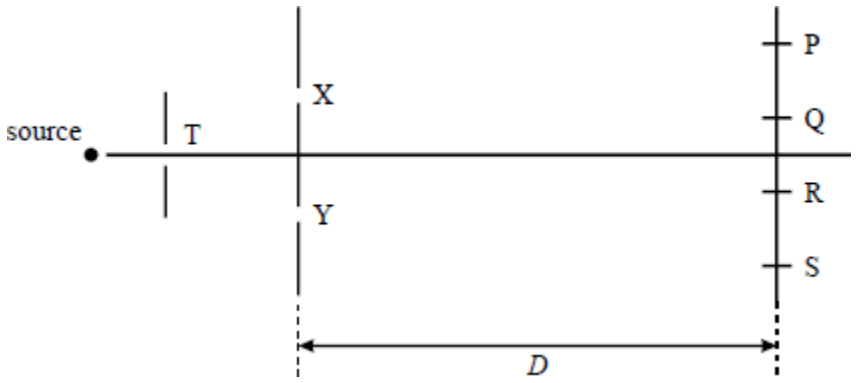
1



Coherent monochromatic light of wavelength λ emerges from the slits X and Y to form dark fringes at P, Q, R and S in a double slit apparatus. Which one of the following statements is true?

A When the distance D is increased, the separation of the fringes increases.

B When the distance between X and Y is increased, the separation of the fringes increases.

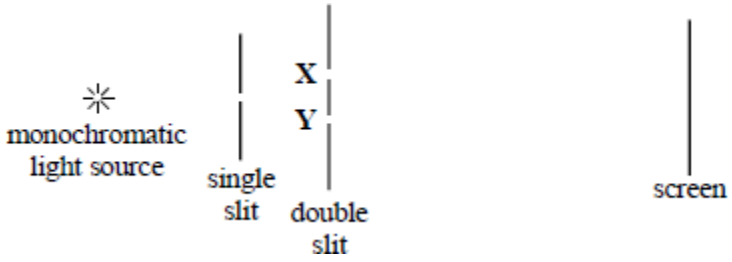
C When the width of the slit T is decreased, the separation of the fringes decreases.

D There is a dark fringe at P because (YP − XP) is 2λ .

(Total 1 mark)

2

The diagram represents the experimental arrangement used to produce interference fringes in Young's double slit experiment.



The spacing of the fringes on the screen will increase if

A the width of the single slit is increased

B the distance **XY** between the two slits is increased

C a light source of lower frequency is used

D the distance between the single and double slits is decreased

(Total 1 mark)

3 Young's two slit interference pattern with red light of wavelength 7.0×10^{-7} m gives a fringe separation of 2.0 mm.

What separation, in mm, would be observed at the same place using blue light of wavelength 4.5×10^{-7} m?

A 0.65

B 1.3

C 2.6

D 3.1

(Total 1 mark)

4 Interference maxima produced by a double source are observed at a distance of 1.0 m from the sources. In which one of the following cases are the maxima closest together?

A red light of wavelength 700 nm from sources 4.0 mm apart

B sound waves of wavelength 20 mm from sources 50 mm apart

C blue light of wavelength 450 nm from sources 2.0 mm apart

D surface water waves of wavelength 10 mm from sources 200 mm apart

(Total 1 mark)

5 In a double slit interference arrangement the fringe spacing is w when the wavelength of the radiation is λ, the distance between the double slits is s and the distance between the slits and the plane of the observed fringes is D. In which one of the following cases would the fringe spacing also be w?

	wave length	distance between slits	distance between slits and fringes
A	2λ	$2s$	$2D$
B	2λ	$4s$	$2D$
C	2λ	$2s$	$4D$
D	4λ	$2s$	$2D$

(Total 1 mark)

6 Interference fringes, produced by monochromatic light, are viewed on a screen placed a distance D from a double slit system with slit separation s. The distance between the centres of two adjacent fringes (the fringe separation) is w. If both s and D are doubled, what will be the new fringe separation?

A $\frac{w}{4}$

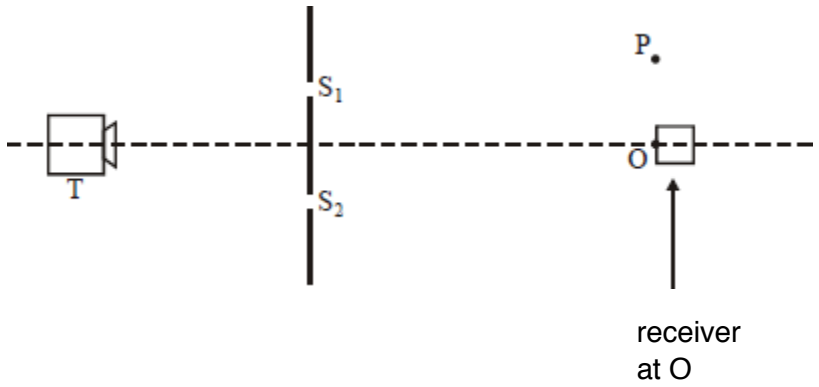
B w

C $2w$

D $4w$

(Total 1 mark)

7 The diagram shows a microwave transmitter T which directs microwaves of wavelength eat two slits S_1 and S_2 formed by metal plates. The microwaves that pass through the two slits are detected by a receiver.



