Total: 5]

Question 38

(a) State the principle of superposition.

....

....

.... [2]

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

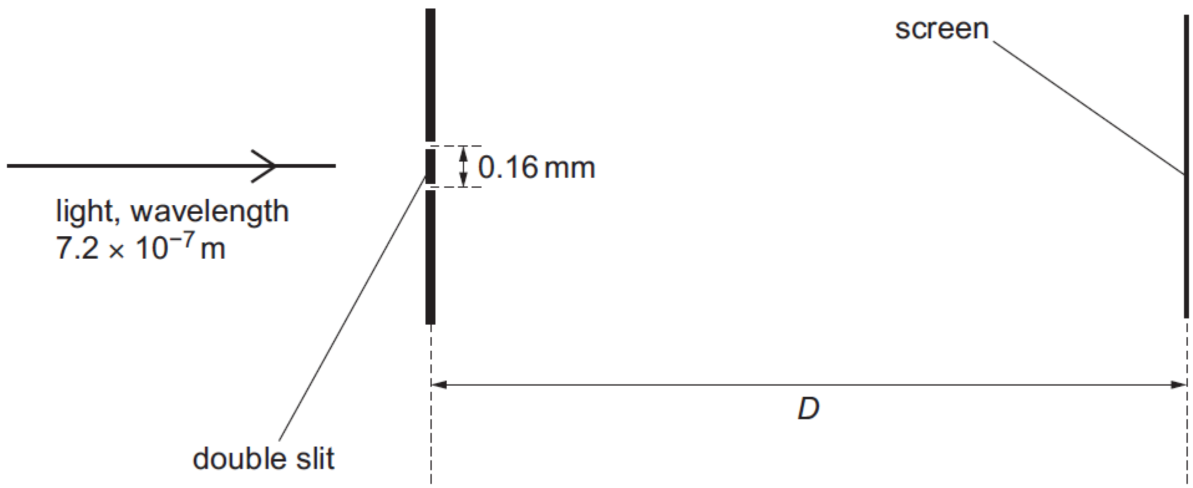


Fig. 4.1 (not to scale)

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.

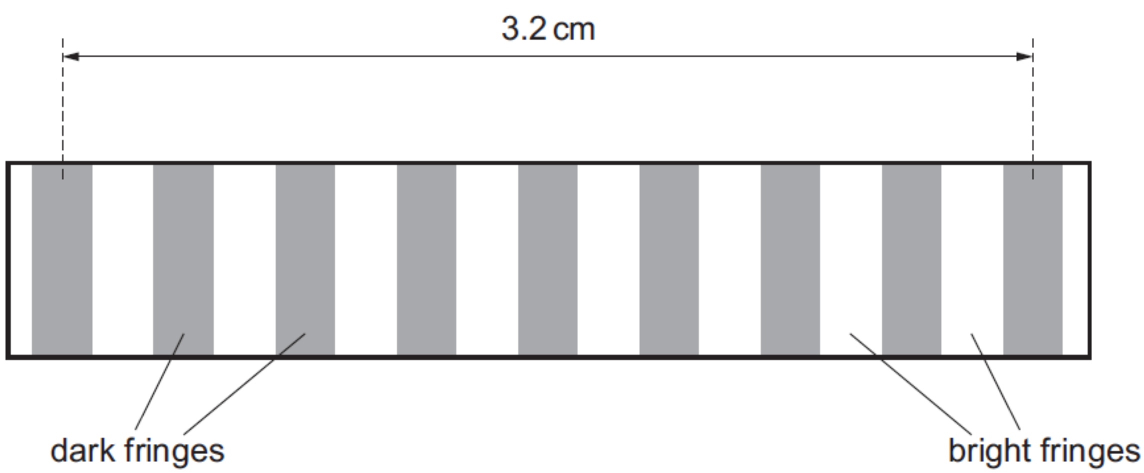


Fig. 4.2 (not to scale)

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

(i) Calculate *D*.

D = ... 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.

