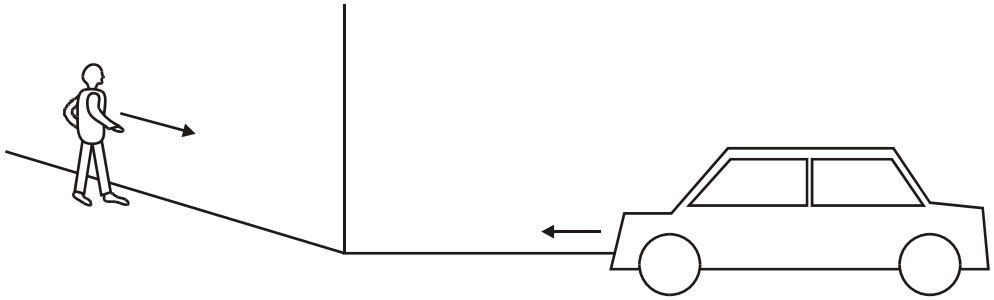
1. A person is walking along one side of a building and a car is driving along another side of the building.



The person can hear the car approach but cannot see it. This is explained by the fact that sound waves

A. travel more slowly than light waves.

B. are diffracted more at the corner of the building than light waves.

C. are refracted more at the corner of the building than light waves.

D. are longitudinal waves.

(1)

2. In a double-slit experiment using light of wavelength λ, 3 fringe spacings are observed per centimetre on the screen. When light of wavelength $\frac{\lambda}{2}$ is used, the number of fringe spacings observed per centimetre is

A. $\frac{2}{3}$.

B. $\frac{3}{2}$.

C. 3.

D. 6.

(1)

3. Two lamps producing light of the same colour are placed close to one another. A two source interference pattern is not observed because

A. the lamps do not emit light of a single frequency.

B. the phase difference between the light from the lamps is continually changing.

C. the intensity of the light emitted by the lamps is not the same.

D. the two lamps are not exact point sources.

(1)

4. The waves from two light sources meet at a point. Which condition is essential for interference to be observed?

A. Constant phase difference between the waves

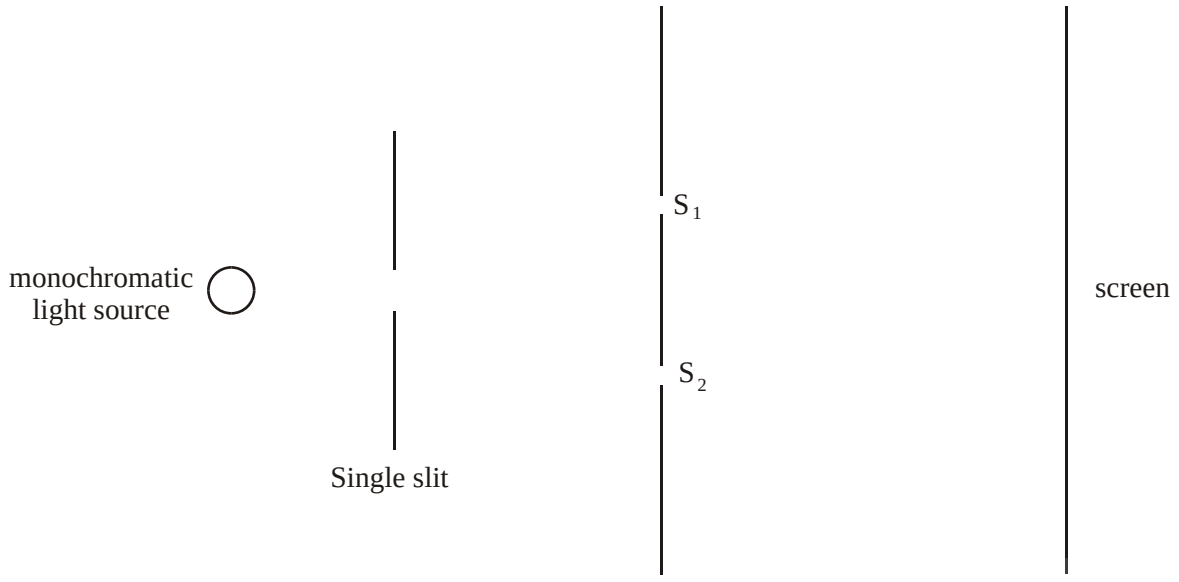
B. Equal amplitude of the waves

C. Equal frequency of the waves

D. Equal intensities of the waves

(1)

5. In the diagram below (which is not to scale), monochromatic light from a single narrow slit falls on two narrow slits S_1 and S_2. A system of interference fringes is observed on the screen.

