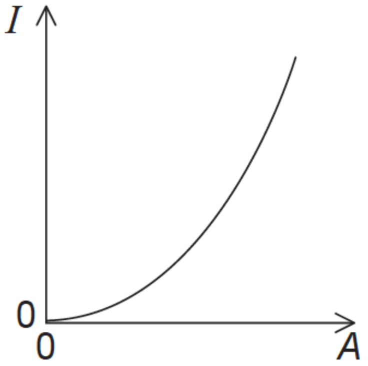
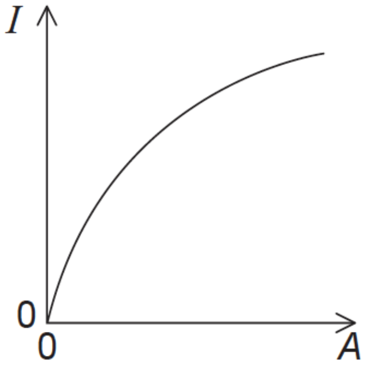
T4-1 *[180 marks]*

1. Which graph shows the variation with amplitude *A* of the intensity *I* for a wave? *[1 mark]*

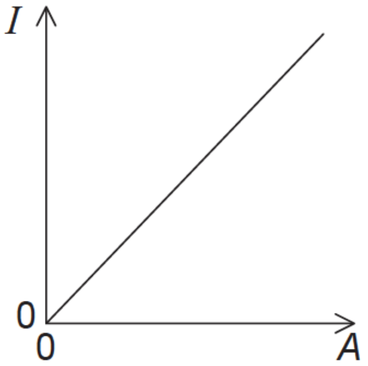
A.



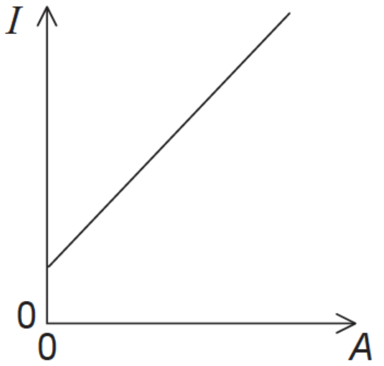
B.



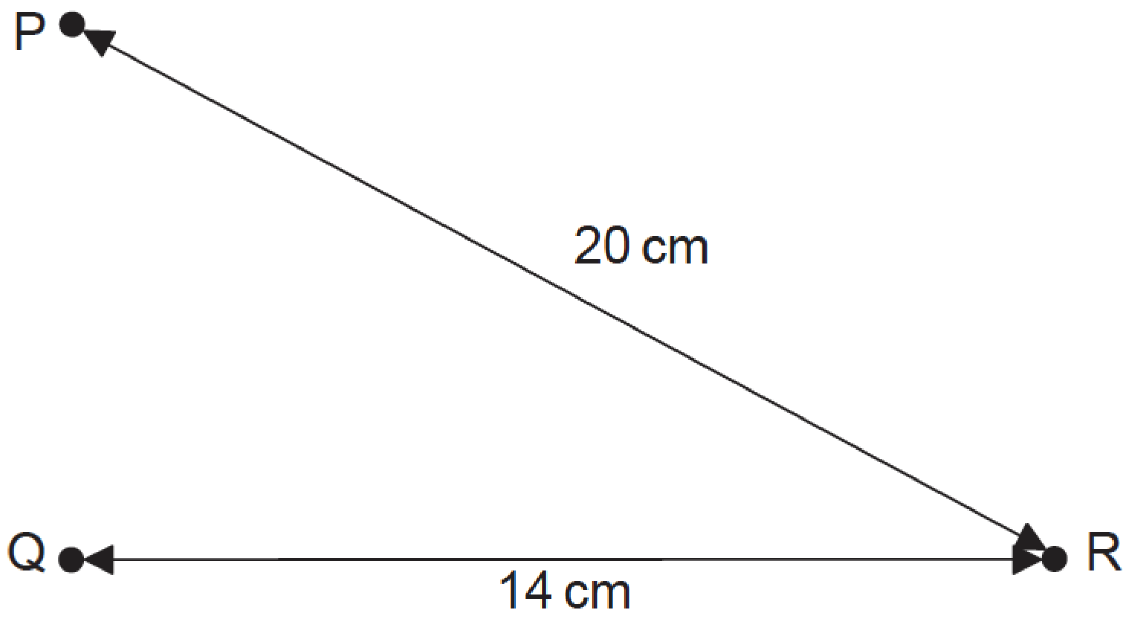
C.



D.



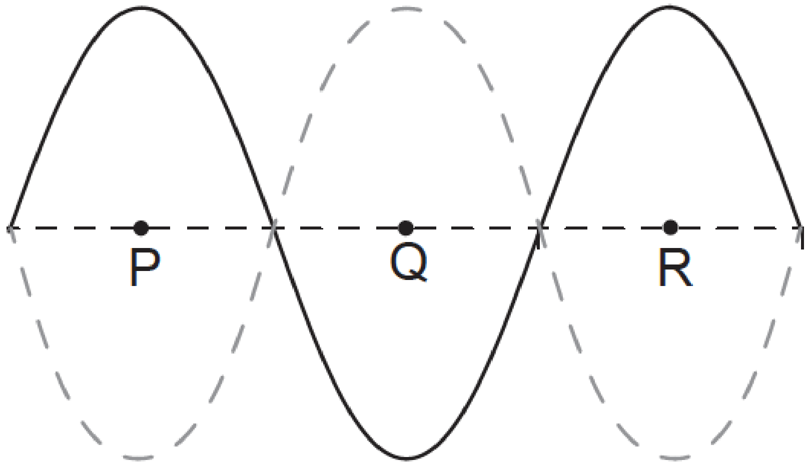
2. Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude *A* at position R. Distances PR and QR are shown in the diagram below. *[1 mark]*



Both wave generators now operate together in phase. What is the amplitude of the oscillation of the resulting wave at R?

A. 0
B. *A*
C. A^2
D. 2*A*

3. A standing (stationary) wave is set up on a stretched string. The diagram below shows the string at three different instants of time. P, Q and R are three points on the string. *[1 mark]*



Which of the following gives two points on the string that are in phase and two points on the string that are one wavelength apart?

	In phase	One wavelength apart
A.	P and Q	P and R
B.	P and R	P and R
C.	P and Q	P and Q
D.	P and R	P and Q

4. An unpolarized ray of light in air is incident on the surface of water. The reflected ray is completely polarized. Which of the following are separated by an angle of 90˚? *[1 mark]*

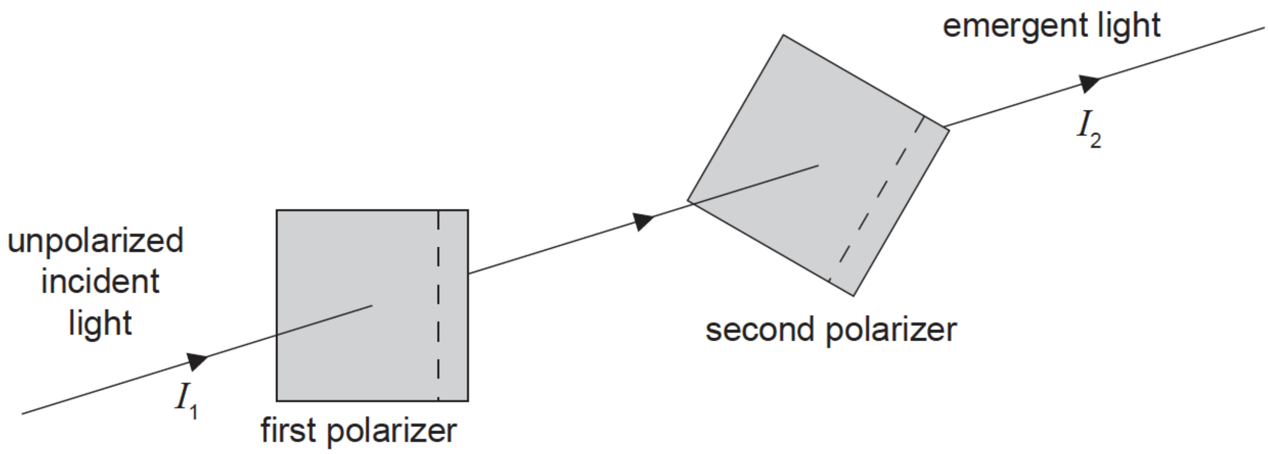
A. The incident ray and the reflected ray

B. The reflected ray and the refracted ray

C. The refracted ray and the incident ray

D. The refracted ray and the surface of the water

5. Two polarizers have polarizing axes that make an angle of 30° to each other. Unpolarized light of intensity I_1 is incident on the first polarizer so that light of intensity I_2 emerges from the second polarizer, as shown below. *[1 mark]*



The cosine of 30° is $\frac{\sqrt{3}}{2}$. What is the ratio $\frac{I_1}{I_2}$?

A. $\frac{3}{8}$
B. $\frac{4}{3}$
C. $\frac{4}{\sqrt{3}}$
D. $\frac{8}{3}$

6. An object performs simple harmonic motion (SHM) about a central point. The object has velocity *v* and acceleration *a* when it has displacement *x* from the point. *[1 mark]*

Which ratio is constant?

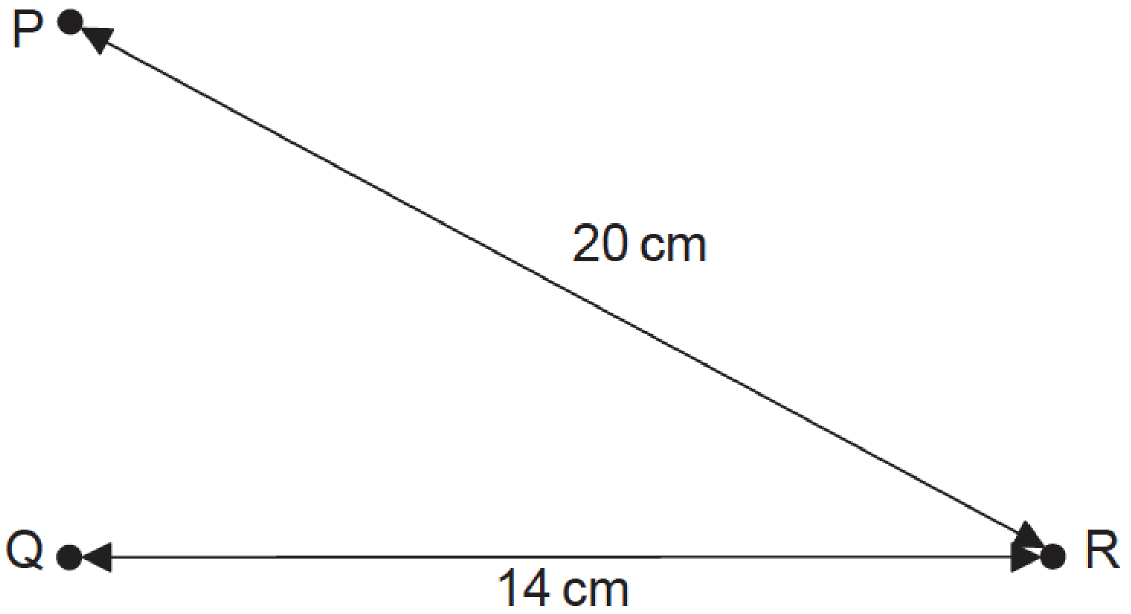
A. $\frac{x}{a}$

B. $\frac{x}{v}$

C. $\frac{x^2}{a}$

D. $\frac{v}{a}$

7. Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude *A* at position R. Distances PR and QR are shown in the diagram below. *[1 mark]*



Both wave generators now operate together in phase. What is the amplitude of the oscillation of the resulting wave at R?

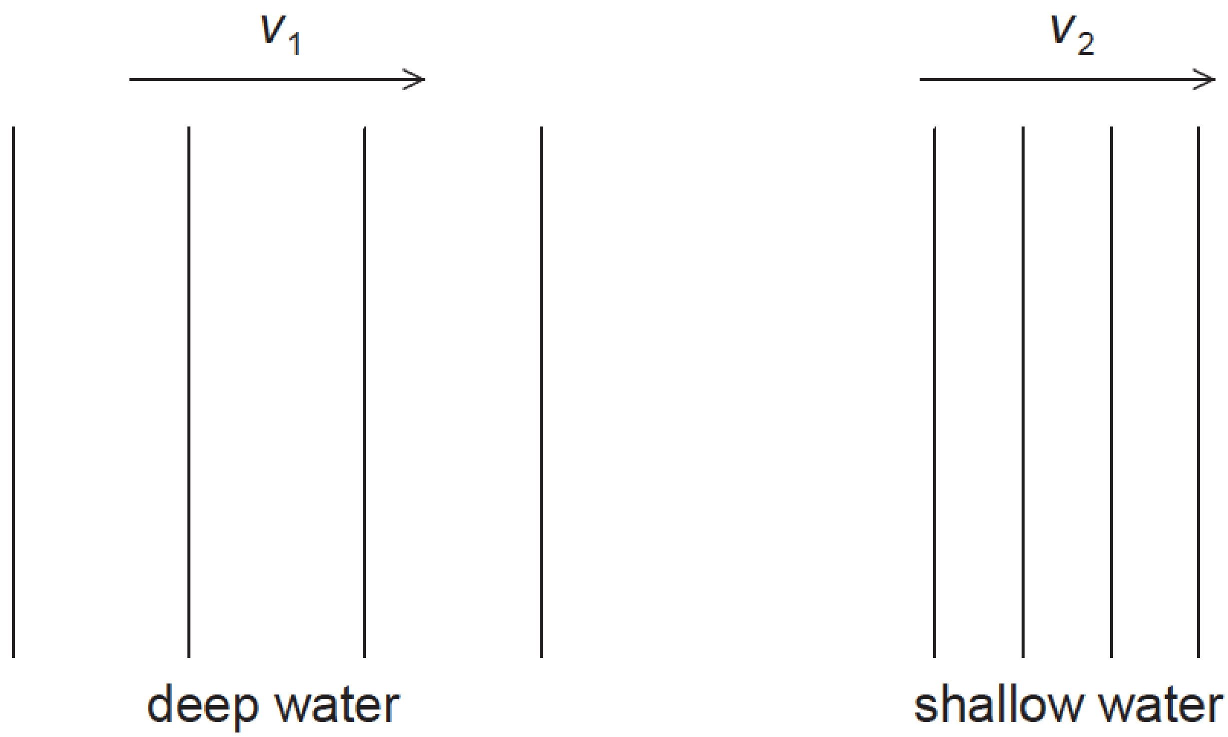
A. 0

B. *A*

C. A^2

D. 2*A*

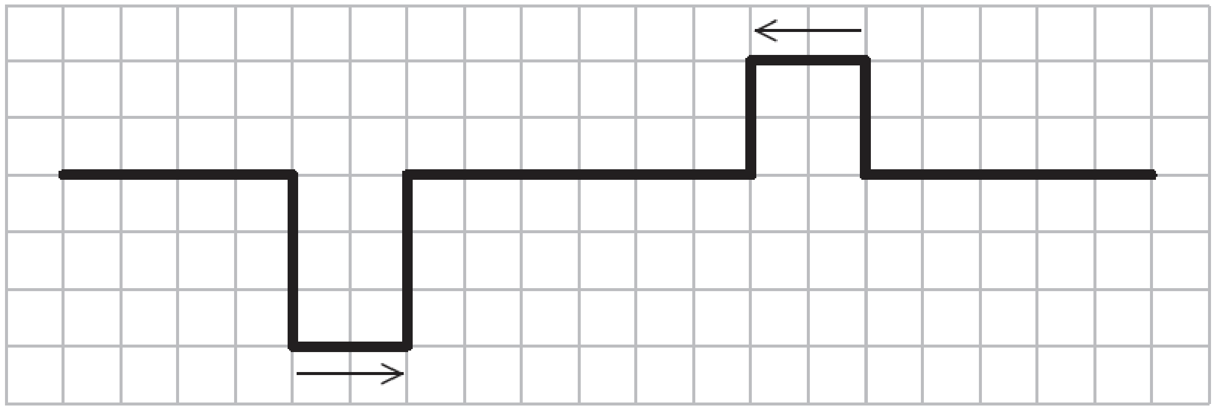
8. A water wave entering a harbour passes suddenly from deep to shallow water. In deep water, the wave has frequency f_1 and speed v_1. In shallow water, the wave has frequency f_2 and speed v_2. *[1 mark]*



Which of the following compares the frequencies and speeds of the wave between deep water and shallow water?