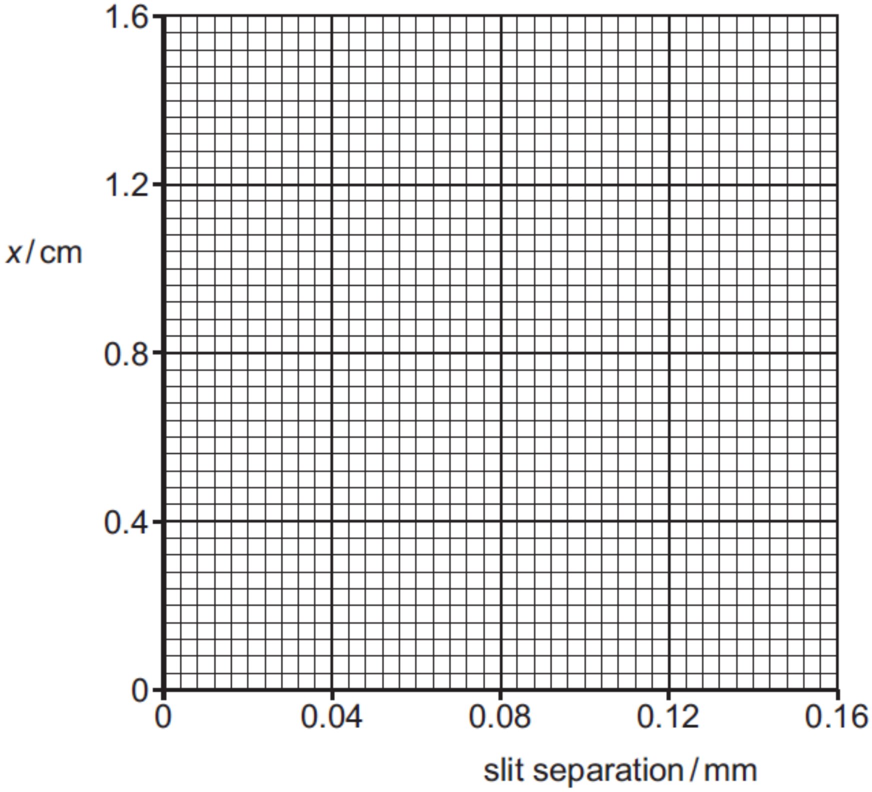


Fig. 4.3

[3]

[Total: 8]

Question 39

(a) Use the definitions of speed v, frequency f and wavelength λ to derive the wave equation

$$v = f\lambda.$$

[2]

(b) A source of sound waves of frequency 236 Hz is travelling at a constant velocity of 20 m s^{-1}.

A stationary observer has a microphone connected to a cathode-ray oscilloscope (CRO). The microphone detects the sound waves as the source moves directly towards the observer.

The resulting trace on the CRO is shown in Fig. 5.1.

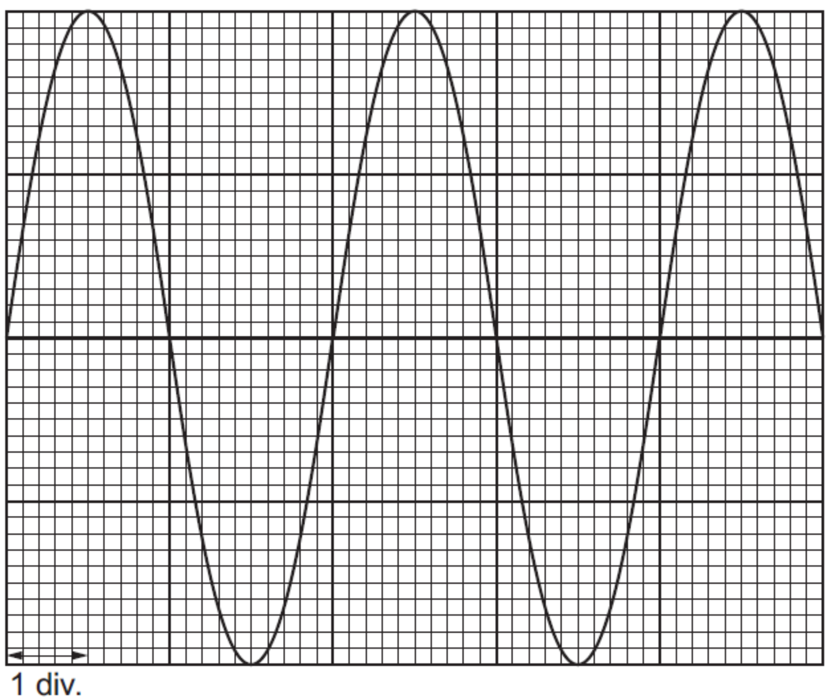


Fig. 5.1

The time-base on the CRO is set to 1.0 ms div^{-1}.