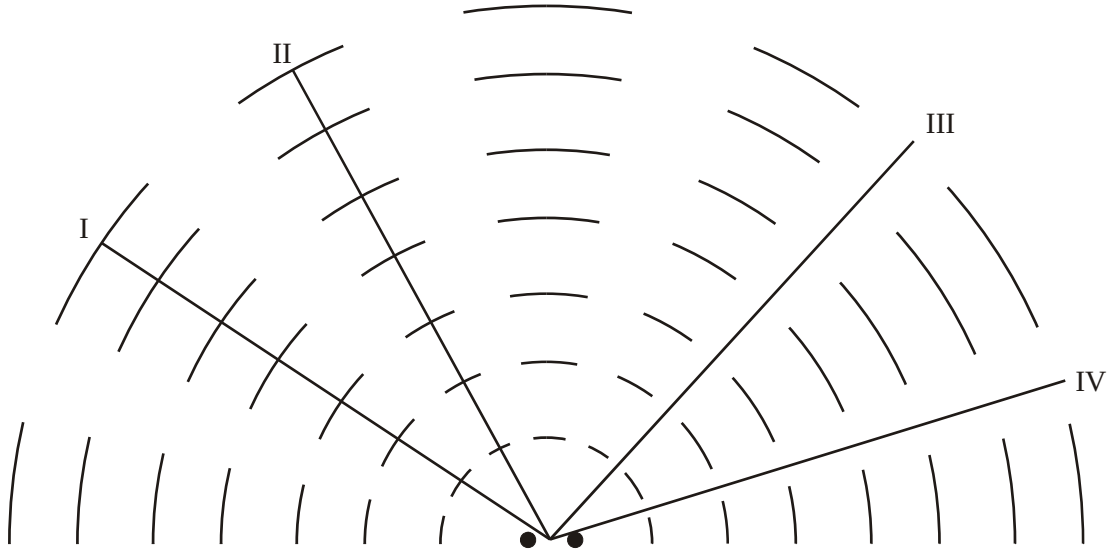


When the screen is moved further away from S_1 and S_2, which **one** of the following correctly describes what happens to the intensity of the bright fringes and the spacing of the bright fringes?

	Intensity of the bright fringes	Spacing of the bright fringes
A.	stays the same	increases
B.	stays the same	decreases
C.	decreases	increases
D.	decreases	decreases

(1)

6. Two identical sources in a ripple tank generate waves of wavelength λ. The interfering waves produce the wave pattern shown below.



Along which of the labelled lines is the path difference between the waves from the sources equal to 1.5 λ?

A. I

B. II

C. III

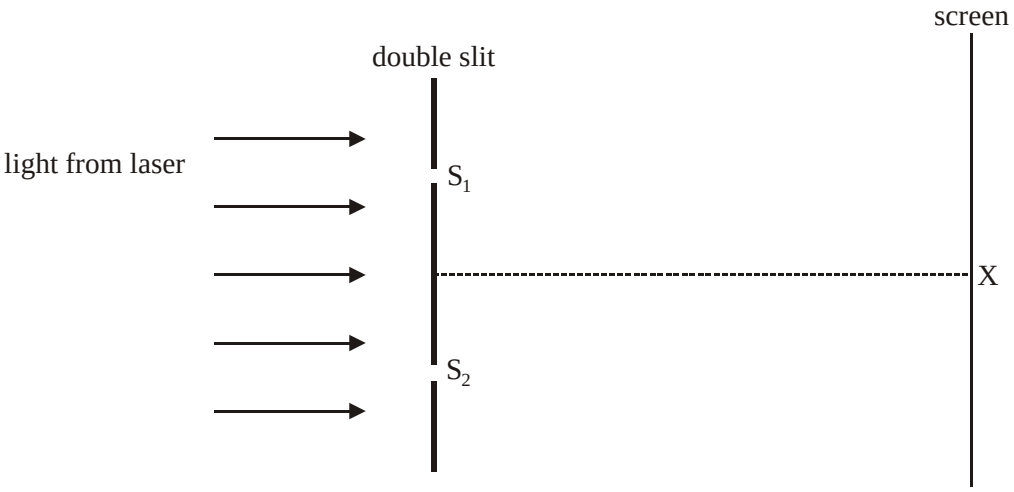
D. IV

(1)

