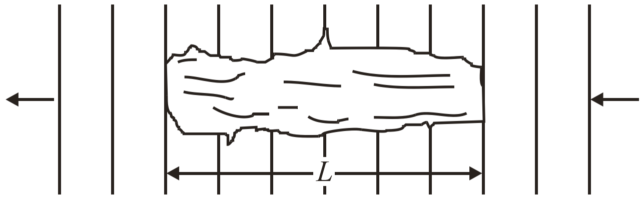
Name: ____________________
HR: ____________________
Date: ____________________
DP Physics

ISTANBUL INTERNATIONAL COMMUNITY SCHOOL
IICS
SINCE 1911

Sound and Optics Review Questions

1. Water waves at the surface of a pond pass a floating log of length *L*. The log is at rest relative to the bank. The diagram shows wave crests at one instant.



The number of crests passing the log per unit time is *N*. The speed of the water waves relative to the log at rest is

A. $\frac{L}{7}(N-1)$.

B. $\frac{L}{6}(N-1)$.

C. $\frac{L}{7}(N)$

D. $\frac{L}{6}(N)$.

(1)

2. The speed of a wave is defined as

A. the speed at which the particles of the wave vibrate.

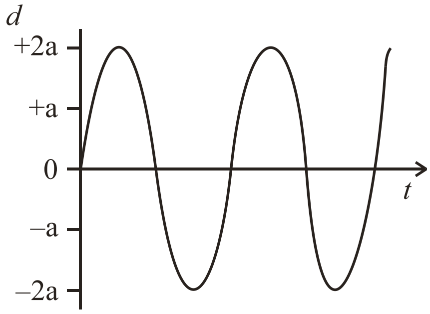
B. the speed of the medium through which the wave passes.

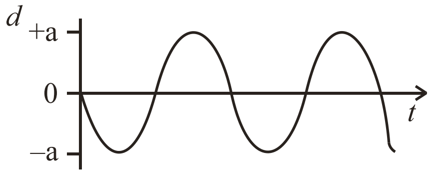
C. the speed of transfer of the energy of the wave.

D. the speed at which the vibrations of the wave are produced.

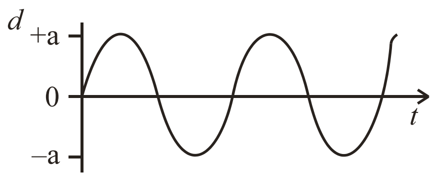
(1)

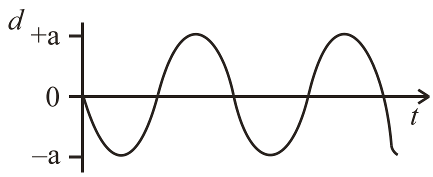
3. The variation with time t of the separate displacements d of a point in a medium due to two waves is shown below.

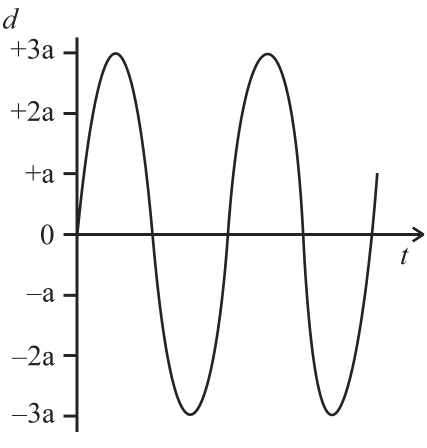


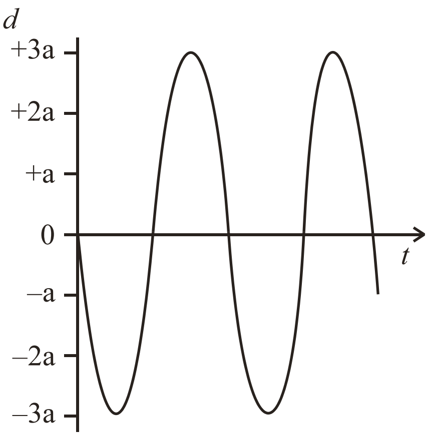


The waves are superposed. Which of the following diagrams shows the variation with time t of the resultant displacement d of the point in the medium?

A.


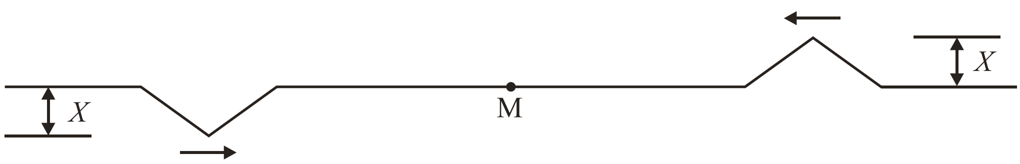
B.


C.


D.


(1)

4. Two identical triangular pulses of amplitude X travel toward each other along a string. At the instant shown on the diagram below, point M is midway between the two pulses.



The amplitude of the disturbance in the string as the pulses move through M is

A. $2X$.

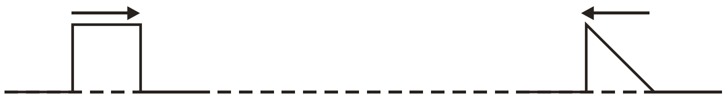
B. X.

C. $\frac{X}{2}$

D. 0.

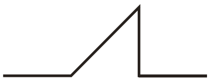
(1)

5. The diagram below shows two wave pulses moving towards one another.

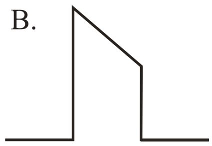


Which **one** of the following diagrams shows the resultant pulse when the two pulses are superposed?

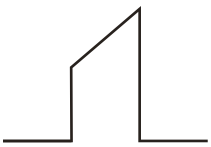
A.



B.



C.

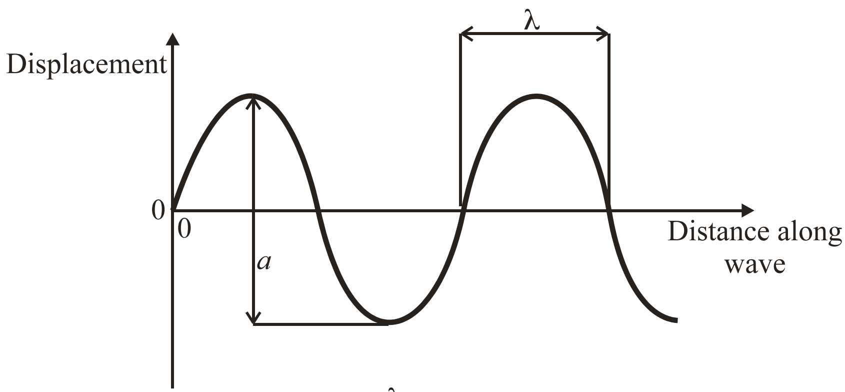


D.

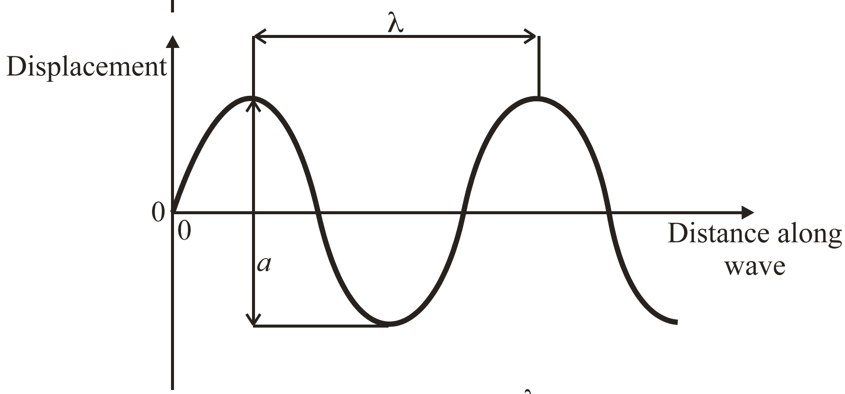
(1)

6. On which **one** of the following graphs is the wavelength λ and the amplitude a of a wave correctly represented?

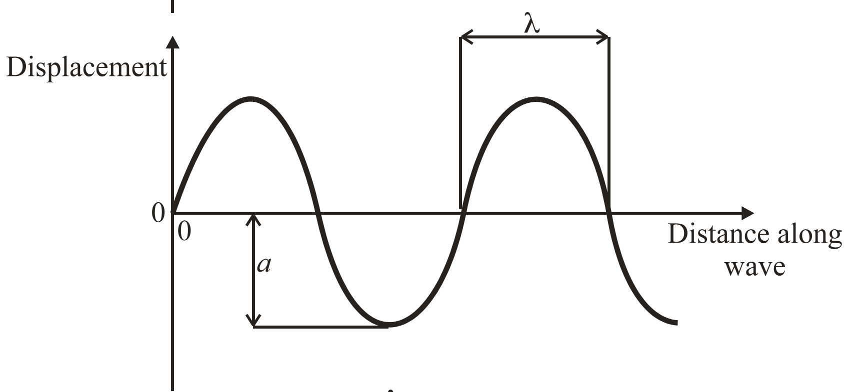
A.



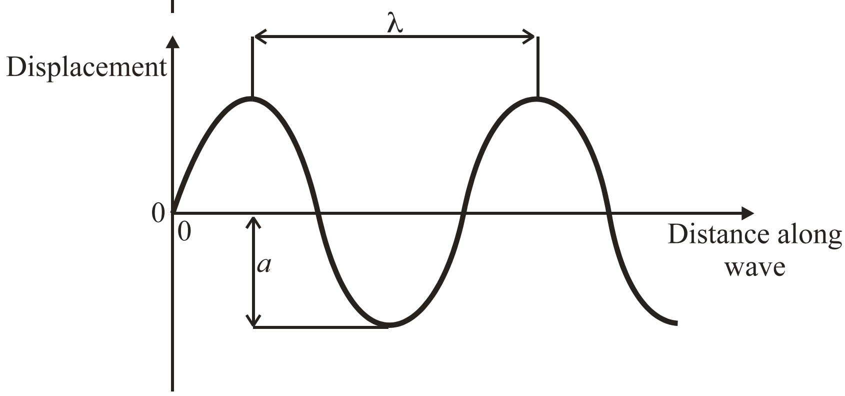
B.



C.

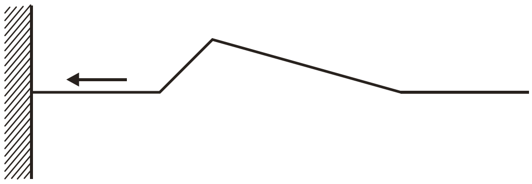


D.



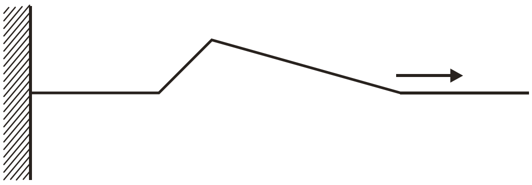
(1)

7. A pulse is sent down a string fixed at one end.

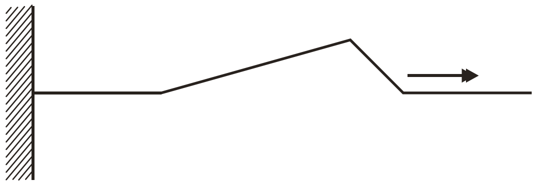


Which **one** of the following diagrams best represents the reflected pulse?

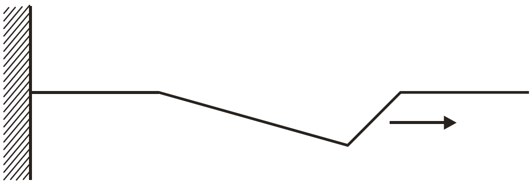
A.



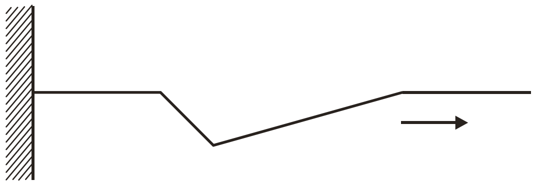
B.



C.



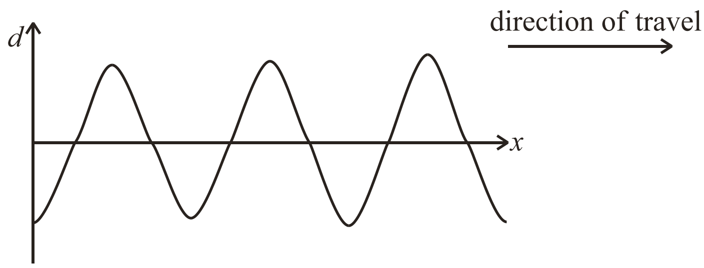
D.



(1)

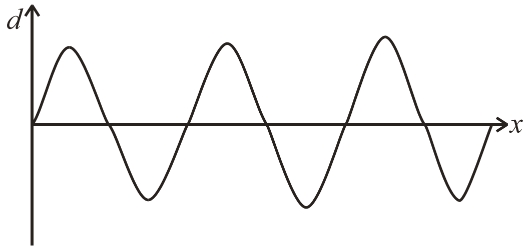
8. The diagram shows the variation with distance *x* along a wave with its displacement *d*.

The wave is travelling in the direction shown.

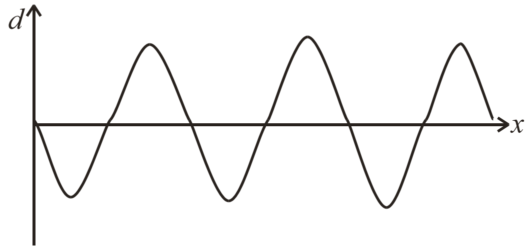


The period of the wave is T. Which **one** of the following diagrams shows the displacement of the wave at $\dfrac{T}{4}$ later?