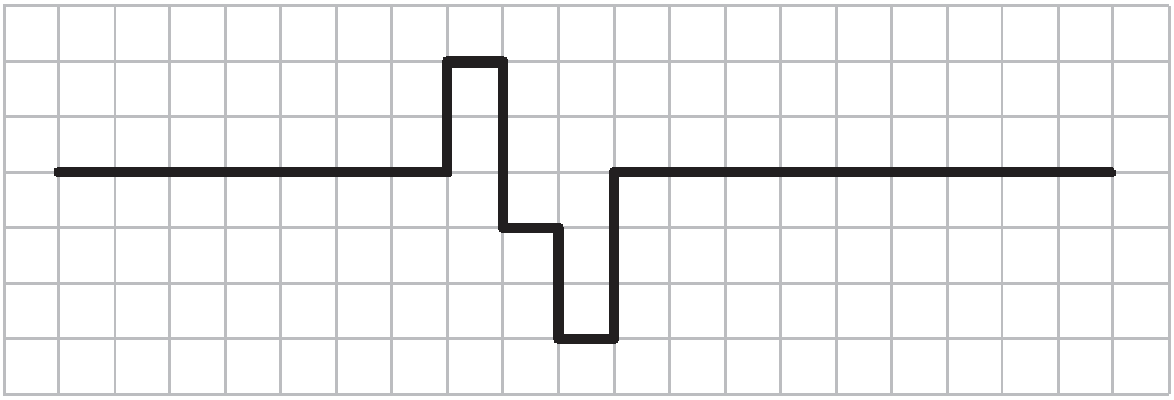
	Frequencies	Wave speeds
A.	$f_1 = f_2$	$v_1 > v_2$
B.	$f_1 = f_2$	$v_1 < v_2$
C.	$f_1 > f_2$	$v_1 = v_2$
D.	$f_1 < f_2$	$v_1 > v_2$

9. Two wave pulses move towards each other as shown in the diagram. *[1 mark]*

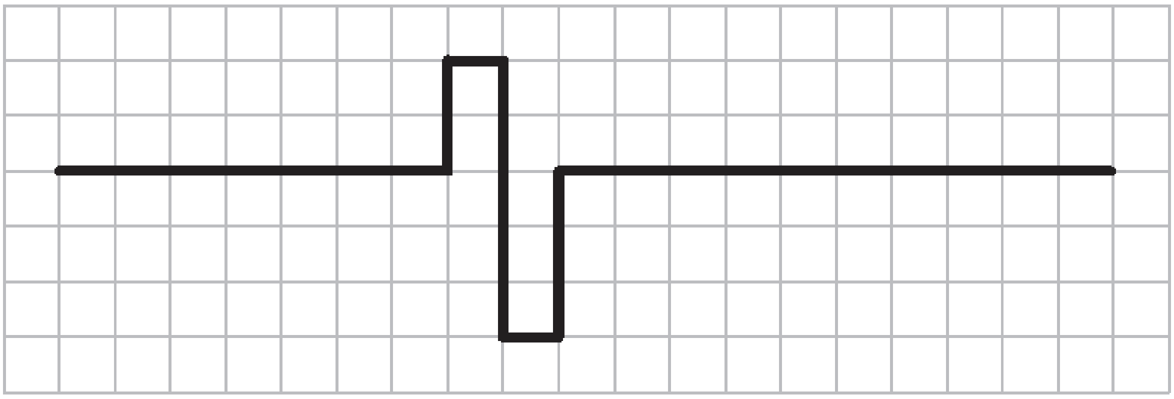


Which diagram shows a possible combination of the two pulses after a short time?

A.



B.



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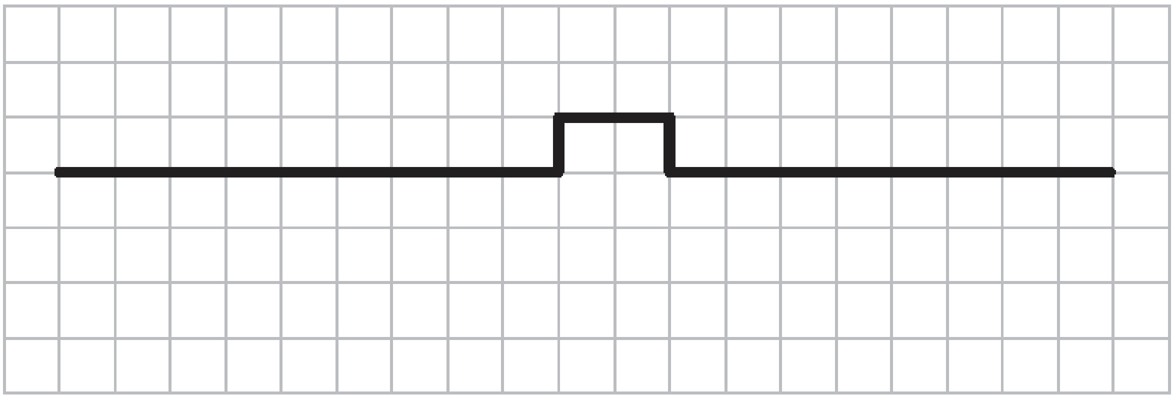
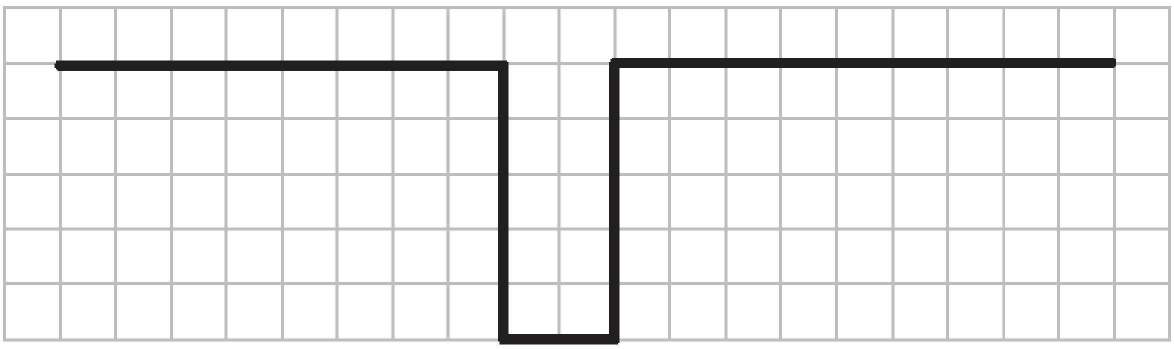
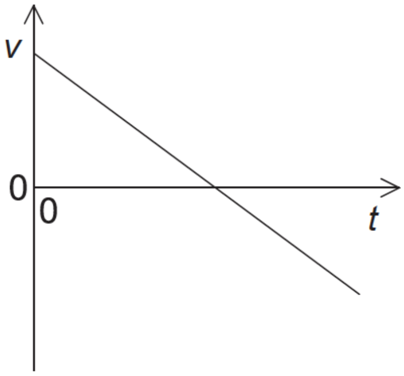


D.

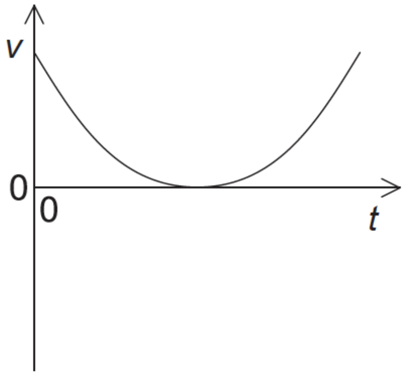


10. A liquid in a U-tube is given an initial displacement and allowed to oscillate. The motion of the liquid is recorded using a motion sensor. Which graph shows the variation with time *t* of the velocity *v* of the liquid? *[1 mark]*

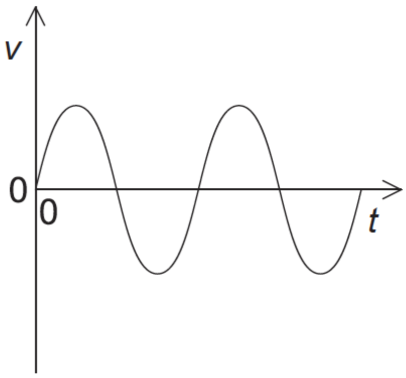
A.



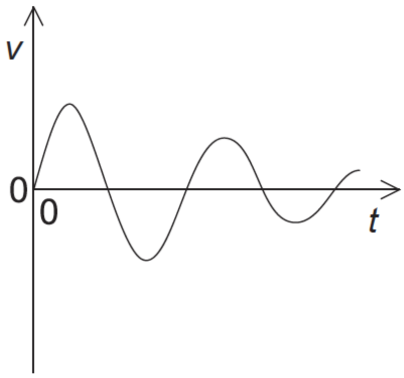
B.



C.

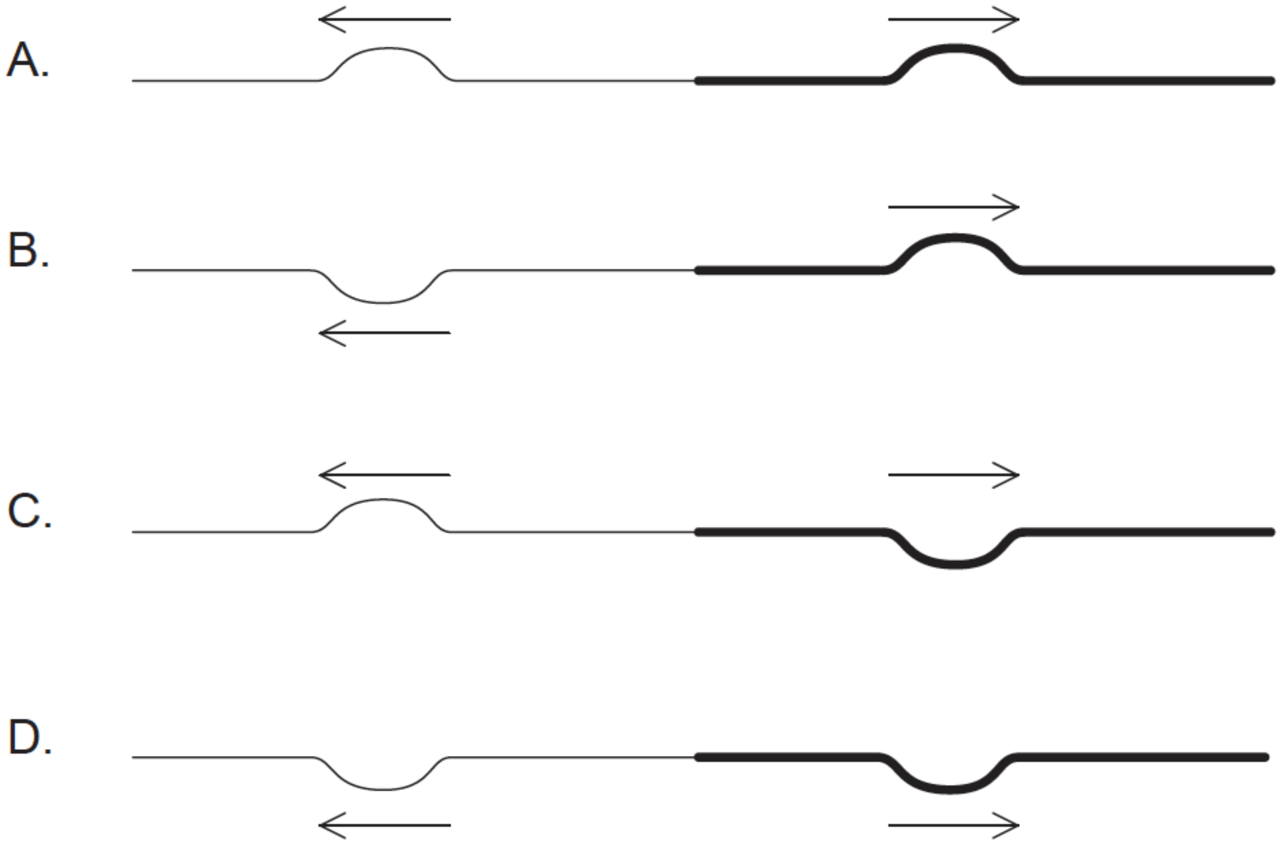


D.



11. A wave pulse is sent along a light string which is attached to a heavy rope as shown. The diagrams are not to scale. *[1 mark]*

Which diagram shows the shape of the string and the rope after a short time?



