Q1.

4 **(a)** State three conditions that must be satisfied in order that two waves may interfere.

1. ....

2. ....

3. .... [3]

(b) The apparatus illustrated in Fig. 4.1 is used to demonstrate two-source interference using light.

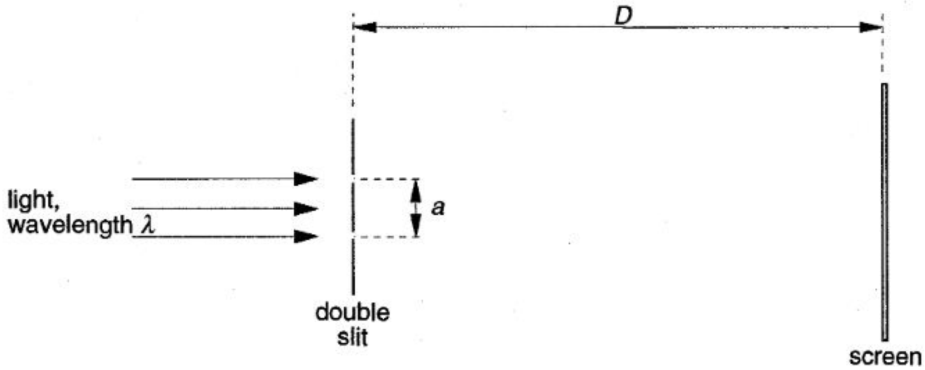


Fig. 4.1 (not to scale)

The separation of the two slits in the double slit arrangement is a and the interference fringes are viewed on a screen at a distance D from the double slit. When light of wavelength λ is incident on the double slit, the separation of the bright fringes on the screen is x.

(i) **1.** Suggest a suitable value for the separation a of the slits in the double slit.

....

2. Write down an expression relating λ, a, D and x.

....
[2]

(ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made.

1. The distance D is increased to $2D$, keeping a and λ constant.

separation: ....

maximum brightness: ....

2. The wavelength λ is increased to 1.5λ, keeping a and D constant.

separation: ....

maximum brightness: ....

3. The intensity of the light incident on the double slit is increased, keeping λ, a and D constant.

separation: ....

maximum brightness: ....

[7]

Q2.

2 Fig. 2.1 shows the variation with distance x along a wave of its displacement d at a particular time.

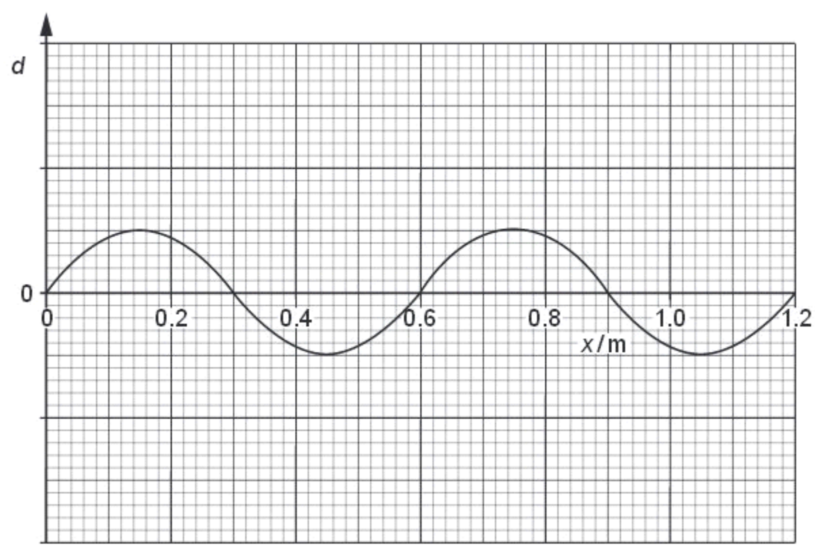


Fig. 2.1

The wave is a progressive wave having a speed of $330\,\text{m}\,\text{s}^{-1}$.

(a) **(i)** Use Fig. 2.1 to determine the wavelength of the wave.

wavelength = ... m

(ii) Hence calculate the frequency of the wave.

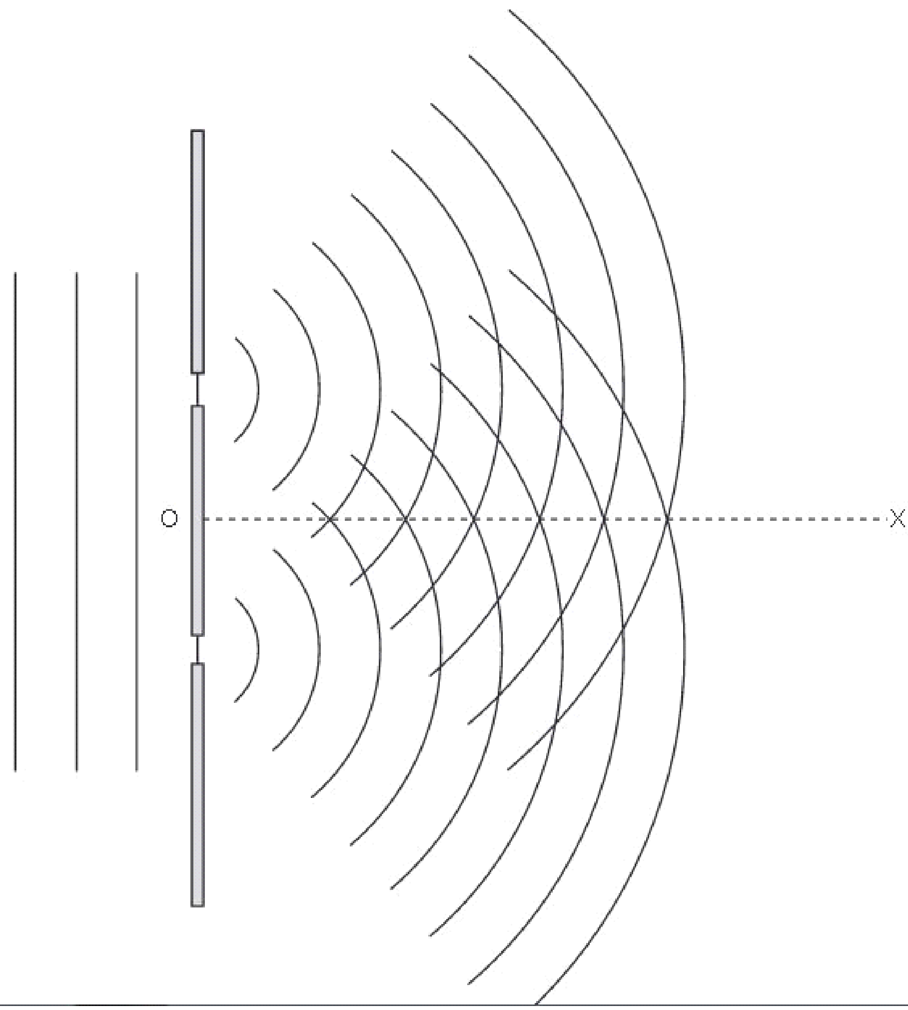
frequency = ... Hz
[3]

(b) A second wave has the same frequency and speed as the wave shown in Fig. 2.1 but has double the intensity. The phase difference between the two waves is 180°.

On the axes of Fig. 2.1, sketch a graph to show the variation with distance *x* of the displacement *d* of this second wave. [2]

Q3.

6 Fig. 6.1 shows wavefronts incident on, and emerging from, a double slit arrangement.



The wavefronts represent successive crests of the wave. The line OX shows one direction along which constructive interference may be observed.

(a) State the principle of superposition.

....

....

.... [3]

(b) On Fig. 6.1, draw lines to show

(i) a second direction along which constructive interference may be observed (label this line CC),

(ii) a direction along which destructive interference may be observed (label this line DD).

[2]

(c) Light of wavelength 650 nm is incident normally on a double slit arrangement. The interference fringes formed are viewed on a screen placed parallel to and 1.2 m from the plane of the double slit, as shown in Fig. 6.2.

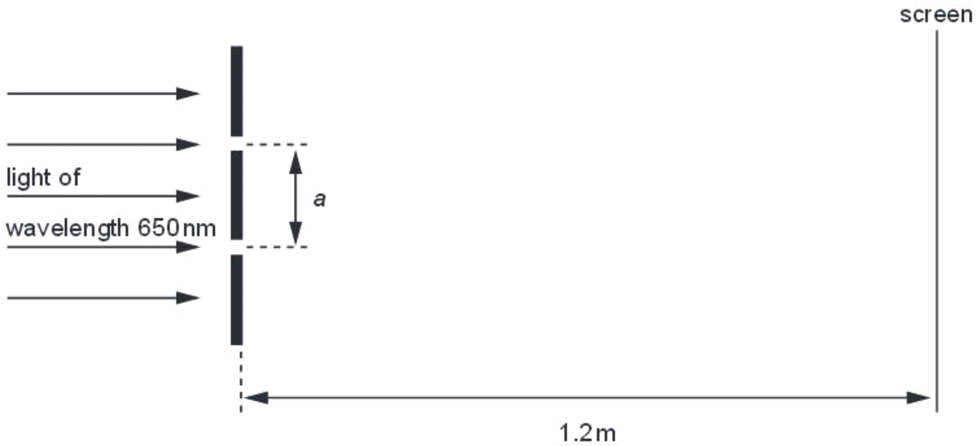


Fig. 6.2

The fringe separation is 0.70 mm.

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

separation = ... m [3]

(ii) The width of both slits is increased without changing their separation *a*. State the effect, if any, that this change has on

1. the separation of the fringes,

....

2. the brightness of the light fringes,

....

3. the brightness of the dark fringes.

....
[3]

Q4.

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

....

....

....[2]

(b) Light of wavelength 590 nm is incident normally on a diffraction grating having 750 lines per millimetre.
The diffraction grating formula may be expressed in the form

$$d \sin\theta = n\lambda.$$

(i) Calculate the value of *d*, in metres, for this grating.

d = ... m [2]

(ii) Determine the maximum value of n for the light incident normally on the grating.

maximum value of n = ... [2]

(iii) Fig. 5.1 shows incident light that is not normal to the grating.

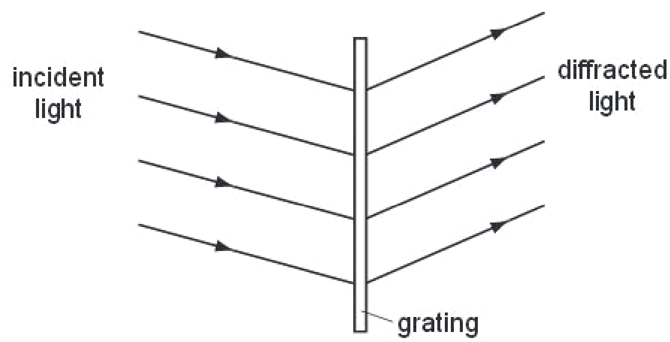


Fig. 5.1

Suggest why the diffraction grating formula, $d\sin\theta = n\lambda$, should **not** be used in this situation.

....

....[1]

(c) Light of wavelengths 590 nm and 595 nm is now incident normally on the grating.
Two lines are observed in the first order spectrum and two lines are observed in the second order spectrum, corresponding to the two wavelengths.
State two differences between the first order spectrum and the second order spectrum.

1. ....

....

2. ....