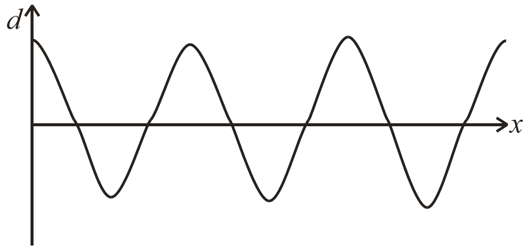
A.



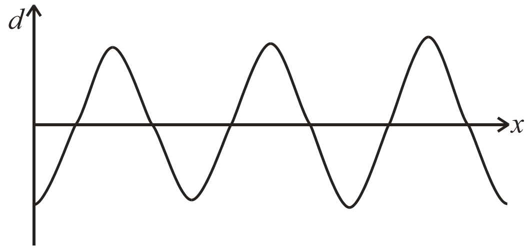
B.



C.



D.



(1)

9. The sound from two vibrating strings is heard at the same time. One string produces sound of frequency 350 Hz and the other, 354 Hz. The observer hears a sound of

A. frequency 350 Hz with a beat frequency of 4 Hz.

B. frequency 354 Hz with a beat frequency of 2 Hz.

C. frequency 352 Hz with a beat frequency of 4 Hz.

D. frequency 352 Hz with a beat frequency of 2 Hz.

(1)

10. A pipe, open at both ends, has a length L. The speed of sound in the air in the pipe is v. The frequency of vibration of the fundamental (first harmonic) standing wave that can be set up in the pipe is

A. $\frac{v}{2L}$.

B. $\frac{L}{2v}$.

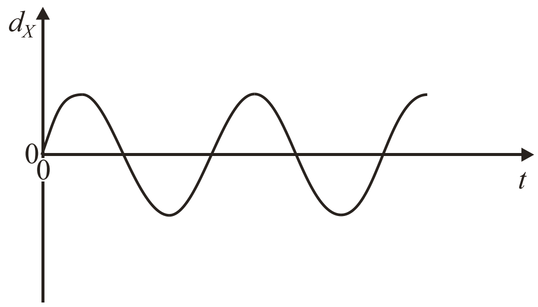
C. $\frac{4v}{L}$.

D. $\frac{L}{4v}$.

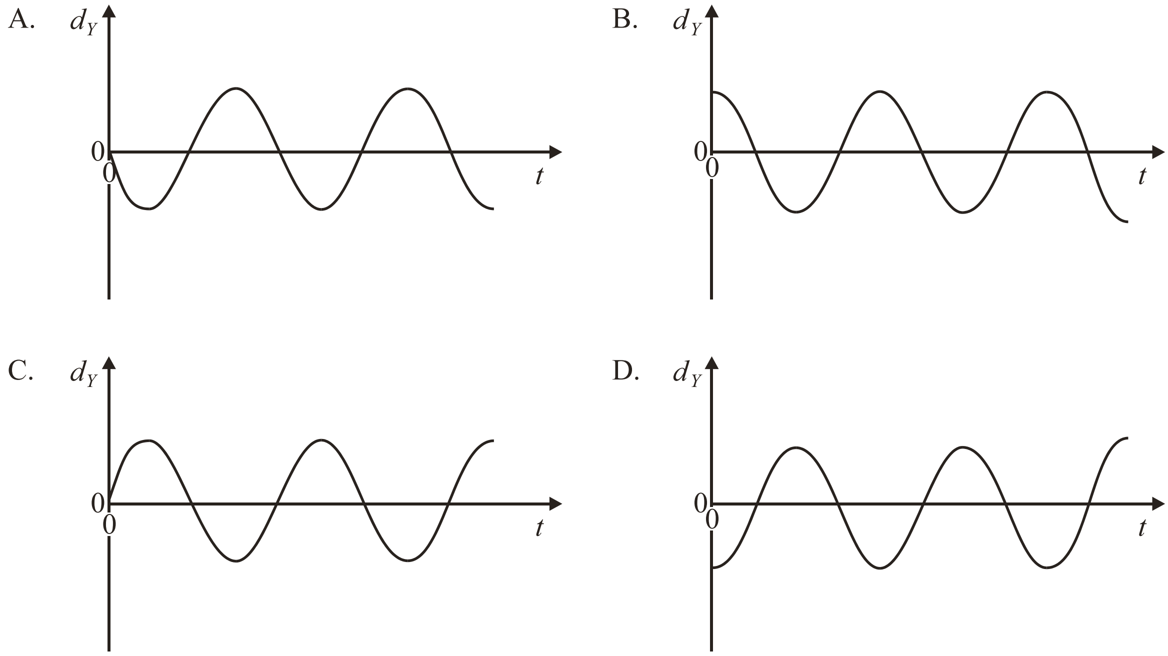
(1)

11. Two particles X and Y are situated a distance $\frac{1}{2}\lambda$ apart on a stationary wave of wavelength λ.

The variation with time t of the displacement d_x of X is shown below.



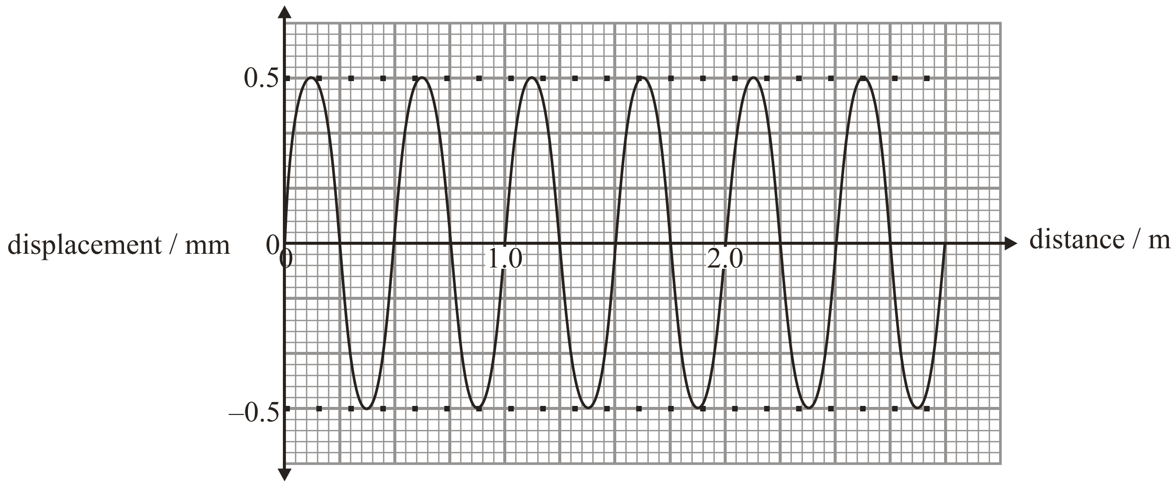
Which **one** of the following correctly shows the variation with time t of the displacement d_Y of particle Y?



(1)

12. This question is about sound waves.

A sound wave of frequency 660 Hz passes through air. The variation of particle displacement with distance along the wave at one instant of time is shown below.



(a) State whether this wave is an example of a longitudinal **or** a transverse wave.

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(1)

(b) Using data from the above graph, deduce for this sound wave,

(i) the wavelength.

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(1)

(ii) the amplitude.

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(1)

(iii) the speed.

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(2)
(Total 5 marks)

13. This question is about light and the electromagnetic spectrum.

(a) Outline the electromagnetic nature of light.

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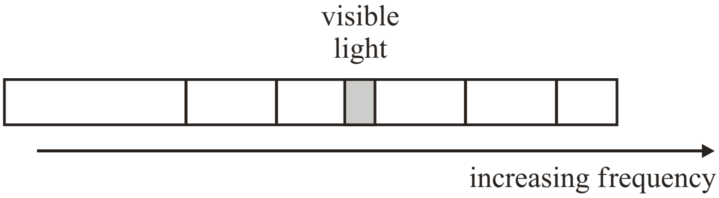
(2)

(b) The diagram below is a representation of the electromagnetic spectrum.



In the diagram the region of visible light has been indicated. Indicate on the diagram above the approximate position occupied by

(i) infrared waves (label this I),

(1)

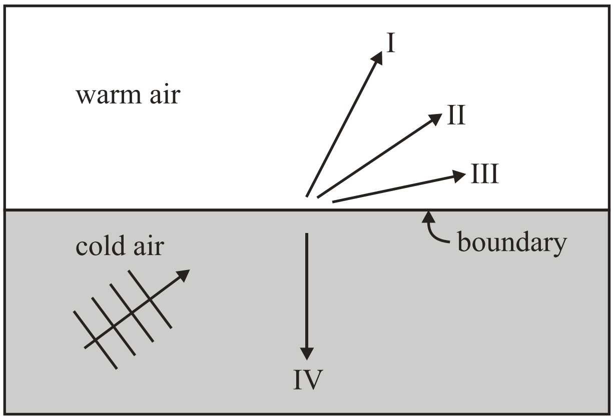
(ii) microwaves (label this M).

(1)

(iii) gamma rays (label this G).

(1)
(Total 5 marks)

14. Sound waves move faster in warm air than in cold air. The diagram below shows plane waves in cold air moving towards a boundary with warm air.



Which of the arrows shows the possible direction of waves after reaching the boundary?

A. I

B. II

C. III

D. IV

(1)

15. When a wave crosses the boundary between two media, which **one** of the following properties of the wave does **not** change?

A. Amplitude

B. Wavelength

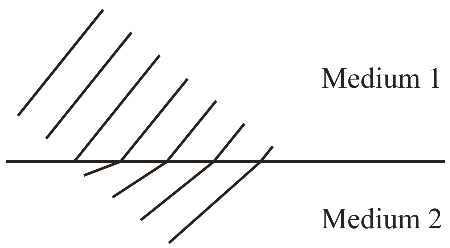
C. Frequency

D. Speed

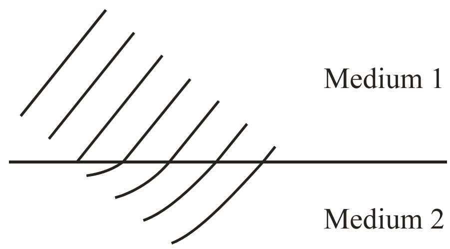
(1)

16. A plane wave approaches and passes through the boundary between two media. The speed of the wave in medium 1 is greater than that in medium 2. Which **one** of the following diagrams correctly shows the wavefronts?

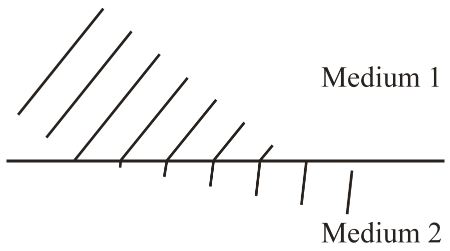
A.



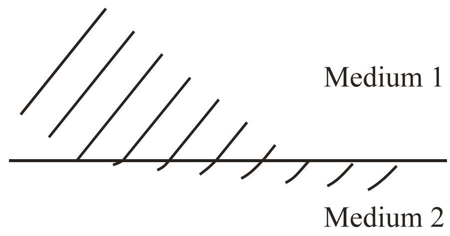
B.



C.



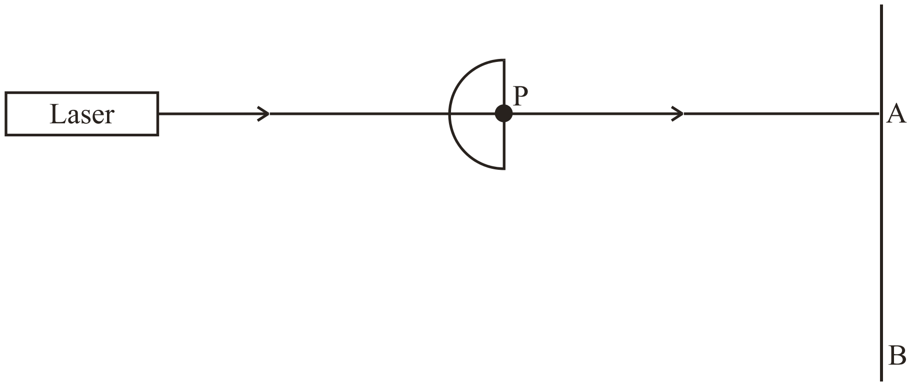
D.



(1)

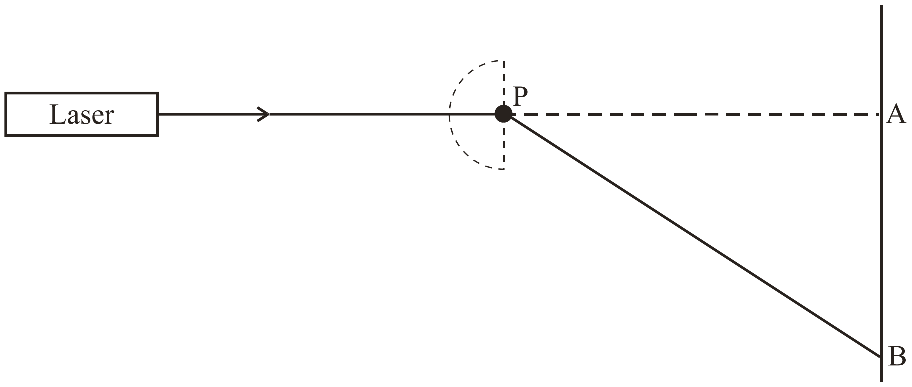
17. This question is about refractive index.

Light from a laser is directed at a semi-circular glass block. The light passes undeviated through the block and on to a screen, forming a spot at A as shown.



The semi-circular block is rotated about the point P. The spot of light on the screen is seen to move downwards. When the spot reaches point B, it disappears.

(a) Complete the diagram below to show the position of the semi-circular block when the spot is at point B. The original position of the block is shown as a dotted line.



(1)

In a particular experiment, the distance PA is 120 cm and distance AB is 138 cm.

(b) Calculate the refractive index of the glass of the block.

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(3)

The laser is changed for one emitting light of higher frequency. The experiment is then repeated.