12. A standing sound wave is set up inside a narrow glass tube which has both ends open. The first harmonic frequency of the standing wave is 500Hz. What is the frequency of the sound wave if the length of the tube is halved and one end is closed? *[1 mark]*

A. 250 Hz

B. 500 Hz

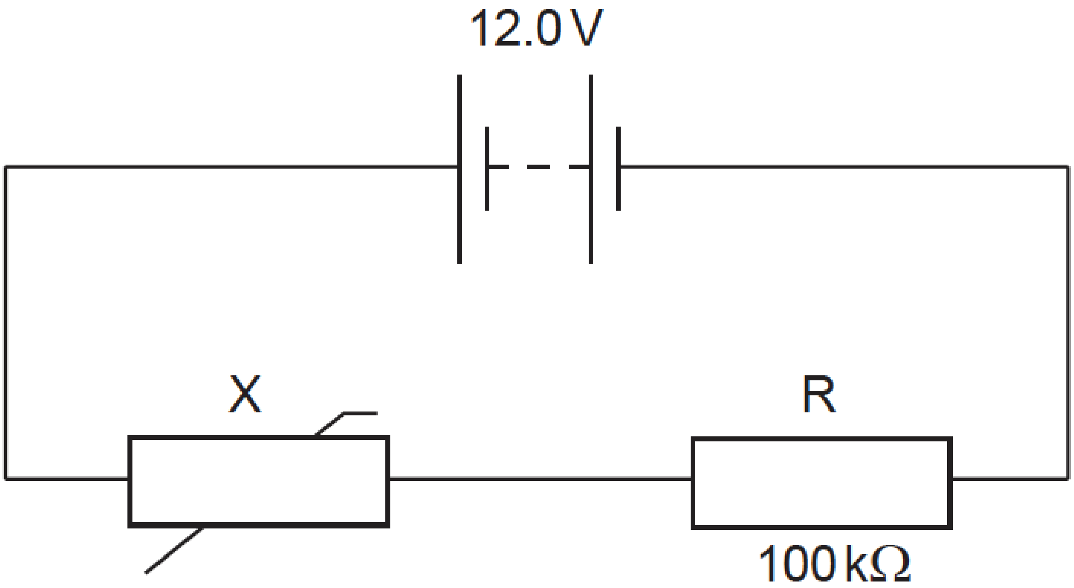
C. 1000 Hz

D. 2000 Hz

This question is in two parts. Part 1 is about a thermistor circuit. Part 2 is about vibrations and waves.

Part 1 Thermistor circuit

The circuit shows a negative temperature coefficient (NTC) thermistor X and a 100 kΩ fixed resistor R connected across a battery.



The battery has an electromotive force (emf) of 12.0 V and negligible internal resistance.

13a. (i) Define *electromotive force (emf)*. *[2 marks]*

(ii) State how the emf of the battery can be measured.

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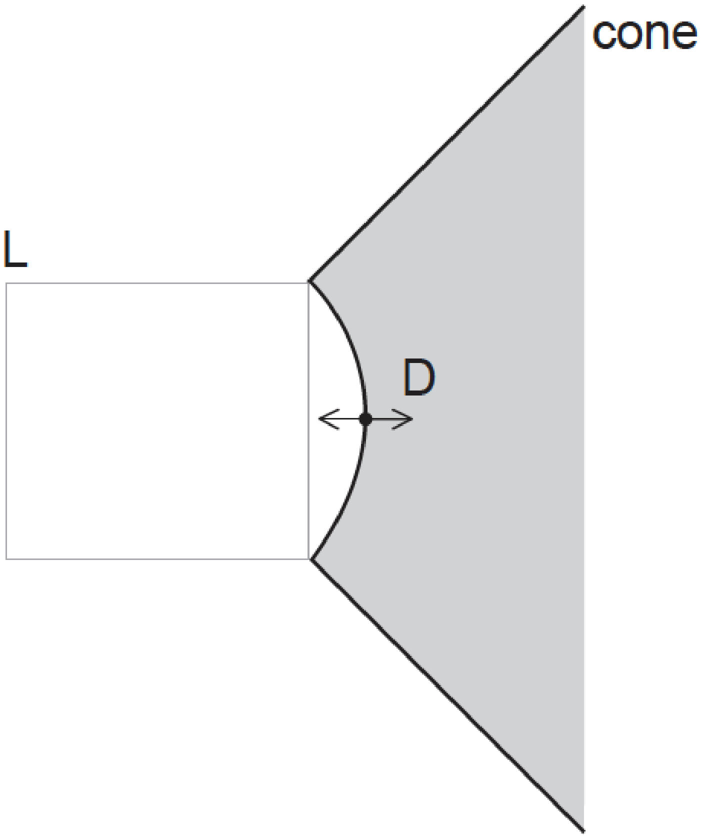
Part 2 Vibrations and waves

The cone and dust cap D of a loudspeaker L vibrates with a frequency of 1.25 kHz with simple harmonic motion (SHM).



13b. Define *simple harmonic motion (SHM)*. *[2 marks]*

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13c. D has mass 6.5×10^{-3} kg and vibrates with amplitude 0.85 mm. *[4 marks]*

(i) Calculate the maximum acceleration of D.

(ii) Determine the total energy of D.

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13d. The sound waves from the loudspeaker travel in air with speed 330 ms^{-1}. *[2 marks]*

(i) Calculate the wavelength of the sound waves.

(ii) Describe the characteristics of sound waves in air.

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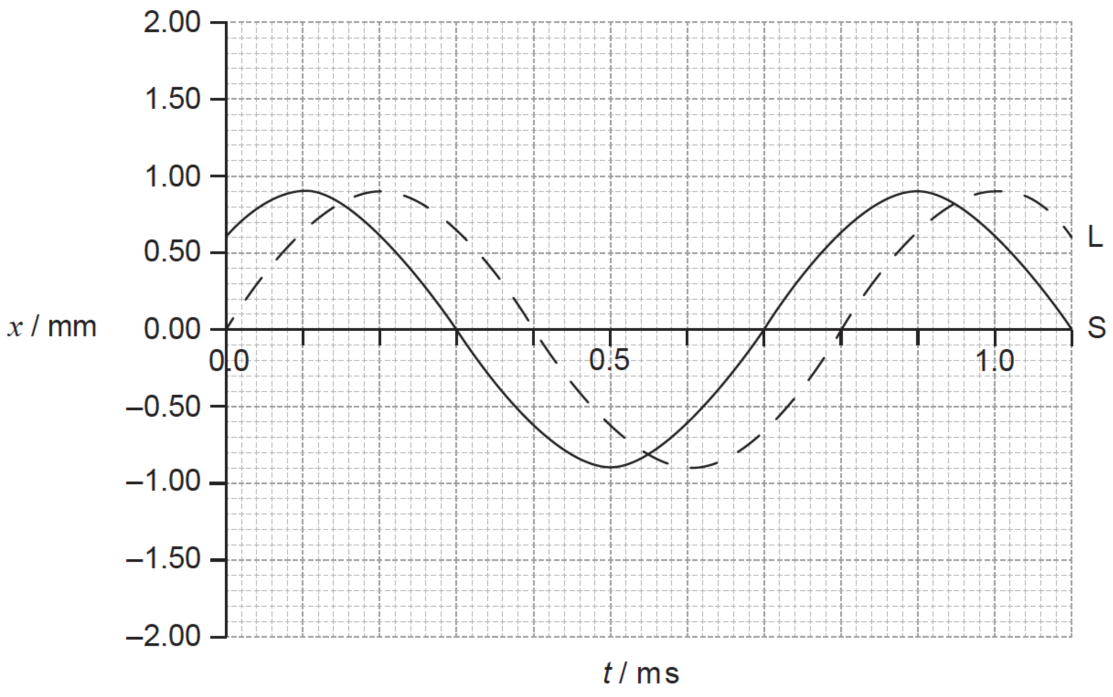
13e. A second loudspeaker S emits the same frequency as L but vibrates out of phase with L. The graph below shows the variation with time *t* of the displacement *x* of the waves emitted by S and L. *[6 marks]*



(i) Deduce the relationship between the phase of L and the phase of S.

(ii) On the graph, sketch the variation with *t* of *x* for the wave formed by the superposition of the two waves.

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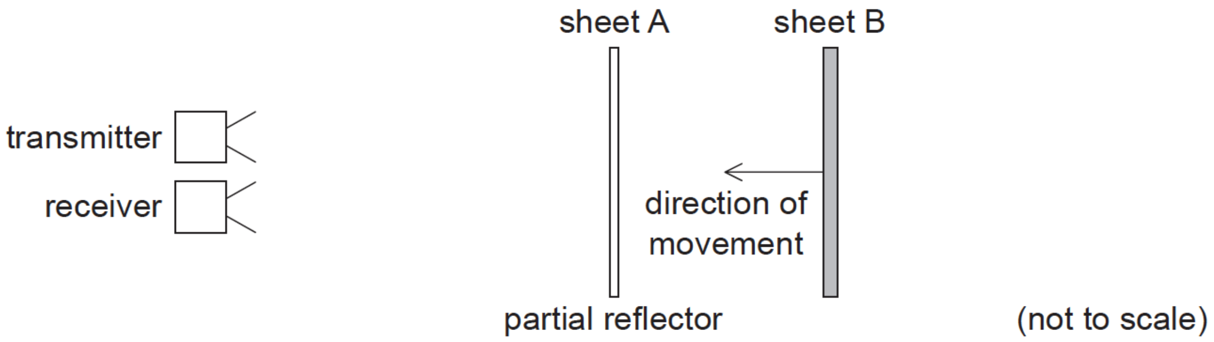
This question is about the properties of waves.

Microwaves from a microwave transmitter are reflected from two parallel sheets, A and B. Sheet A partially reflects microwave energy while allowing some to pass through. All of the microwave energy incident on sheet B is reflected.



Sheet A is fixed and sheet B is moved towards it. While sheet B is moving, the intensity of the signal detected at the receiver goes through a series of maximum and minimum values.

14a. Outline why a minimum in the intensity occurs for certain positions of sheet B. *[3 marks]*

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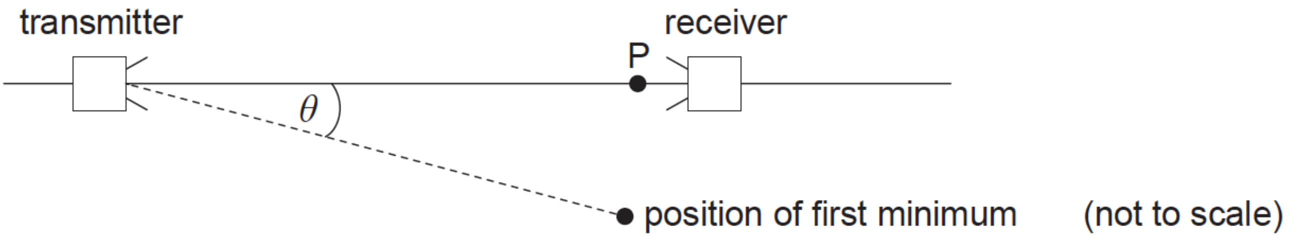
14b. The apparatus is arranged to demonstrate diffraction effects. *[3 marks]*



The microwaves emerge from the transmitter through an aperture that acts as a single slit.

(i) Outline what is meant by diffraction.

(ii) A maximum signal strength is observed at P. When the receiver is moved through an angle θ, a first minimum is observed. The width of the aperture of the transmitter is 60 mm. Estimate the value of θ.

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14c. Microwaves can be used to demonstrate polarization effects. Outline why an ultrasound receiver and transmitter **cannot** be used to demonstrate polarization. *[2 marks]*

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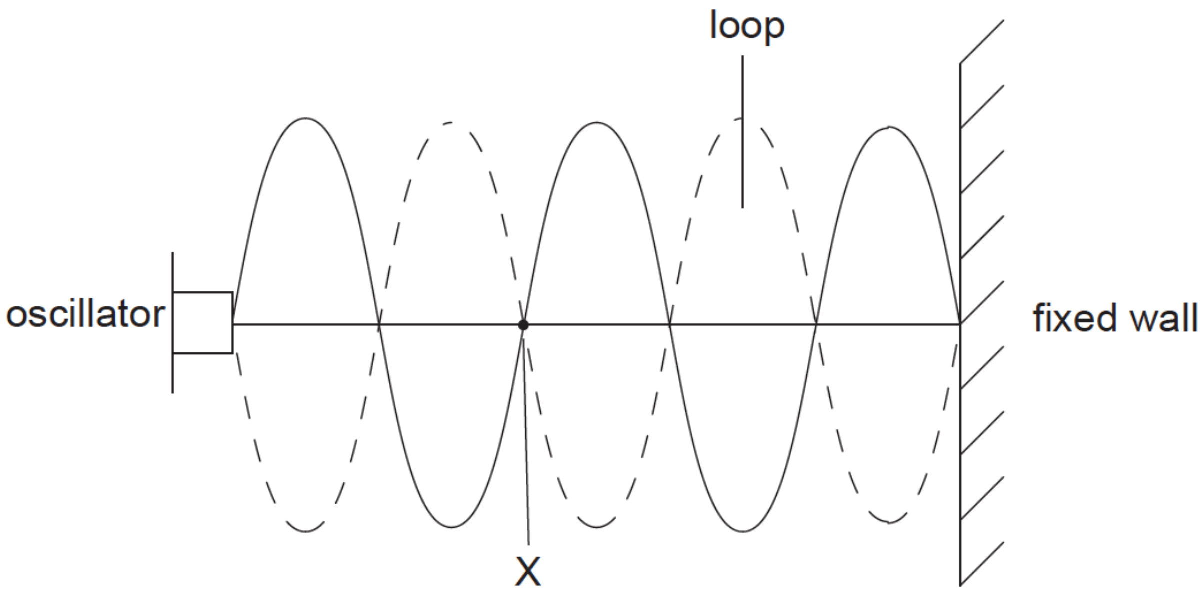
This question is about standing (stationary) waves.

The diagram shows an arrangement used to produce a standing (stationary) wave on a stretched string of length 2.4 m. A standing wave with five loops appears when the frequency of the oscillator is set to 150 Hz, as shown below.



15a. State the name given to point X on the string. *[1 mark]*

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15b. (i) Calculate the speed of the wave along the string. *[3 marks]*

(ii) Calculate the frequency of the oscillator that would produce a standing wave with two loops on this string.

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This question is about polarized light.

An analyser is used with polarized light.