When the receiver is moved to P from O, which is equidistant from S_1 and S_2, the signal received decreases from a maximum to a minimum. Which one of the following statements is a correct deduction from this observation?

A The path difference $S_1O - S_2O = 0.5\,\lambda$

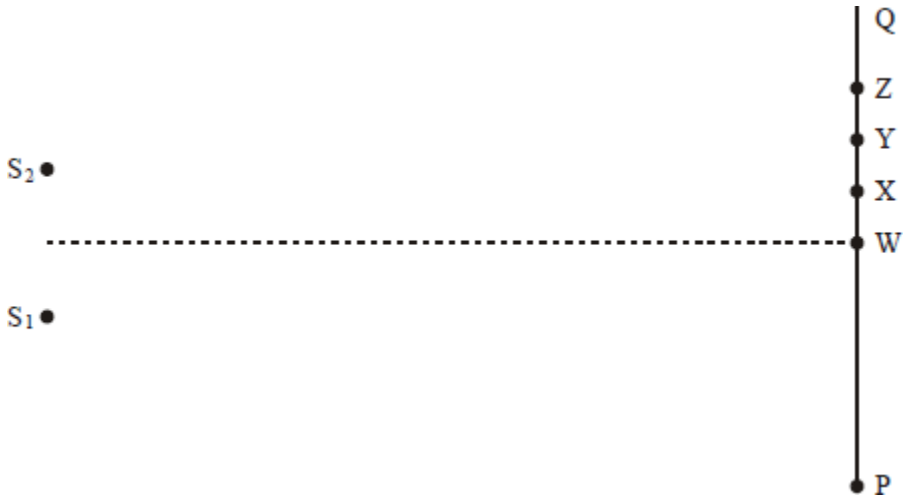
B The path difference $S_1O - S_2O = \lambda$

C The path difference $S_1P - S_2P = 0.5\,\lambda$

D The path difference $S_1P - S_2P = \lambda$

(Total 1 mark)

8



Point sources of sound of the same frequency are placed at S_1 and S_2. When a sound detector is slowly moved along the line PQ, consecutive maxima of sound intensity are detected at W and Y and consecutive minima at X and Z. Which one of the following is a correct expression for the wavelength of the sound?

A $S_1X - S_1W$

B $S_1Y - S_1X$

C $S_1X - S_2X$

D $S_1Y - S_2Y$

(Total 1 mark)

9

A laser illuminates a pair of slits of separation 0.24 mm. The wavelength of light from the laser is 6.3×10^{-7} m. Interference fringes are observed on a screen 4.3 m from the slits.

(a) Calculate the fringe separation. Give an appropriate unit for your answer.

fringe separation .....

(3)

(b) State the conditions necessary for two light sources to be coherent.

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(2)
(Total 5 marks)

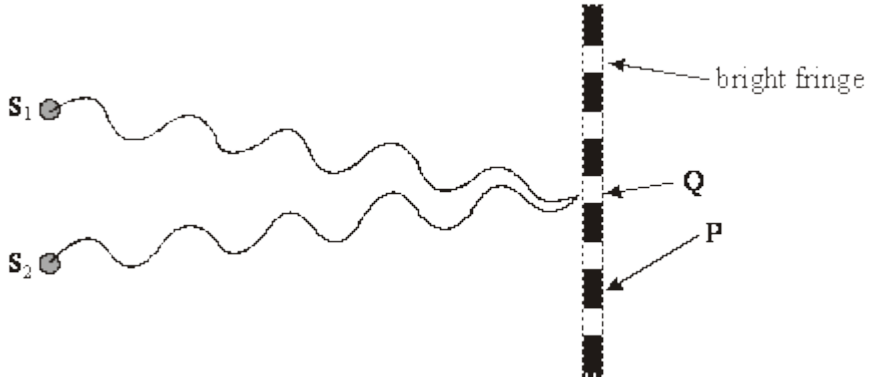
10 An interference pattern is produced using monochromatic light from two coherent sources. The separation of the two sources is 0.25 mm and the fringe separation is 7.8 mm. The interference pattern is observed on a screen that is 3.5 m from the sources.

(a) Calculate the wavelength of the light used to produce the interference pattern.

wavelength .....

(3)

(b) The figure below shows light from two coherent sources, S_1 and S_2, superposing to create a bright fringe at point **Q**. **Q** is equidistant from S_1 and S_2. The diagram is not to scale.



Explain how the dark fringe at the point **P** is caused.

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(3)
(Total 6 marks)

11 The diagram for this question is drawn to scale and 1 mm on the diagram represents an actual distance of 5 mm.

S_1 and S_2 are identical *coherent* transmitters emitting, in phase, microwaves with a wavelength of 25 mm. They are positioned 250 mm apart on a horizontal surface and a detector can be placed anywhere along the line YY' which is in the same plane as the transmitters and parallel to the line containing S_1 and S_2.

(a) Explain what is meant by *coherent*.

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(2)

(b) By making measurements on the diagram and using the scale, determine the number of wavelengths in the path

(i) S_1R,

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(ii) S_2R.

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(iii) Use your answers to (i) and (ii) to determine whether or not you expect the signal received by a detector placed at R to be a maximum. Explain your answer.

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(5)

(c) Describe how you would expect the signal strength to vary as the detector is moved from R to P via Q.

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(2)

(d) Calculate the frequency of the microwaves.