(c) State and explain whether the distance AB will be greater or less than 138 cm.

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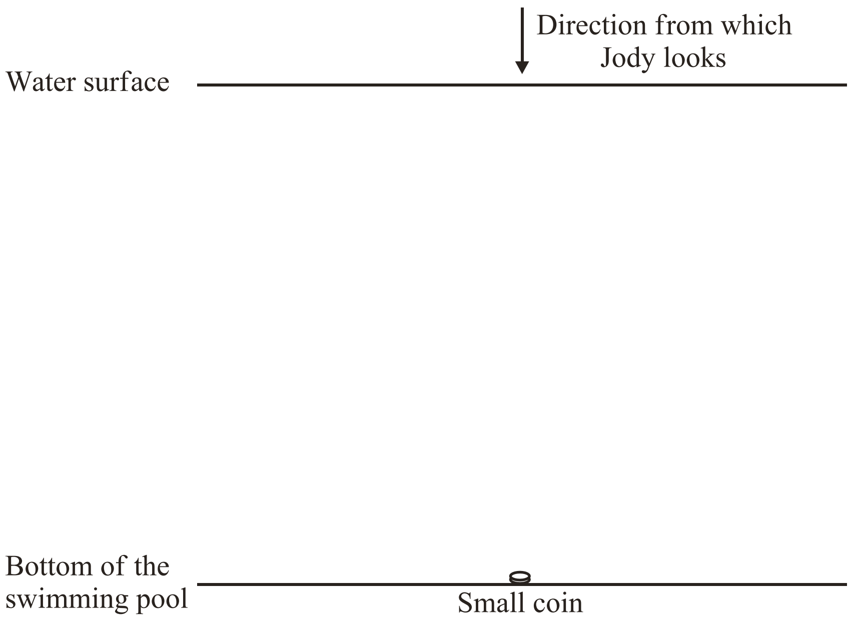
(3)
(Total 7 marks)

18. This question is about real and apparent depth.

Jody looks straight down on to the surface of the water in a swimming pool. A small coin is lying on the bottom of the swimming pool. The situation is represented in the diagram below.



(a) On the diagram above, draw appropriate rays to show the position of the image of the coin as seen by Jody.

(2)

(b) Explain whether the image that Jody observes is real **or** virtual.

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(1)

The real depth d and the apparent depth a are related by the expression = n where n is the refractive index of the water. The refractive index of the water in the swimming pool is 1.3 and the coin is at a depth of 3.0 m.

(c) Determine the position of the image, relative to the bottom of the pool, as observed by Jody.

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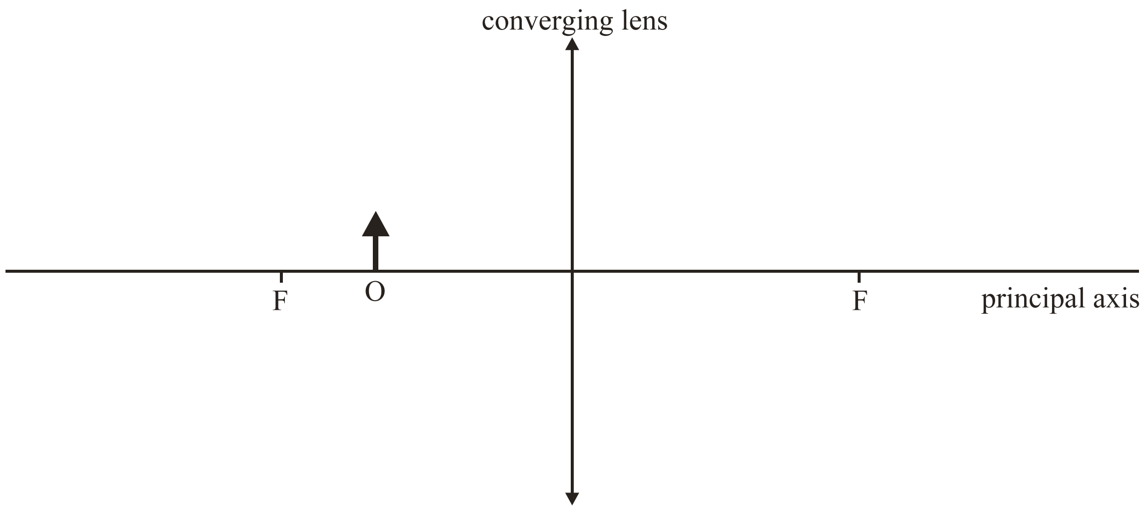
(3)
(Total 6 marks)

19. This question is about the simple magnifying glass.
An object O is placed in front of a converging lens in the position shown in the diagram below.
The principal foci of the lens are marked F.



(a) On the diagram,

(i) construct rays to locate the position of the image.
(1)

(ii) draw in the image and label it I.
(1)

(iii) show on the diagram where the eye must be placed in order to view this image.
(1)

For a particular lens, the focal length is10.0 cm and the distance of O from the lens is such that the image is formed at the *near point* of the eye. The distance of the lens from the eye is 3.0 cm.

(b) (i) Explain what is meant by the term *near point*.

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(1)

(ii) Calculate the distance of the object from the lens if the near point is 25.0 cm from the eye.

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(4)

(iii) State, and explain, where the object should be placed if the image is to be formed at the *far point*.

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....

(2)

(Total 10 marks)

20. This question is about refraction.

(a) With the aid of a suitable diagram define the term *refractive index* as applied to an optical material.

(2)

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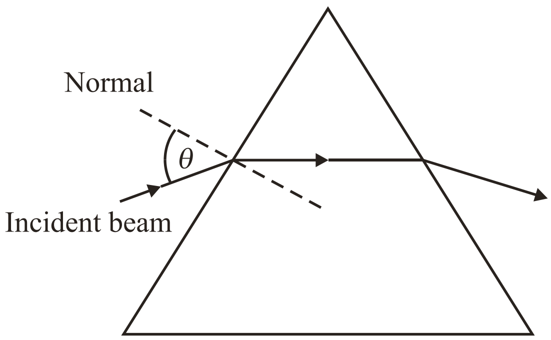
The diagram below shows the path followed by a ray of red light that is incident on one face of a glass prism at an angle θ to the normal.



(b) (i) The red light is now replaced by blue light. On the diagram sketch the corresponding path followed by a ray of blue light incident at the same angle θ.

(3)

(ii) State and explain whether the refractive index for red light in the glass is greater than, equal to or less than the refractive index for blue light.

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(1)

(Total 6 marks)

21. This question is about a spectrum.

(a) Describe what is meant by the spectrum of white light.

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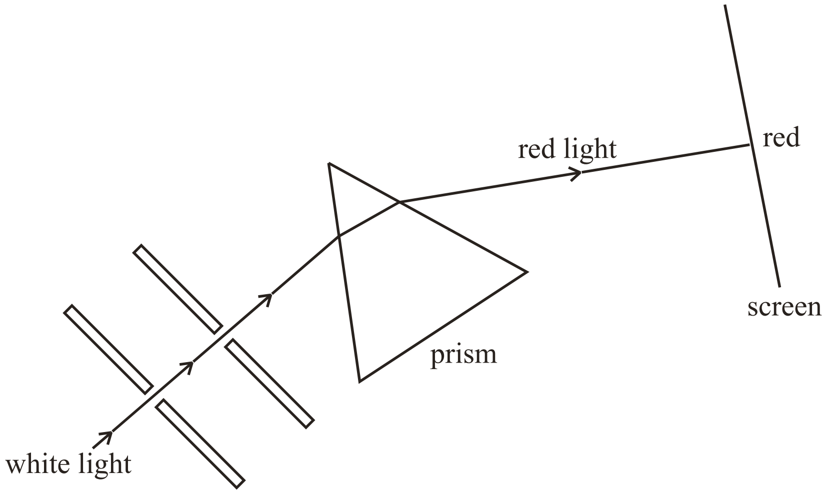
(2)

A student used the apparatus illustrated below in order to show the spectrum of white light.



(b) Complete the diagram to show the path of blue light through the prism and to the screen.

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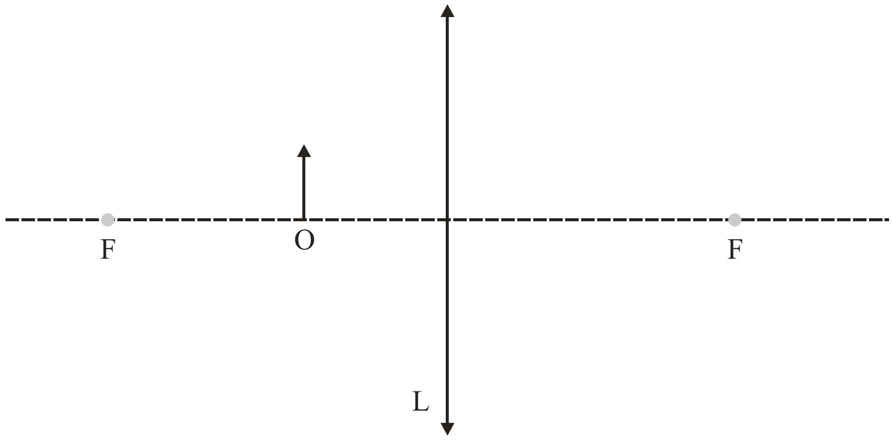
....

(3)
(Total 5 marks)

22. This question is about converging lenses.

(a) The diagram shows a small object O represented by an arrow placed in front of a *converging* lens L. The focal points of the lens are labelled F.



(i) Define the *focal point* of a converging lens.

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(2)

(ii) On the diagram above, draw rays to locate the position of the image of the object formed by the lens.

(3)

(iii) Explain whether the image is real or virtual.

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(1)

(b) A convex lens of focal length 6.25 cm is used to view an ant of length 0.80 cm that is crawling on a table. The lens is held 5.0cm above the table.

(i) Calculate the distance of the image from the lens.

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(2)

(ii) Calculate the length of the image of the ant.

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(2)
(Total 10 marks)

23. This question is about an astronomical telescope.

(a) Define the focal point of a convex (converging) lens.

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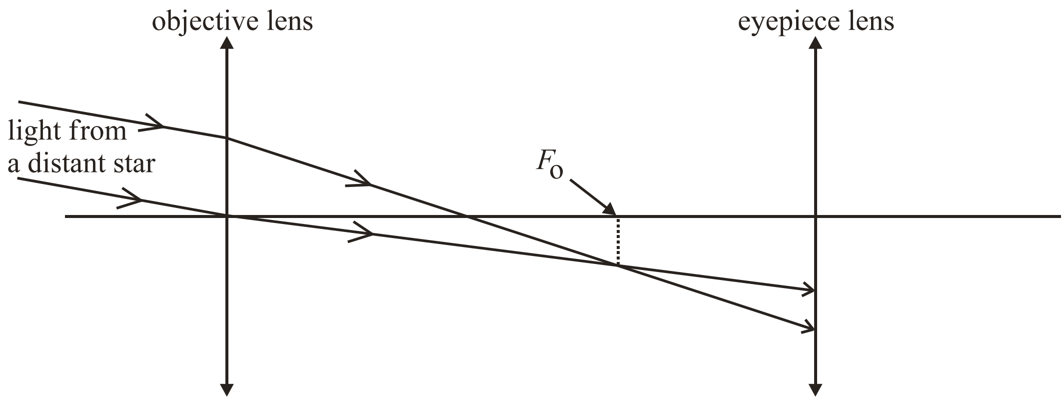
(2)

The diagram below shows two rays of light from a distant star incident on the objective lens of an astronomical telescope. The paths of the rays are also shown after they pass through the objective lens and are incident on the eyepiece lens of the telescope.



The principal focus of the objective lens is F_O

(b) On the diagram above, mark

(i) the position of principal focus of the eyepiece lens (label this F_E).

(1)

(ii) the position of the image of the star formed by the objective lens (label this I).

(1)

(c) State where the final image is formed when the telescope is in normal adjustment.

....

(1)

(d) Complete the diagram above to show the direction in which the final image of the star is formed for the telescope in normal adjustment.

(2)

The eye ring of an astronomical telescope is a device that is placed outside the eyepiece lens of the telescope at the position where the image of the objective lens is formed by the eyepiece lens. The diameter of the eye ring is the same as the diameter of the image of the objective lens. This ensures that all the light passing through the telescope passes through the eye ring.

(e) A particular astronomical telescope has an objective lens of focal length 98.0 cm and an eyepiece lens of focal length 2.00 cm (*i.e.* f_0 = 98.0cm, f_e = 20.0cm). Determine the position of the eye ring.

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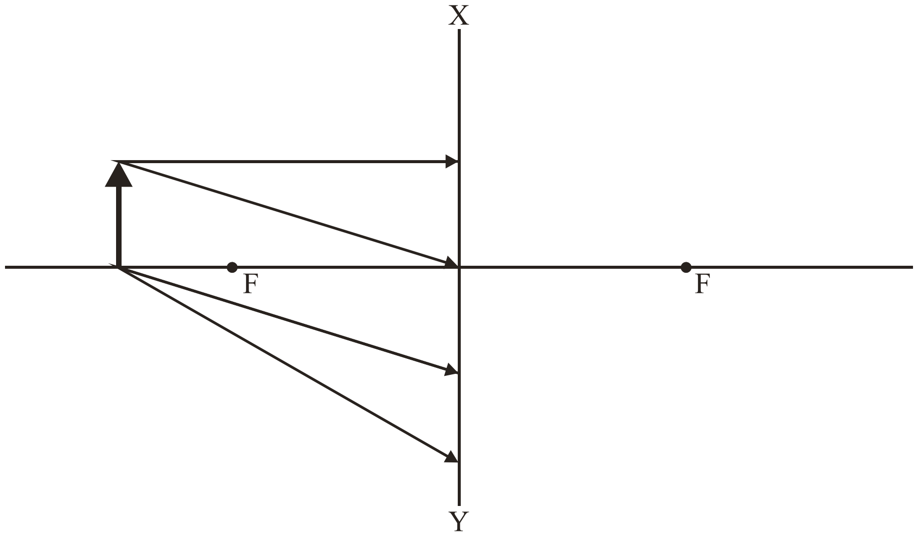
(4)
(Total 11 marks)

24. This question is about a concave (diverging) lens.

The diagram below shows four rays of light from an object O that are incident on a thin **concave** (**diverging**) lens. The *focal points* of the lens are shown labelled F. The lens is represented by the straight line XY.