....[2]

Q5.

6 A long tube, fitted with a tap, is filled with water. A tuning fork is sounded above the top of the tube as the water is allowed to run out of the tube, as shown in Fig. 6.1.

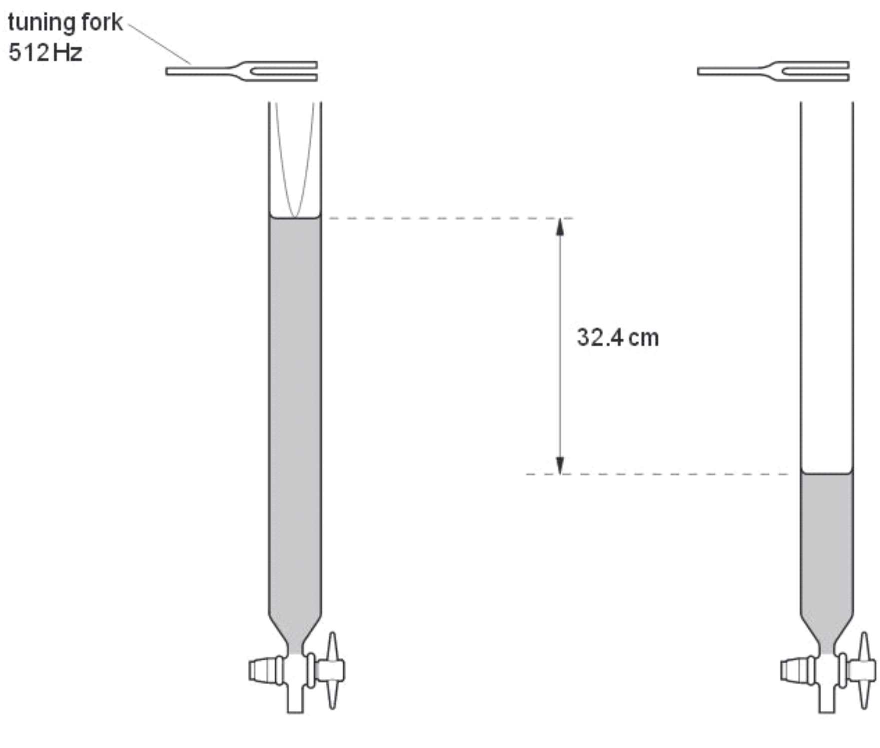


Fig. 6.1 Fig. 6.2

A loud sound is first heard when the water level is as shown in Fig. 6.1, and then again when the water level is as shown in Fig. 6.2.

Fig. 6.1 illustrates the stationary wave produced in the tube.

(a) On Fig. 6.2,

(i) sketch the form of the stationary wave set up in the tube, [1]

(ii) mark, with the letter N, the positions of any nodes of the stationary wave. [1]

(b) The frequency of the fork is 512 Hz and the difference in the height of the water level for the two positions where a loud sound is heard is 32.4 cm.

Calculate the speed of sound in the tube.

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

(c) The length of the column of air in the tube in Fig. 6.1 is 15.7 cm.

Suggest where the antinode of the stationary wave produced in the tube in Fig. 6.1 is likely to be found.

....

....

.... [2]

Q6.

5 Light reflected from the surface of smooth water may be described as a polarised transverse wave.

(a) By reference to the direction of propagation of energy, explain what is meant by

(i) a *transverse wave*,

....

....[1]

(ii) *polarisation*.

....

....[1]

(b) A glass tube, closed at one end, has fine dust sprinkled along its length. A sound source is placed near the open end of the tube, as shown in Fig. 5.1.

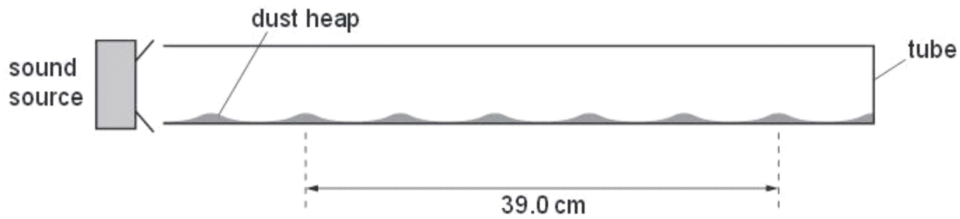


Fig. 5.1

The frequency of the sound emitted by the source is varied and, at one frequency, the dust forms small heaps in the tube.

(i) Explain, by reference to the properties of stationary waves, why the heaps of dust are formed.

....

....

....

....[3]

(ii) One frequency at which heaps are formed is 2.14 kHz.
The distance between six heaps, as shown in Fig. 5.1, is 39.0 cm.
Calculate the speed of sound in the tube.

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

(c) The wave in the tube is a stationary wave. Explain, by reference to the formation of a stationary wave, what is meant by the speed calculated in **(b)(ii)**.

....

....

....

....[3]

Q7.

5 **(a)** State what is meant by

For Examiner's Use

(i) the *frequency* of a progressive wave,

....

....

....[2]

(ii) the *speed* of a progressive wave.

....

....[1]

(b) One end of a long string is attached to an oscillator. The string passes over a frictionless pulley and is kept taut by means of a weight, as shown in Fig. 5.1.

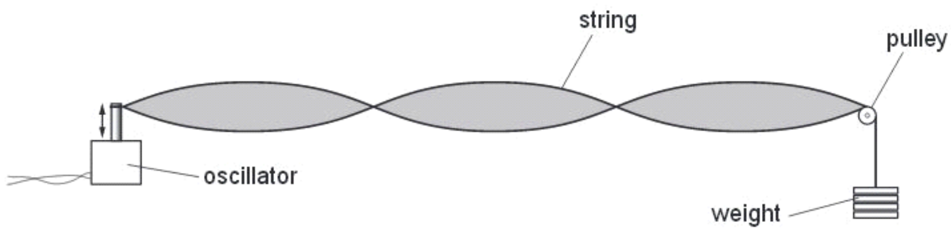


Fig. 5.1

The frequency of oscillation is varied and, at one value of frequency, the wave formed on the string is as shown in Fig. 5.1.

(i) Explain why the wave is said to be a *stationary wave*.

....

....[1]

(ii) State what is meant by an *antinode*.

....

....[1]

(iii) On Fig. 5.1, label the antinodes with the letter A. [1]

(c) A weight of 4.00 N is hung from the string in **(b)** and the frequency of oscillation is adjusted until a stationary wave is formed on the string. The separation of the antinodes on the string is 17.8 cm for a frequency of 125 Hz.
The speed *v* of waves on a string is given by the expression

$$v = \sqrt{\frac{T}{m}}\ ,$$

where *T* is the tension in the string and *m* is its mass per unit length.
Determine the mass per unit length of the string.

mass per unit length = ... kg m^{-1} **[5]**

Q8.

5 Two sources S_1 and S_2 of sound are situated 80 cm apart in air, as shown in Fig. 5.1.

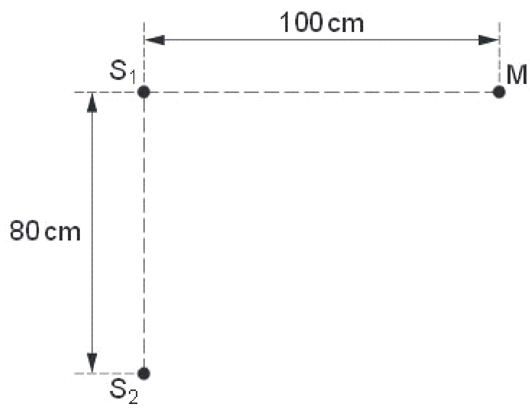


Fig. 5.1

The frequency of vibration can be varied. The two sources always vibrate in phase but have different amplitudes of vibration.

A microphone M is situated a distance 100 cm from S_1 along a line that is normal to S_1S_2.

As the frequency of S_1 and S_2 is gradually increased, the microphone M detects maxima and minima of intensity of sound.

(a) State the two conditions that must be satisfied for the intensity of sound at M to be zero.

1. ....

....

2. ....

....
[2]

(b) The speed of sound in air is 330 m s^{-1}.

The frequency of the sound from S_1 and S_2 is increased. Determine the number of minima that will be detected at M as the frequency is increased from 1.0 kHz to 4.0 kHz.

number = ... [4]

Q9.

5 A double-slit interference experiment is set up using coherent red light as illustrated in Fig. 5.1.

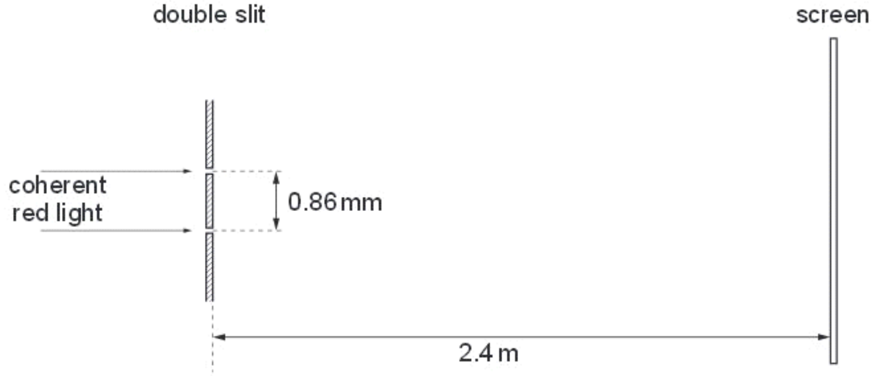


Fig. 5.1 (not to scale)

The separation of the slits is 0.86 mm.
The distance of the screen from the double slit is 2.4 m.
A series of light and dark fringes is observed on the screen.

(a) State what is meant by *coherent* light.

....

.... [1]

(b) Estimate the separation of the dark fringes on the screen.

separation = ... mm [3]

(c) Initially, the light passing through each slit has the same intensity.
The intensity of light passing through one slit is now reduced.
Suggest and explain the effect, if any, on the dark fringes observed on the screen.

....

....

.... [2]

Q10.

For Examiner's Use

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

....

....

.... [2]

(b) A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating, as shown in Fig. 4.1.

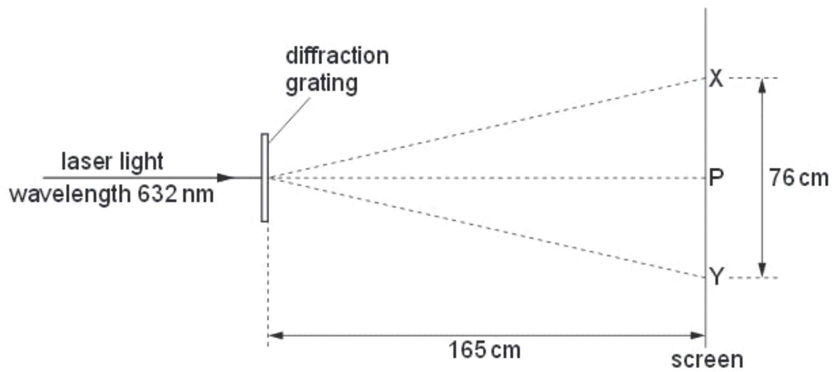


Fig. 4.1

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.
The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.
X and Y are separated by a distance of 76 cm.
Calculate the number of lines per metre on the grating.

number per metre = ... [4]

(c) The grating in **(b)** is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 4.2.