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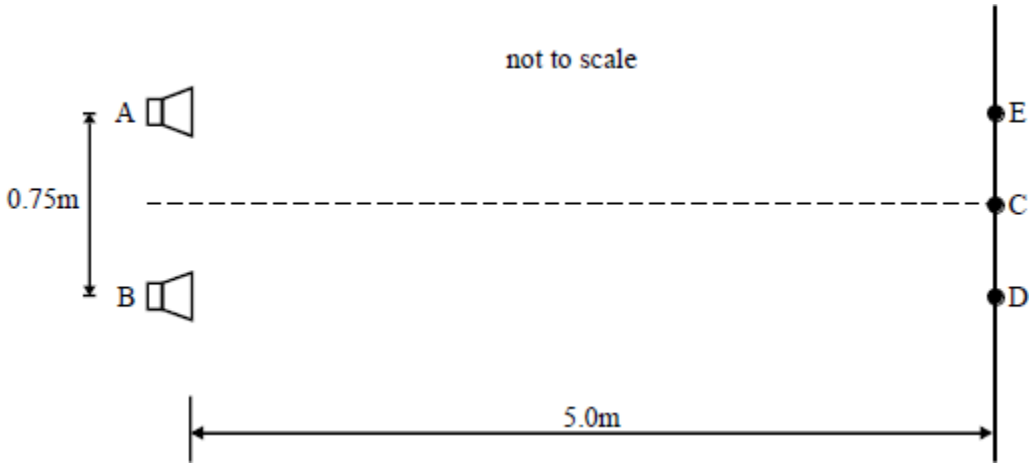
(1)
(Total 10 marks)

12 The diagram shows two identical loudspeakers, A and B, placed 0.75 m apart. Each loudspeaker emits sound of frequency 2000 Hz.



Point C is on a line midway between the speakers and 5.0 m away from the line joining the speakers. A listener at C hears a maximum intensity of sound. If the listener then moves from C to E or D, the sound intensity heard decreases to a minimum. Further movement in the same direction results in the repeated increase and decrease in the sound intensity.

speed of sound in air = 330 m s^{-1}

(a) Explain why the sound intensity

(i) is a maximum at C,

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(ii) is a minimum at D or E.

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(4)

(b) Calculate

(i) the wavelength of the sound,

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(ii) the distance CE.

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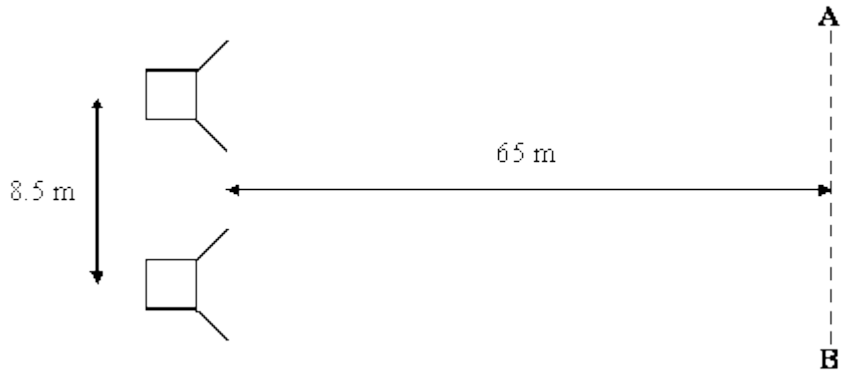
(4)
(Total 8 marks)

13 The diagram below shows an arrangement used to demonstrate the interference of sound waves. The two loudspeakers act as *coherent sources* of sound.



(a) Explain what is meant by the term coherent sources.

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(2)

(b) In the diagram, the loudspeakers are separated by 8.5 m and are emitting sound of wavelength 0.77 m. When a sound engineer walks along the line **AB**, 65 m from the loudspeakers, he observes a regular rise and fall in the sound intensity.

(i) Explain this observation.

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(2)

(ii) Calculate the distance moved along **AB** between two consecutive maxima of sound.

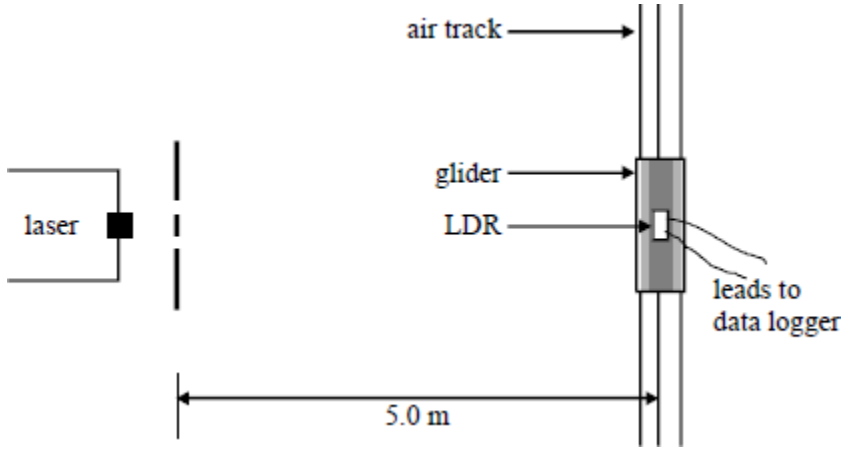
Distance moved .....