16a. Outline the function of an analyser in this context. *[2 marks]*

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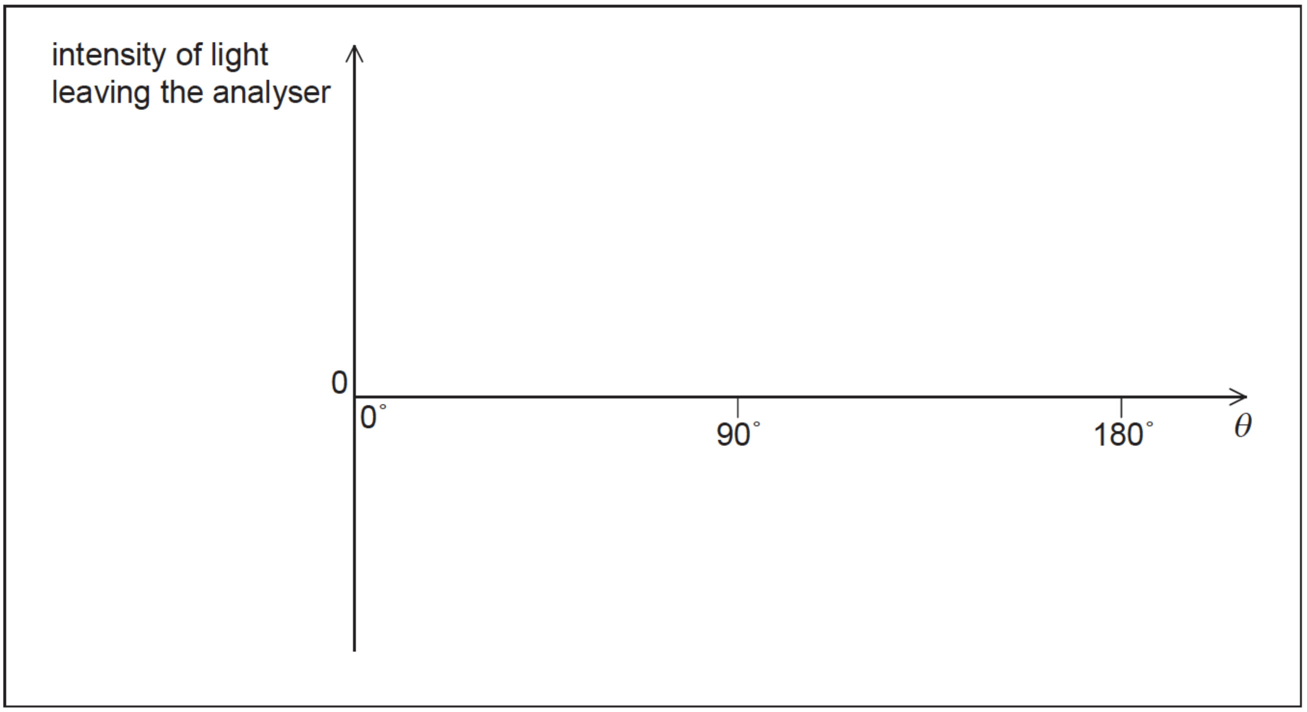
16b. Polarized light of intensity I_0 is incident on the analyser. *[3 marks]*

(i) The transmission axis of the analyser is at an angle of 25° to the electric field of the polarized light. Calculate, in terms of I_0, the intensity of the light that leaves the analyser.

(ii) The angle θ between the transmission axis of the analyser and the electric field of the polarized light is varied. On the axes, sketch a graph to show the variation with θ of the intensity of the light leaving the analyser.



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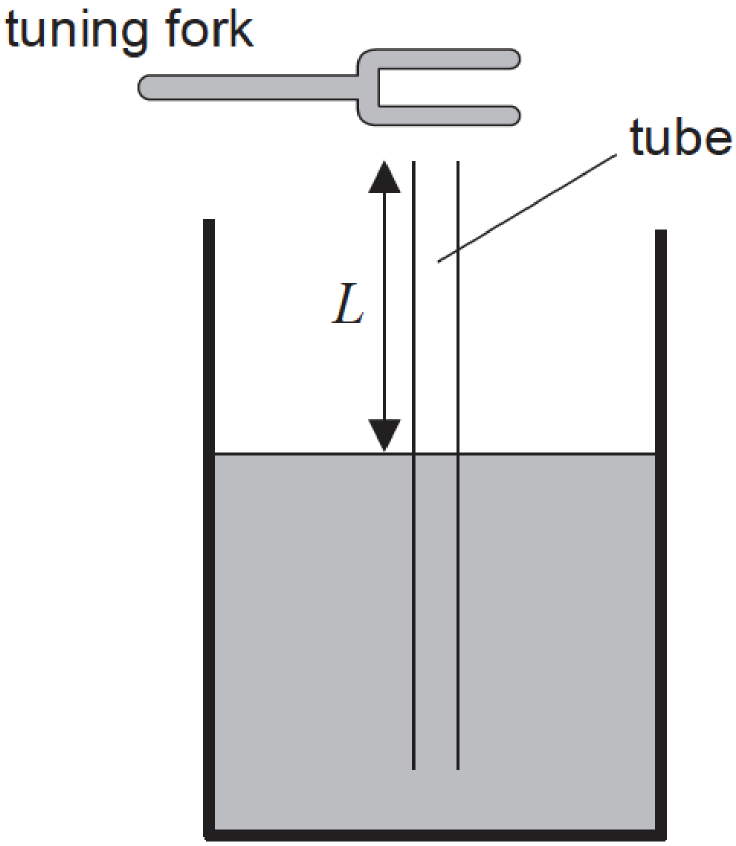
This question is about standing (stationary) waves in a tube.

17a. A thin tube is immersed in a container of water. A length L of the tube extends above the surface of water. *[4 marks]*



A tuning fork is sounded above the tube. For particular values of *L*, a standing wave is established in the tube.

(i) Explain how a standing wave is formed in this tube.

(ii) The frequency of the tuning fork is 256 Hz. The smallest length *L* for which a standing wave is established in the tube is 33.0 cm. Estimate the speed of sound in the tube.

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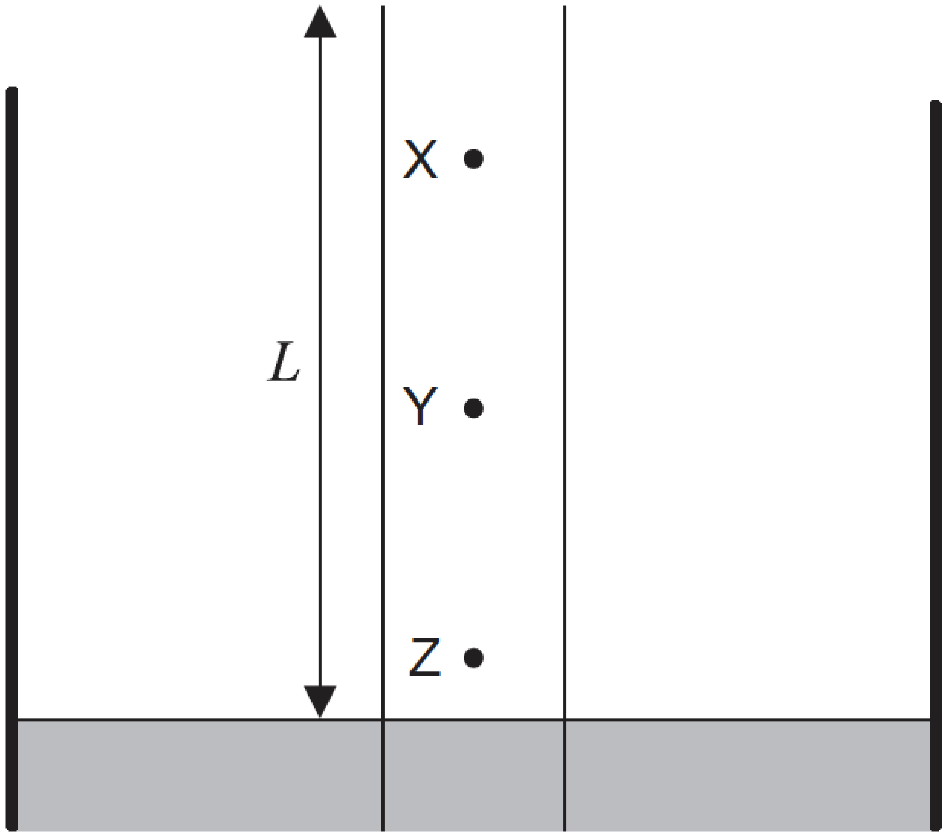
17b. The diagram shows an enlarged view of the tube shown in (a). X, Y and Z are three molecules of air in the tube. *[2 marks]*



The length *L* is 33.0 cm.

(i) State the direction of oscillation of molecule Y.

(ii) Identify the molecule that has the greatest amplitude.

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This question is about polarization.

18. State what is meant by polarized light. *[1 mark]*

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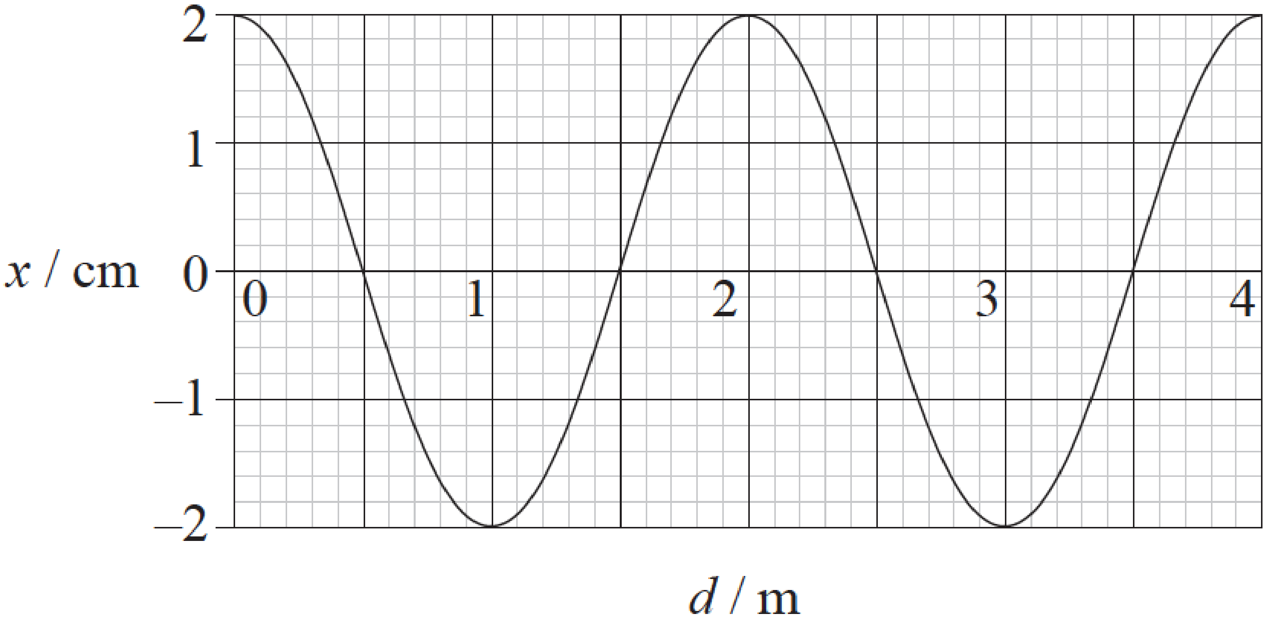
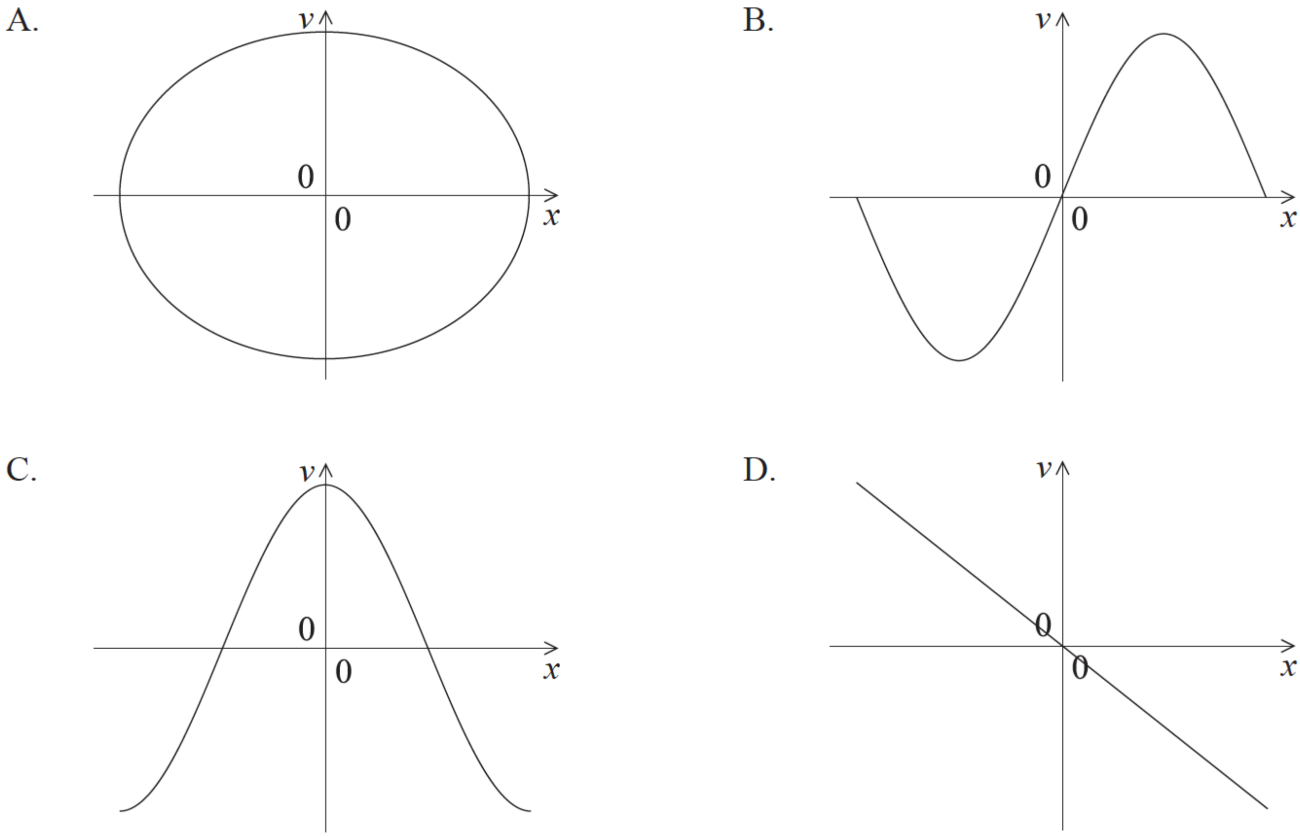
19. A wave of period 5.0m s travels through a medium. The graph shows the variation with distance *d* of the displacement *x* of points in the medium. *[1 mark]*



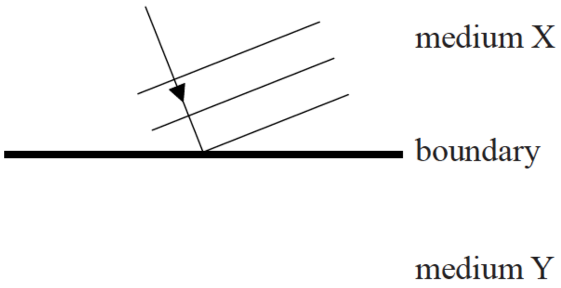
What is the average speed of a point in the medium during one full oscillation?