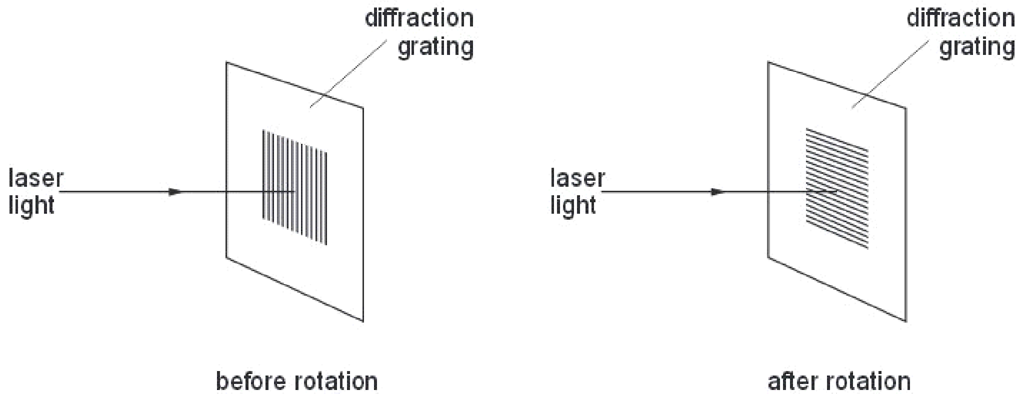


Fig. 4.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

....

....

....

....[2]

(d) In another experiment using the apparatus in **(b)**, a student notices that the distances XP and PY, as shown in Fig. 4.1, are not equal.
Suggest a reason for this difference.

....

....[1]

Q11.

4 (a) State two features of a stationary wave that distinguish it from a progressive wave.

1. ....

....

2. ....

....

[2]

(b) A long tube is open at one end. It is closed at the other end by means of a piston that can be moved along the tube, as shown in Fig. 4.1.

Fig. 4.1

A loudspeaker producing sound of frequency 550 Hz is held near the open end of the tube.
The piston is moved along the tube and a loud sound is heard when the distance L between the piston and the open end of the tube is 45 cm.
The speed of sound in the tube is 330 m s^{-1}.

(i) Show that the wavelength of the sound in the tube is 60 cm.

[1]

(ii) On Fig. 4.1, mark all the positions along the tube of

1. the displacement nodes (label these with the letter N),

2. the displacement antinodes (label these with the letter A).

[3]

(c) The frequency of the sound produced by the loudspeaker in **(b)** is gradually reduced.

Determine the lowest frequency at which a loud sound will be produced in the tube of length $L = 45\,\text{cm}$.

frequency = ... Hz [3]

Q12.

5 **(a)** A source of sound has frequency *f*. Sound of wavelength λ is produced by the source.

(i) State

1. what is meant by the *frequency* of the source,

....

....[1]

2. the distance moved, in terms of λ, by a wavefront during *n* oscillations of the source.

distance = ...[1]

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

[2]

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

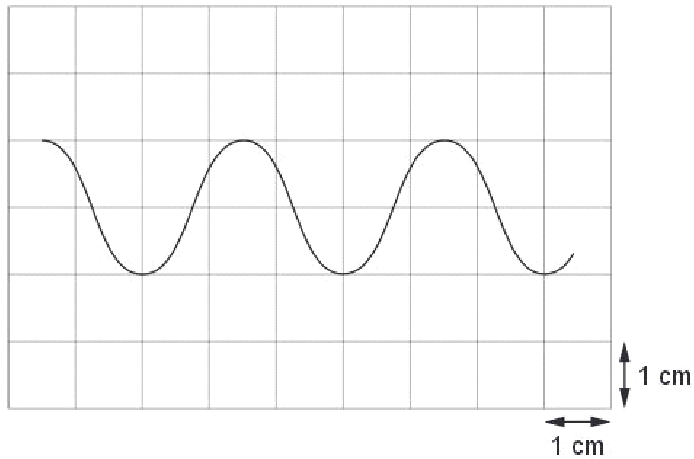


Fig. 5.1

The time-base setting of the c.r.o. is 2.0 ms cm^{-1}.

(i) Determine the frequency of the sound wave.

frequency = ...Hz [2]

(ii) A second sound wave has the same frequency as that calculated in **(i)**. The amplitude of the two waves is the same but the phase difference between them is 90°.

On Fig. 5.1, draw the waveform of this second wave. [1]

Q13.

7 **(a)** Explain the term *interference*.

....

....

.... **[1]**

(b) A ripple tank is used to demonstrate interference between water waves.

Describe

(i) the apparatus used to produce two sources of coherent waves that have circular wavefronts,

....

....

....

.... **[2]**

(ii) how the pattern of interfering waves may be observed.

....

....

....

.... **[2]**

(c) A wave pattern produced in **(b)** is shown in Fig. 7.1.

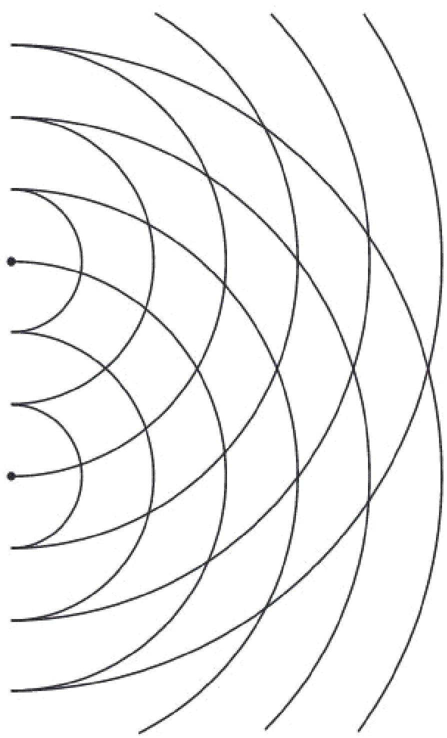


Fig. 7.1

Solid lines on Fig. 7.1 represent crests.

On Fig. 7.1,

(i) draw two lines to show where maxima would be seen (label each of these lines with the letter X), **[1]**

(ii) draw one line to show where minima would be seen (label this line with the letter N). **[1]**

Q14.

6 (a) Apparatus used to produce interference fringes is shown in Fig. 6.1. The apparatus is not drawn to scale.

Ex

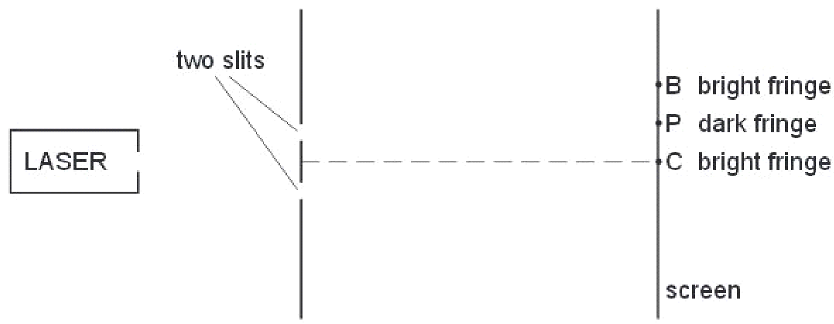


Fig. 6.1 (not to scale)

Laser light is incident on two slits. The laser provides light of a single wavelength. The light from the two slits produces a fringe pattern on the screen. A bright fringe is produced at C and the next bright fringe is at B. A dark fringe is produced at P.

(i) Explain why one laser and two slits are used, instead of two lasers, to produce a visible fringe pattern on the screen.

....

.... **[1]**

(ii) State the phase difference between the waves that meet at

1. B .... [1]

2. P .... [1]

(iii) **1.** State the *principle of superposition*.

....

....

.... [2]

2. Use the principle of superposition to explain the dark fringe at P.

....

.... [1]

(b) In Fig. 6.1 the distance from the two slits to the screen is 1.8 m. The distance CP is 2.3 mm and the distance between the slits is 0.25 mm.
Calculate the wavelength of the light provided by the laser.

For Examiner's Use

wavelength = ... nm [3]

Q15.

6 **(a)** A transverse progressive wave travels along a stretched string from left to right. The shape of part of the string at a particular instant is shown in Fig. 6.1.

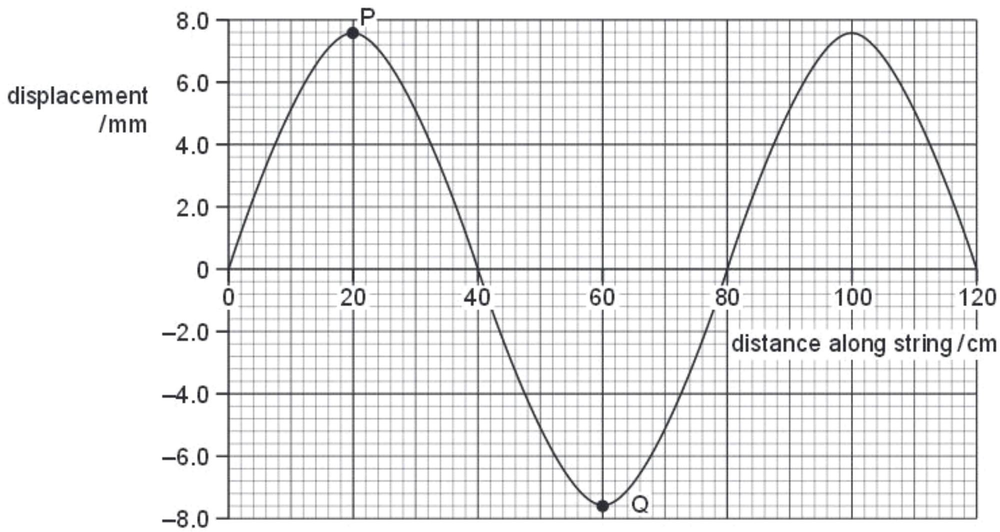


Fig. 6.1

The frequency of the wave is 15 Hz.
For this wave, use Fig. 6.1 to determine

(i) the amplitude,

amplitude = ... mm [1]

(ii) the phase difference between the points P and Q on the string,

phase difference = ... [1]

(iii) the speed of the wave.

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

(b) The period of vibration of the wave is T. The wave moves forward from the position shown in Fig 6.1 for a time 0.25 T. On Fig. 6.1, sketch the new position of the wave. [2]

(c) Another stretched string is used to form a stationary wave. Part of this wave, at a particular instant, is shown in Fig. 6.2.

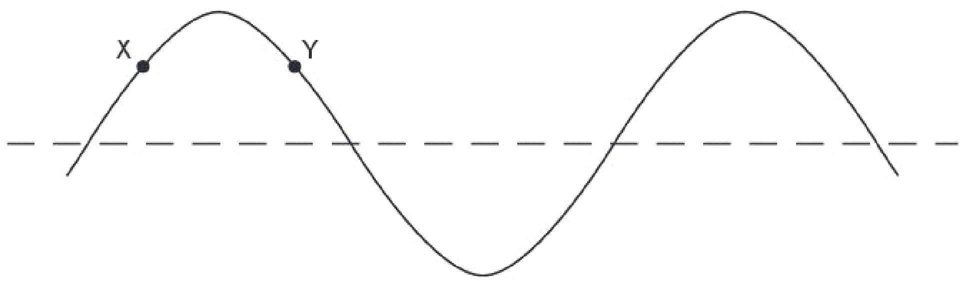


Fig. 6.2

The points on the string are at their maximum displacement.