(i) Calculate the frequency of the sound waves detected by the microphone.

frequency = ... Hz [2]

(ii) Determine the speed of the sound in air.

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

[Total: 6]

Question 40

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.

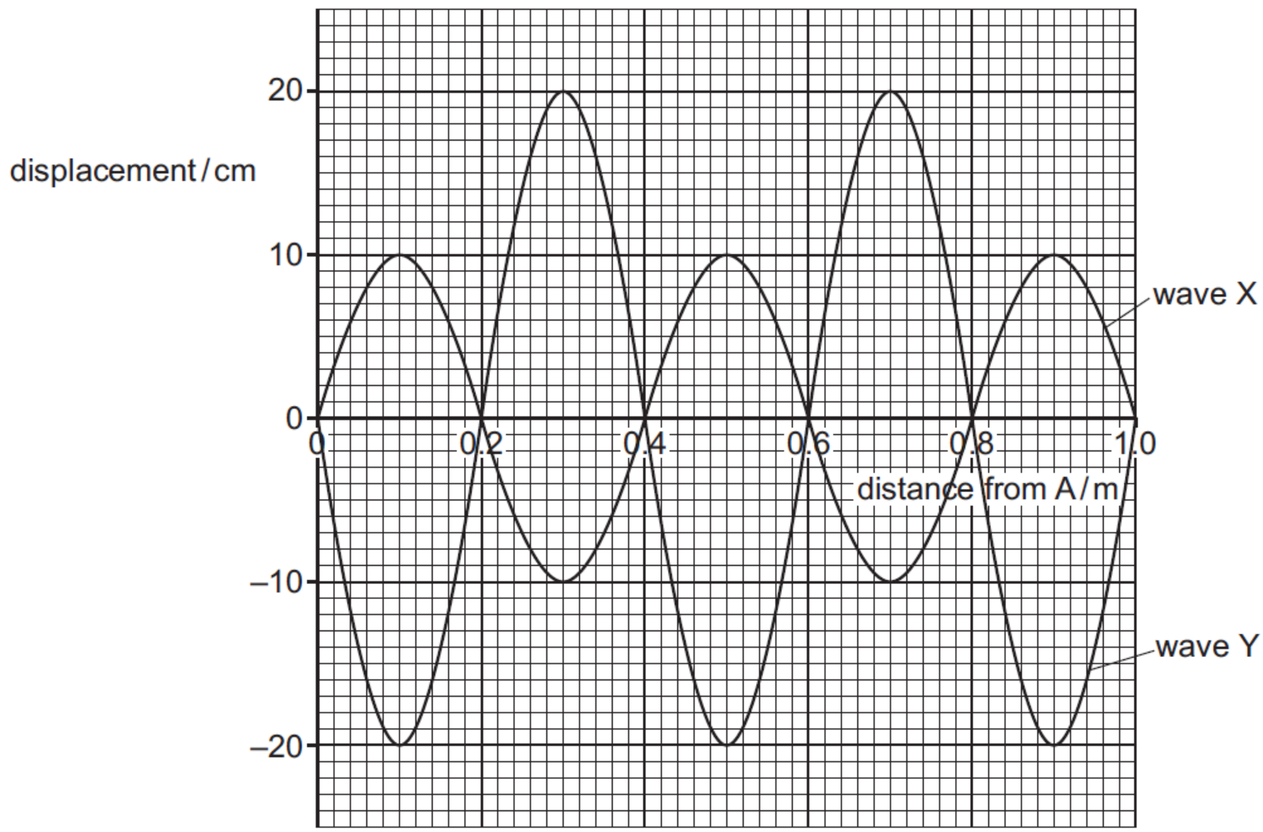


Fig. 3.1

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

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

....

....

.... [1]

(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.