(a) Define the term *focal point*.

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(2)

(b) On the diagram,

(i) complete the paths of the four rays in order to locate the position of the image formed by the lens.

(4)

(ii) show where the eye must be placed in order to view the image.

(1)

(c) State and explain whether the image is real **or** virtual.

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....

....

(2)

(d) The focal length of the lens is 50.0 cm. Determine the linear magnification of an object placed 75.0 cm from the lens.

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(3)

(e) Half of the lens is now covered such that only rays on one side of the principal axis are incident on the lens. Describe the effects, if any, that this will have on the linear magnification and the appearance of the image.

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(2)
(Total 14 marks)

25. This question is about waves and wave motion.

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

Transverse wave

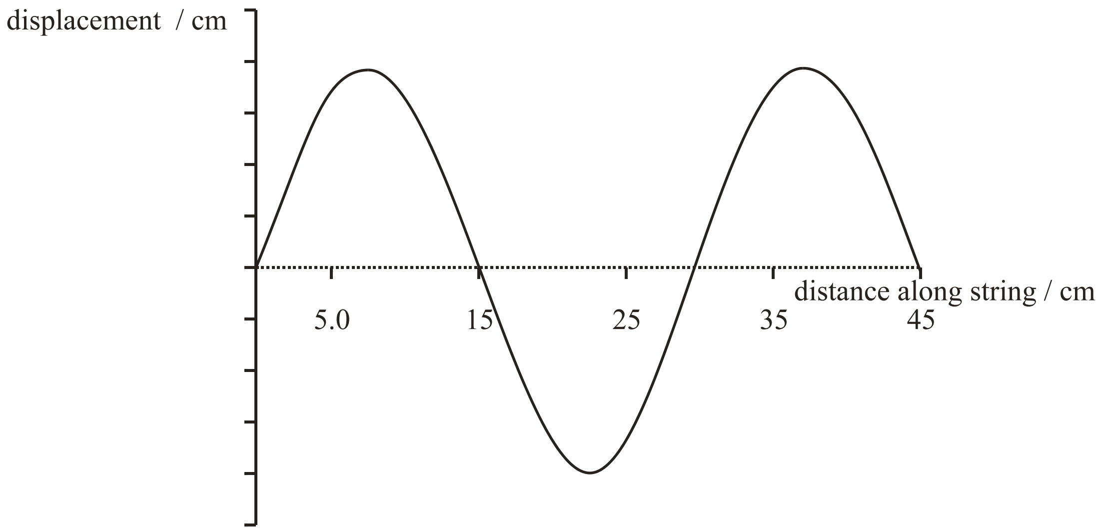
(2)

(b) State **one** example, other than a wave on a string, of a transverse wave.

....

(1)

A transverse wave is travelling along a string that is under tension. The diagram below shows the displacement of part of the string at time $t = 0$. The dotted line shows the position of the string when there is no wave travelling along it.



(c) On the diagram above, draw lines to identify for this wave

(i) the amplitude (label this A).

(1)

(ii) the wavelength (label this λ).

(1)

(d) The period of the wave is 1.2×10^{-3} s. Deduce that the speed of the wave is 250 m s^{-1}.

....

....

....

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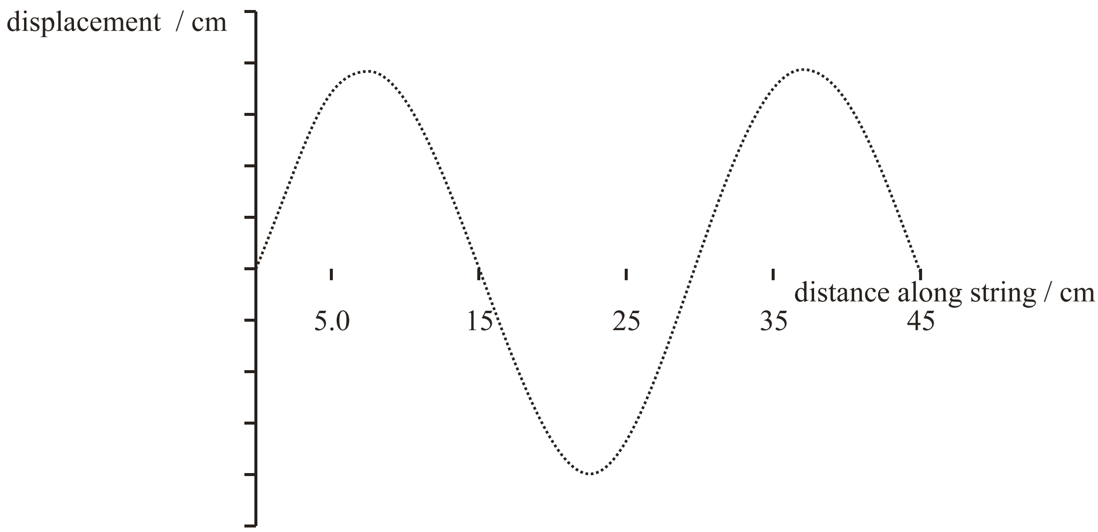
....

(2)

(e) Using the axes below, draw the displacement of the string when $t = 3.0 \times 10^{-4}$ s. (The displacement of the string at $t = 0$ is shown as a dotted line.)



(3)

The string is maintained at the same tension and is adjusted in length to 45 cm. It is made to resonate at its first harmonic (fundamental) frequency.

(f) Explain what is meant by resonance.

....

....

....

....

(2)

(g) Describe how the string can be made to resonate at its first harmonic frequency only.

....

....

....

....

(2)

(h) Determine the frequency of the first harmonic of the string.

....

....

....

....

(2)
(Total 16 marks)

26. This question is about waves and wave properties.

(a) By making reference to waves, distinguish between a *ray* and a *wavefront*.

....

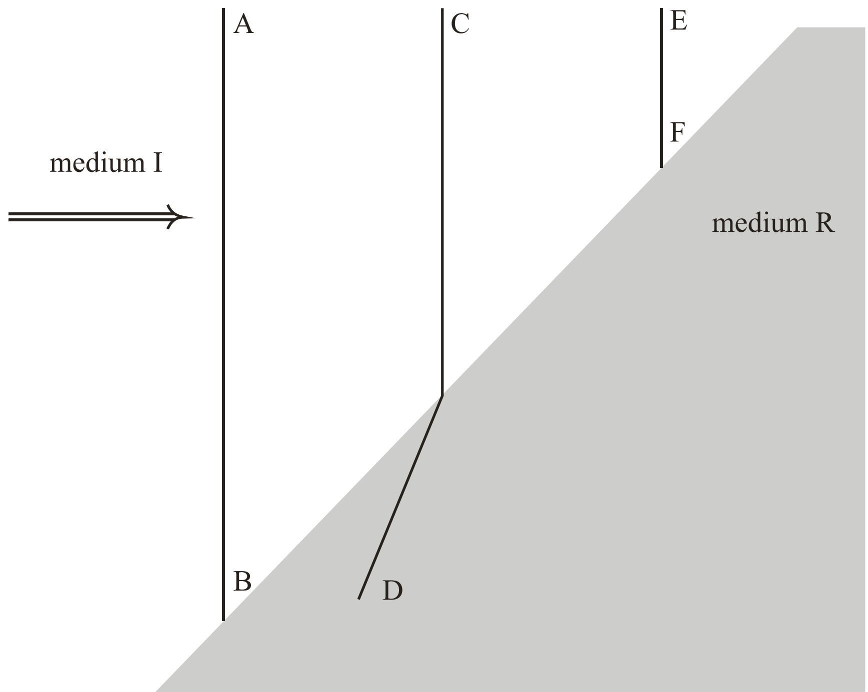
....

....

....

(3)

The diagram below shows three wavefronts incident on a boundary between medium I and medium R. Wavefront CD is shown crossing the boundary. Wavefront EF is incomplete.



(b) (i) On the diagram above, draw a line to complete the wavefront EF.

(1)

(ii) Explain in which medium, I **or** R, the wave has the higher speed.

....

....

....

....

(3)

(iii) By taking appropriate measurements from the diagram, determine the ratio of the speeds of the wave travelling from medium I to medium R.

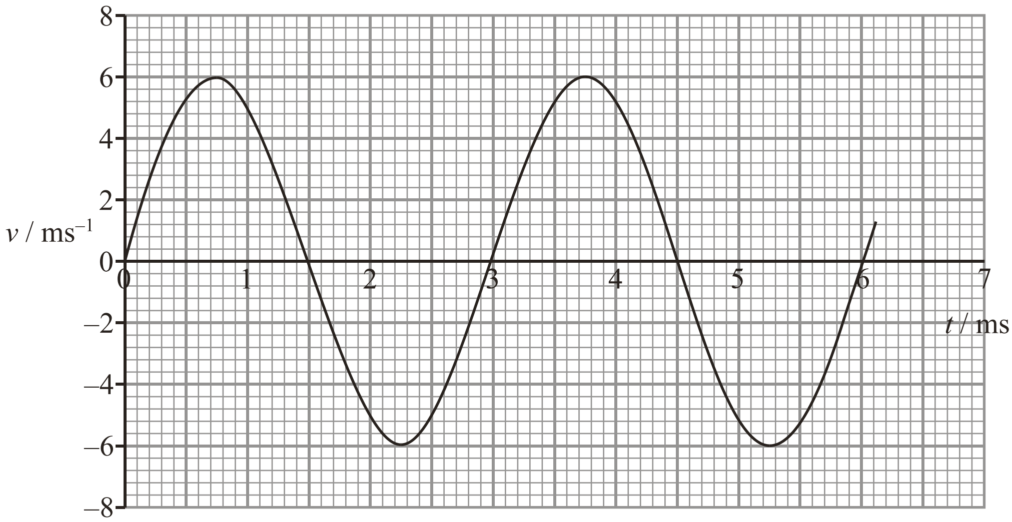
....

....

....

(2)

The graph below shows the variation with time t of the velocity v of one particle of the medium through which the wave is travelling.



(c) (i) Explain how it can be deduced from the graph that the particle is oscillating.

....

....

....

(2)

(ii) Determine the frequency of oscillation of the particle.

....

....

(2)

(iii) Mark on the graph with the letter M one time at which the particle is at maximum displacement.

(1)

(iv) Estimate the area between the curve and the *x*-axis from the time $t = 0$ to the time $t = 1.5$ ms.

....

....

(2)

(v) Suggest what the area in c (iv) represents.

....

(1)

(d) By reference to energy transfer and the amplitude of vibration of particles in a wave, distinguish between a travelling wave and a standing wave.

Energy transfer: ....

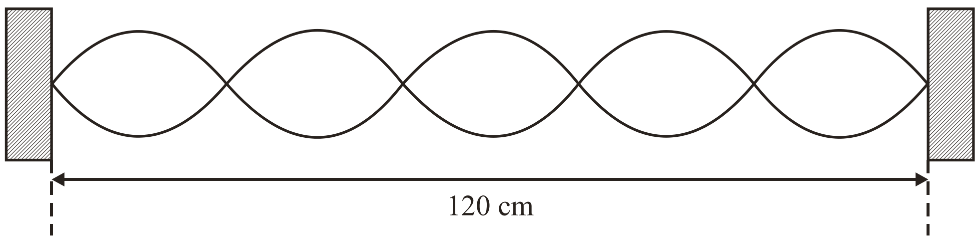
....

Amplitude: ....

....

(4)

A stretched string is fixed at both ends and then plucked at its centre. The diagram below illustrates the vibrating string.



The distance between the fixed points is 120 cm.

(e) (i) Mark on the diagram a distance equal to the wavelength of the standing wave.

(1)

(ii) The frequency of vibration of the string is 250 Hz. Determine the speed of the wave on the string.

....

....

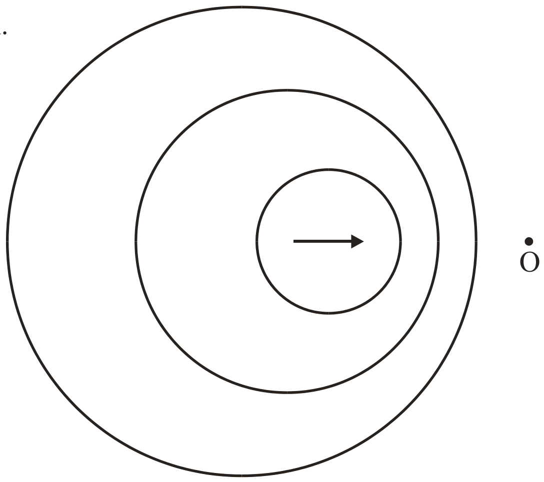
....

....

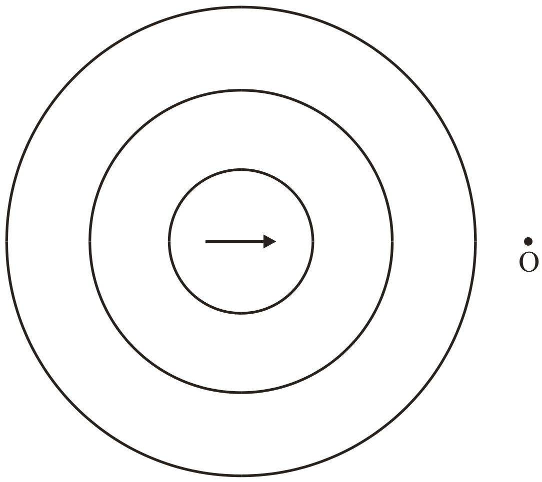
(3)
(Total 25 marks)

27. Which **one** of the following diagrams best represents wavefronts produced by a source of sound of constant frequency as it moves at constant speed towards a stationary observer at O?