(i) State the phase difference between the particles labelled X and Y.

phase difference = ... [1]

(ii) Explain the following terms used to describe stationary waves on a string:

antinode: ....

node: ....
[1]

(iii) State the number of antinodes shown on Fig. 6.2 for this wave.

number of antinodes = ... [1]

(iv) The period of vibration of this wave is τ. On Fig. 6.2, sketch the stationary wave $0.25\,\tau$ after the instant shown in Fig. 6.2. [1]

Q16.

6 **(a)** A laser is used to produce an interference pattern on a screen, as shown in Fig. 6.1.

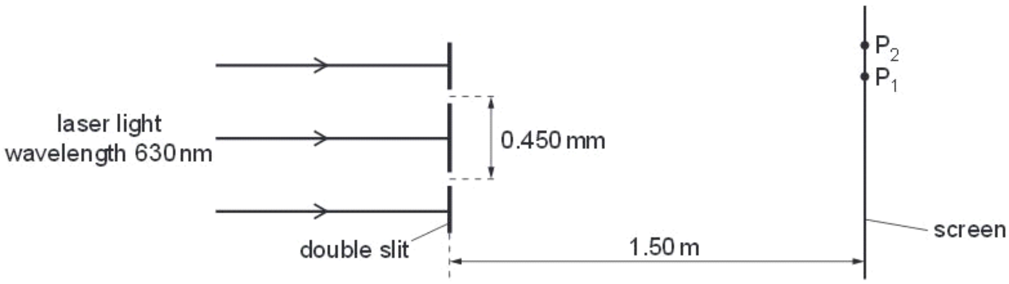


Fig. 6.1 (not to scale)

The laser emits light of wavelength 630 nm. The slit separation is 0.450 mm. The distance between the slits and the screen is 1.50 m. A maximum is formed at P_1 and a minimum is formed at P_2.
Interference fringes are observed only when the light from the slits is coherent.

(i) Explain what is meant by *coherence*.

....

....

.... [2]

(ii) Explain how an interference maximum is formed at P_1.

....

.... [1]

(iii) Explain how an interference minimum is formed at P_2.

....

.... [1]

(iv) Calculate the fringe separation.

fringe separation = ... m [3]

(b) State the effects, if any, on the fringes when the amplitude of the waves incident on the double slits is increased.

....

....

....

....[3]

Q17.

6 **(a)** Use the principle of superposition to explain the formation of a stationary wave.

....

....

....

....

....[3]

(b) Describe an experiment to determine the wavelength of sound in air using stationary waves. Include a diagram of the apparatus in your answer.

....

....

....

....

....

....

....

....

....

....[3]

(c) The variation with distance x of the intensity I of a stationary sound wave is shown in Fig. 6.1.

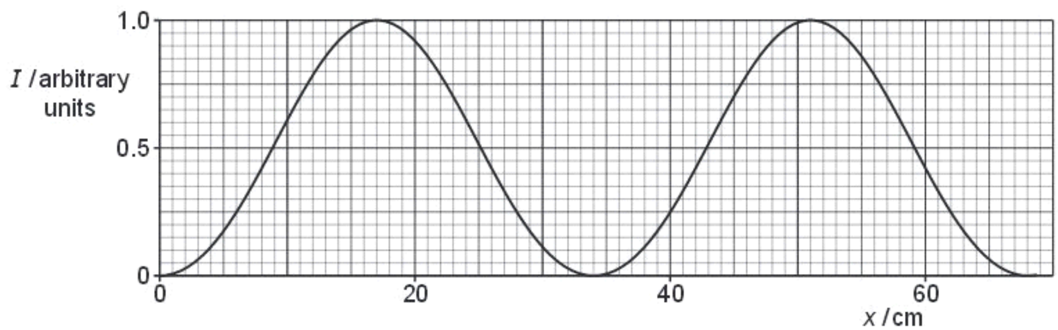


Fig. 6.1

(i) On the x-axis of Fig. 6.1, indicate the positions of all the nodes and antinodes of the stationary wave. Label the nodes **N** and the antinodes **A**. [1]

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

Use Fig. 6.1 to determine the frequency of the sound wave.

frequency = ... Hz [3]

Q18.

6 **(a)** Monochromatic light is diffracted by a diffraction grating. By reference to this, explain what is meant by

Ex

(i) diffraction,

....

....

....[2]

(ii) coherence,

....

....

....[1]

(iii) superposition.

....

....

....[1]

(b) A parallel beam of red light of wavelength 630 nm is incident normally on a diffraction grating of 450 lines per millimetre.

Calculate the number of diffraction orders produced.

number of orders = ... [3]

(c) The red light in **(b)** is replaced with blue light. State and explain the effect on the diffraction pattern.

....

....

....

....

....[3]

Q19.

5 **(a)** State three conditions required for maxima to be formed in an interference pattern produced by two sources of microwaves.

1. ....

....

2. ....

....

3. ....

....

[3]

Exa

(b) A microwave source M emits microwaves of frequency 12 GHz. Show that the wavelength of the microwaves is 0.025 m.

[3]

(c) Two slits S_1 and S_2 are placed in front of the microwave source M described in **(b)**, as shown in Fig 5.1.

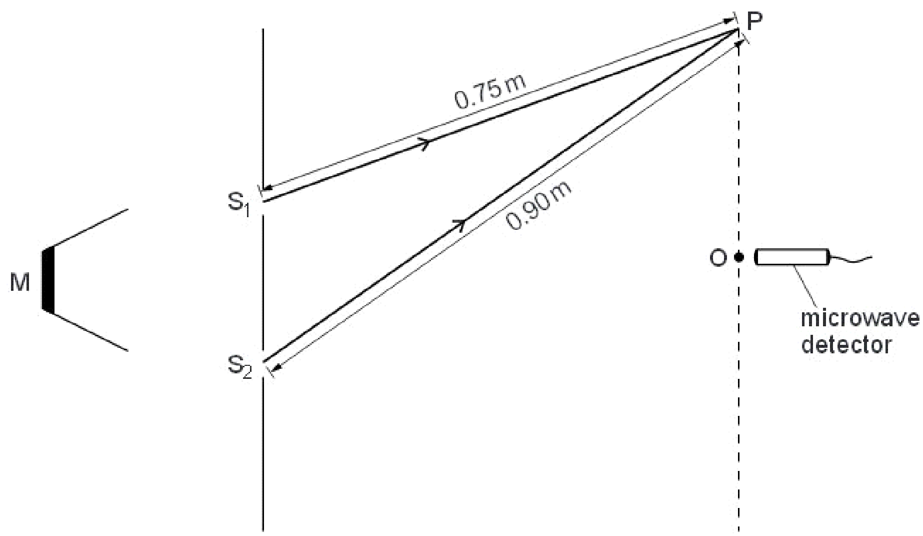


Fig. 5.1 (not to scale)

The distances S_1O and S_2O are equal. A microwave detector is moved from O to P. The distance S_1P is 0.75 m and the distance S_2P is 0.90 m.

The microwave detector gives a maximum reading at O.

State the variation in the readings on the microwave detector as it is moved slowly along the line from O to P.

....

....

....

....

.... [3]

(d) The microwave source M is replaced by a source of coherent light.

State two changes that must be made to the slits in Fig. 5.1 in order to observe an interference pattern.

1. ....

2. ....
[2]

Q20.

5 Fig. 5.1 shows a string stretched between two fixed points P and Q.

Fig. 5.1

A vibrator is attached near end P of the string. End Q is fixed to a wall. The vibrator has a frequency of 50 Hz and causes a transverse wave to travel along the string at a speed of 40 m s^{-1}.

(a) (i) Calculate the wavelength of the transverse wave on the string.

wavelength = ... m [2]

(ii) Explain how this arrangement may produce a stationary wave on the string.

....

....

....[2]

(b) The stationary wave produced on PQ at one instant of time *t* is shown on Fig. 5.2. Each point on the string is at its maximum displacement.

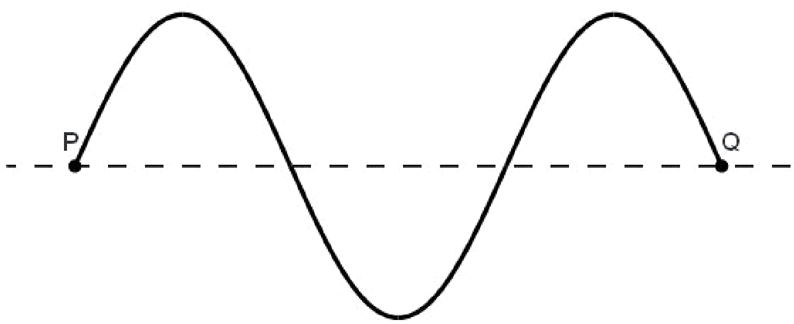


Fig. 5.2 (not to scale)

(i) On Fig. 5.2, label all the nodes with the letter **N** and all the antinodes with the letter **A**. [2]

(ii) Use your answer in **(a)(i)** to calculate the length of string PQ.

length = ... m [1]

(iii) On Fig. 5.2, draw the stationary wave at time (t + 5.0 ms). Explain your answer.

....[3]

Q21.

For Examiner's Use

5 **(a)** Explain the principle of superposition.

....

....

.... [2]

(b) Sound waves travel from a source S to a point X along two paths SX and SPX, as shown in Fig. 5.1.

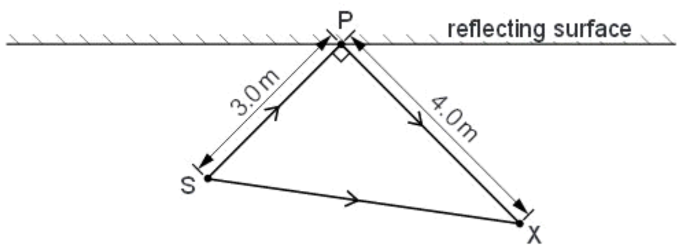


Fig. 5.1

(i) State the phase difference between these waves at X for this to be the position of

1. a minimum,

phase difference = ... unit .... [1]

2. a maximum.

phase difference = ... unit .... [1]

(ii) The frequency of the sound from S is 400 Hz and the speed of sound is 320 m s^{-1}. Calculate the wavelength of the sound waves.

wavelength = ... m [2]

(iii) The distance SP is 3.0 m and the distance PX is 4.0 m. The angle SPX is 90°. Suggest whether a maximum or a minimum is detected at point X. Explain your answer.

....

.... [2]

Q22.

5 The variation with time t of the displacement x of a point in a transverse wave T_1 is shown in Fig. 5.1.

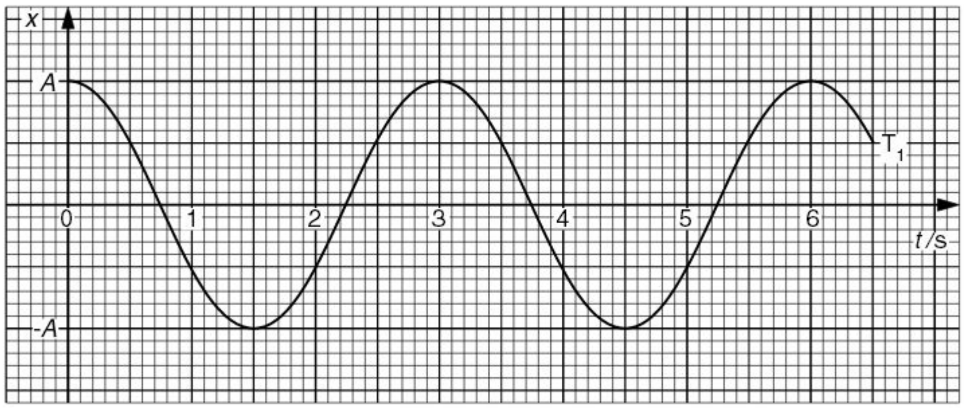


Fig. 5.1

(a) By reference to displacement and direction of travel of wave energy, explain what is meant by a *transverse wave*.