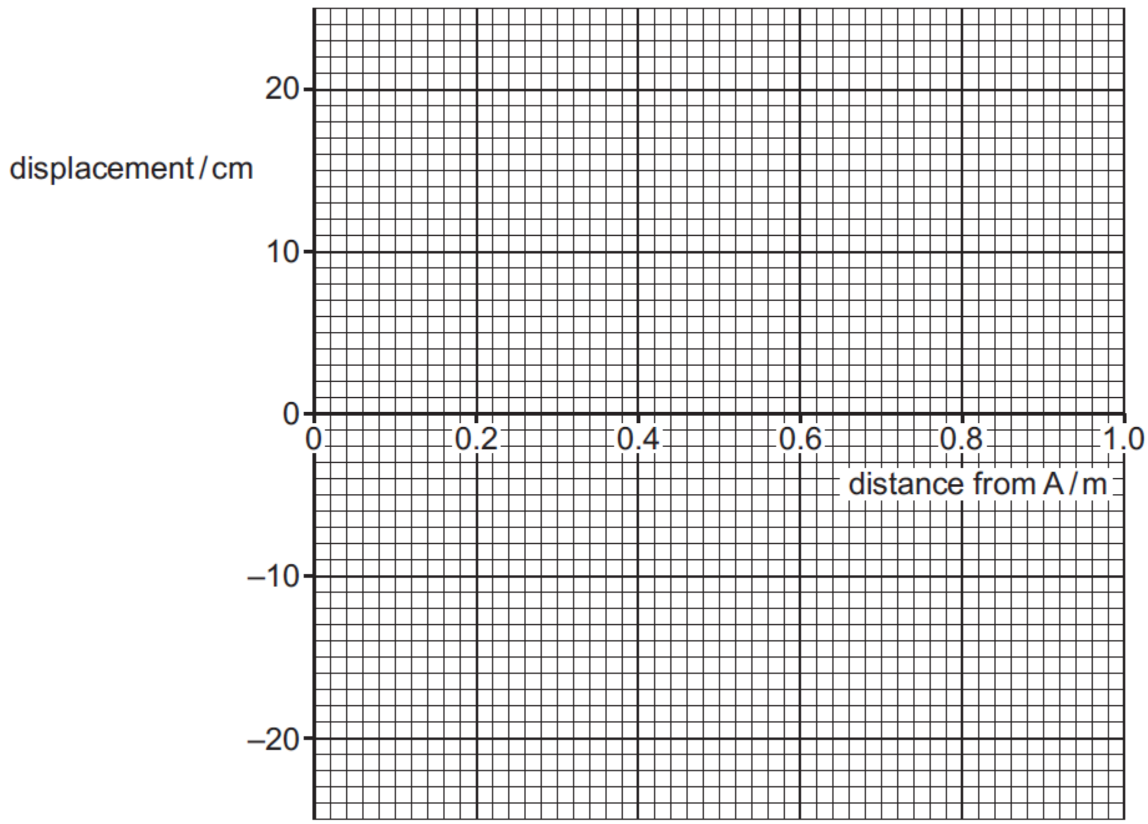


Fig. 3.2

[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 $\dfrac{I_X}{I_Y}$.

ratio = ... [2]

[Total: 8]

Question 41

(a) State why sound waves **cannot** be polarised.

....

.... [1]

(b) A plane-polarised light wave is incident on a polarising filter as shown in Fig. 5.1.

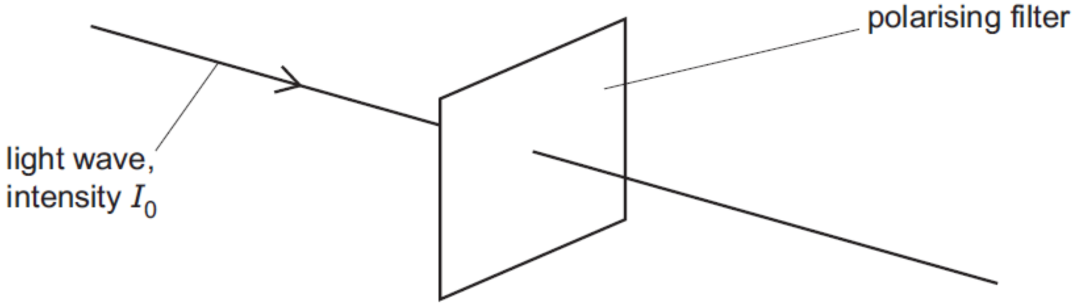


Fig. 5.1

The intensity of the light incident on the filter is I_0.