A. 0m s^{-1}
B. 4.0m s^{-1}
C. 16m s^{-1}
D. 400m s^{-1}

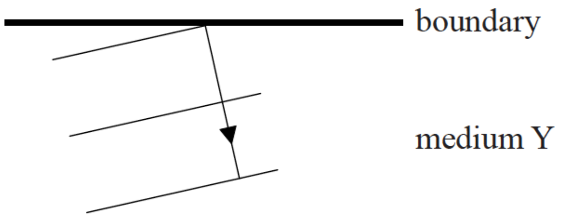
20. A body undergoes simple harmonic motion. Which graph correctly shows the variation with displacement *x* of the velocity *v* of the body? *[1 mark]*



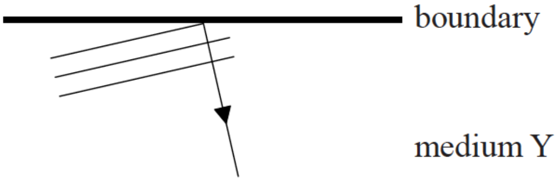
21. The speed of a wave in medium X is greater than the speed of the wave in medium Y. Which diagram shows the correct refraction of the wavefronts at the boundary between X and Y? *[1 mark]*



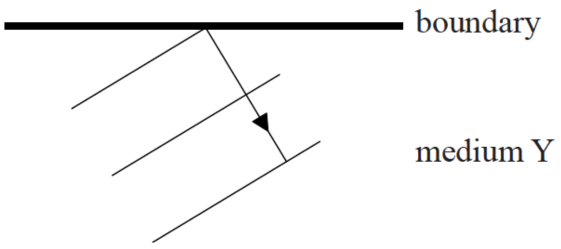
A.



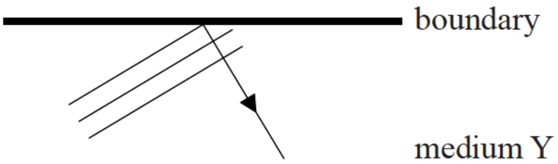
B.



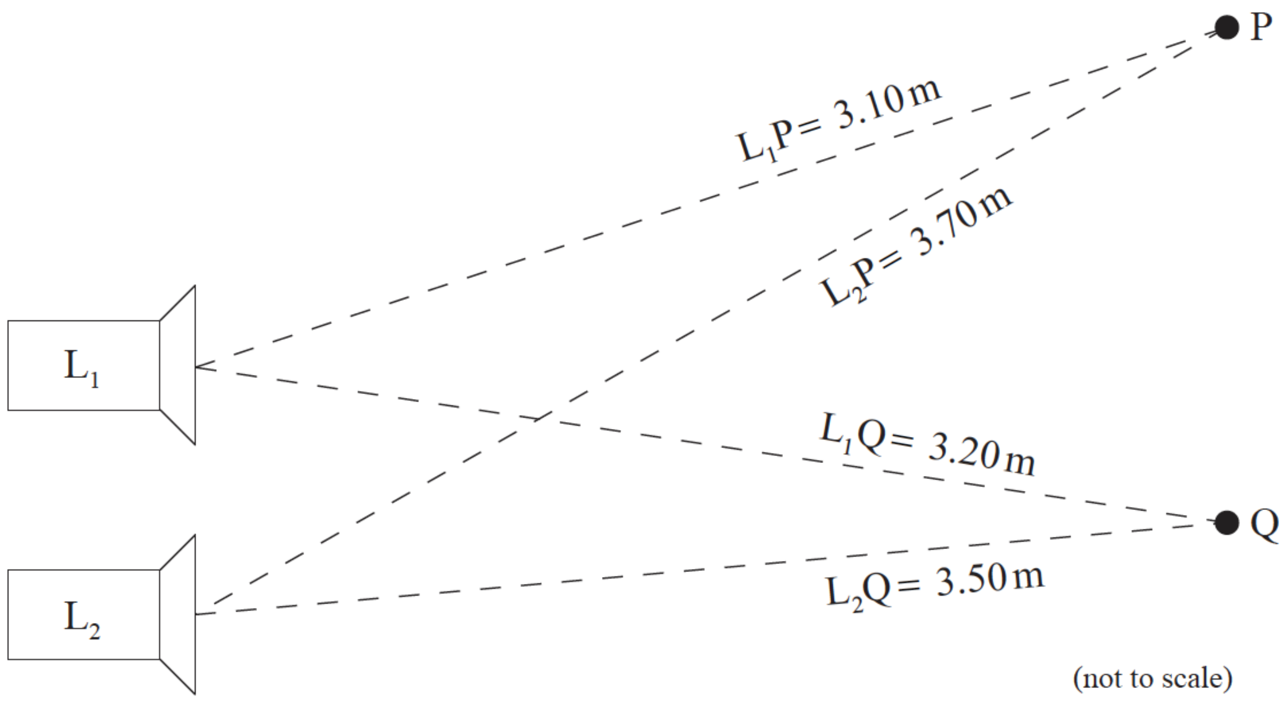
C.



D.



22. Two loudspeakers, L_1 and L_2, emit identical sound waves. *[1 mark]*



The waves leaving L_1 and L_2 are in phase and are observed at points P and Q.

The wavelength of the sound is 0.60 m. The distances of points P and Q from the loudspeakers are shown in the diagram.

Which of the following is true about the intensity of the sound at P and the intensity of the sound at Q?

	Intensity at P	Intensity at Q
A.	maximum	maximum
B.	maximum	minimum
C.	minimum	maximum
D.	minimum	minimum

23. A high solid wall separates two gardens X and Y. Music from a loudspeaker in X can be heard in Y even though X cannot be seen from Y. The music can be heard in Y due to *[1 mark]*

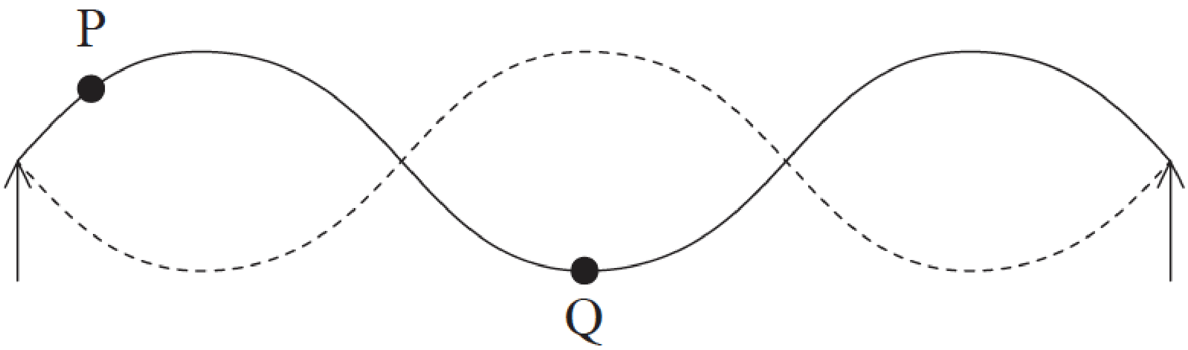
A. absorption.

B. diffraction.

C. reflection.

D. refraction.

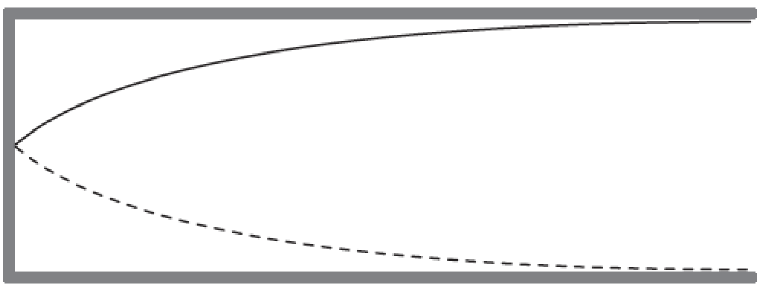
24. A string is made to vibrate at its third harmonic. The diagram shows two points P and Q at a particular instant in time. *[1 mark]*



Which of the following compares the period of vibration of P and Q and the average speed of P and Q?

	Period of vibration of P and Q	Average speed of P and Q
A.	same	same
B.	same	different
C.	different	same
D.	different	different

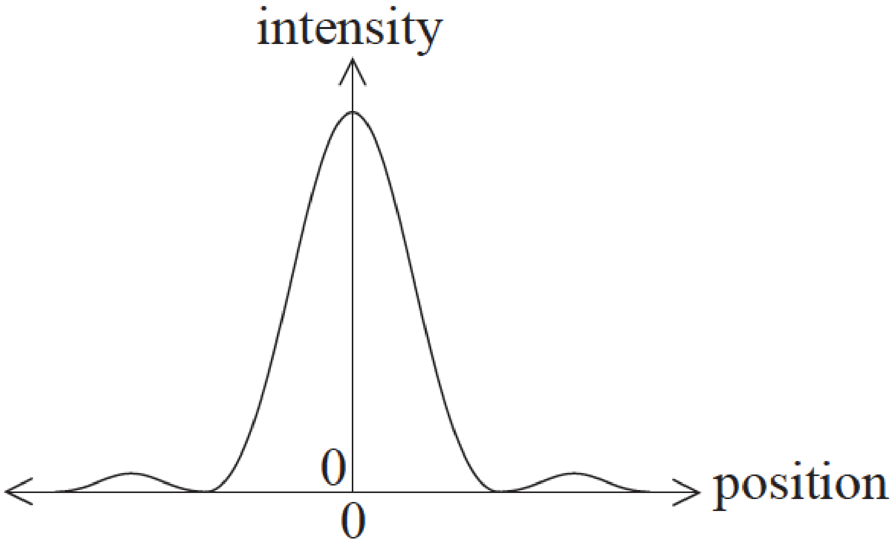
25. The diagram shows the fundamental (first harmonic) of a standing (stationary) sound wave in a pipe open at one end. *[1 mark]*



At any instant, all the molecules of air in the pipe oscillate with the same

A. phase.
B. amplitude.
C. velocity.
D. acceleration.

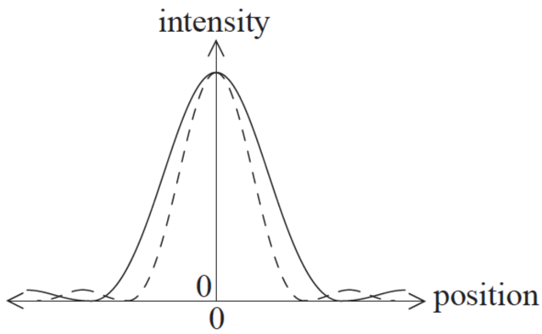
26. Monochromatic coherent light is incident on a narrow rectangular slit. The diffracted light is observed on a distant screen. The graph below shows how the intensity of the light varies with position on the screen. *[1 mark]*



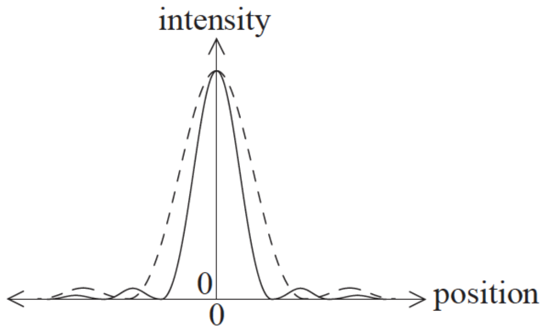
The width of the slit is reduced.

Which graph shows how the intensity of light observed varies with position on the screen? The original diffraction pattern is shown with a dotted line.

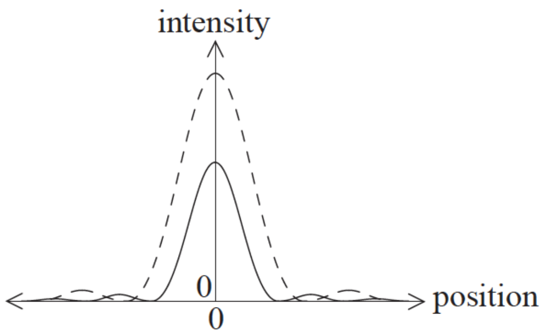
A.



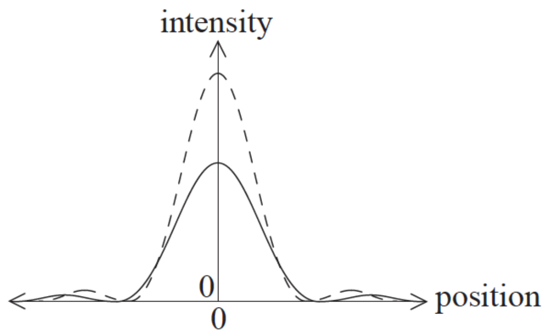
B.



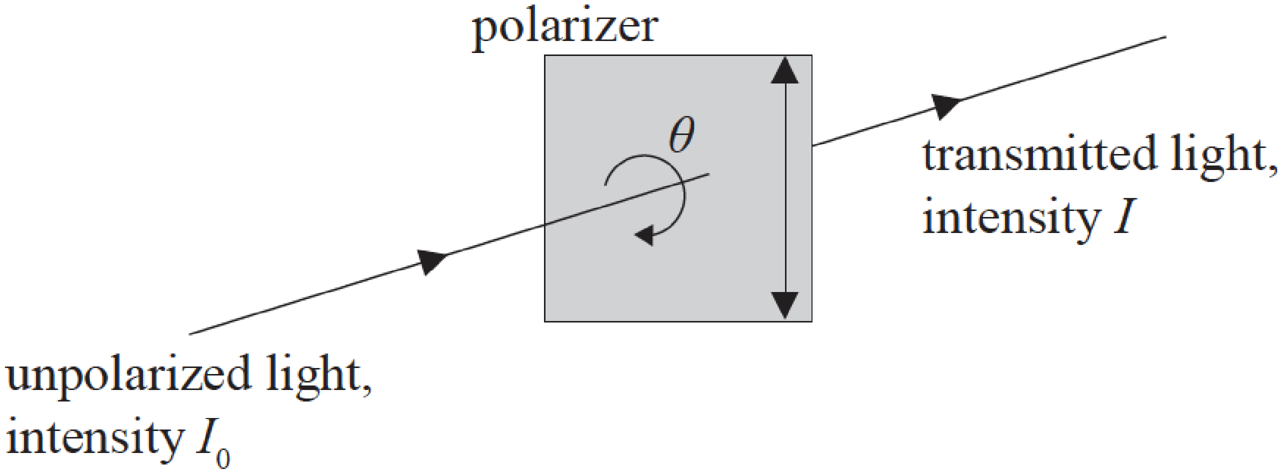
C.



D.



27. Unpolarized light of intensity I_0 is incident on a polarizer that has a vertical transmission axis. *[1 mark]*



The polarizer is rotated by an angle θ about the direction of the incident light. The intensity of the transmitted light is I.
Which graph correctly shows the variation with the angle θ of the ratio $\frac{I}{I_0}$?