....

....[1]

(b) A second transverse wave T_2, of amplitude A has the same waveform as wave T_1 but lags behind T_1 by a phase angle of 60°. The two waves T_1 and T_2 pass through the same point.

(i) On Fig. 5.1, draw the variation with time t of the displacement x of the point in wave T_2. [2]

(ii) Explain what is meant by the *principle of superposition* of two waves.

....

....

....[2]

(iii) For the time t = 1.0 s, use Fig. 5.1 to determine, in terms of A,

1. the displacement due to wave T_1 alone,

displacement = ...

2. the displacement due to wave T_2 alone,

displacement = ...

3. the resultant displacement due to both waves.

displacement = ...
[3]

Q23.

4 **(a)** Fig. 4.1 shows the variation with time *t* of the displacement *x* of one point in a progressive wave.

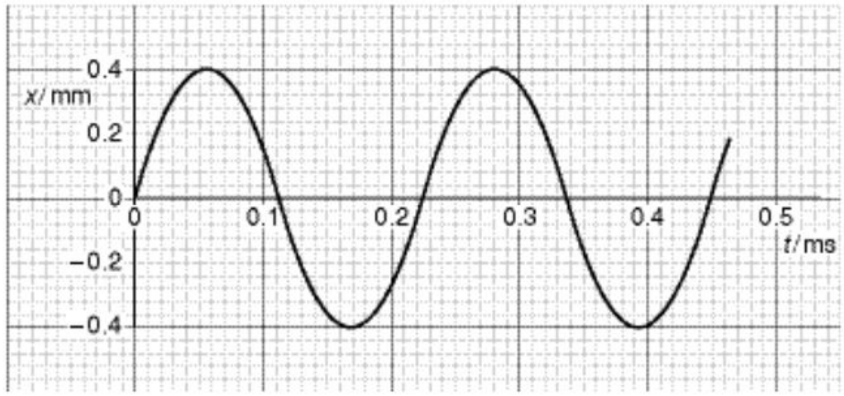


Fig. 4.1

Fig. 4.2 shows the variation with distance *d* along the same wave of the displacement *x*.

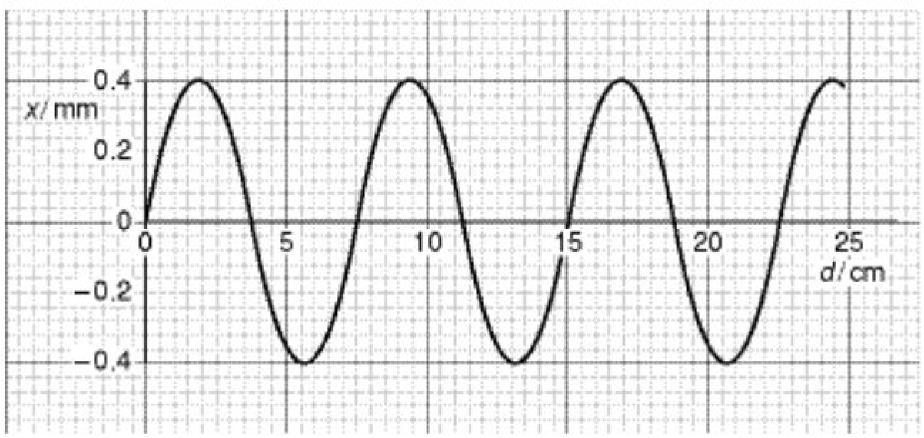


Fig. 4.2

(i) Use Figs. 4.1 and 4.2 to determine, for this wave,

1. the amplitude,

amplitude = ……………………………. mm

2. the wavelength,

wavelength = ……………………………... m

3. the frequency,

frequency = ………………………..……. Hz

4. the speed.

speed = ……………………………… m s^{-1}
[6]

(ii) On Fig. 4.2, draw a second wave having the same amplitude but half the frequency as that shown. [1]

(b) Light of wavelength 590 nm is incident at right angles to a diffraction grating having 5.80×10^5 lines per metre, as illustrated in Fig. 4.3.

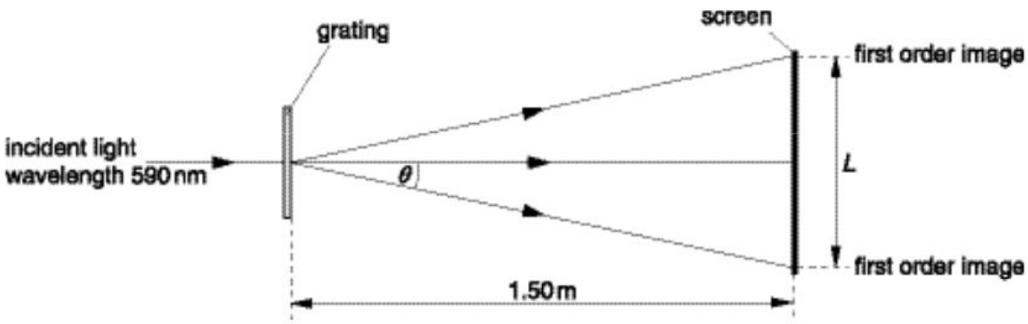


Fig. 4.3

A screen is placed parallel to and 1.50 m from the grating. Calculate

(i) the spacing, in μm, of the lines of the grating,

spacing = ………………………………… μm

(ii) the angle θ to the original direction of the light at which the first order diffracted image is seen,

angle = ………………………………………. °

(iii) the minimum length L of the screen so that both first order diffracted images may be viewed at the same time on the screen.

length = …………………………………….. m
[5]

Q24.

2 The spectrum of electromagnetic waves is divided into a number of regions such as radio waves, visible light and gamma radiation.

For Examiner's Use

(a) State three distinct features of waves that are common to all regions of the electromagnetic spectrum.

1. ....

2. ....

3. .... [3]

(b) A typical wavelength of visible light is 495 nm. Calculate the number of wavelengths of this light in a wave of length 1.00 m.

number = ………………………….. [2]

(c) State a typical wavelength for

(i) X-rays,

wavelength = ………………………….. m

(ii) infra-red radiation.

wavelength = ………………………….. m
[2]

Q25.

4 A string is stretched between two fixed points. It is plucked at its centre and the string vibrates, forming a stationary wave as illustrated in Fig. 4.1.

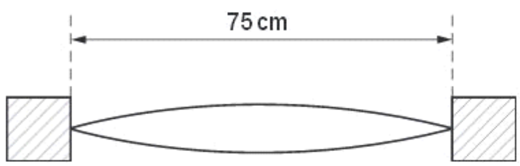


Fig. 4.1

The length of the string is 75 cm.

(a) State the wavelength of the wave.

wavelength = ………………………….. m [1]

(b) The frequency of vibration of the string is 360 Hz. Calculate the speed of the wave on the string.

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

(c) By reference to the formation of the stationary wave on the string, explain what is meant by the speed calculated in **(b)**.

....

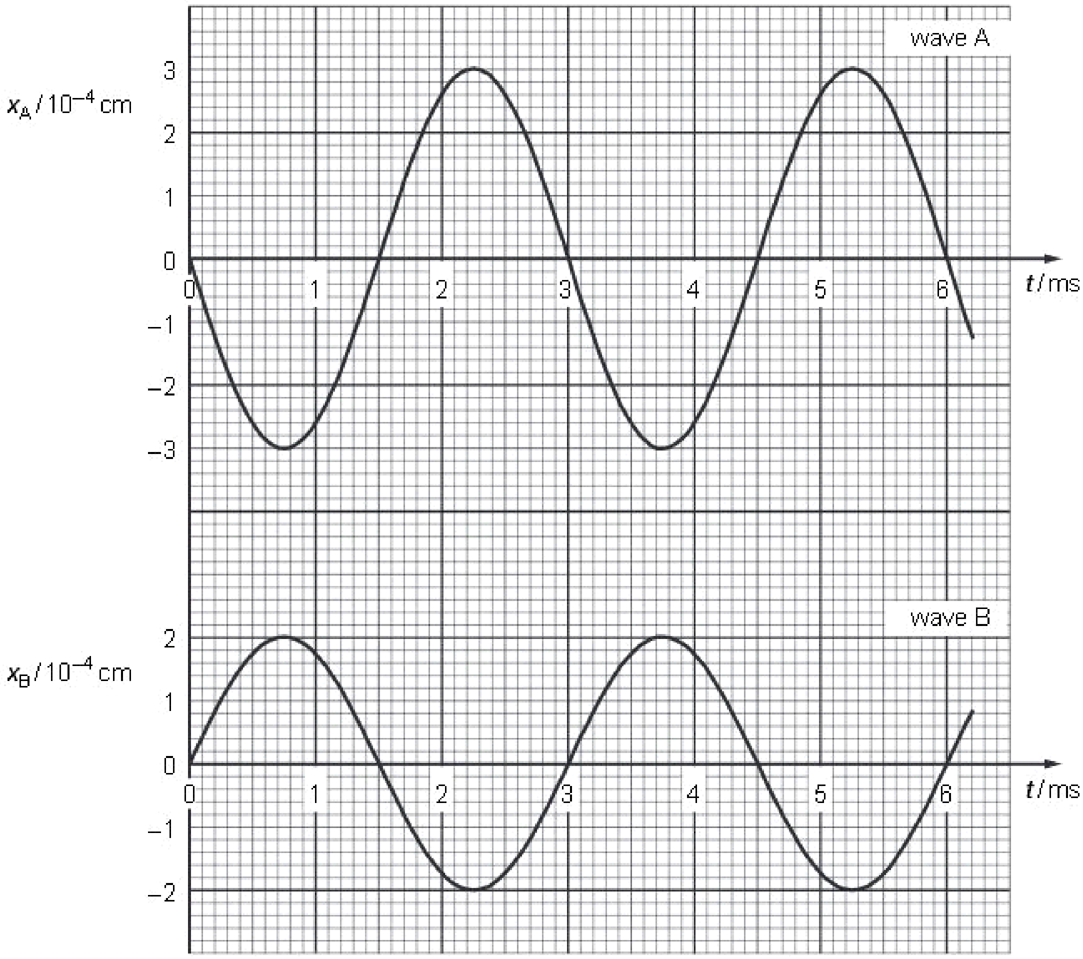
....

.... [3]

Q26.

5 Fig. 5.1 shows the variation with time t of the displacements x_A and x_B at a point P of two sound waves A and B.

Exa



(a) By reference to Fig. 5.1, state one similarity and one difference between these two waves.

similarity: ....

difference: .... [2]

(b) State, with a reason, whether the two waves are coherent.

....

.... [1]

For Examiner's Use

(c) The intensity of wave A alone at point P is I.