(2)

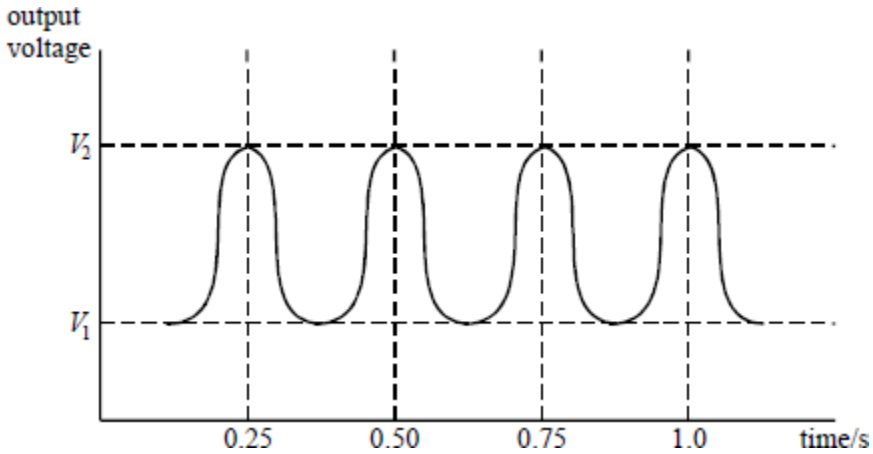
(Total 6 marks)

14 A laser is used with a double slit positioned 5.0 m from a white screen. The separation of the slits is 0.25 mm and the wavelength of the laser light is 630 nm.

The screen is removed and a linear air track positioned so that a glider on the air track moves in the same plane that was occupied by the screen.



A light dependent resistor, LDR, is attached to a glider and connected by loosely hanging leads to a datalogger. When the glider moves at a constant speed, the datalogger records the output voltage from a circuit containing the LDR. Output from the datalogger, plotted against time, is shown below.



(a) (i) Explain why the LDR output voltage varies with the position of the glider.

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(ii) Calculate the separation between two adjacent positions of the glider when the LDR is under maximum illumination.

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(iii) Use your answer to (ii) and the graph to calculate a speed for the glider consistent with these results.

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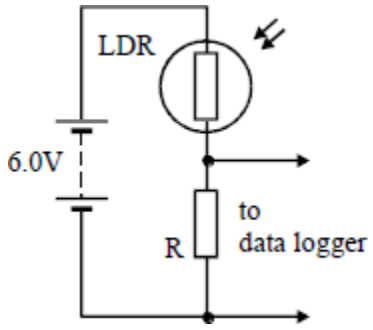
(5)

(b) A potential divider current is used to derive an output from the LDR.



In this experiment the resistance of the LDR is 10 kΩ when under maximum illumination and 100 kΩ when under minimum illumination. The value of R is 5k Ω. Calculate the values of V_1 and V_2 shown on the graph and state which corresponds to maximum illumination.

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(3)

(c) If the experiment were to be repeated how could you ensure that the glider is launched with the same speed each time?

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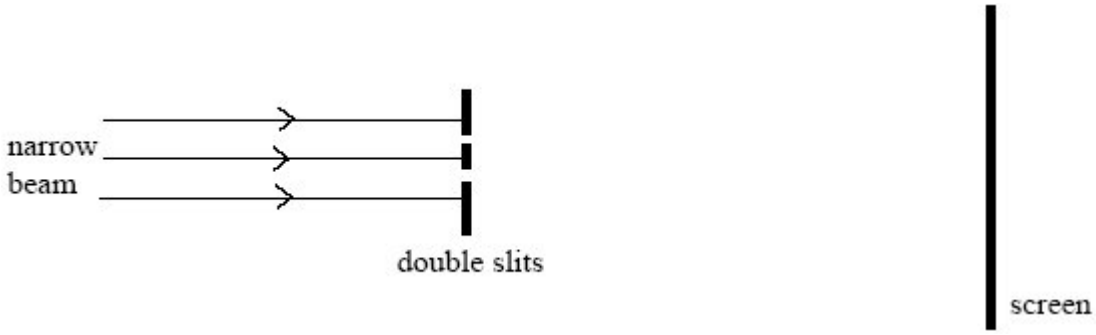
(2)

(Total 10 marks)

15 A narrow beam of monochromatic red light is directed at a double slit arrangement. Parallel red and dark fringes are seen on the screen shown in the diagram above.



(a) (i) Light passing through each slit spreads out. What is the name for this effect?

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(1)

(ii) Explain the formation of the fringes seen on the screen.

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(4)

(iii) The slit spacing was 0.56 mm. The distance across 4 fringe spacings was 3.6 mm when the screen was at a distance of 0.80 m from the slits. Calculate the wavelength of the red light.

Answer ..... m

(4)

(b) Describe how the appearance of the fringes would differ if white light had been used instead of red light.