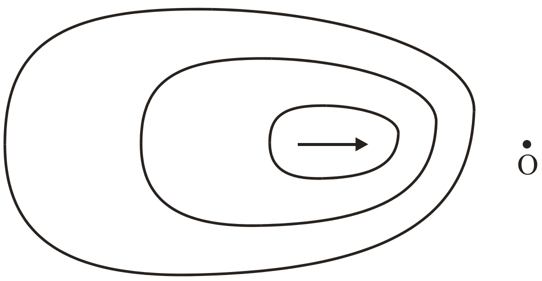
A.



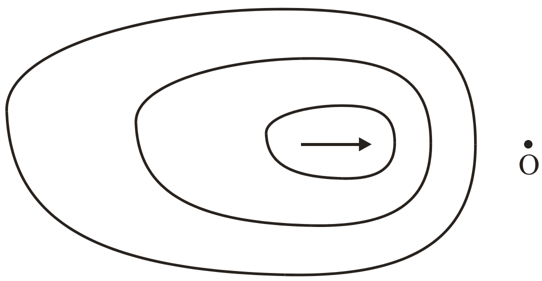
B.



C.



D.



(1)

28. A source of sound moves directly towards a stationary observer. The frequency of the sound detected by the observer is different from the source frequency because

A. the loudness of the sound increases as the source moves towards the observer.

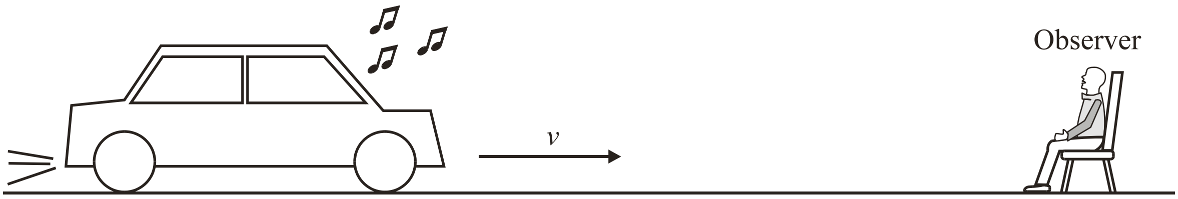
B. the apparent wavelength of the sound is longer.

C. the speed of sound relative to the observer is increased.

D. the apparent wavelength of the sound is shorter.

(1)

29. A sound emitting source moves along a straight line with speed *v* relative to an observer at rest.



The speed of sound relative to the medium is *c*. The observer measures the speed of sound emitted by the source as

A. c.

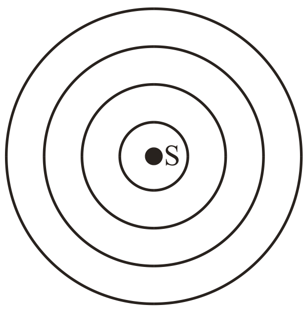
B. $c + v$.

C. $c - v$.

D. $v - c$.

30. This question is about the Doppler effect.

The diagram below shows wavefronts produced by a stationary wave source S. The spacing of the wavefronts is equal to the wavelength of the waves. The wavefronts travel with speed V.



(a) The source S now moves to the right with speed $\frac{1}{2}V$. In the space below, draw **four** successive wavefronts to show the pattern of waves produced by the moving source.

(3)

(b) Derive the Doppler formula for the observed frequency f_0 of a sound source, as heard by a stationary observer, when the source approaches the stationary observer with speed v. The speed of sound is V and the frequency of the sound emitted by the source is f.

....

....

....

....

(3)

The Sun rotates about its centre. The light from one edge of the Sun, as seen by a stationary observer, shows a Doppler shift of 0.004 nm for light of wavelength 600.000 nm.

(c) Assuming that the Doppler formula for sound may be used for light, estimate the linear speed of a point on the surface of the Sun due to its rotation.

....

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....

(3)

(Total 9 marks)

31. This question is about waves and wave properties.

(a) (i) Describe what is meant by a *continuous travelling wave*.

....

....

....

(2)

(ii) With reference to your answer in (a)(i), state what is meant by the speed of a travelling wave.

....

....

(1)

(b) Define, for a wave,

(i) *frequency*.

....

....

(1)

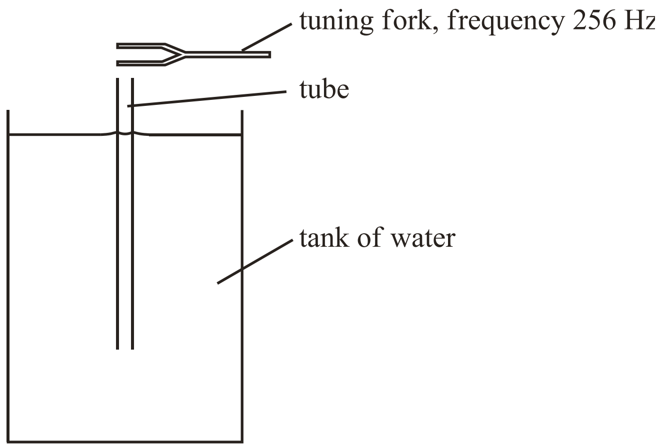
(ii) *wavelength*.

....

....

(1)

A tube that is open at both ends is placed in a deep tank of water, as shown below.



A tuning fork of frequency 256 Hz is sounded continuously above the tube. The tube is slowly raised out of the water and, at one position of the tube, a maximum loudness of sound is heard.

(c) (i) Explain the formation of a standing wave in the tube.

....

....

....

(2)

(ii) The tube is raised a further small distance. Explain, by reference to resonance, why the loudness of the sound changes.

....

....

....

....

....

(4)

(iii) The tube is gradually raised from a position of maximum loudness until the next position of maximum loudness is reached. The length of the tube above the water surface is increased by 65.0 cm. Calculate the speed of sound in the tube.

....

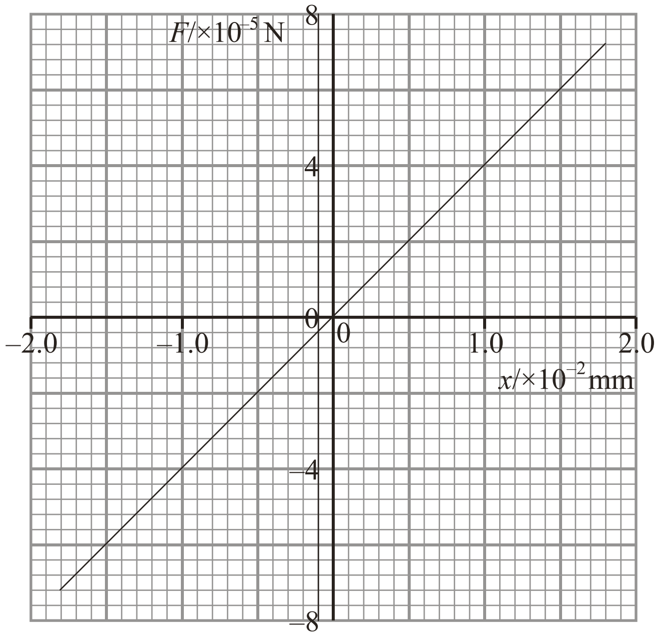
....

....

....

(2)

A sound wave is incident on the ear of a person. The pressure variation of the sound wave causes a force F to be exerted on a moveable part of the ear called the eardrum. The variation of the displacement x of the eardrum caused by the force F is shown below.



(d) The eardrum has an area of 30 mm^2. Calculate the pressure, in pascal, exerted on the eardrum for a displacement x of 1.0×10^{-2} mm.

....

....

....

(2)

(e) (i) Calculate the energy required to cause the displacement to change from $x = 0$ to $x = +1.5 \times 10^{-2}$ mm.

....

....

....

(3)

The sound wave causing a maximum displacement of the eardrum of 1.5×10^{-2} mm has frequency 1000 Hz.

(ii) Deduce that the energy causing the displacement in (e)(i) is delivered in a time of 0.25 ms. Also, determine the mean power of the sound wave to cause this displacement.

....

....

....

....

(4)

(iii) Suggest the form of energy into which the energy of the sound wave has been transformed at the eardrum.

....

(1)

In an experiment to measure the speed of sound, two coherent sources S_1 and S_2 produce sound waves of frequency 1700 Hz. A sound detector is moved along a line AB, parallel to S_1S_2 as shown below.

When the detector is at P, such that $S_1P = S_2P$, maximum loudness of sound is detected. As the detector is moved along AB, regions of minimum and maximum loudness are detected. Point X is the *third* position of minimum loudness from P. The distance $(S_2X - S_1X)$ is 0.50 m.

(f) (i) Determine the speed of the sound.

....

....

....

....

(3)

(ii) At X, no sound is detected. The loudness of the sound produced by S_1 alone is then reduced. State and explain the effect of this change on the loudness of sound heard at X and at P.

at X: ....

....

....

at P: ....

....

....

(4)

(Total 30 marks)

32. 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

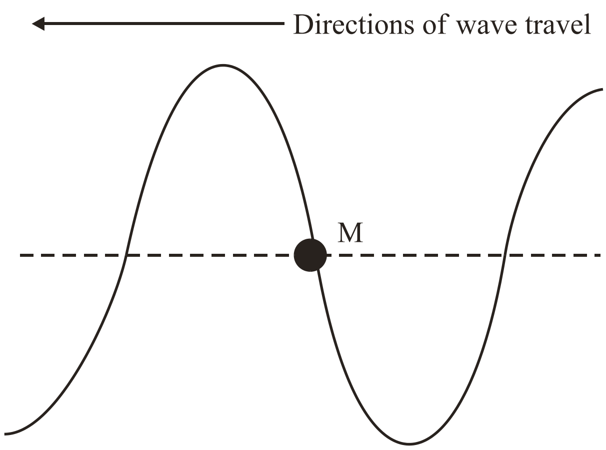
(i) a transverse wave and

(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.

.... **(1)**

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

Interference of waves

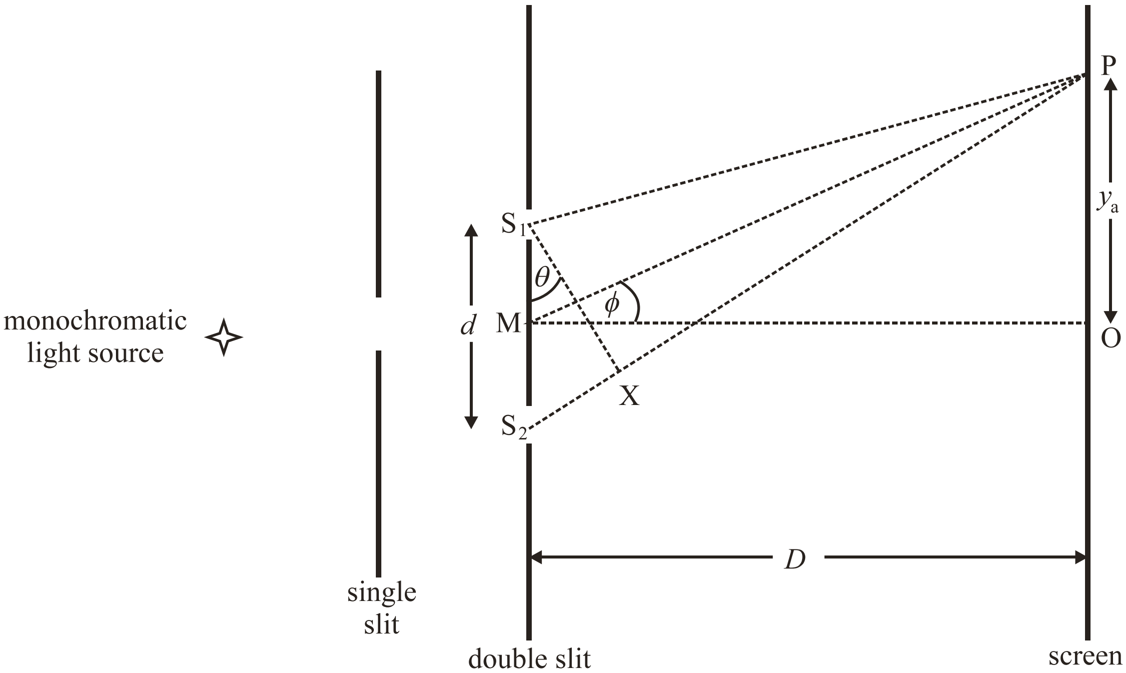
(d) By reference to the principle of superposition, explain what is meant by constructive interference.

....

....

.... **(4)**

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.

....

....

(2)

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

....

....

(2)

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

....

(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.

....

....

....

(2)

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

....

....

....

(3)
(Total 24 marks)

33. This question is about the interference of waves.

(a) State the principle of superposition.

....

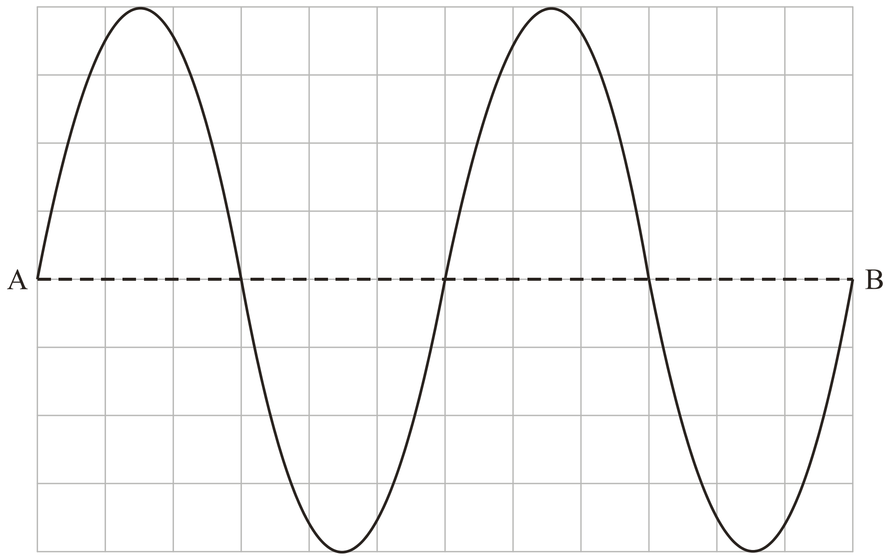
....