(i) Show that the intensity of wave B alone at point P is $\frac{4}{9}I$.

[2]

(ii) Calculate the resultant intensity, in terms of I, of the two waves at point P.

resultant intensity = ………………………………… I [2]

(d) Determine the resultant displacement for the two waves at point P

(i) at time t = 3.0 ms,

resultant displacement = ………………………………… cm [1]

(ii) at time t = 4.0 ms.

resultant displacement = ………………………………… cm [2]

Q27.

4 **(a)** In order that interference between waves from two sources may be observed, the waves must be coherent.

Explain what is meant by

(i) *interference*,

....

....

.... [2]

(ii) *coherence*.

....

.... [1]

(b) Red light of wavelength 644 nm is incident normally on a diffraction grating having 550 lines per millimetre, as illustrated in Fig. 4.1.

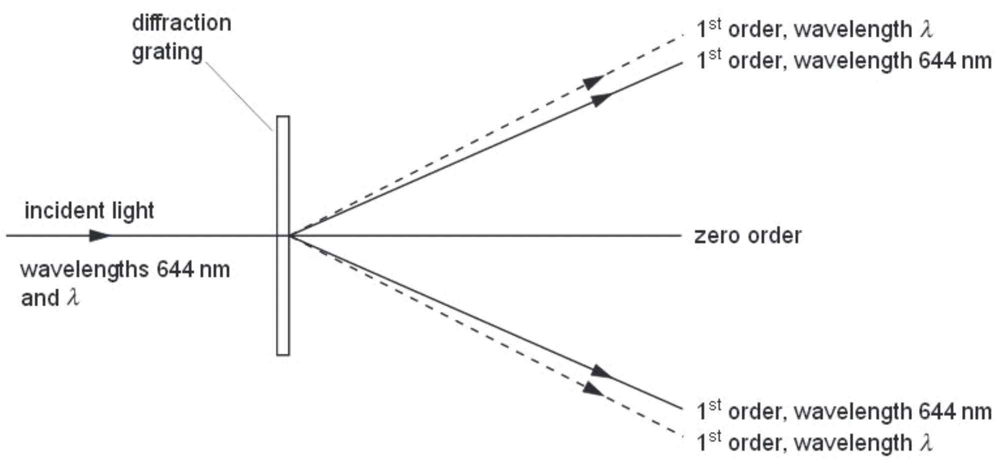


Fig. 4.1

Red light of wavelength λ is also incident normally on the grating. The first order diffracted light of both wavelengths is illustrated in Fig. 4.1.

(i) Calculate the number of orders of diffracted light of wavelength 644 nm that are visible on each side of the zero order.

Ex

number = ... [4]

(ii) State and explain

1. whether λ is greater or smaller than 644 nm,

....

.... [1]

2. in which order of diffracted light there is the greatest separation of the two wavelengths.

....

....

.... [2]

Q28.

5 **(a)** Fig. 5.1 shows the variation with time *t* of the displacement *y* of a wave W as it passes a point P. The wave has intensity I.

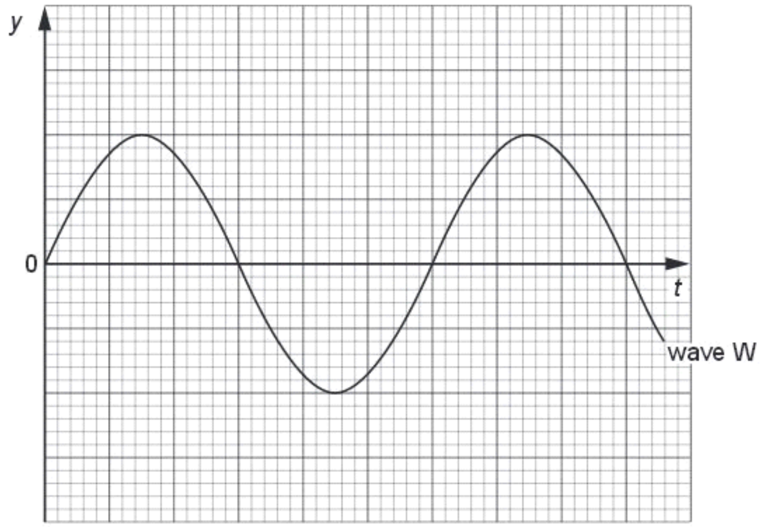


Fig. 5.1

A second wave X of the same frequency as wave W also passes point P.
This wave has intensity $\frac{1}{2}I$. The phase difference between the two waves is 60°.
On Fig. 5.1, sketch the variation with time *t* of the displacement *y* of wave X. [3]

(b) In a double-slit interference experiment using light of wavelength 540 nm, the separation of the slits is 0.700 mm. The fringes are viewed on a screen at a distance of 2.75 m from the double slit, as illustrated in Fig. 5.2 (not to scale).

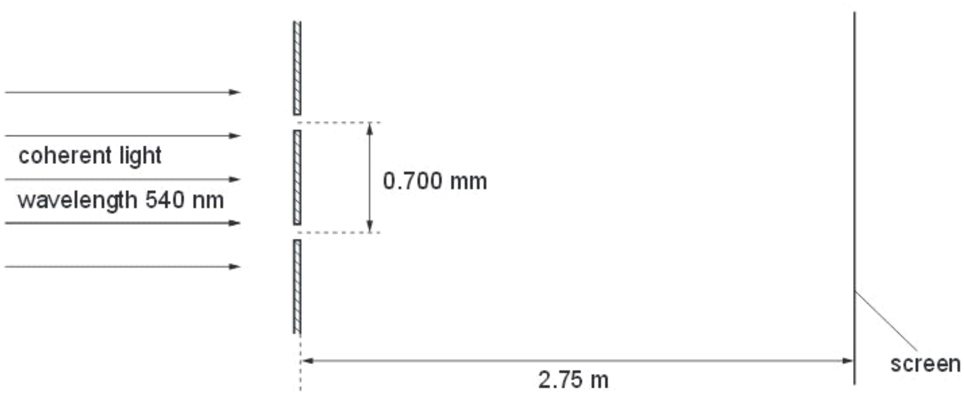


Fig. 5.2

Calculate the separation of the fringes observed on the screen.

separation = ... mm [3]

(c) State the effect, if any, on the appearance of the fringes observed on the screen when the following changes are made, separately, to the double-slit arrangement in **(b)**.

(i) The width of each slit is increased but the separation remains constant.

....

....

....

.... [3]

(ii) The separation of the slits is increased.

....

....

.... [2]

Q29.

6 **(a)** Explain what is meant by the *diffraction* of a wave.

....

....

.... [2]

(b) **(i)** Outline briefly an experiment that may be used to demonstrate diffraction of a transverse wave.

....

....

.... **[3]**

(ii) Suggest how your experiment in **(i)** may be changed to demonstrate the diffraction of a longitudinal wave.

....

....

.... **[3]**

Q30.

5 **(a)** State what is meant by a *progressive wave*.

....

....

.... [2]

(b) The variation with distance x along a progressive wave of a quantity y, at a particular time, is shown in Fig. 5.1.

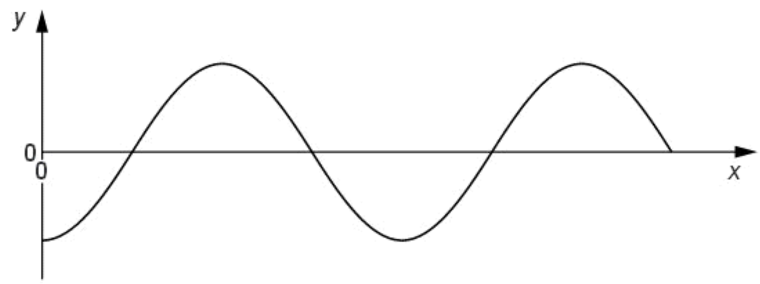


Fig. 5.1

(i) State what the quantity y could represent.

....

.... [1]

(ii) Distinguish between the quantity y for

1. a transverse wave,

....

.... [1]

2. a longitudinal wave.

....

.... [1]

(c) The wave nature of light may be demonstrated using the phenomena of diffraction and interference.

Outline how diffraction and how interference may be demonstrated using light.
In each case, draw a fully labelled diagram of the apparatus that is used and describe what is observed.

diffraction

....

....

....

interference

....

....

....

[6]

Q31.

5 A uniform string is held between a fixed point P and a variable-frequency oscillator, as shown in Fig. 5.1.

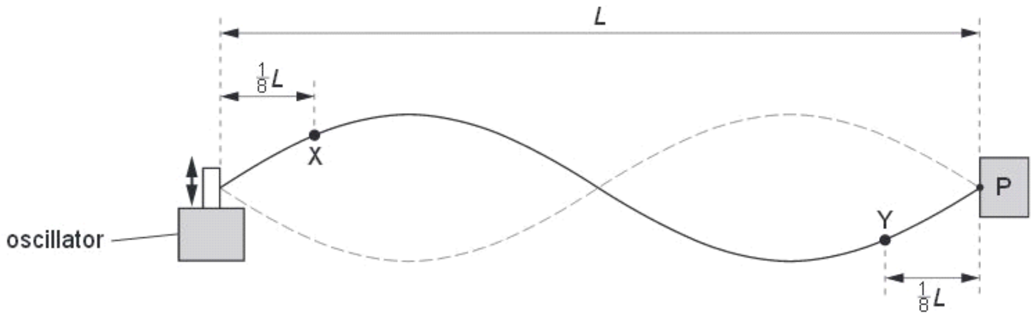


Fig. 5.1

The distance between point P and the oscillator is L.

The frequency of the oscillator is adjusted so that the stationary wave shown in Fig. 5.1 is formed.

Points X and Y are two points on the string.

Point X is a distance $\frac{1}{8}L$ from the end of the string attached to the oscillator. It vibrates with frequency f and amplitude A.

Point Y is a distance $\frac{1}{8}L$ from the end P of the string.

(a) For the vibrations of point Y, state

(i) the frequency (in terms of f),

frequency = ... [1]

(ii) the amplitude (in terms of A).

amplitude = ... [1]

(b) State the phase difference between the vibrations of point X and point Y.

phase difference = ... [1]

(c) (i) State, in terms of *f* and *L*, the speed of the wave on the string.

speed = ... [1]

(ii) The wave on the string is a stationary wave.

Explain, by reference to the formation of a stationary wave, what is meant by the speed stated in **(i)**.

....

....

....

....

.... [3]

For Examiner's Use

Q32.

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

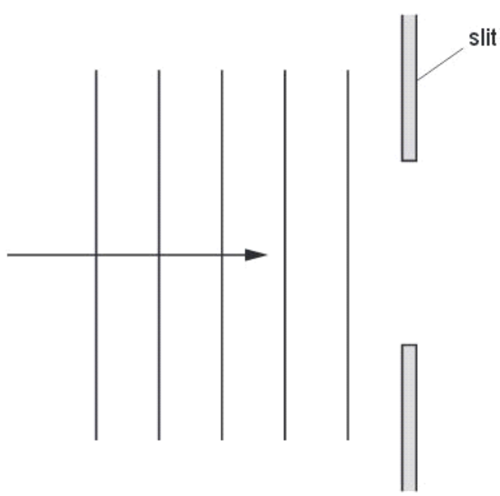
....

....

.... [2]

For Examiner's Use

(b) Plane wavefronts are incident on a slit, as shown in Fig. 5.1.