The light is incident normally on the filter and the transmission axis of the filter is initially perpendicular to the plane of polarisation of the light.

The filter is now rotated through 360° about the direction of travel of the light wave.

(i) On Fig. 5.2, sketch the variation of the intensity I of the transmitted light with the angle of rotation α as the filter is rotated through 360° from its initial position.

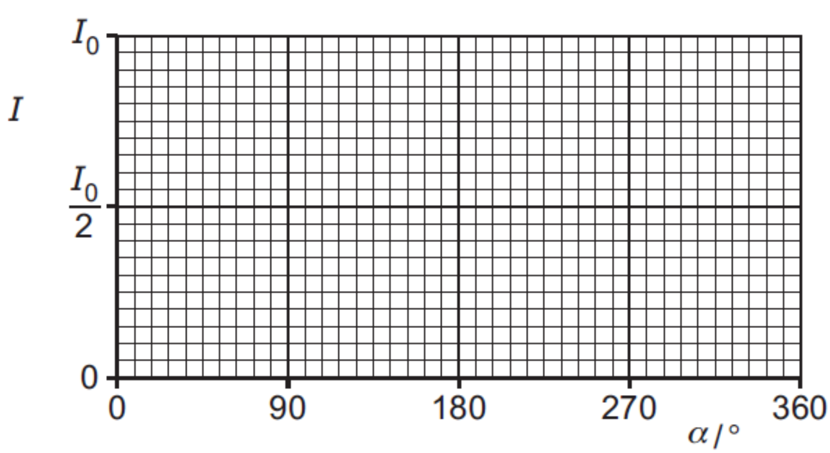


Fig. 5.2

[3]

(ii) The amplitude of the incident light wave is A_0 when the intensity of the wave is I_0.

Use Malus's law to determine, in terms of A_0, the amplitude of the transmitted wave when $\alpha = 20°$.

amplitude = ... A_0 [4]

[Total: 8]

Question 42

(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.