....

(2)

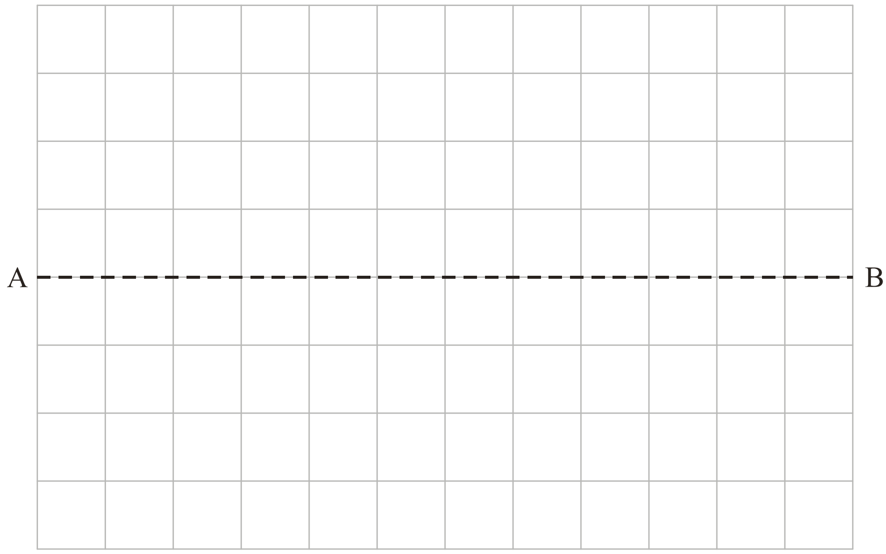
A wire is stretched between two points A and B.

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.

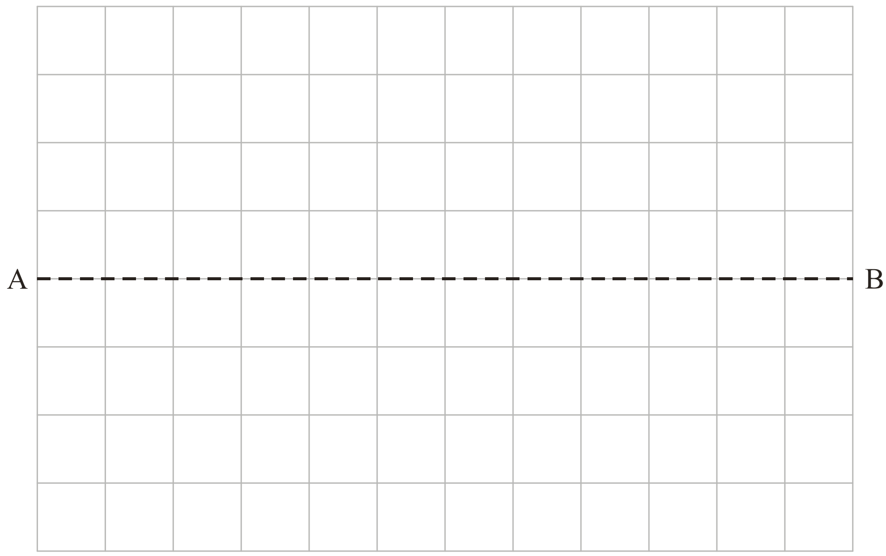


(b) On the grids below, draw the displacement of the wire due to wave X and wave Y.

Wave X

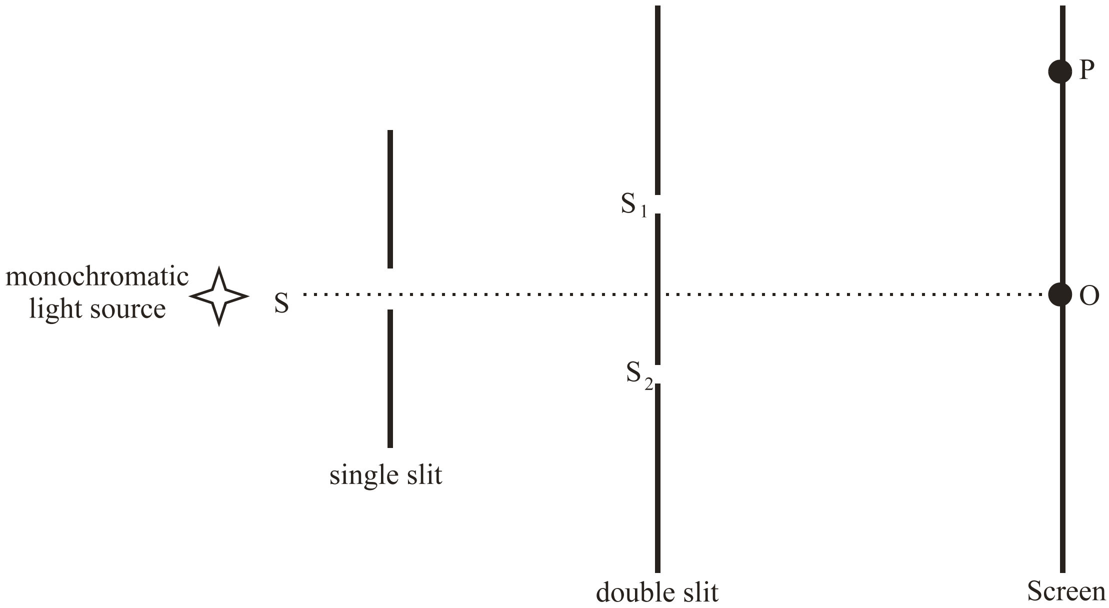


Wave Y



(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*.

....

....

(1)

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

....

....

....

....

(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.

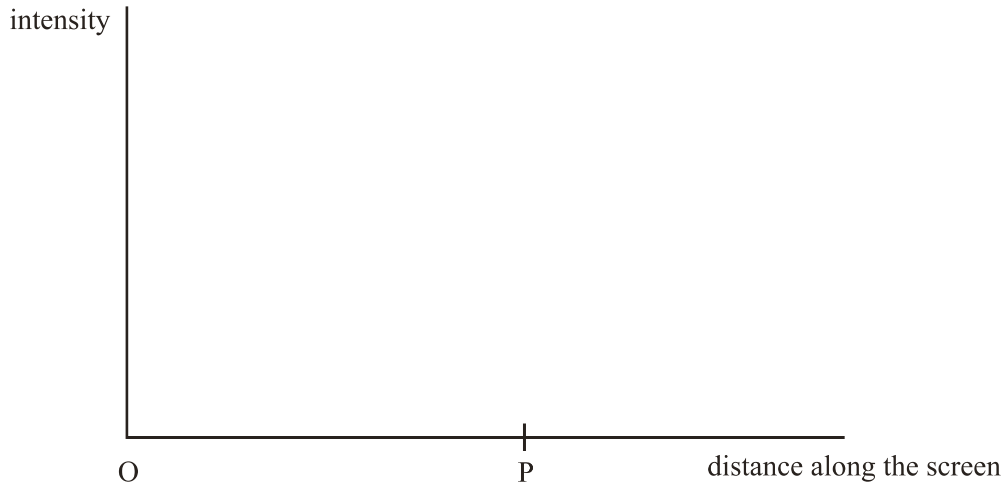
(d) (i) State the condition necessary for there to be maximum constructive interference at the point P.

....

....

(1)

(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.

....

....

....

....

(2)
(Total 14 marks)

Name: ________________
HR: ________________
Date: ________________
DP Physics

ISTANBUL INTERNATIONAL COMMUNITY SCHOOL
IICS SINCE 1911

Sound and Optics Review Markscheme

1. B **[1]**

2. C **[1]**

3. A **[1]**

4. D **[1]**

5. B **[1]**

6. D **[1]**

7. C **[1]**

8. B **[1]**

9. C **[1]**

10. A **[1]**

11. A **[1]**

12. (a) longitudinal; 1

(b) (i) wavelength = 0.5 m; 1

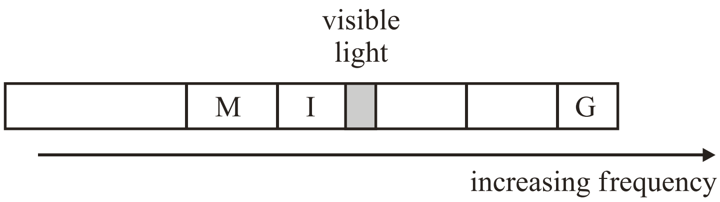
(ii) amplitude = 0.5 mm; 1

(iii) correct substitution into speed = frequency × wavelength;
to give $v = 660 \times 0.5 = 330 \text{ m s}^{-1}$; 2 max

[5]

13. (a) light consists of oscillating magnetic and electric fields at right angles to each other;
which transfer energy at speed c in vacuum (in a direction at right angles to both fields); 2

(b)



(i) correct labelling of infrared waves; 1

(ii) correct labelling of microwaves; 1

(iii) correct labelling of gamma rays; 1

*Award **[1]** if all positions are incorrect but order MIG is right.*

[5]

14. C

[1]

15. C

[1]

16. A

[1]

17. (a) diagram showing ray emerging along flat face; 1

(b) $\tan\theta = \dfrac{138}{120}$, $\theta = 49.0°$;
critical angle = 41.0°;
$n = \dfrac{1}{\sin C} = 1.52$; *(allow ecf if sensible)* 3

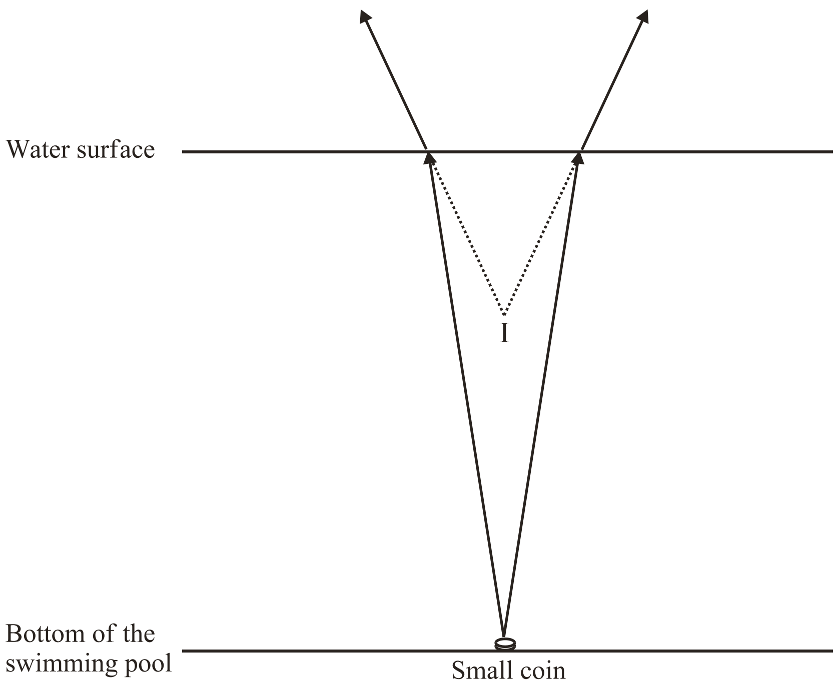
*Award **[1 max]** if the critical angle is = 49.0°*
(answer $n = \dfrac{1}{\sin C} = 1.33$).

(c) n is greater at higher frequency;
so C is smaller;
hence AB is larger; 3

*Award **[2]** if logic totally reversed.*

[7]

18. (a)



two rays from the coin showing refraction into the air;
extrapolated back to locate the labelled image **I**; 2 max

(b) virtual, since the rays form the coin to not come to a focus / *OWTTE*; 1 max

*Correct answer with wrong or weak or no explanation would receive **[0]**.*

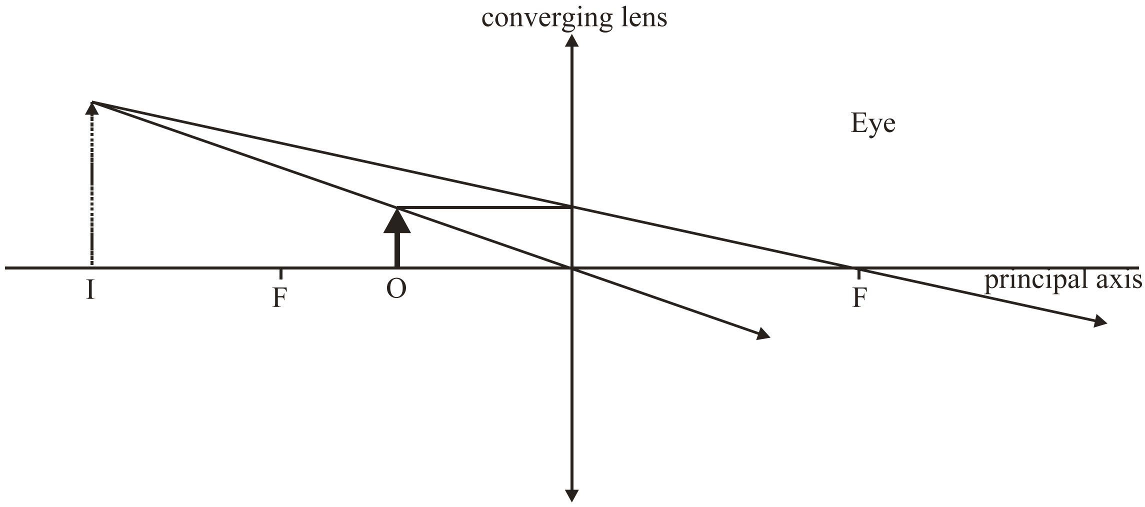
(c) $a = \frac{d}{n}$;