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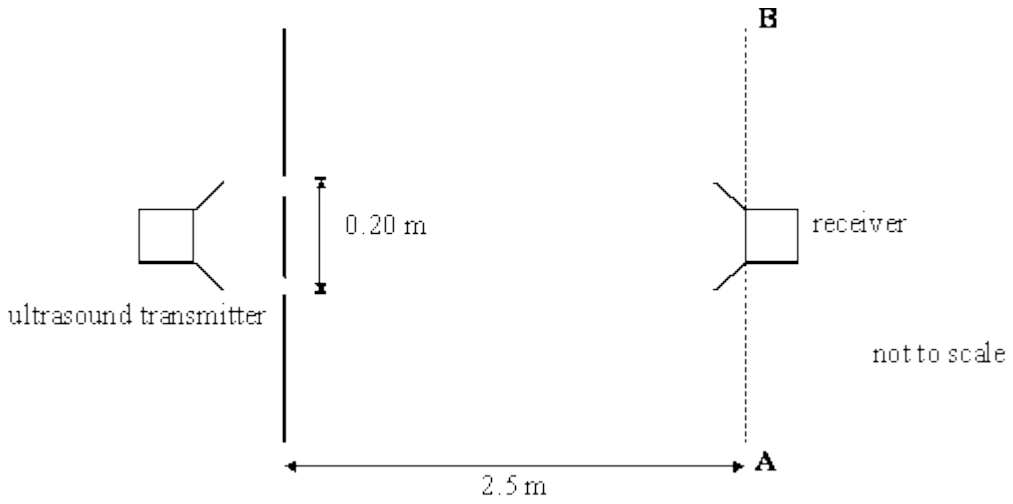
(3)
(Total 12 marks)

16 The diagram below shows a laboratory ultrasound transmitter emitting ultrasonic waves through two slits placed 0.20 m apart. A receiver, moving along line **AB,** parallel to the line of the slits, detects regular rises and falls in the strength of the signal. A student measures a distance of 0.22 m between the first and the third maxima in the signal when the receiver is 2.5 m from the slits.



(a) (i) Calculate the distance between successive maxima.

Distance between successive maxima .....

(1)

(ii) Calculate the wavelength of the ultrasonic waves.

Wavelength .....

(2)

(b) One of the slits is now covered. No other changes are made to the experiment.

State the differences between the observations made as the receiver is moved along **AB** before and after this change. Explain the changes that you mention.

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(3)
(Total 6 marks)

17 A laser emits light of wavelength 6.3×10^{-7} m and is used to illuminate a double slit which has a separation of 2.4×10^{-4} m. Interference fringes are observed 4.2 m from the slits.

(a) Calculate the fringe separation.

(2)

(b) The double slit acts as a pair of *coherent* sources. Explain what is meant by *coherent* sources.

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(2)

(c) The diagram shows the light from the slits, S_1 and S_2, meeting at **P** where the first dark fringe is observed.

Explain why a dark fringe is observed at **P**.

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(3)
(Total 7 marks)

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

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(2)

(b)

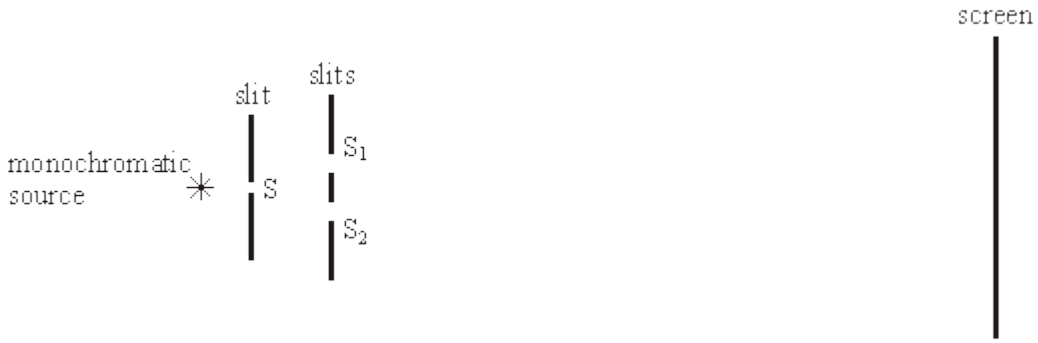

Figure 1

Young's fringes are produced on the screen from the monochromatic source by the arrangement shown in **Figure 1**.

You may be awarded marks for the quality of written communication in your answers.

(i) Explain why slit S should be narrow.

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(ii) Why do slits S_1 and S_2 act as coherent sources?

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(4)

(c) The pattern on the screen may be represented as a graph of intensity against position on the screen. The central fringe is shown on the graph in **Figure 2**. Complete this graph to represent the rest of the pattern by drawing on **Figure 2**.