7. This question is about the wave properties of light and electrons.

The diagram below (not to scale) is an arrangement for observing the interference pattern produced on a screen when the light from two narrow slits S1 and S2 overlaps. A beam of light from a laser is incident on the slits and after passing through the slits, the light is incident on a screen. The separation between the slits is large compared to the width of the slits and the distance between the slits and the screen is large compared to the slit separation.

The point X on the screen is equidistant from S_1 and S_2.



(a) Explain why an interference pattern will not be observed on the screen if the laser is replaced with a tungsten filament lamp.

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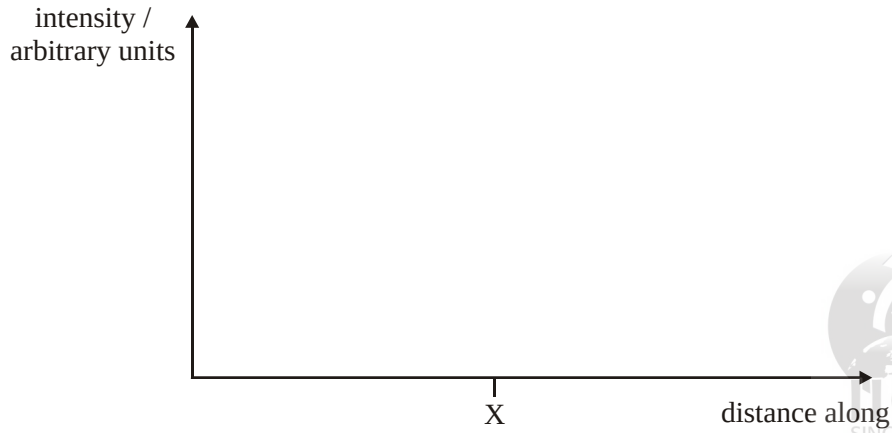
(b) On the axes below, draw a sketch-graph to show how the intensity of the observed interference pattern varies with distance along the screen.



(c) The wavelength of the light from the laser is 633 nm and the angular separation of the bright fringes on the screen is 4.00×10^{-4} rad. Calculate the distance between S_1 and S_2.

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(3)

(d) Consider now a "thought" experiment in which the light from the laser is replaced by a beam of electrons that has been accelerated from rest through a potential difference V.

Deduce that the de Broglie wavelength λ of the electrons is

$$\lambda = \frac{h}{\sqrt{2m_e Ve}}$$

where h is the Planck constant, m_e the electron mass and e the electron charge.

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(3)

(e) The electron beam is accelerated from rest through a potential difference of 400 V. Calculate the separation of S_1 and S_2 such that the angular separation of the electron interference fringes is 4.00×10^{-4} rad.

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(2)

(Total 12 marks)

8. This question is about the interference of waves.

(a) State the principle of superposition.