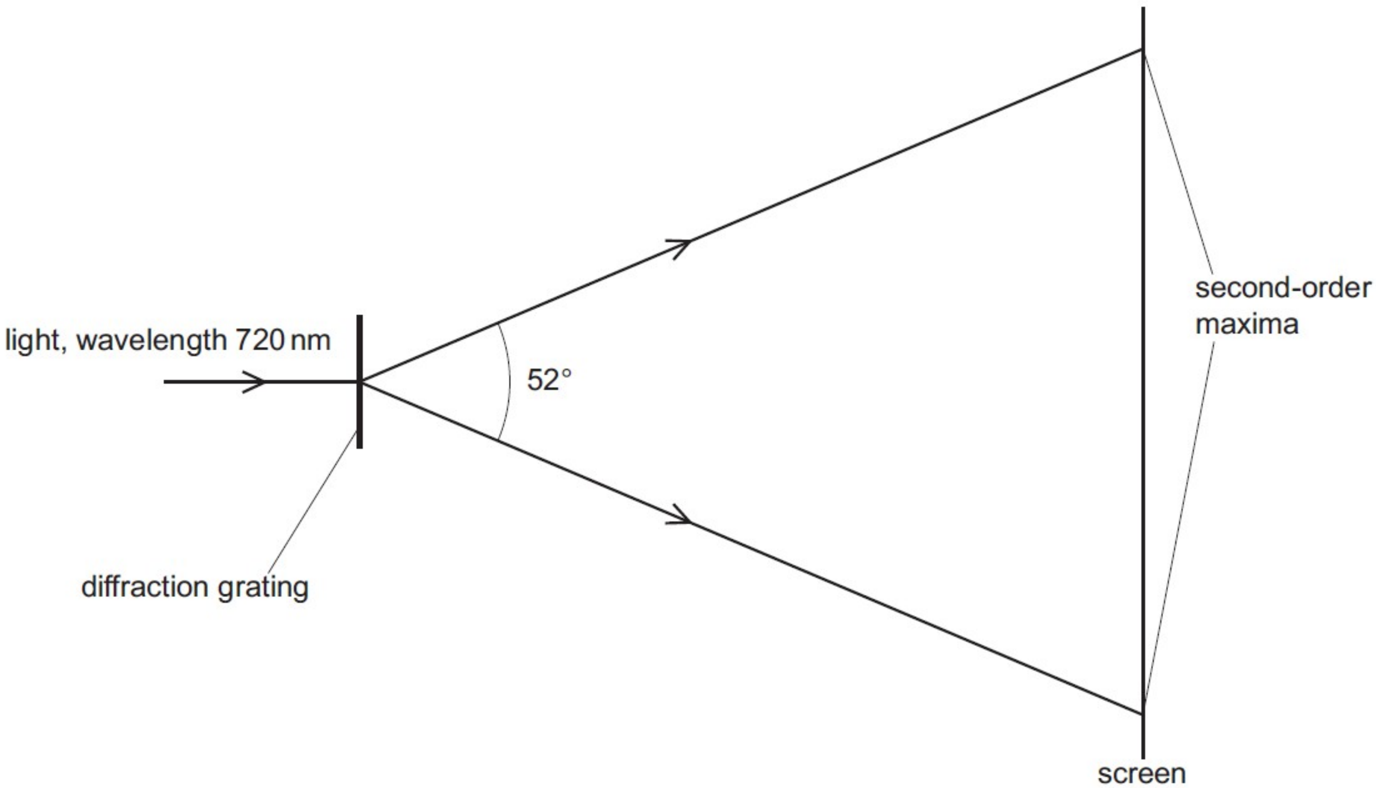


Fig. 6.1 (not to scale)

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]

(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.

λ = ... nm [2]

[Total: 8]

Question 43

(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.

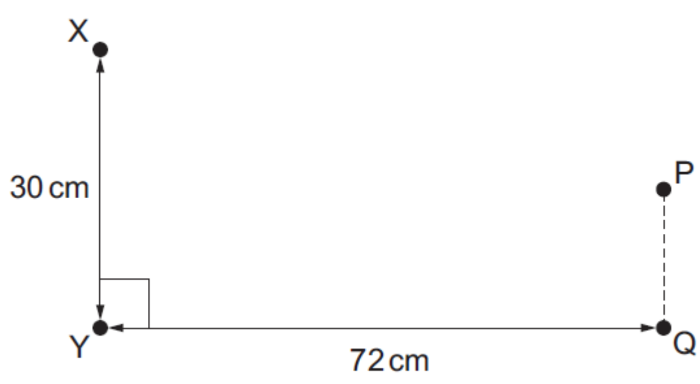


Fig. 4.1 (not to scale)

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.

(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]

Question 44

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

....

....

.... [2]

(b) A beam of vertically polarised light of wavelength 540 nm is incident normally on a diffraction grating, as shown in Fig. 4.1.