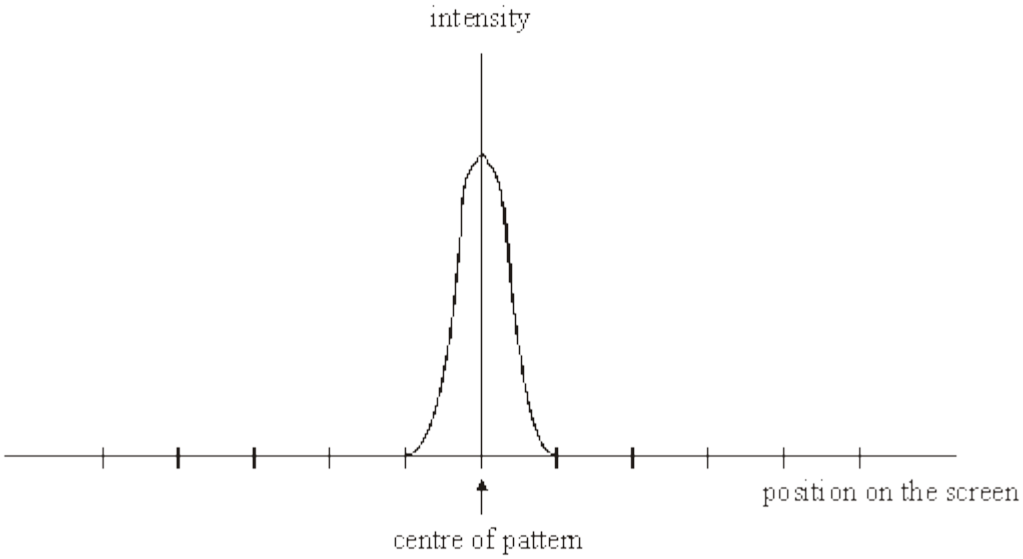
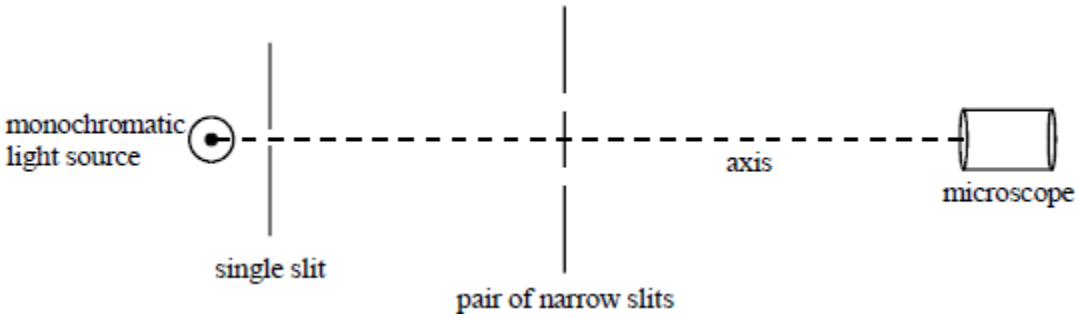


Figure 2

(2)
(Total 8 marks)

19 The diagram shows two closely spaced narrow slits illuminated by light from a single slit in front of a monochromatic light source. A microscope is used to view the pattern of bright and dark fringes formed by light from the two slits.



(a) (i) Explain qualitatively why these fringes are formed.

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(ii) Describe what is observed if one of the narrow slits is covered by an opaque object.

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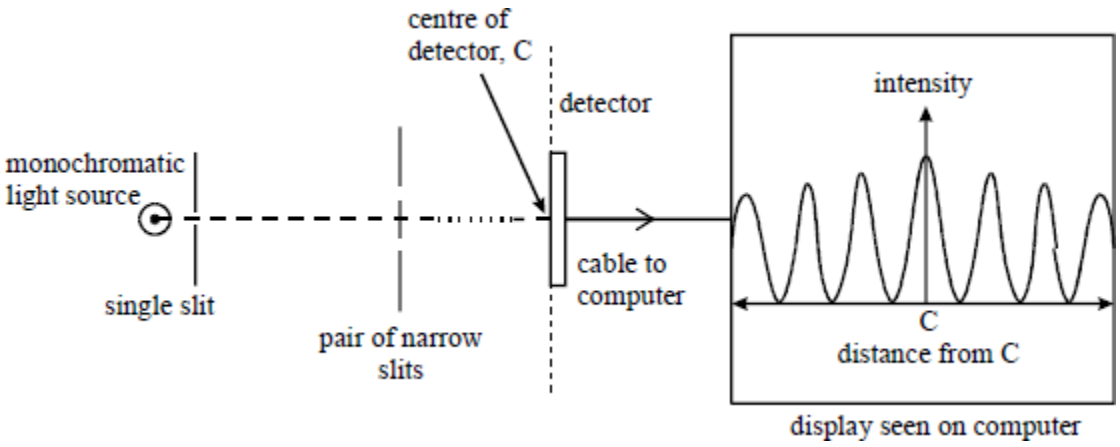
(8)

(b) The microscope is replaced by a fibre-optic detector linked to a computer. The detector consists of the flat end of many optical fibres fixed together along a line. The other end of each optical fibre is attached to a light-sensitive diode in a circuit connected to a computer. The signal to the computer from each diode is in proportion to the intensity of light incident on the diode. The computer display shows how the intensity of light at the detector varies along the line of the detector when both of the narrow slits are open.



(i) Describe and explain how the pattern on the display would change if the slit separation were increased.

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(ii) Each fibre consists of a core of refractive index 1.50 surrounded by cladding of refractive index 1.32. Calculate the critical angle at the core-cladding boundary.