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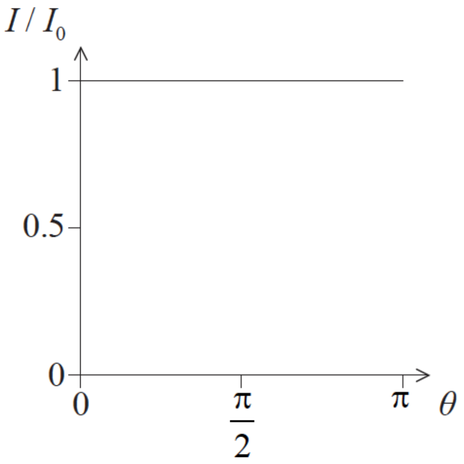

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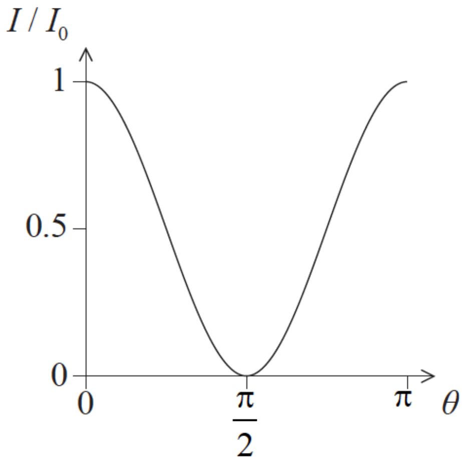

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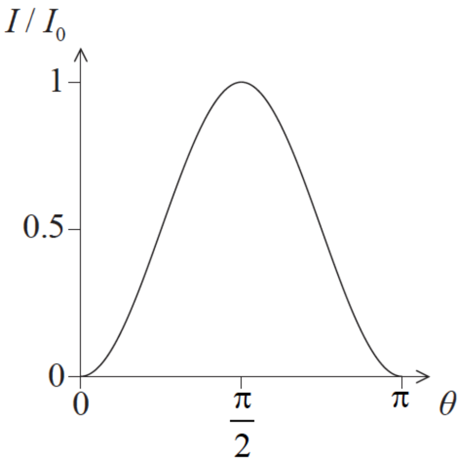

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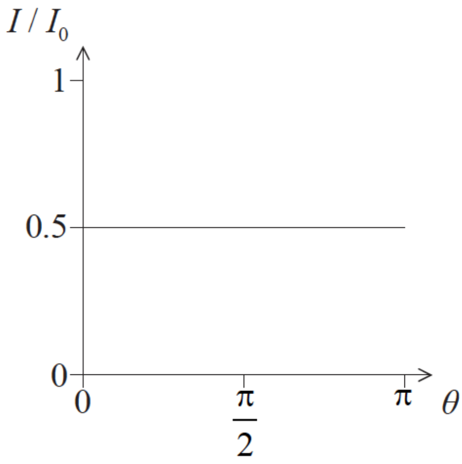
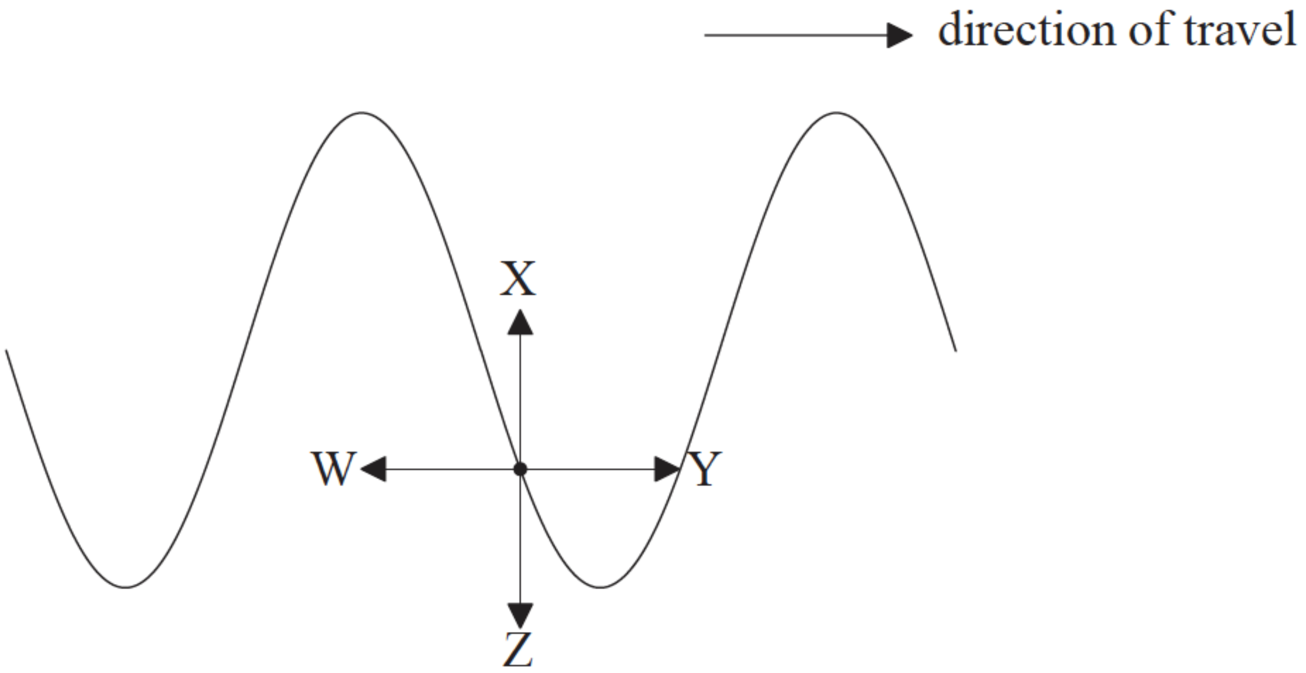


28. The diagram shows, at a particular instant in time, part of a rope along which a wave is travelling. *[1 mark]*



The wave is travelling from left to right.

Which arrow shows the direction of motion of the rope at the point shown?

A. W

B. X

C. Y

D. Z

29. The lowest frequency emitted by an organ pipe that is open at both ends is *f*. What is the lowest frequency emitted by an organ pipe of the same length that is closed at one end? *[1 mark]*

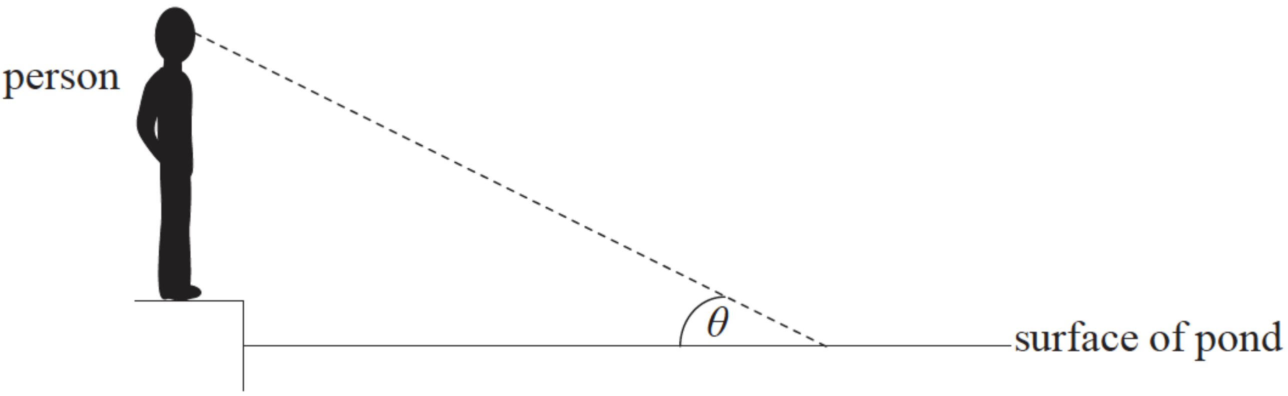
A. $\frac{f}{4}$

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

C. $2f$

D. $4f$

30. A person wearing polarizing sunglasses stands at the edge of a pond in bright sunlight. *[1 mark]*



The surface of the pond is flat and the line of sight of the person makes an angle θ with the surface. The refractive index of the pond water is n. What is the value of θ for which the intensity of the sunlight reflected by the surface to the person's eye is a minimum?

A. $\tan^{-1}(n)$

B. $\cos^{-1}\left(\frac{1}{n}\right)$

C. $\cos^{-1}(n)$

D. $\tan^{-1}\left(\frac{1}{n}\right)$

This question is in **two** parts. **Part 1** is about solar radiation and the greenhouse effect. **Part 2** is about a mass on a spring.

Part 1 Solar radiation and the greenhouse effect

The following data are available.

Quantity	Symbol	Value
Radius of Sun	R	7.0×10^{8} m
Surface temperature of Sun	T	5.8×10^{3} K
Distance from Sun to Earth	d	1.5×10^{11} m
Stefan-Boltzmann constant	σ	5.7×10^{-8} W m^{-2} K^{-4}

31a. State the Stefan-Boltzmann law for a black body. *[2 marks]*

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31b. Deduce that the solar power incident per unit area at distance *d* from the Sun is given by *[2 marks]*

$$\frac{\sigma R^2 T^4}{d^2}$$

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31c. Calculate, using the data given, the solar power incident per unit area at distance *d* from the Sun. *[2 marks]*

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31d. State **two** reasons why the solar power incident per unit area at a point on the surface of the Earth is likely to be different from your answer in (c). *[2 marks]*

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31e. The average power absorbed per unit area at the Earth's surface is $240 Wm^{-2}$. By treating the Earth's surface as a black body, show that the average surface temperature of the Earth is approximately 250K. *[2 marks]*

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31f. Explain why the actual surface temperature of the Earth is greater than the value in (e). *[3 marks]*

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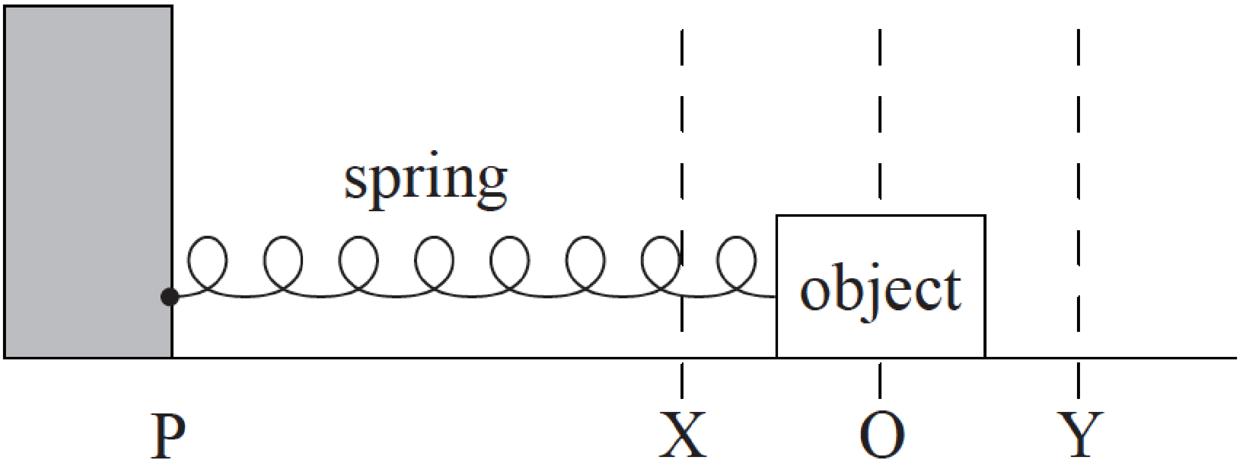
Part 2 A mass on a spring

An object is placed on a frictionless surface and attached to a light horizontal spring.



The other end of the spring is attached to a stationary point P. Air resistance is negligible. The equilibrium position is at O. The object is moved to position Y and released.

31g. Outline the conditions necessary for the object to execute simple harmonic motion. *[2 marks]*

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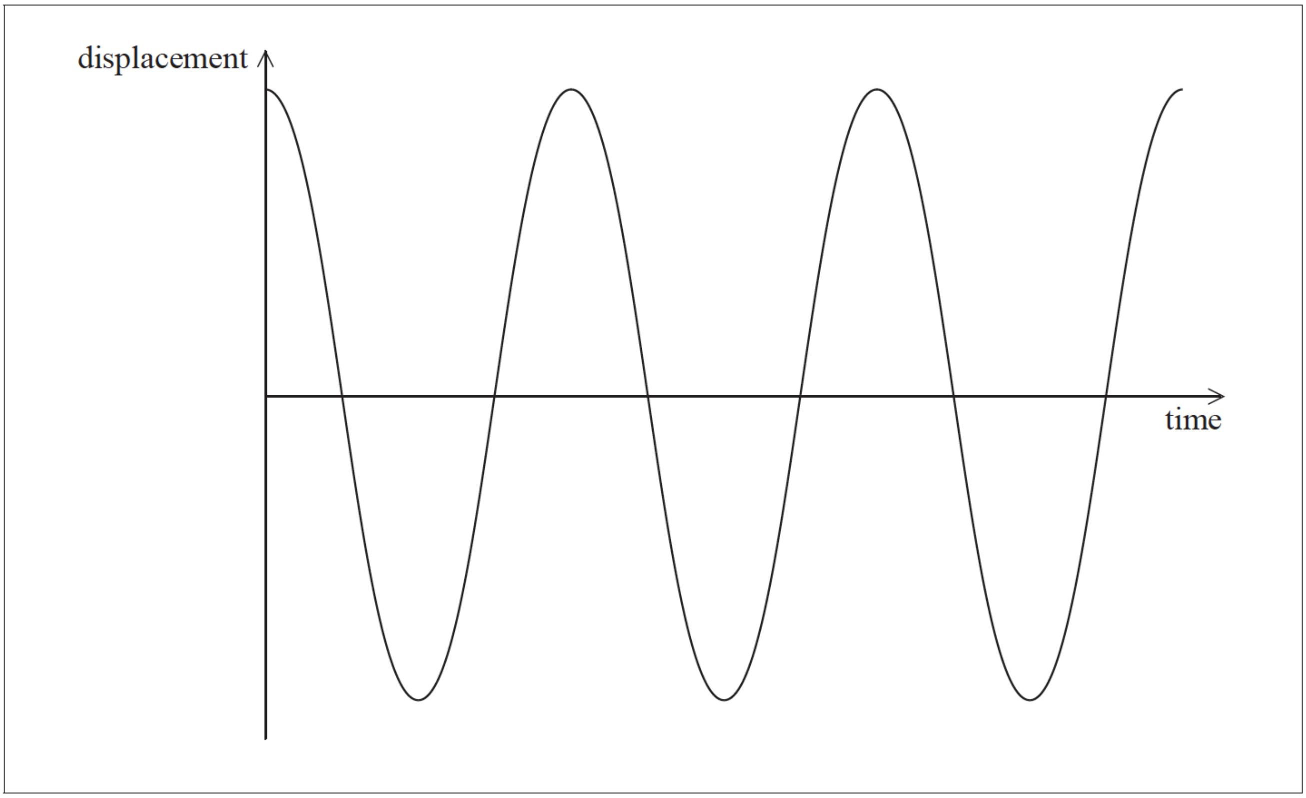
31h. The sketch graph below shows how the displacement of the object from point O varies with time over three time periods. *[4 marks]*



(i) Label with the letter A a point at which the magnitude of the acceleration of the object is a maximum.

(ii) Label with the letter V a point at which the speed of the object is a maximum.

(iii) Sketch on the same axes a graph of how the displacement varies with time if a **small** frictional force acts on the object.