Complete Fig. 5.1 to show four wavefronts that have emerged from the slit. [2]

(c) Monochromatic light is incident normally on a diffraction grating having 650 lines per millimetre, as shown in Fig. 5.2.

For Examiner's Use

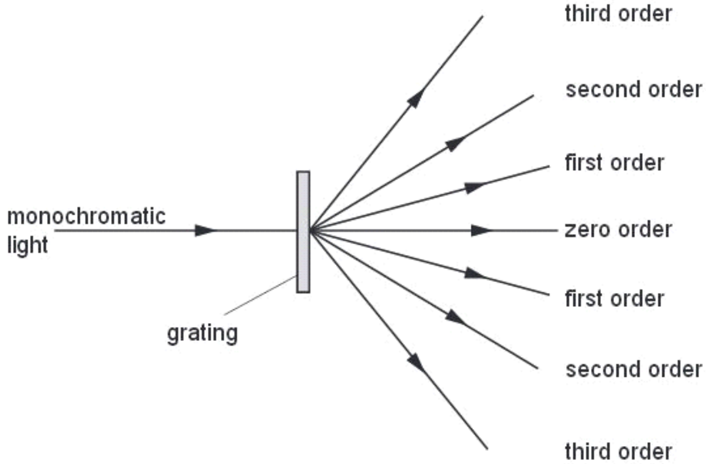


Fig. 5.2

An image (the zero order) is observed for light that has an angle of diffraction equal to zero.

For incident light of wavelength 590 nm, determine the number of orders of diffracted light that can be observed on each side of the zero order.

number = ... [3]

(d) The images in Fig. 5.2 are viewed, starting with the zero order and then with increasing order number.
State how the appearance of the images changes as the order number increases.

....

.... [1]

Q33.

5 A student is studying a water wave in which all the wavefronts are parallel to one another. The variation with time t of the displacement x of a particular particle in the wave is shown in Fig. 5.1.

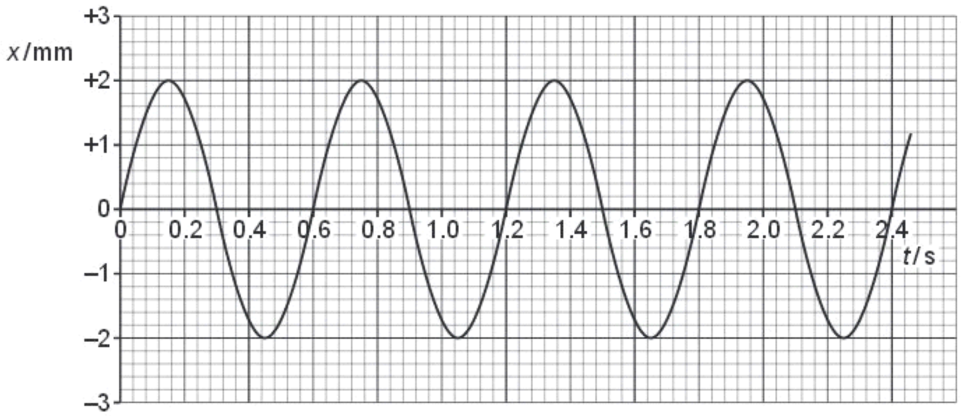


Fig. 5.1

The distance d of the oscillating particles from the source of the waves is measured. At a particular time, the variation of the displacement x with this distance d is shown in Fig. 5.2.

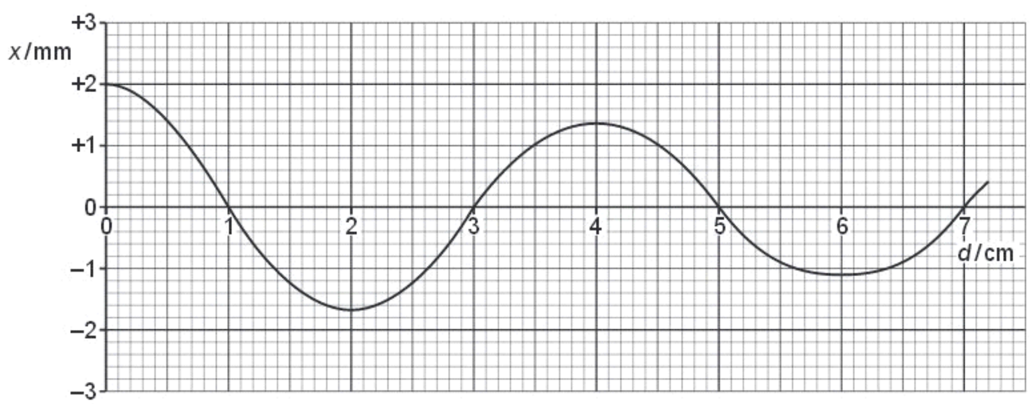


Fig. 5.2

(a) Define, for a wave, what is meant by

(i) *displacement*,

....

....**[1]**

(ii) *wavelength*.

....

....[1]

(b) Use Figs. 5.1 and 5.2 to determine, for the water wave,

(i) the period *T* of vibration,

T = ... s [1]

(ii) the wavelength λ,

λ = ... cm [1]

(iii) the speed *v*.

v = ... cm s^{-1} [2]

(c) **(i)** Use Figs. 5.1 and 5.2 to state and explain whether the wave is losing power as it moves away from the source.

....

....

....[2]

(ii) Determine the ratio

$$\frac{\text{intensity of wave at source}}{\text{intensity of wave 6.0 cm from source}}.$$

ratio = ... [3]

Q34.

3 A loudspeaker produces a sound wave of constant frequency.

Outline how a cathode-ray oscilloscope (c.r.o.) may be used to determine this frequency.

....

....

....

....

.... **[4]**

Ex

Q35.

6 **(a)** State the principle of superposition.

....

....

.... [2]

(b) Coherent light of wavelength 590 nm is incident normally on a double slit, as shown in Fig. 6.1.

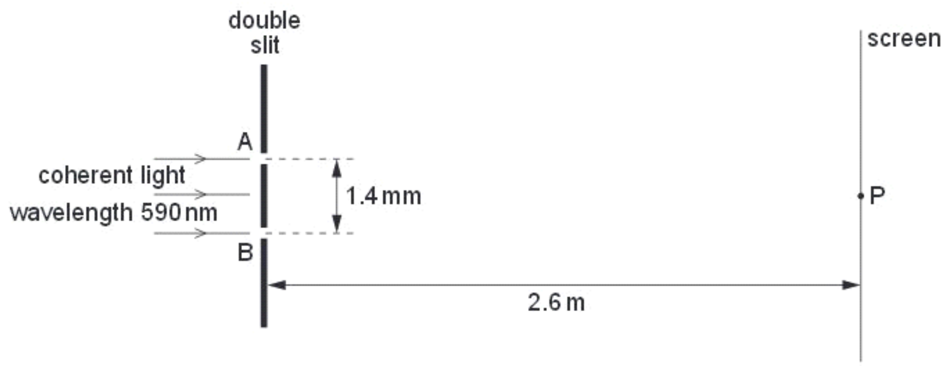


Fig. 6.1 (not to scale)

The separation of the slits A and B is 1.4 mm.
Interference fringes are observed on a screen placed parallel to the plane of the double slit.
The distance between the screen and the double slit is 2.6 m.

At point P on the screen, the path difference is zero for light arriving at P from the slits A and B.

(i) Determine the separation of bright fringes on the screen near to point P.

separation = ... mm [3]

(ii) The variation with time of the displacement x of the light wave arriving at point P on the screen from slit A and from slit B is shown in Fig. 6.2a and Fig. 6.2b respectively.

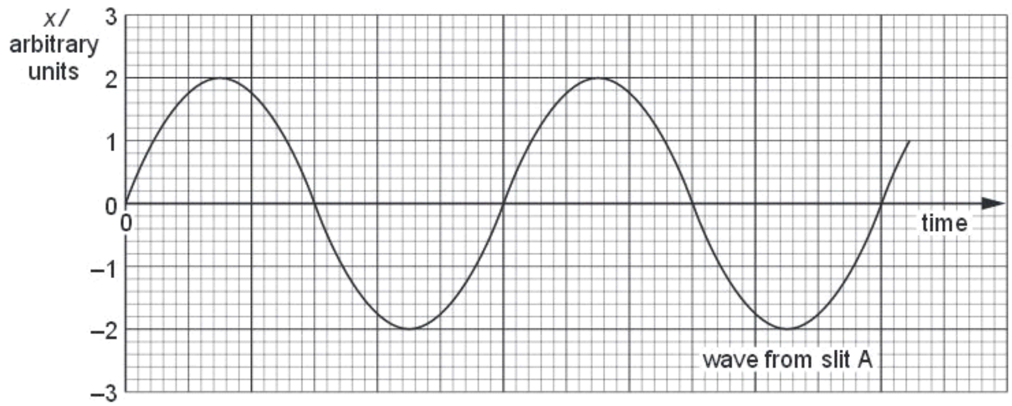


Fig. 6.2a

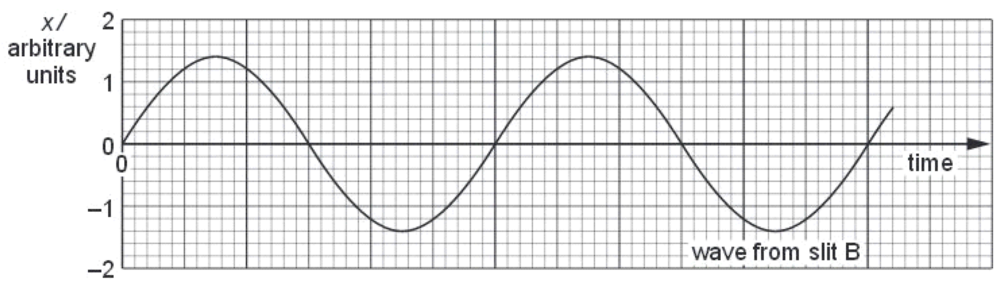


Fig. 6.2b

1. State the phase difference between waves forming the dark fringe on the screen that is next to point P.

phase difference = ... ° **[1]**

2. Determine the ratio

$$\frac{\text{intensity of light at a bright fringe}}{\text{intensity of light at a dark fringe}}.$$

ratio = ... [3]

Q36.

6 (a) State the *principle of superposition*.

For Examiner's Use

....

....

....[2]

(b) An arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.

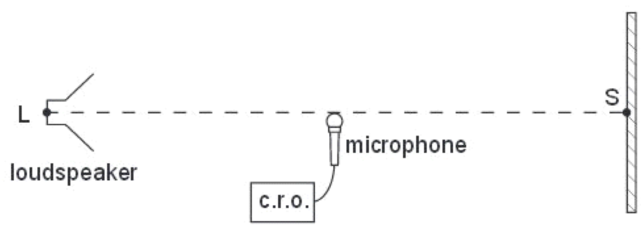


Fig. 6.1

Sound waves of constant frequency are emitted from the loudspeaker L and are reflected from a point S on a hard surface.
The loudspeaker is moved away from S until a stationary wave is produced.

Explain how sound waves from L give rise to a stationary wave between L and S.

....

....

.... [2]

(c) A microphone connected to a cathode ray oscilloscope (c.r.o.) is positioned between L and S as shown in Fig. 6.1. The trace obtained on the c.r.o. is shown in Fig. 6.2.