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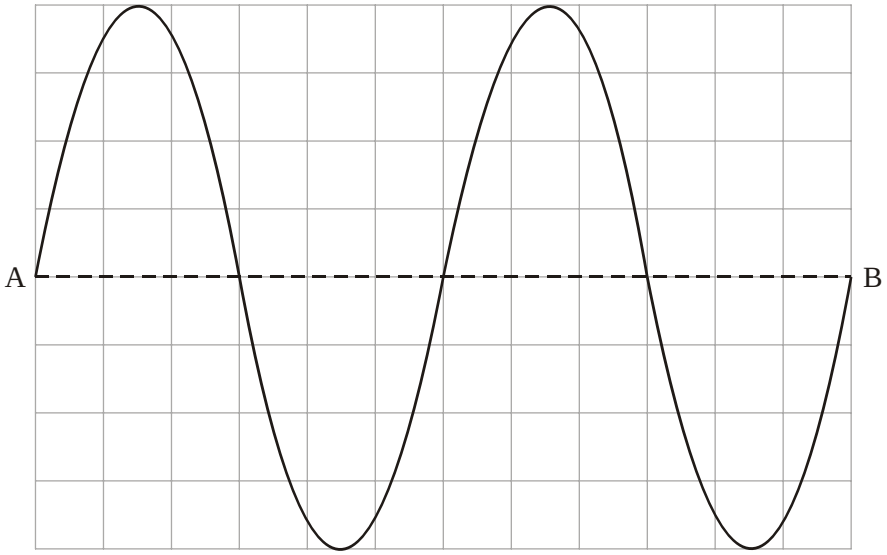
(2)

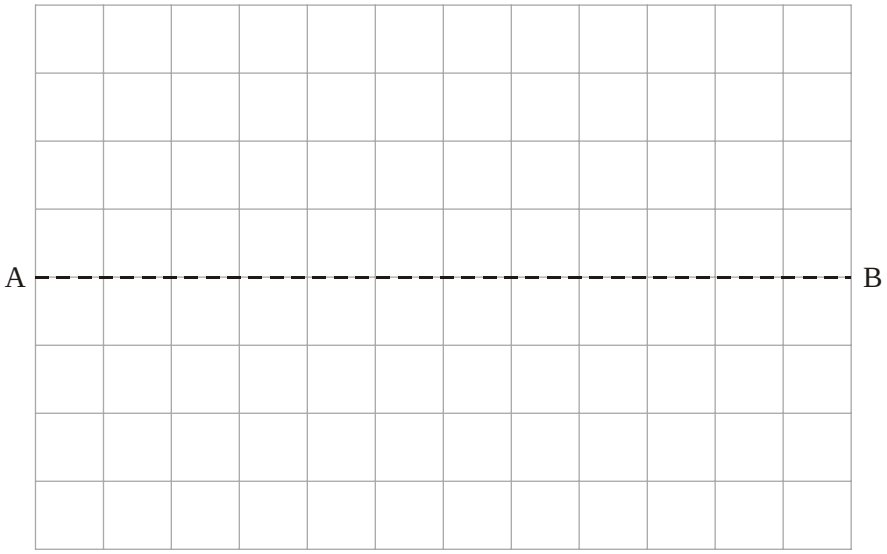
A wire is stretched between two points A and B.

A standing wave is set up in the wire. This wave can be thought of as being made up from the superposition of two waves, a wave X travelling from A to B and a wave Y travelling from B to A. At one particular instant in time, the displacement of the wire is as shown. A background grid is given for reference and the equilibrium position of the wire is shown as a dotted line.

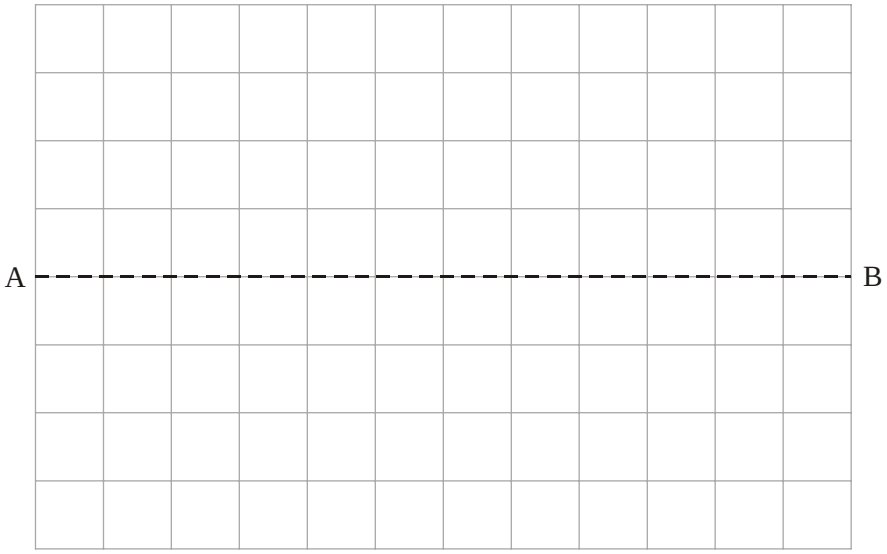


(b) On the grids below, draw the displacement of the wire due to wave X and wave Y.