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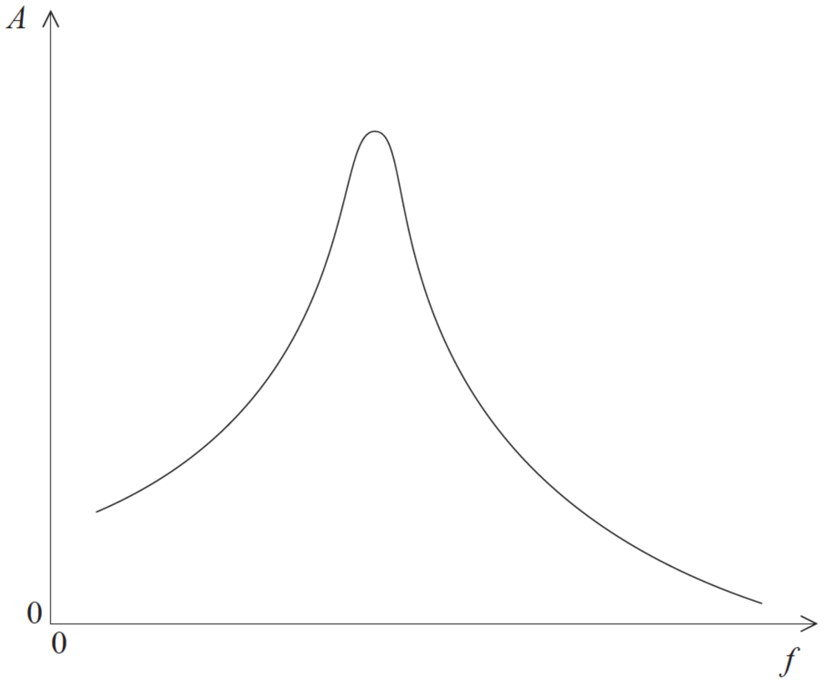
31i. Point P now begins to move from side to side with a small amplitude and at a variable driving frequency *f*. The frictional force is still small. *[4 marks]*

At each value of *f*, the object eventually reaches a constant amplitude *A*.

The graph shows the variation with *f* of *A*.



(i) With reference to resonance and resonant frequency, comment on the shape of the graph.

(ii) On the same axes, draw a graph to show the variation with *f* of *A* when the frictional force acting on the object is increased.

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This question is about sound.

A source emits sound of frequency f. The source is moving towards a stationary observer at constant speed. The observer measures the frequency of the sound to be f'.

32a. (i) Explain, using a diagram, why f' is greater than f. *[5 marks]*

(ii) The frequency f is 275 Hz. The source is moving at speed 20.0 ms^{-1}. The speed of sound in air is 330 ms^{-1}. Calculate the observed frequency f' of the sound.

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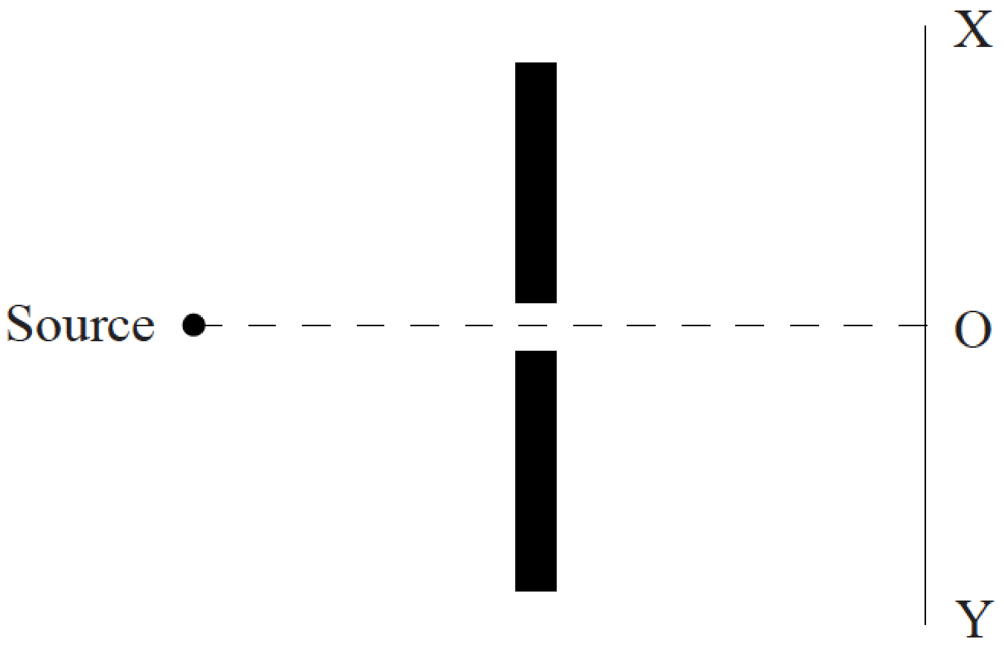
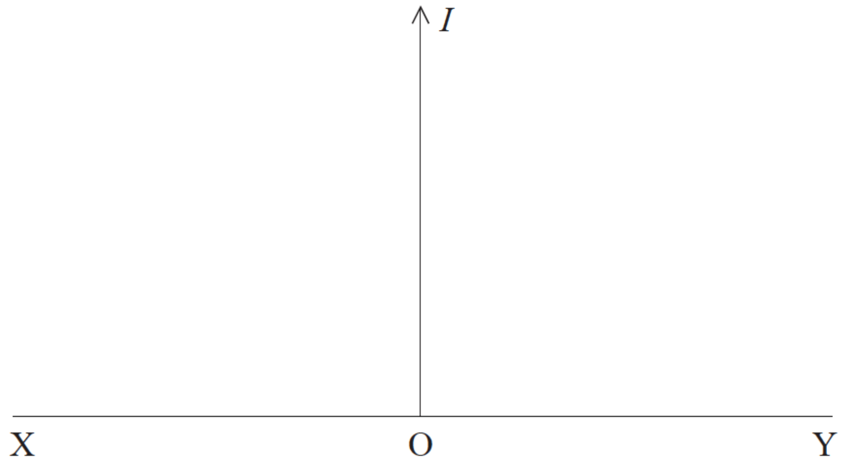
32b. A source of sound is placed in front of a barrier that has an opening of width comparable to the wavelength of the sound. *[4 marks]*



A sound detector is moved along the line XY. The centre of XY is marked O.

(i) On the axes below, sketch a graph to show how the intensity *I* of the sound varies as the detector moves from X to Y.



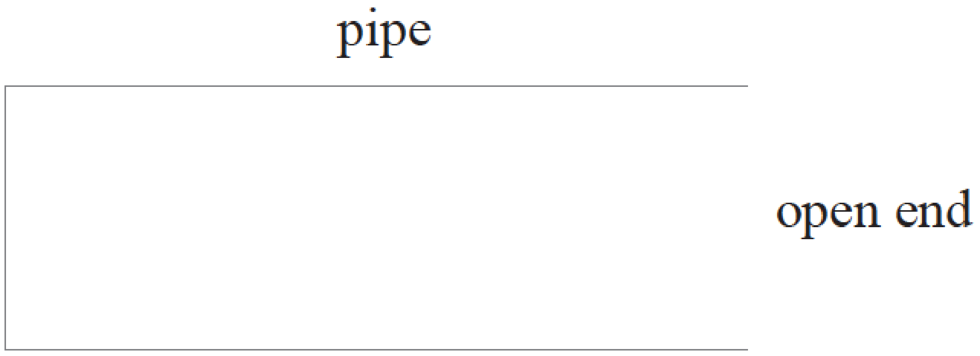
(ii) State the effect on the intensity pattern of increasing the wavelength of the sound.

32c. (i) Outline the difference between a polarized wave and an unpolarized wave. *[3 marks]*

(ii) State why sound waves cannot be polarized.

This question is about standing waves and the Doppler effect.

The horn of a train can be modeled as a pipe with one open end and one closed end. The speed of sound in air is $330 ms^{-1}$.



33a. On leaving the station, the train blows its horn. Both the first harmonic and the next highest harmonic are produced by the horn. The difference in frequency between the harmonics emitted by the horn is measured as 820 Hz. *[5 marks]*

(i) Deduce that the length of the horn is about 0.20 m.

(ii) Show that the frequency of the first harmonic is about 410 Hz.

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33b. (i) Describe what is meant by the Doppler effect. *[4 marks]*

(ii) The train approaches a stationary observer at a constant velocity of $50 ms^{-1}$ and sounds its horn at the same frequency as in (a)(ii). Calculate the frequency of the sound as measured by the observer.

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This question is about the nature and properties of electromagnetic waves.

34a. Electromagnetic waves propagating in a medium suffer dispersion. Describe what is meant by dispersion. *[2 marks]*

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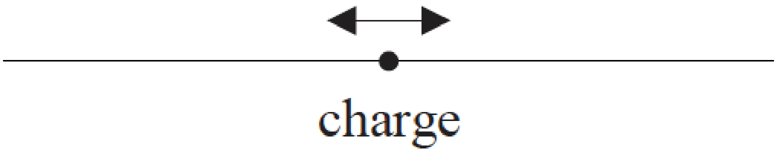
34b. A charge moves backwards and forwards along a wire, as shown in the diagram below. *[2 marks]*



Outline, with reference to the motion of the charge, why electromagnetic radiation is produced by the moving charge.

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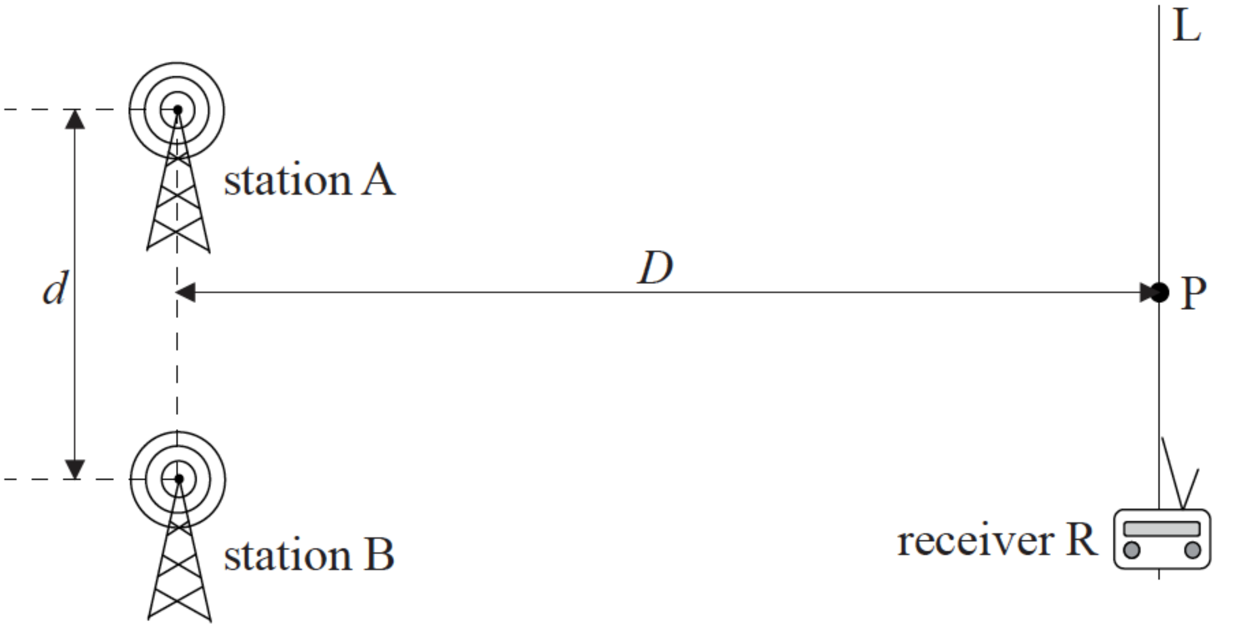
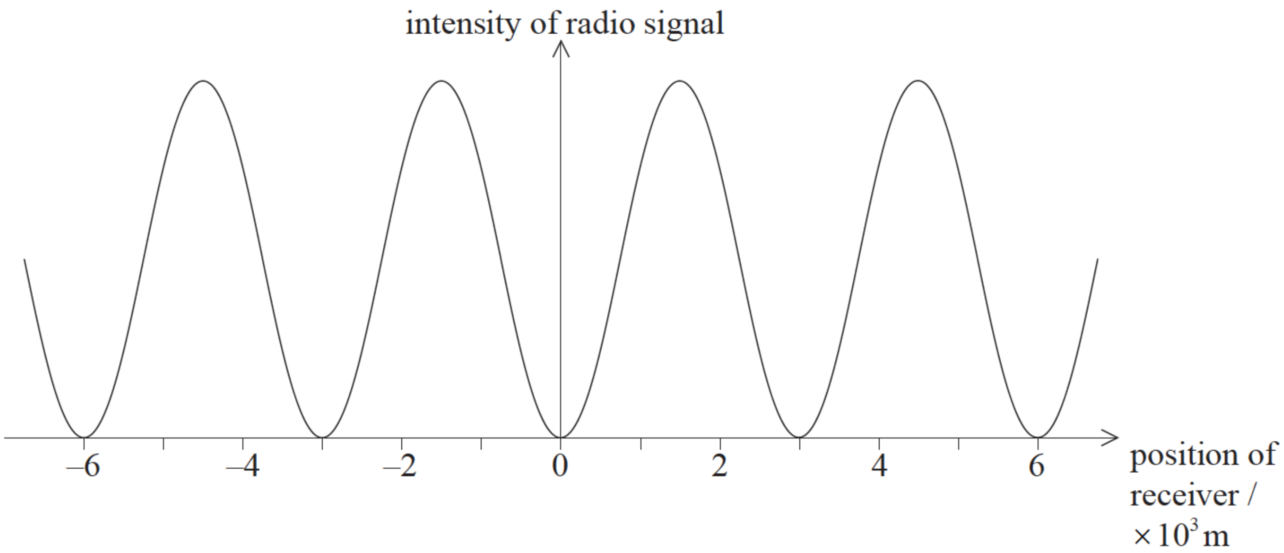
This question is about interference.

35a. Two radio stations, A and B, broadcast two coherent signals. The separation *d* between A and B is much less than the distance *D* from the stations to the receiver R. Point P is at the same distance from A and B. *[5 marks]*



The graph shows how the intensity of the radio signal varies with position as the receiver is moved along line L. The position of the receiver is zero when the receiver is at P.



(i) Deduce that the two sources A and B are 180º out-of-phase.

(ii) The wavelength of the radio signal is 40m. Calculate the ratio $\frac{D}{d}$.