$= \frac{3.0}{1.3} = 2.3$ m;

distance from bottom of pool = 0.7 m; 3 max

[6]

19. (a)



(i) two appropriate rays; 1 max

(ii) correct image position; 1 max

(iii) eye to the right of the lens; 1 max

(b) (i) if the object is nearer than this to the eye then the eye cannot focus it clearly / *OWTTE*; 1 max

(ii) $\frac{1}{u} = -\frac{1}{v} + \frac{1}{f}$;

$v = -(25 - 3)\text{cm} = -22\text{ cm}$

$\frac{1}{u} = \frac{1}{22} + \frac{1}{10}$:

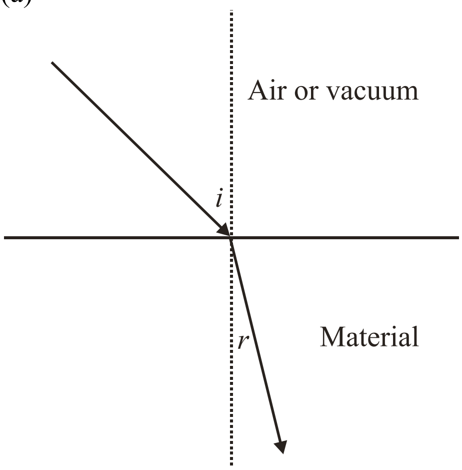
to give $u = 6.9$ cm; 4 max

*Alternatively for scale drawing award **[1]** for scale, **[2]** for rays, **[1]** for position of image and **[1]** for subtraction.*

(iii) at the focal point;
the far point is at infinity; 2 max

[10]

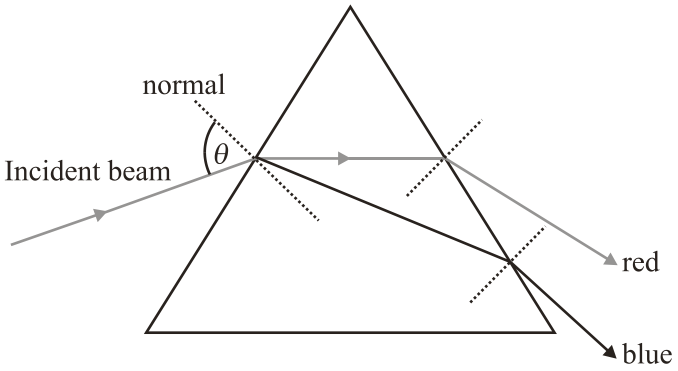
D«**20.** (a)



definition consistent with diagram $n = \frac{\sin i}{\sin r}$;

with i in air or vacuum; 2

(b) (i)



refraction at first surface;
refraction at emergent surface;
deviation greater than red light; 3

*If the refractions are correct but the angle of refraction is less than that for red light award **[2]**.*

(ii) less — refraction angle is greater therefore sin i / sin r is smaller; 1

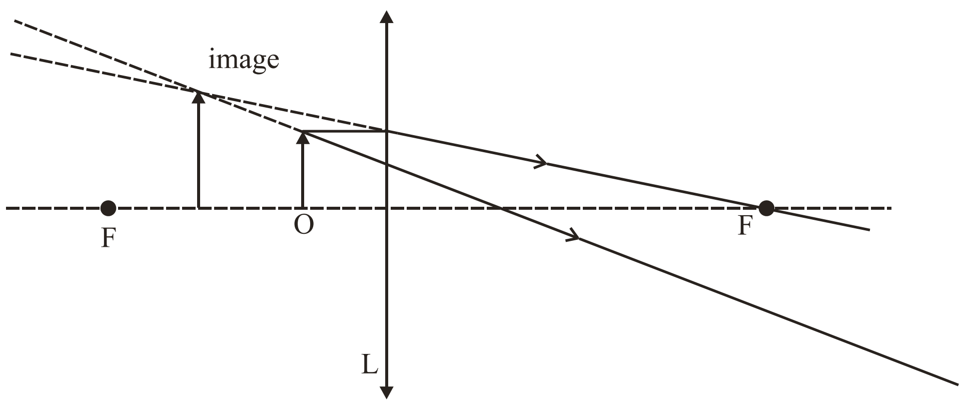
[6]

21. (a) distribution of colours;
separated according to wavelength / frequency; 2

(b) dispersion at both faces of prism;
refraction at both faces correct (by eye) – rays cross normal, $i > r$, $i < r$;
greater deviation for the blue than for the red; 3

[5]

22. (a)



(i) it is the point on the principal axis;
through which a ray parallel to the principal axis passes after going through the lens; 2

*Award **[0]** if focal point is defined as a distance.*

(ii) *Award **[2]** for any **two** appropriate rays and **[1]** for correct positioning of the image (upright).* 3

(iii) it is virtual because no rays pass through the image / cannot be formed on a screen; 1

*Award **[0]** if no explanation is provided.*

(b) (i) $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

$$\frac{1}{v} = \frac{1}{6.25} - \frac{1}{5.0};$$

$v = –25$ cm, so distance is 25 cm; 2

Accept negative sign in answer for distance.

(ii) $M = \frac{v}{u}$

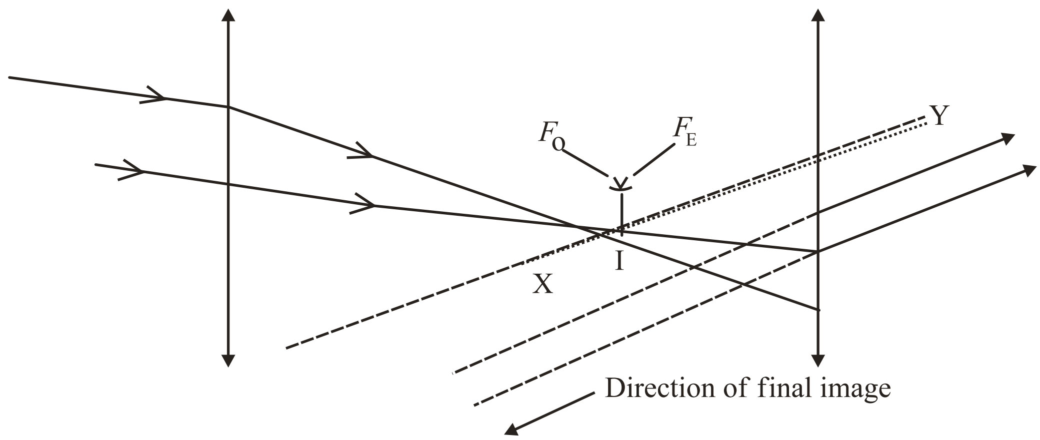
$M = \frac{-25}{5} = -5 \left(Accept\, M = -\frac{v}{u} = 5 \right)$

$L' = 5 \times 0.8 = 4.0$ cm; 2

[10]

23. (a) that point (on the principal axes) to which rays parallel to the principal axis; are brought to a focus after refraction at the lens / *OWTTE*; 2

(b)



(i) at F_O / other side of eyepiece; *(judge by eye)* 1

(ii) as shown on diagram; 1

(c) at infinity; 1 max

(d) two rays parallel to XY; *(judge by eye)*
extrapolated to show direction of final image; 2

(e) object distance $u = f_O + f_e = 100$ cm;

$$\frac{1}{v} + \frac{1}{100} = \frac{1}{f_e} = \frac{1}{2}$$

$\frac{1}{v} = \frac{1}{2} - \frac{1}{100}$ to give $v = 2.04$ cm;

beyond eyepiece lens / between eyepiece lens and eye;

or

scale drawing:

suitable scale;

object distance;

rays to locate image;

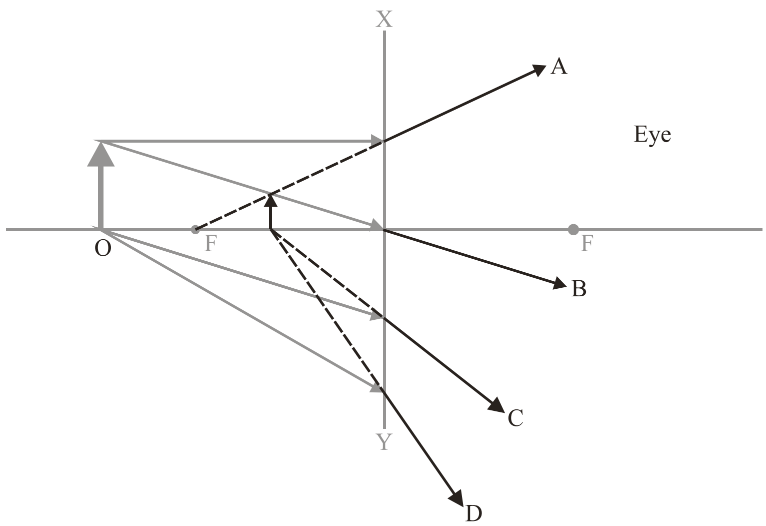
image distance 2 cm beyond eyepiece lens; 4 max

[11]

24. (a) focal point: the point on the principal axis to which rays parallel to the principal axis are brought to a focus after refraction by the lens / it is a point on the PA from which rays will be parallel to the PA after refraction by the lens; 2 max

*Look for a precise definition to gain **[2 max]** – award **[1]** for an inexact definition. Use discretion.*

(b) (i)



correct ray A;

correct ray B;

correct rays C and D;

correct location of the image; 4 max

*If a correct diagram is given for a **convex** lens award **[1]** but then use ECF for the rest of the question.*

(ii) anywhere to the right of the lens; 1

(c) virtual;

because any two rays from any one point of the object are not brought to a focus by the lens; 2 max

OWTTE;

*Virtual with incorrect explanation award **[1]** with no explanation **[0]**.*

(d)

Award marks either by calculation or drawing.

calculation:

use $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with $f = -50$;

to give $v = -30.0$ cm;

to give $m = \frac{-30}{75} = -0.4$;

Only penalise once for incorrect sign.

drawing:

suitable scale;

correct rays;

correct measurement; 3 max

(e) no effect on linear magnification;

only effect on appearance is that image will be fainter; 2

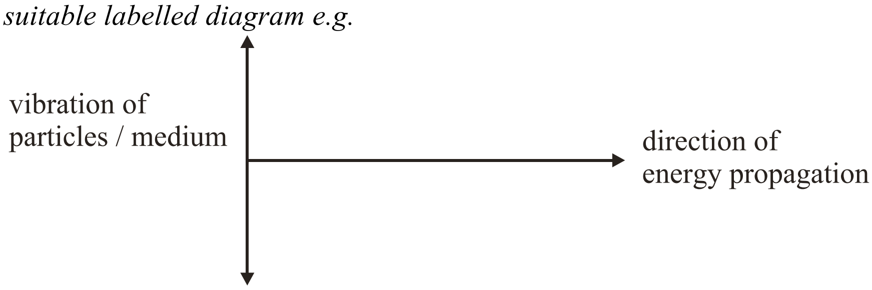
[14]

25. (a) a wave in which the direction of energy propagation;

is at right angles to the direction of vibration of the particles of the medium through which the wave is travelling / *OWTTE*; 2

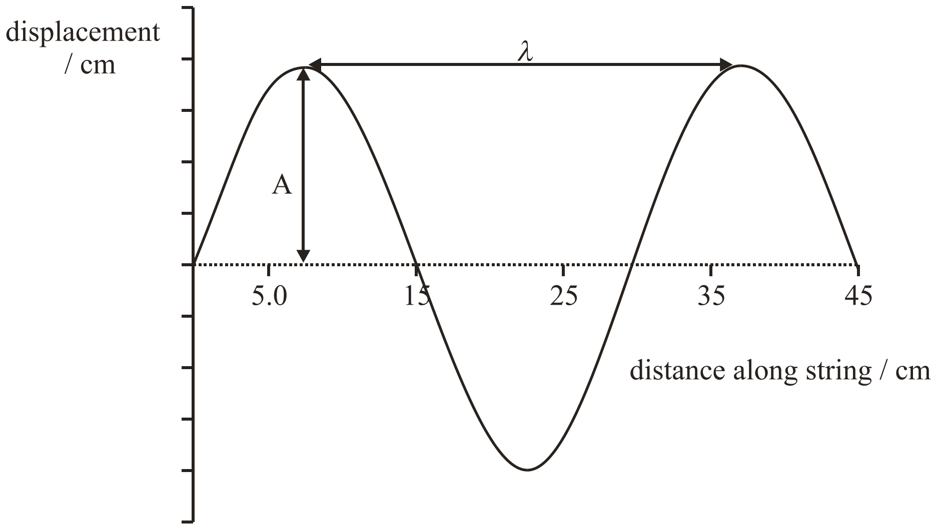
or

suitable labelled diagram e.g.