Wave X

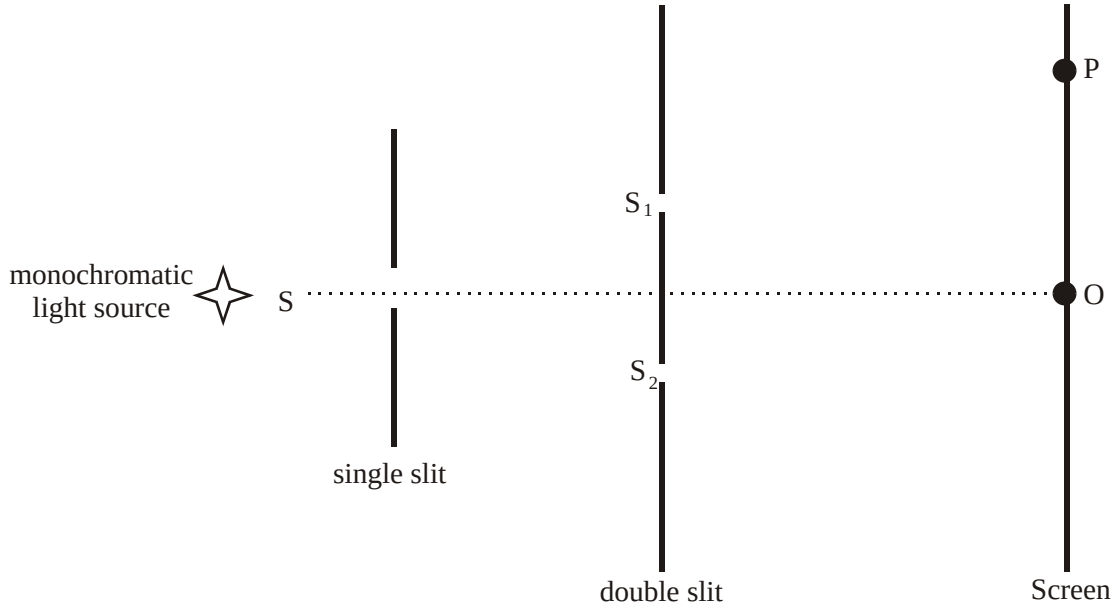


Wave Y



(4)

The diagram below shows an arrangement (not to scale) for observing the interference pattern produced by the superposition of two light waves.



S_1 and S_2 are two very narrow slits. The single slit S ensures that the light leaving the slits S_1 and S_2 is coherent.

(c) (i) Define *coherent*.

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(1)

(ii) Explain why the slits S_1 and S_2 need to be very narrow.

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(2)

The point O on the diagram is equidistant from S_1 and S_2 and there is maximum constructive interference at point P on the screen. There are no other points of maximum interference between O and P.

(d) (i) State the condition necessary for there to be maximum constructive interference at the point P.

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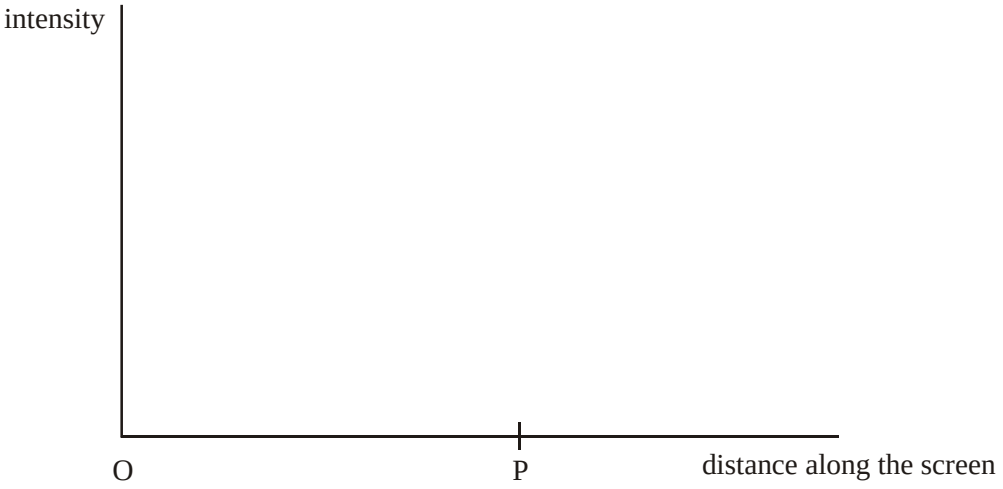
(ii) On the axes below, draw a graph to show the variation of intensity of light on the screen between the points O and P.