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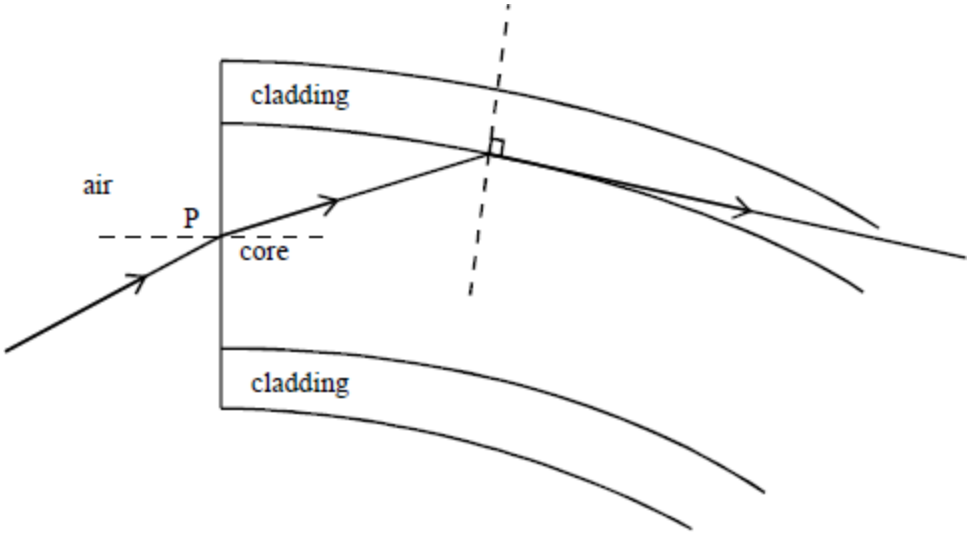
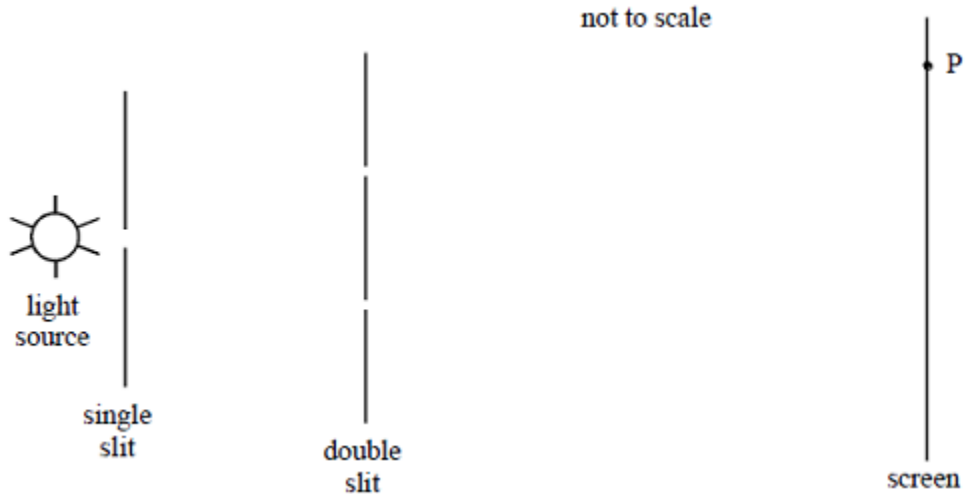
(iii) The diagram below shows a light ray entering an optical fibre at point P on the flat end of the fibre. The angle of incidence of this light ray at the core-cladding boundary is equal to the critical angle. On the diagram, sketch the path of another light ray from air, incident at the same point P, which is totally internally reflected at the core-cladding boundary.



(7)
(Total 15 marks)

20 (a) The diagram below shows schematically an arrangement for producing interference fringes using a double slit.



A dark fringe (minimum intensity) is observed at the point labelled **P**.

(i) Show clearly on the diagram the distance that is equal to the *path difference* between the light rays from the two slits to the point **P**.

(1)

(ii) Explain how the path difference determines that the light intensity at point **P** is a minimum.

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(3)

(iii) Explain briefly the role of diffraction in producing the interference patterns (You may draw a sketch to support your explanation if you wish.)

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(2)

(b) In one experiment the separation of the slits is 4.0×10^{-4} m. The distance from the slits to the screen is 0.60 m.

Calculate the distance between the centres of two adjacent dark fringes when light of wavelength 5.5×10^{-7} m is used.

(2)

(c) A student has learned that electrons behave like waves and decides to try demonstrate this using the arrangement in the diagram above. The lamp is replaced by a source of electrons and the system is evacuated.

The student accelerates the electrons to a velocity of 1.4×10^{6} m s^{-1}. The beam of electrons is then incident on the double slits. The electrons produce light when incident on the screen.

mass of an electron	$= 9.1 \times 10^{-31}$ kg
Planck constant	$= 6.6 \times 10^{-34}$ J s

(i) Calculate the de Broglie wavelength associated with the electrons.

(3)

(ii) Explain briefly, with an appropriate calculation, why the student would be unsuccessful in demonstrating observable interference using the slit separation of 4.0×10^{-4} m.

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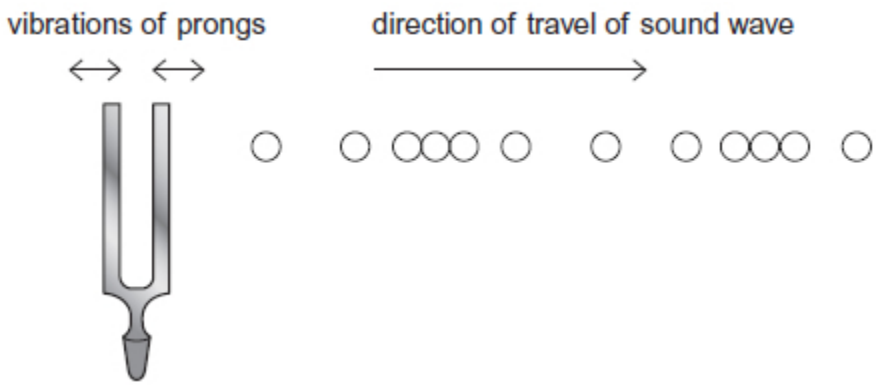
(2)
(Total 13 marks)

21 Musicians can use tuning forks to tune their instruments.
A tuning fork produces a specific frequency when it vibrates.