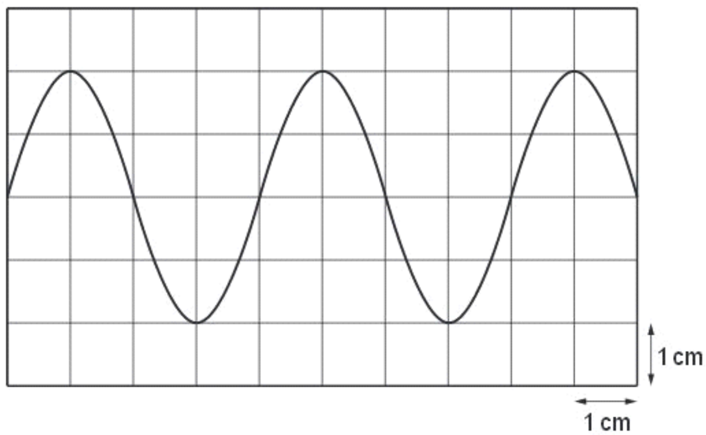


Fig. 6.2

The time-base setting on the c.r.o. is 0.10 ms cm^{-1}.

(i) Calculate the frequency of the sound wave.

For Examiner's Use

frequency = ... Hz [2]

(ii) The microphone is now moved towards S along the line LS. When the microphone is moved 6.7 cm, the trace seen on the c.r.o. varies from a maximum amplitude to a minimum and then back to a maximum.

1. Use the properties of stationary waves to explain these changes in amplitude.

....

....

.... [1]

2. Calculate the speed of sound.

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

Q37.

5 **(a)** By reference to vibrations of the points on a wave and to its direction of energy transfer, distinguish between transverse waves and longitudinal waves.

For Examiner Use

....

....

....

....[2]

(b) Describe what is meant by a *polarised* wave.

....

....

....[2]

(c) The variation with distance x of the displacement y of a transverse wave is shown in Fig. 5.1.

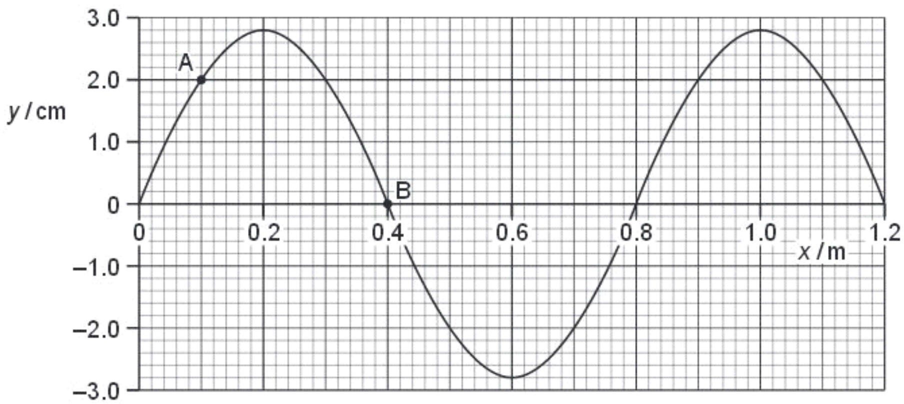


Fig. 5.1

(i) Use Fig. 5.1 to determine

1. the amplitude of the wave,

amplitude = ... cm [1]

2. the phase difference between the points labelled A and B.

phase difference = ...[2]

(ii) Determine the amplitude of a wave with twice the intensity of that shown in Fig. 5.1.

For Examiner's Use

amplitude = ... cm [1]

Q38.

4 (a) Describe the diffraction of monochromatic light as it passes through a diffraction grating.

....

....

.... [2]

(b) White light is incident on a diffraction grating, as shown in Fig. 4.1.

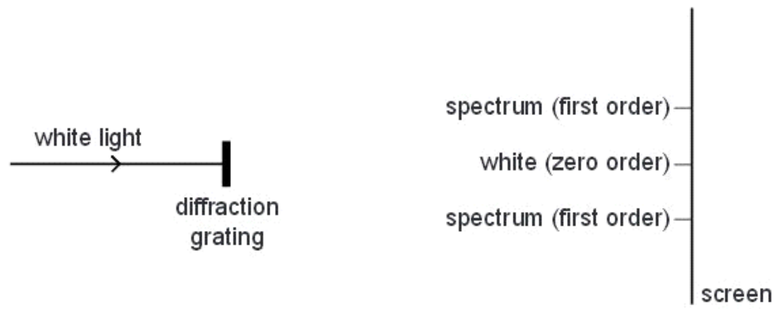


Fig. 4.1 (not to scale)

The diffraction pattern formed on the screen has white light, called zero order, and coloured spectra in other orders.

(i) Describe how the principle of superposition is used to explain

1. white light at the zero order,

....

....

.... [2]

2. the difference in position of red and blue light in the first-order spectrum.

....

....

.... [2]

(ii) Light of wavelength 625 nm produces a second-order maximum at an angle of 61.0° to the incident direction.
Determine the number of lines per metre of the diffraction grating.

For Examiner's Use

number of lines = ... m^{-1} [2]

(iii) Calculate the wavelength of another part of the visible spectrum that gives a maximum for a different order at the same angle as in **(ii)**.

wavelength = ……………………..……..nm [2]

Q39.

4 Fig. 4.1 shows an arrangement for producing stationary waves in a tube that is closed at one end.

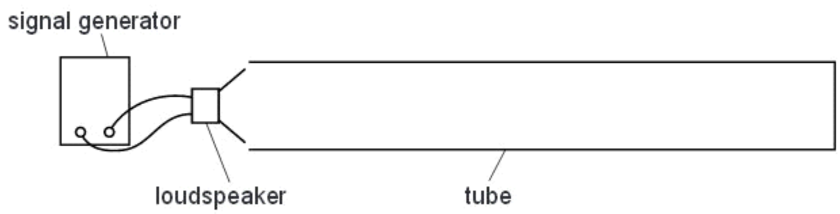


Fig. 4.1

(a) Explain how waves from the loudspeaker produce stationary waves in the tube.

....

....

....

....

....[3]

(b) One of the stationary waves that may be formed in the tube is represented in Fig. 4.2.

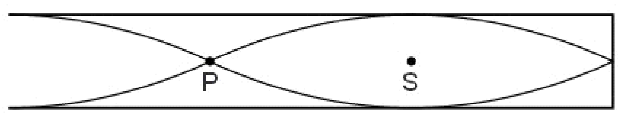


Fig. 4.2

(i) Describe the motion of the air particles in the tube at

1. point P,

....[1]

2. point S.

....[1]

(ii) The speed of sound in the tube is $330\,m\,s^{-1}$ and the frequency of the waves from the loudspeaker is 880 Hz. Calculate the length of the tube.

length = ... m [3]

Q40.

5 (a) State one property of electromagnetic waves that is **not** common to other transverse waves.

.... [1]

(b) The seven regions of the electromagnetic spectrum are represented by blocks labelled A to G in Fig. 5.1.

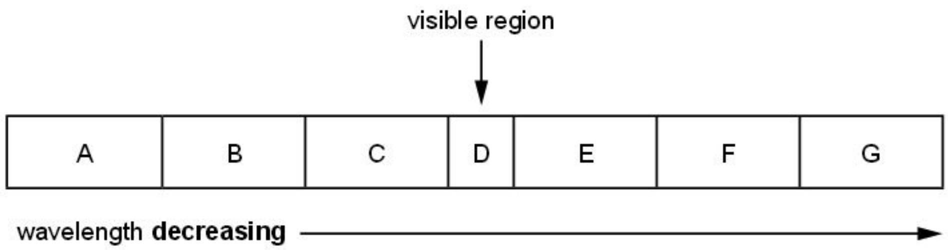


Fig. 5.1

A typical wavelength for the visible region D is 500 nm.

(i) Name the principal radiations and give a typical wavelength for each of the regions B, E and F.

B: name: .... wavelength: .... m

E: name: .... wavelength: .... m

F: name: .... wavelength: .... m
[3]

(ii) Calculate the frequency corresponding to a wavelength of 500 nm.

frequency = ... Hz [2]

(c) All the waves in the spectrum shown in Fig. 5.1 can be polarised. Explain the meaning of the term *polarised*.

....

....

....

.... [2]

Q41.

5 A long rope is held under tension between two points A and B. Point A is made to vibrate vertically and a wave is sent down the rope towards B as shown in Fig. 5.1.

For Examiner's Use

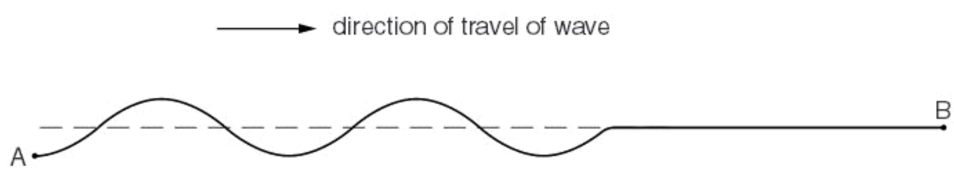


Fig. 5.1 (not to scale)

The time for one oscillation of point A on the rope is 0.20 s. The point A moves a distance of 80 mm during one oscillation. The wave on the rope has a wavelength of 1.5 m.

(a) (i) Explain the term *displacement* for the wave on the rope.

....

....[1]

(ii) Calculate, for the wave on the rope,

1. the amplitude,

amplitude = ... mm [1]

2. the speed.

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

(b) On Fig. 5.1, draw the wave pattern on the rope at a time 0.050 s later than that shown. [2]

(c) State and explain whether the waves on the rope are

(i) progressive or stationary,

....

....[1]

(ii) longitudinal or transverse.

....

....[1]

Q42.

5 (a) (i) Define, for a wave,

Ex

1. wavelength λ,

....

....[1]

2. frequency f.

....

....[1]

(ii) Use your definitions to deduce the relationship between λ, f and the speed v of the wave.

[1]

(b) Plane waves on the surface of water are represented by Fig. 5.1 at one particular instant of time.

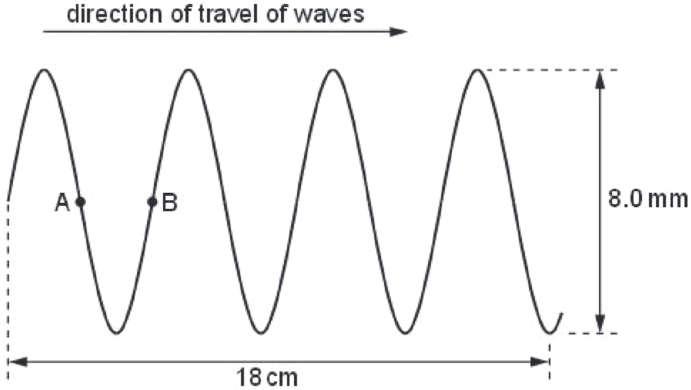


Fig. 5.1 (not to scale)

The waves have frequency 2.5 Hz.

Determine, for the waves,

(i) the amplitude,

amplitude = ... mm [1]

(ii) the speed,

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

(iii) the phase difference between points A and B.

phase difference = ... unit .... [1]

(c) The wave in **(b)** was produced in a ripple tank. Describe briefly, with the aid of a sketch diagram, how the wave may be observed.

....

....

....