(2)

(e) In this particular arrangement, the distance between the double slit and the screen is 1.50 m and the separation of S_1 and S_2 is 3.00×10^{-3} m.

The distance OP is 0.25 mm. Determine the wavelength of the light.

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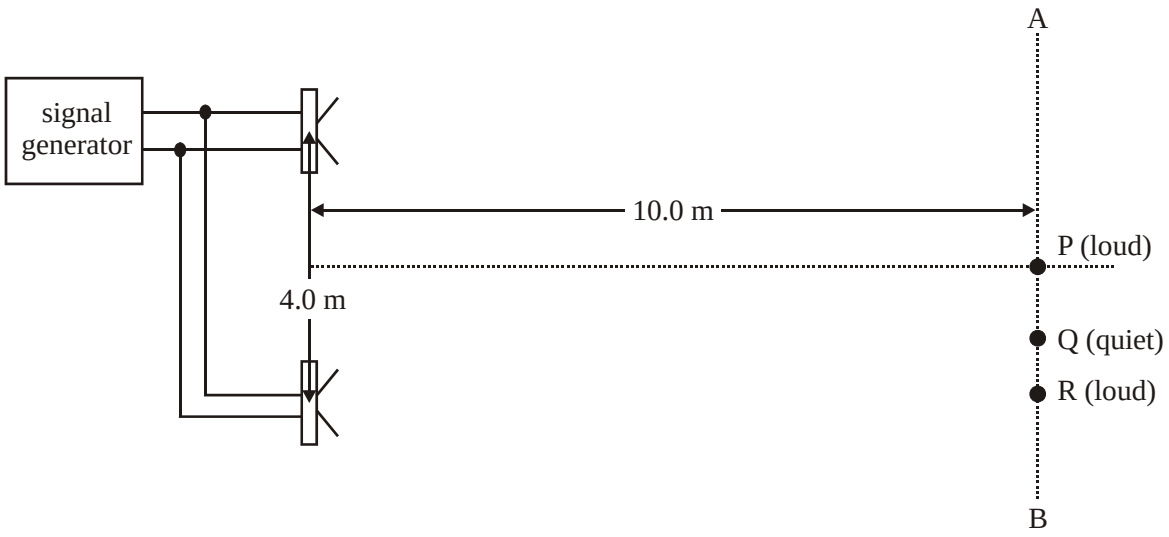
(2)

(Total 14 marks)

9. This question is about sound waves.

In order to demonstrate two-source interference of sound waves, two loudspeakers are connected to the same output of a signal generator. The loudspeakers are fixed 4.0 m apart.

In the diagram below, the line AB is parallel to the loudspeakers and at a distance of 10.0 m from the loudspeakers. Point P is midway between the loudspeakers.



Katerina walks along the line AB carrying a microphone connected to a detector. She registers a sound that alternates in intensity from loud to quiet.

(a) Describe the conditions necessary for a sound of minimum intensity to be registered at Q.

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(3)

As Katerina runs along the line AB she counts the number of loud sounds registered in a given time. The frequency of the sound emitted by both loudspeakers is 360 Hz and the speed of sound in air is 330 ms^{-1}.

(b) Estimate the speed at which she is running if the maximum sounds occur with a frequency of about 2 Hz.