Figure 1 shows a tuning fork vibrating in air at a single instant in time.
The circles represent the positions of air particles in the sound wave.

Figure 1



(a) The tuning fork emits a wave that has a frequency of 0.51 kHz.

(i) State the meaning of the term frequency of a wave.

.....

(1)

(ii) Air particles vibrate in different phases in the direction in which the wave is travelling.

Calculate the minimum separation of particles that vibrate 180° out of phase.

speed of sound in air = 340 m s^{-1}

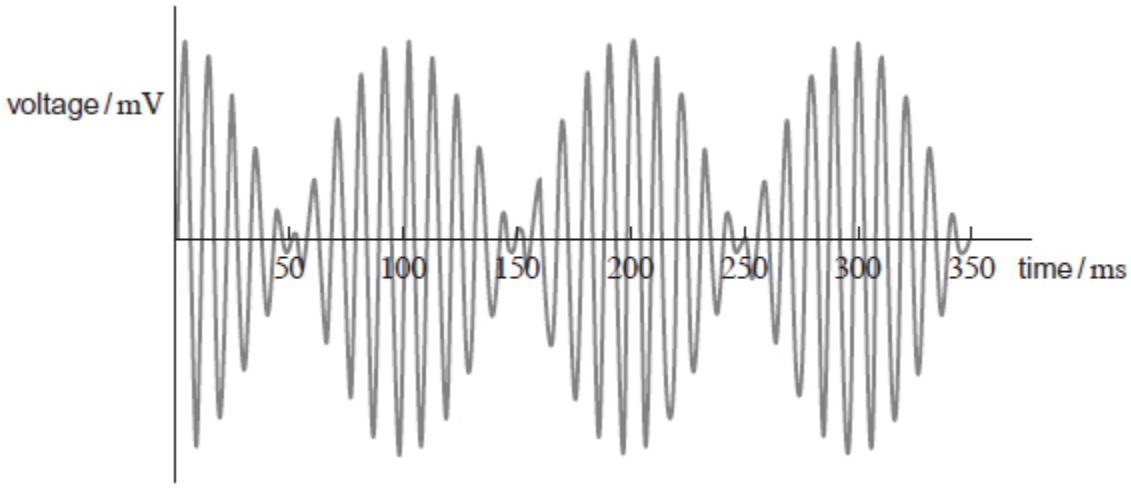
minimum separation ..... m

(3)

(b) A student sets a tuning fork of lower frequency vibrating at the same time as the 0.51 kHz tuning fork in part (a).

The student detects the resultant sound wave with a microphone. The variation with time of the voltage generated by the microphone is shown in **Figure 2**.

Figure 2



(i) Explain why the two tuning forks are **not** coherent sources of sound waves.

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(2)

(ii) Explain why the resultant sound has a minimum amplitude at 50 ms.

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(3)

(iii) Calculate the frequency of the tuning fork that emits the lower frequency.

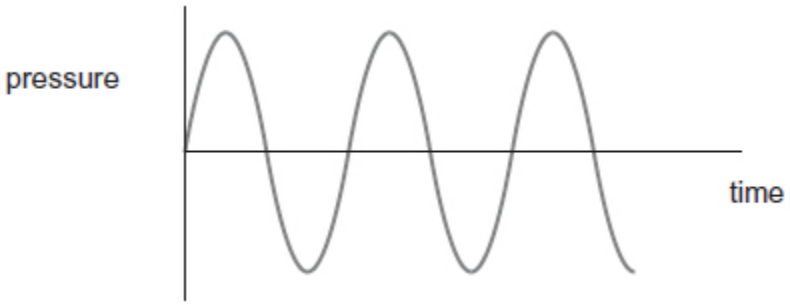
frequency ..... Hz

(3)

(c) A signal generator connected to a loudspeaker produces a sinusoidal sound wave with a frequency of 440 Hz.

The variation in air pressure with time for this sound is shown in **Figure 3**.

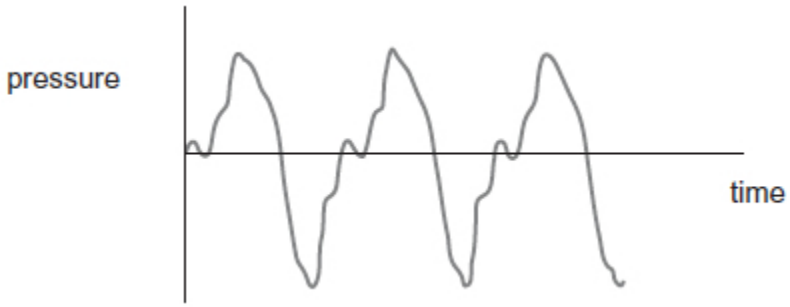
Figure 3



A violin string has a fundamental frequency (first harmonic) of 440 Hz.

Figure 4 shows the variation in air pressure with time for the sound created by the violin string.

Figure 4



(i) The two sounds have the same pitch but sound different.

What term describes the difference between the sounds heard?
Tick (✓) the correct answer.

Frequency modulation	☐
Octaves	☐
Path difference	☐
Quality	☐

(1)

(ii) The complex sound in **Figure 4** can be electronically synthesised.

Describe the process of electronically synthesising this sound.

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(3)

(Total 16 marks)