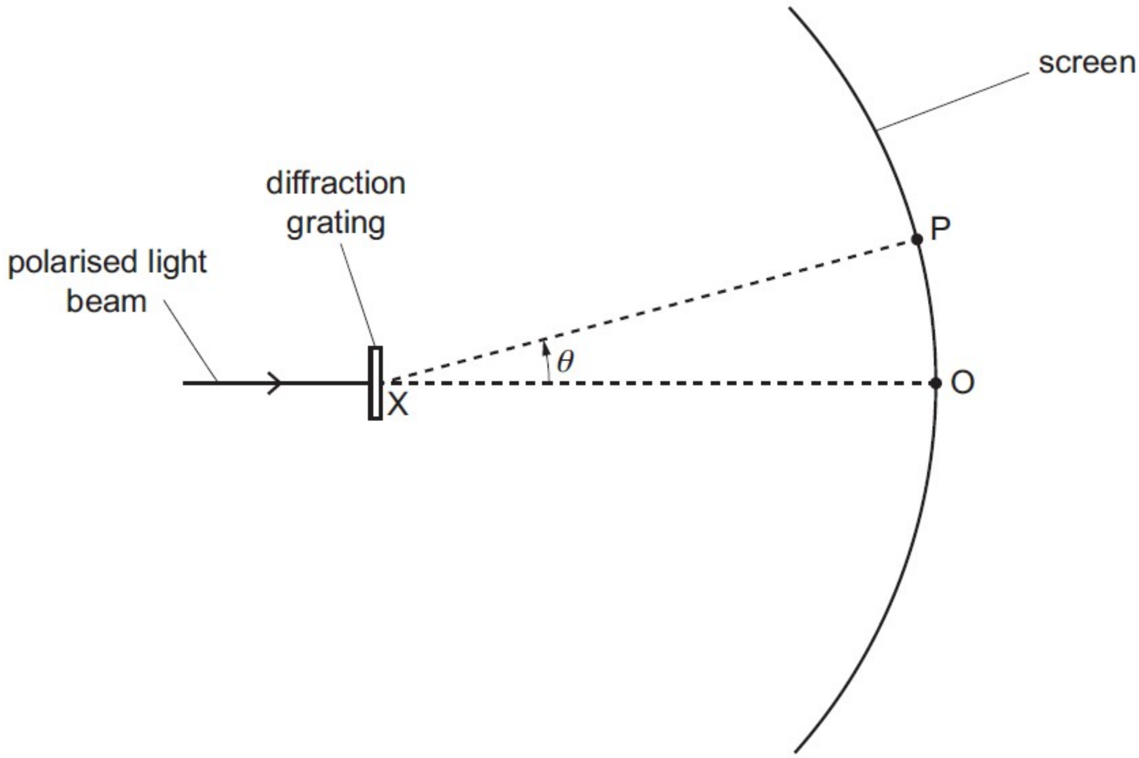


Fig. 4.1 (not to scale)

The diffraction grating has a line spacing of 5.0×10^{-6} m.

The light transmitted by the diffraction grating illuminates a circular screen. The diffraction grating is at the centre X of the circle.

The central bright fringe is formed at point O on the screen and has intensity I_0.

P is a point on the screen where the line XP is at a variable angle θ to the line XO. The intensity I of light on the screen at P varies with θ.

(i) Show that the angle θ at which the first-order bright fringe is formed is 6.2°.

[2]

(ii) Determine the value of θ at which the second-order bright fringe is formed.

θ = ...° [1]

(iii) On Fig. 4.2, sketch the variation of the intensity I with θ for values of θ from –15° to +15°.

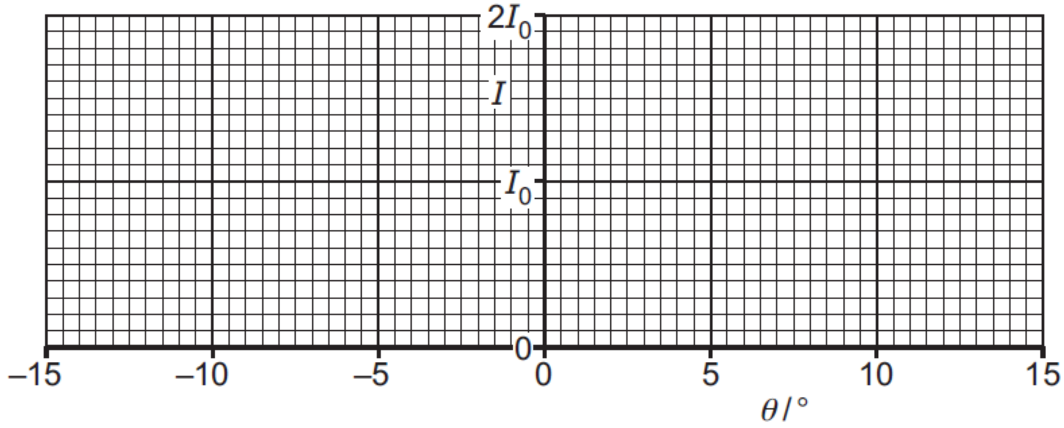


Fig. 4.2

[3]

(c) A polarising filter is placed in the path of the light beam that is incident on the diffraction grating in Fig. 4.1. The transmission axis of the filter is at 45° to the vertical.

Suggest how the variation of intensity with θ for the light on the screen compares with the answer in **(b)(iii)**.

....

....

.... [2]

[Total: 10]

Question 45

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.