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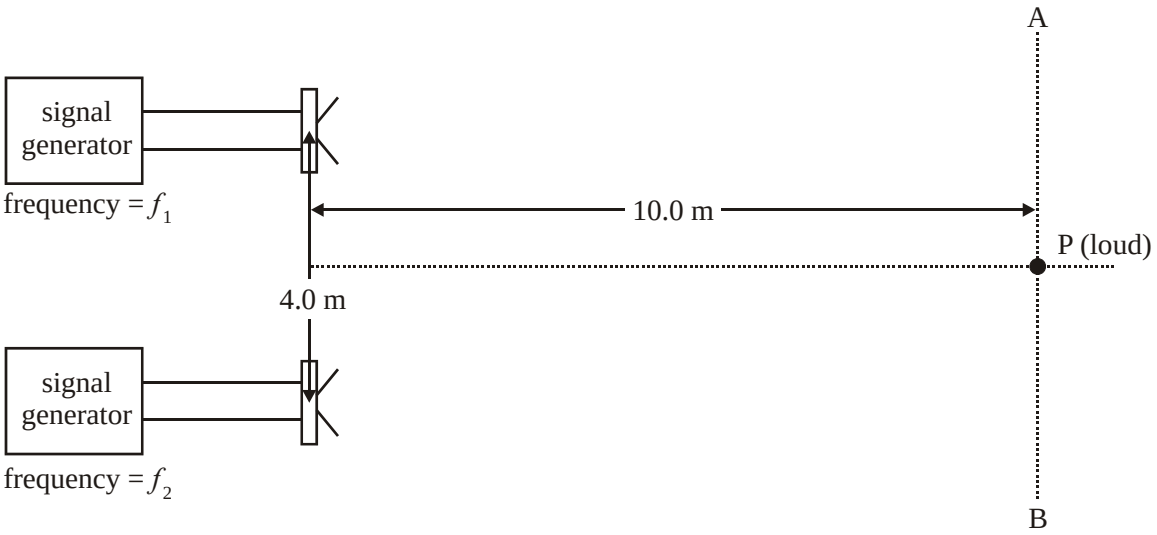
(6)

One of the loudspeakers is now disconnected from the source and connected to another signal generator as shown below.



(c) The frequencies of **both** generators are altered. With this new arrangement, Katerina now stands at the point P and registers a sound of frequency 360 Hz that varies in amplitude at a frequency of 2.0 Hz. Explain quantitatively how this observation arises.

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(3)

(Total 12 marks)

10. This question is about wave properties and interference.

The diagram below represents the direction of oscillation of a disturbance that gives rise to a wave.

(a) By redrawing the diagram in the spaces below, add arrows to show the direction of wave energy transfer to illustrate the difference between

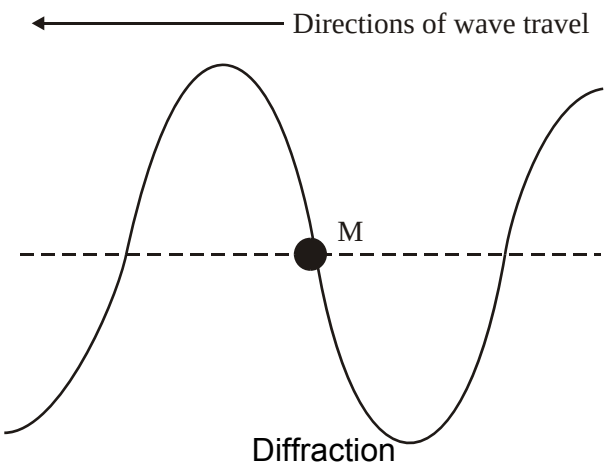
(i) a transverse wave and

(1)

(ii) a longitudinal wave.

(1)

A wave travels along a stretched string. The diagram below shows the variation with distance along the string of the displacement of the string at a particular instant in time. A small marker is attached to the string at the point labelled M. The undisturbed position of the string is shown as a dotted line.



(b) On the diagram above

(i) draw an arrow to indicate the direction in which the marker is moving.

(1)

(ii) indicate, with the letter A, the amplitude of the wave.

(1)

(iii) indicate, with the letter λ, the wavelength of the wave.