(b) any em wave / elastic waves in solids / accept water; 1

(c)



1

correct annotation

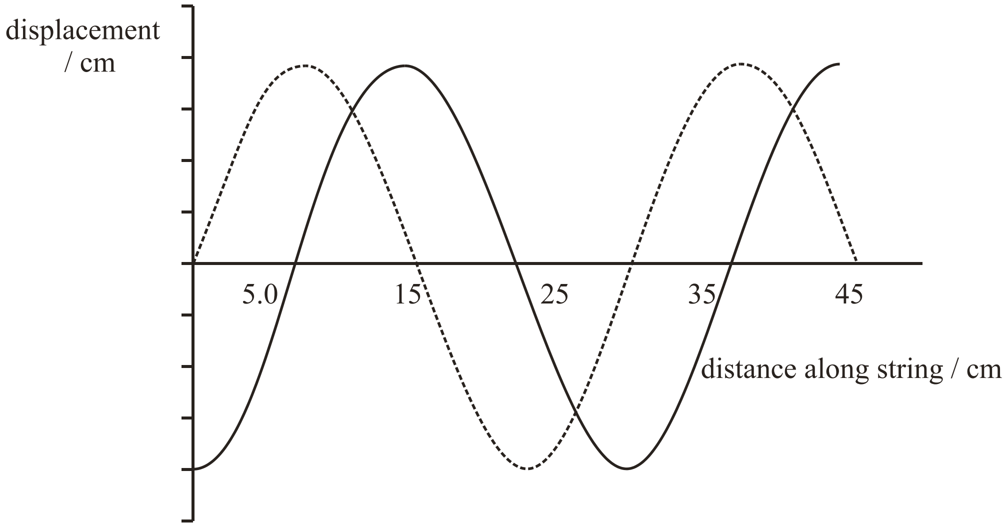
(i) A (4.0 cm); 1

(ii) λ (30.0 cm); 1

(d) $f = \frac{1}{T} = \frac{1}{1.2 \times 10^{-3}} = 830$ Hz;

$c = f\lambda = 830 \times 0.30 = 250$ m s^{-1}; 2

(e)



troughs / peaks moved to the right;
by λ /4 (7.5 cm); *(judge by eye)*
wave continuous between $x = 0$ and $x = 45$ cm; 3

(f) a system resonates when a periodic force is applied to it;
and the frequency of the force is equal to the natural frequency of vibration of the system / *OWTTE*; 2

(g) the string could be clamped at one end and vibrated at the other end by a signal generator / tuning fork;
whose frequency is adjusted until one loop of vibration is observed / *OWTTE*;
or
string is clamped at both ends;
and plucked in the middle; 2

(h) $\lambda = 0.90$ m;

$f = \frac{c}{\lambda} = \frac{250}{0.90} = 280$ hz; 2

[16]

26. (a) ray: direction in which wave (energy) is travelling;
wavefront: line joining (neighbouring) points that have the same phase / displacement /
Or suitable reference to Huygens' principle;
ray is normal to a wavefront; 3

(b) (i) wavefront parallel to D; 1

(ii) frequency is constant;
since $v = f\lambda$, $v \propto \lambda$;
wavelength larger in medium I, **hence** higher speed in medium I; 3
Allow solution based on angles marked on diagram or speed of wavefronts.

(iii) ratio = $\frac{v_I}{v_R} = \frac{\lambda_I}{\lambda_R}$ (or based on Snell's law);

$= \frac{3.0}{1.5} = 2.0$ *allow ± 0.5*; 2

(c) (i) velocity / displacement / direction in (+) and (–) directions;
idea of periodity; 2

(ii) period = 3.0 ms;
frequency = $\frac{1}{T}$ = 330 Hz; 2

(iii) *Accept any one of the following.*
at time t = 0, 1.5 ms, 3.0 ms, 4.5 ms, *etc*.; 1

(iv) area of half-loop = 140 ± 10 squares / mean $v = 4.0$ m s^{-1} *accept ± 0.2*;
$= 140 \times 0.4 \times 0.1 \times 10^{-3}$ / $4.0 \times 1.5 \times 10^{-3}$;
$= 5.6 \times 10^{-3}$ m / 6.0×10^{-3} m; 2
*Award **[1]** for area of triangle.*

(v) (twice) the amplitude; 1
Allow distance moved in 1.5 m s.

(d) travelling wave transfers energy;
standing wave does not transfer energy;
amplitude same for all particles in a travelling wave;
amplitude varies from zero to a maximum in a standing wave; 4

(e) (i) distance shown as length of two loops; 1

(ii) wavelength = $\frac{2}{5} \times 120 = 48$ cm;
$v = f\lambda = 250 \times 0.48$;
$= 120$ m s^{-1}; 3

[25]

27. A

[1]

28. D

[1]

29. A

[1]

30. (a) circular wavefronts originating from four successive source positions;
bunching of wavefronts in front, spreading out at back;
approximately, correct spacing of wavefronts in front, and behind source; 3

(b) f waves in distance $(V - v)$;

apparent wavelength = $\frac{(V-v)}{f}$;

apparent frequency = $\frac{f \times V}{(V-v)}$; 3

*Allow any other valid and correct approach or statement of formula. Award **[0]** for quote of formula with no working shown.*

(c) $\lambda' = \lambda \frac{(V-v)}{V}$;

$599.996 = \frac{600 \times (3 \times 10^8 - v)}{(3 \times 10^8)}$;

$v = 2000$ m s^{-1}; 3

Allow alternative version for red-shift.

[9]

31. (a) (i) energy transfer;
no interruption in transfer / without mass motion of the medium; 2
Do not accept "continuous".

(ii) speed / rate at which energy / wavefronts are propagated; 1

(b) (i) frequency: number of oscillations/vibrations <u>per unit time</u>; 1
Do not accept specific units e.g. seconds.

(ii) wavelength: distance moved by wave during one oscillation of the source; 1
Accept distance between successive crests or troughs.

(c) (i) wave travels down tube and is reflected;
incident and reflected waves interfere to give standing wave; 2

(ii) air (column) in tube has natural frequency of vibration;
when fork frequency equals natural frequency;
<u>maximum amplitude of vibration</u> / <u>maximum loudness</u>;
when fork frequency not equal to natural frequency,
no resonance / loudness drops; 4

(iii) $\frac{1}{2}\lambda = 65$ cm;

speed = 0.65 × 2 × 256 = 330 m s^{-1}; 2
*Award **[1 max]** for 660 m s^{-1}.*

(d) pressure = $\frac{\text{force}}{\text{area}}$

$= \frac{(4.0 \times 10^{-5})}{(30 \times 10^{-6})}$

= 1.3 Pa; 2

(e) (i) idea of using area under the line / $\frac{1}{2}kx^2$;

energy = $\frac{1}{2} \times 6 \times 10^{-5} \times 1.5 \times 10^{-2} \times 10^{-3}$ ***or*** 112.5 (±2.5) squares;

= 4.5×10^{-10} J; *(Allow ±0.1 × 10^{-10} if candidate counts squares.)* 3

(ii) period = 1.0 ms;
and energy is supplied in $\underline{\tfrac{1}{4}\text{period}}$ (= 0.25 ms);

power = $\dfrac{4.5\times10^{-10}}{0.25\times10^{-3}}$;

$= 1.8 \times 10^{-6}$ W; 4

(iii) strain energy / energy of deformation of eardrum / kinetic energy of eardrum / vibrational energy; 1

(f) (i) path difference is 2.5 λ;
wavelength = 0.20 m;
speed = $f\lambda = 1700 \times 0.2 = 340$ m s^{-1}; 3

(ii) at X: loudness increases;
waves not same amplitude at X so not complete destructive interference;
at P: loudness decreases;
because sum of amplitudes less than before; 4
*Award **[1]** for two correct statements without explanations.*
*Award **[0]** for statement with incorrect reasoning. Award **[1]** for correct statement with partially correct reasoning.*

[30]

32. Wave properties

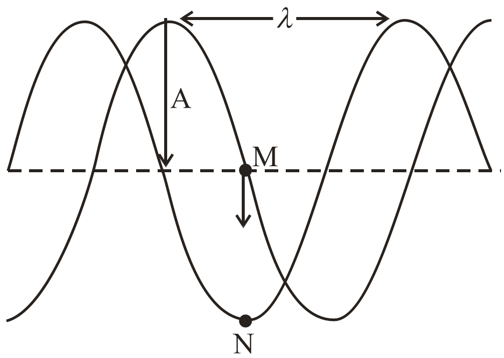
(a) (i)

1

(ii)

1

(b)



(i) downwards; 1

(ii) correct marking of A; 1

(iii) correct marking of λ; 1

(iv) +ve sine curve;
correct position of N; 2
Watch for ecf from (i).

(c) (i) $f = \dfrac{v}{\lambda}$ = to give 2.0 Hz; 1

(ii) $T = 0.5$ s;

$s = \dfrac{vT}{4} = 1.25\ (1.3)$ cm;

or

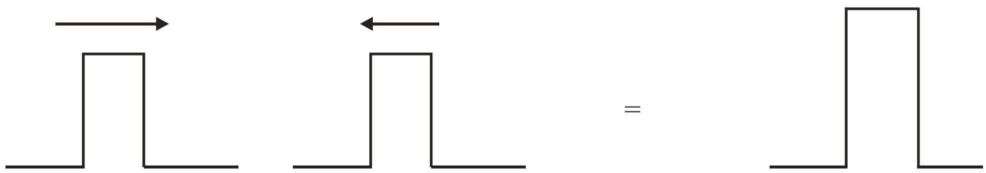
in $\dfrac{T}{4}$ wave moves forward $\frac{1}{4}\lambda$;

$= \dfrac{5}{4} = 1.25\ (1.3)$ cm; 2 max

(d) *Principle of superposition*:
when two or more waves overlap, the resultant displacement at any point;
is the sum of the displacements due to each wave separately / *OWTTE*;

Award ***[2 max]*** *for an answer that shows a clear understanding of the principle,* ***[1]*** *for a reasonable understanding and* ***[0]*** *for a weak answer.*

Explanation:



suitable diagram;
when two +ve pulses (or two wave crests) overlap, they reinforce / OWTTE; 4

Any situation where resultant displacement looks as though it is the sum of the individual displacements. Mark the description of the principle and the description of constructive interference together.

(e) (i) $S_2X = n\lambda$;
where $n = 0, 1, 2$; *(Accept "n is an integer")* 2

(ii) $\sin\theta \approx \theta$;
therefore $\theta = \dfrac{S_2X}{d}$; 2

(iii) $\phi = \dfrac{y_n}{D}$; 1

Award the small angle approximation mark anywhere in (i) or (ii).

(f) (i) $\theta = \dfrac{S_2X}{d} = \dfrac{n\lambda}{d}$ *so* $\lambda = \dfrac{d\theta}{n}$;
substitute to get $\lambda = 4.73 \times 10^{-7}$ m; 2

(ii) θ and ϕ are small;

therefore $\dfrac{\lambda}{d} = \dfrac{y}{D}$;

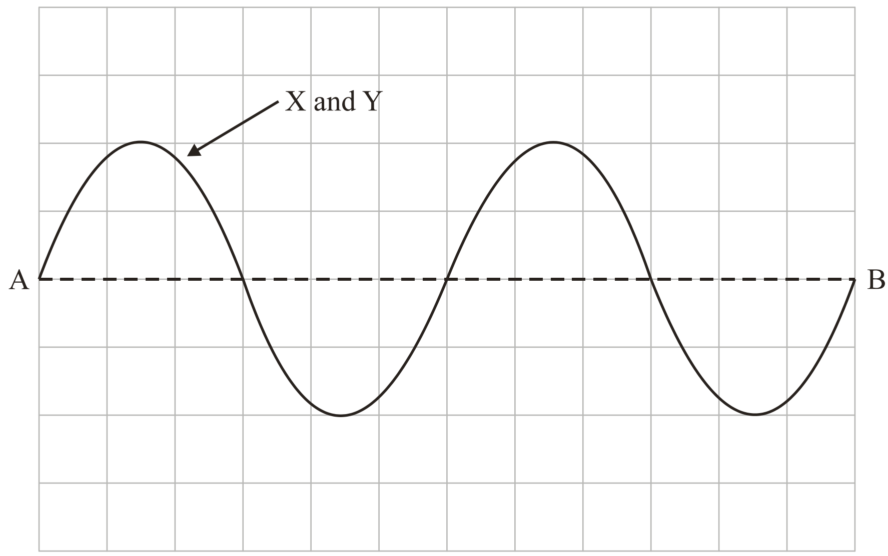
so $y = \dfrac{D\lambda}{d} = 0.510$ mm; 3

[24]

33. (a) the net **displacement** of the medium/particles (through which waves travel);
is equal to the sum of individual **displacements** (produced by each wave); 2 max

*Award a good understanding **[2 max]** and a reasonable one **[1 max]**.*

(b) *Wave X and wave Y should be identical.*



correct phase for wave X;
correct phase for wave Y;
amplitudes the same for each wave;
amplitude for each wave is two divisions; 4 max

(c) (i) the phase difference between light leaving S_1 and S_2 is constant; 1

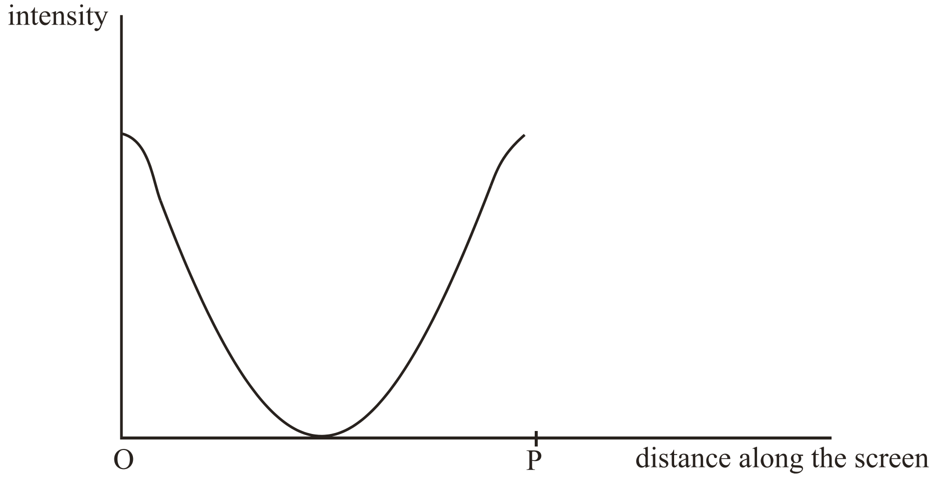
Do not penalize the candidate if they state "has the same phase".

(ii) to produce **sufficient** diffraction;
for the beams to overlap;
OWTTE; 2 max

(d) (i) path difference between S_1 and S_2 is an integral number of wavelengths; 1

Accept "waves arrive at P in phase".

(ii)



maximum at O and P;
general shape with minimum about half way between O and P; 2 max

(e) fringe spacing = 2.5×10^{-4} m;

$\lambda = \dfrac{(2.5 \times 10^{-4} \times 3.00 \times 10^{-3})}{1.50} = 5.0 \times 10^{-7}$ m; 2

[14]