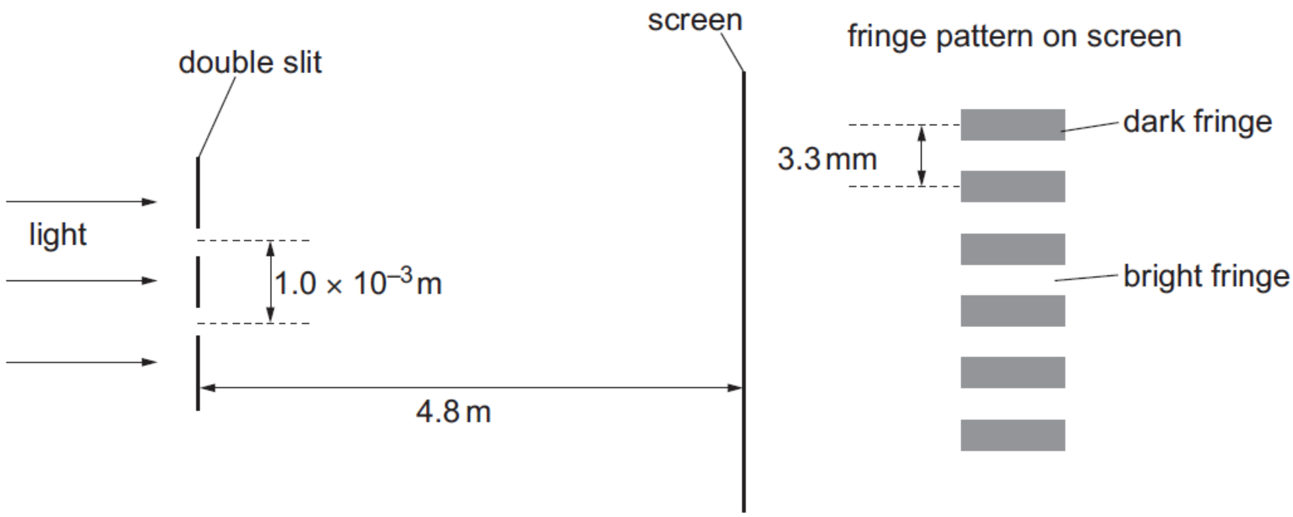


Fig. 4.1 (not to scale)

The separation of the slits is 1.0×10^{-3} 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]

(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]

Question 46

(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.

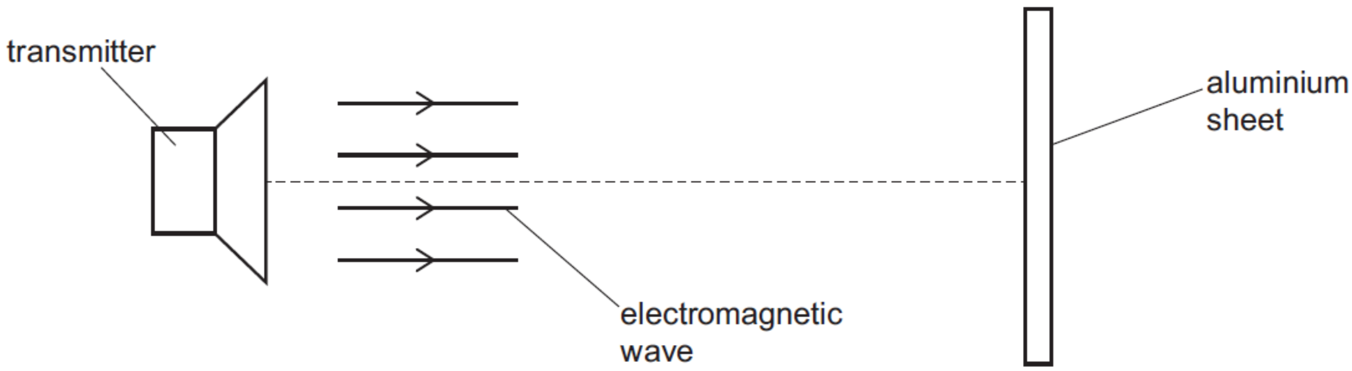


Fig. 4.1

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]

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

distance = ... m [1]

[Total: 9]

End of Question Paper • Waseem Ahmad, A Level Physics Teacher • examspath.com