(1)

(iv) draw the displacement of the string a time $\frac{T}{4}$ later, where T is the period of oscillation of the wave. Indicate, with the letter N, the new position of the marker.

(2)

The wavelength of the wave is 5.0 cm and its speed is 10 cm s^{-1}.

(c) Determine

(i) the frequency of the wave.

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(1)

(ii) how far the wave has moved in $\frac{T}{4}$ s.

Interference of waves

(d) By reference to the principle of superposition, explain what is meant by constructive interference.

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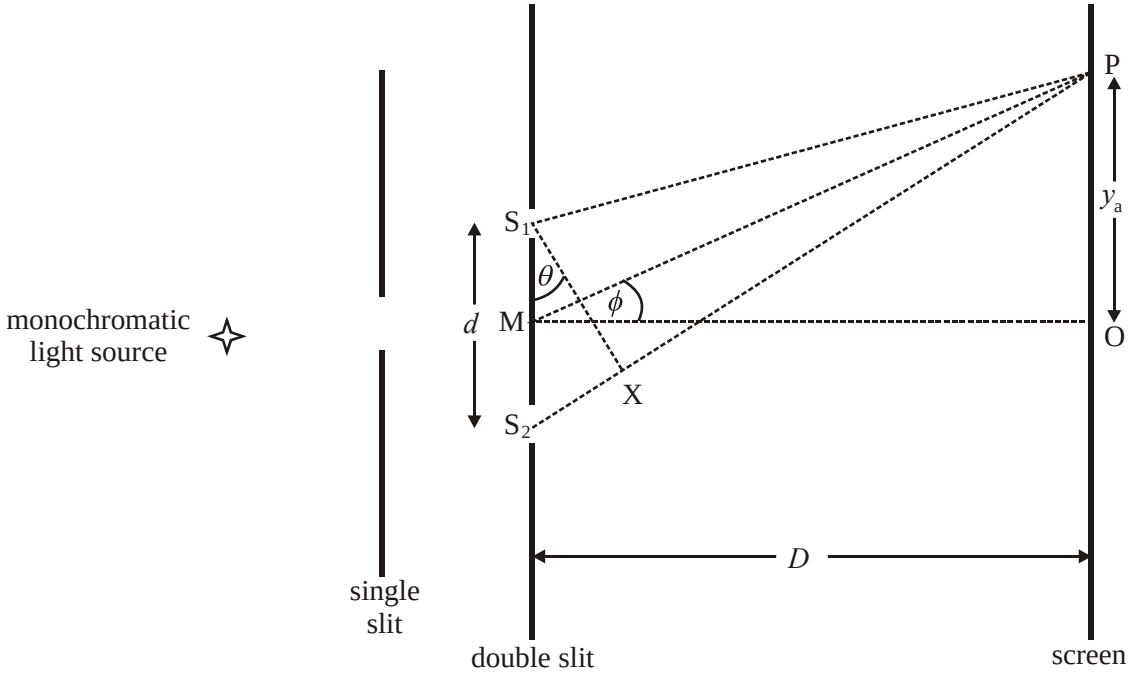
The diagram below (not drawn to scale) shows an arrangement for observing the interference pattern produced by the light from two narrow slits S_1 and S_2.



The distance S_1S_2 is d, the distance between the double slit and screen is D and $D \gg d$ such that the angles θ and ϕ shown on the diagram are small. M is the mid-point of S_1S_2 and it is observed that there is a bright fringe at point P on the screen, a distance y_n from point O on the screen. Light from S_2 travels a distance S_2X further to point P than light from S_1

(e) (i) State the condition in terms of the distance S_2X and the wavelength of the light λ, for there to be a bright fringe at P.

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(2)

(ii) Deduce an expression for θ in terms of S_2X and d.

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(iii) Deduce an expression for ϕ in terms of D and y_n.

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(1)

For a particular arrangement, the separation of the slits is 1.40 mm and the distance from the slits to the screen is 1.50 m. The distance y_n is the distance of the eighth bright fringe from O and the angle $\theta = 2.70 \times 10^{-3}$ rad.

(f) Using your answers to (e) to determine

(i) the wavelength of the light.

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(2)

(ii) the separation of the fringes on the screen.

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(3)

(Total 24 marks)