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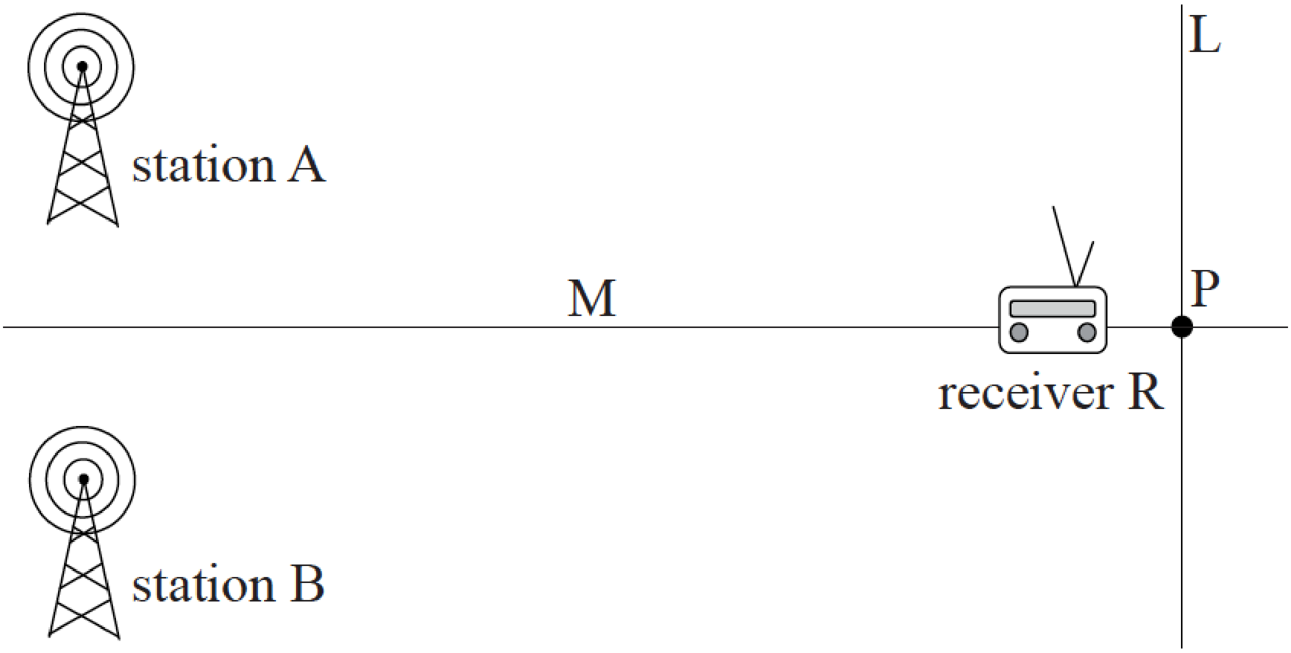
35b. The receiver R then moves along a different line M which is at 90º to line L. *[2 marks]*



Discuss the variation of the intensity of the radio signal with position as the receiver is moved along line M.

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36. For a body undergoing simple harmonic motion the velocity and acceleration are *[1 mark]*

A. always in the same direction.
B. always in opposite directions.
C. in the same direction for a quarter of the period.
D. in the same direction for half the period.

37. Which of the following correctly relates the direction of oscillation of the particles in a medium to the direction of energy propagation for transverse and longitudinal waves? *[1 mark]*

	Transverse wave	Longitudinal wave
A.	perpendicular	perpendicular
B.	perpendicular	parallel
C.	parallel	perpendicular
D.	parallel	parallel

38. Two identical waves of wavelength λ leave two sources in phase. The waves meet and superpose after travelling different distances. Which path difference will result in destructive interference? *[1 mark]*

A. $\frac{\lambda}{4}$

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

C. $\frac{3\lambda}{4}$

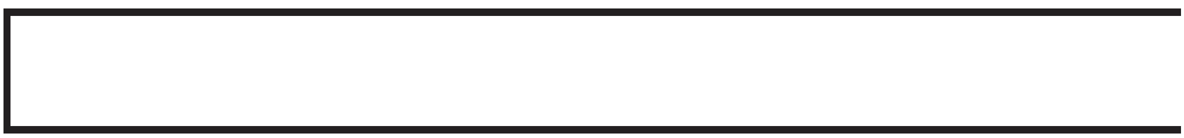
D. λ

39. The diagrams show four different organ pipes drawn to scale. Standing waves in the fundamental (first harmonic) mode are set up inside each pipe. Which pipe produces a fundamental note with the lowest frequency? *[1 mark]*

A.

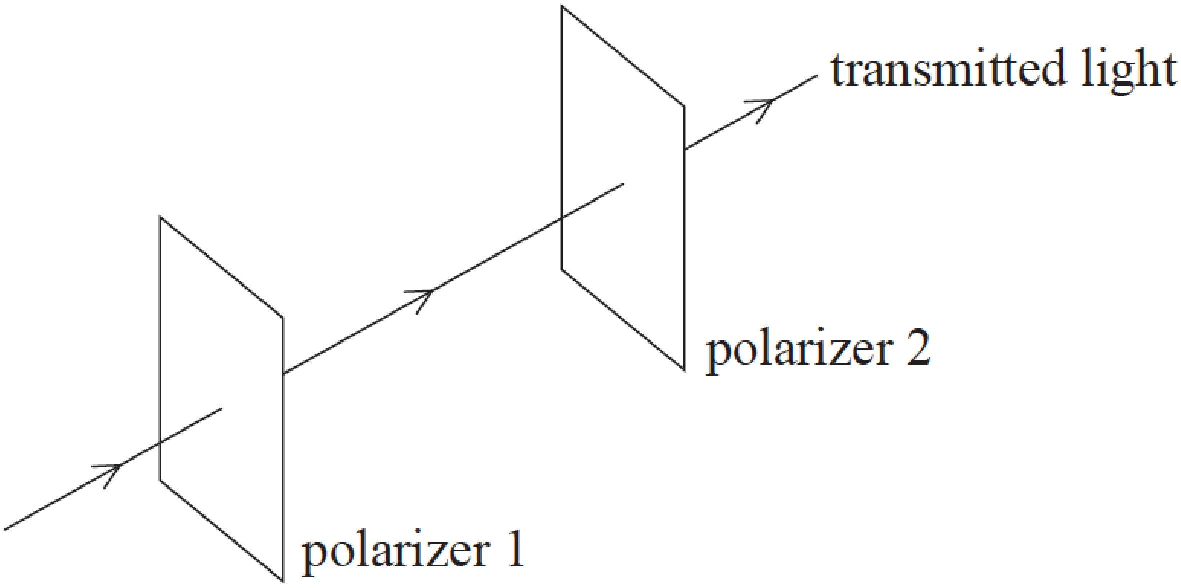
B.

C.



D.

40. Two polarizing filters are set up so the transmitted light is at a maximum intensity. *[1 mark]*

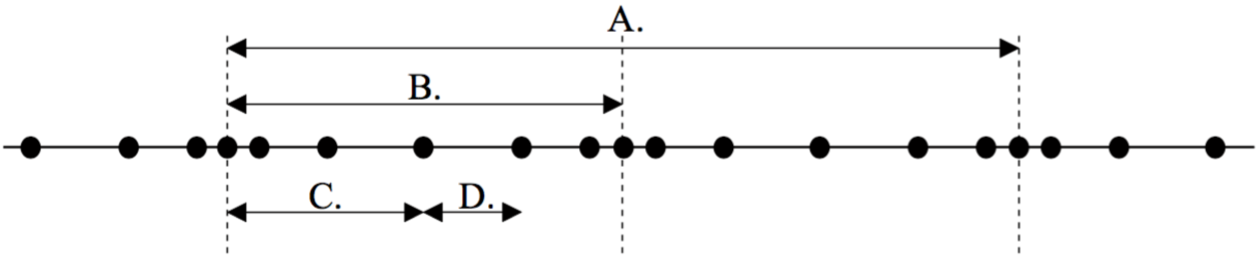


Through which angle should polarizer 2 be rotated so that no light is transmitted?

A. 45º
B. 60º
C. 90º
D. 180º

41. Gas particles are equally spaced along a straight line. A sound wave passes through the gas. The positions of the gas particles at one instant are shown below. *[1 mark]*

Which of the distances shown is equal to the wavelength of the wave?



42. Light of wavelength 600 nm travels from air to glass at normal incidence. The refractive index of the glass is 1.5. *[1 mark]*
The speed of light in air is *c*. Which of the following correctly identifies the speed of the waves and their wavelength in the glass?

	Speed	Wavelength
A.	$\frac{2c}{3}$	900 nm
B.	c	900 nm
C.	c	400 nm
D.	$\frac{2c}{3}$	400 nm

43. Which of the following correctly describes the direction of a ray drawn relative to a wavefront for longitudinal and transverse waves? *[1 mark]*

	Longitudinal wave	Transverse wave
A.	parallel	parallel
B.	parallel	perpendicular
C.	perpendicular	parallel
D.	perpendicular	perpendicular

This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about voltage–current (*V*–*I*) characteristics.

Part 1 Simple harmonic motion (SHM) and waves

44a. A particle P moves with simple harmonic motion. State, with reference to the motion of P, what is meant by simple harmonic motion. *[2 marks]*

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44b. The particle P in (b) is a particle in medium M_1 through which a transverse wave is travelling. *[5 marks]*

(i) Describe, in terms of energy propagation, what is meant by a transverse wave.

(ii) The speed of the wave through the medium is $0.40 ms^{-1}$. Calculate, using your answer to (b)(i), the wavelength of the wave.

(iii) The wave travels into another medium M_2. The refractive index of M_2 relative to M_1 is 1.8. Calculate the wavelength of the wave in M_2.

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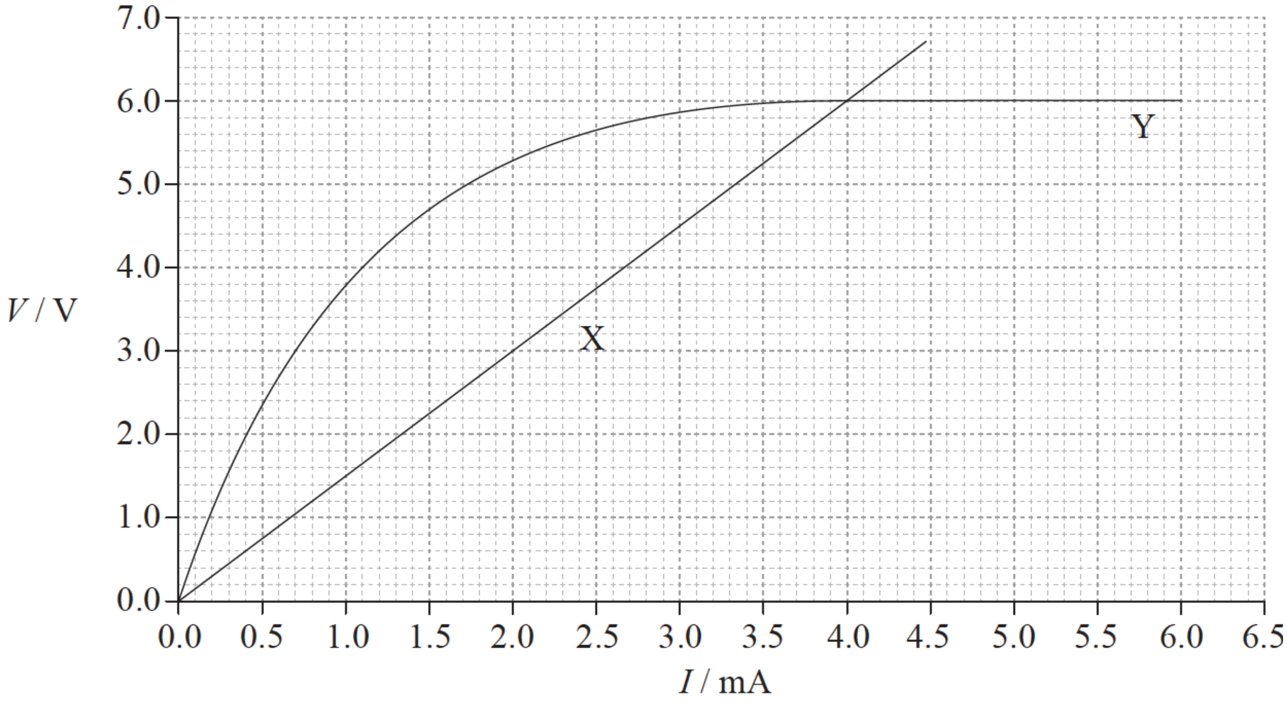
Part 2 Voltage–current (*V*–*I*) characteristics

The graph shows the voltage–current (*V*–*I*) characteristics, at constant temperature, of two electrical components X and Y.



44c. Outline, with reference to the graph and to Ohm's law, whether or not each component is ohmic. *[3 marks]*

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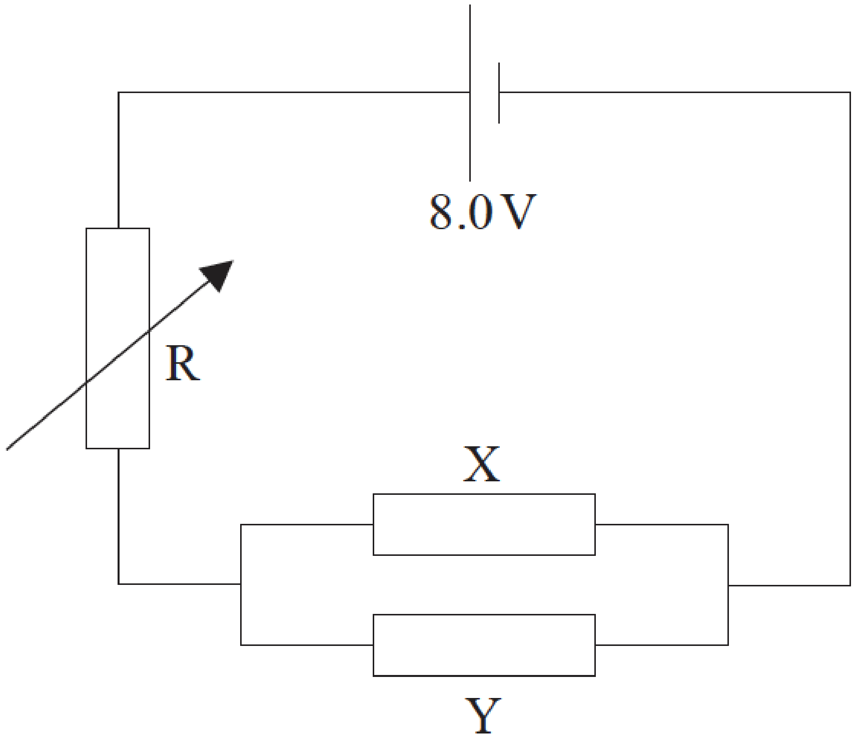
44d. Components X and Y are connected in parallel. The parallel combination is then connected in series with a variable resistor R and a cell of emf 8.0V and negligible internal resistance. *[8 marks]*



The resistance of R is adjusted until the currents in X and Y are equal.

(i) Using the graph, calculate the resistance of the parallel combination of X and Y.

(ii) Using your answer to (e)(i), determine the resistance of R.

(iii) Determine the power delivered by the cell to the circuit.

This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about atomic and nuclear energy levels.

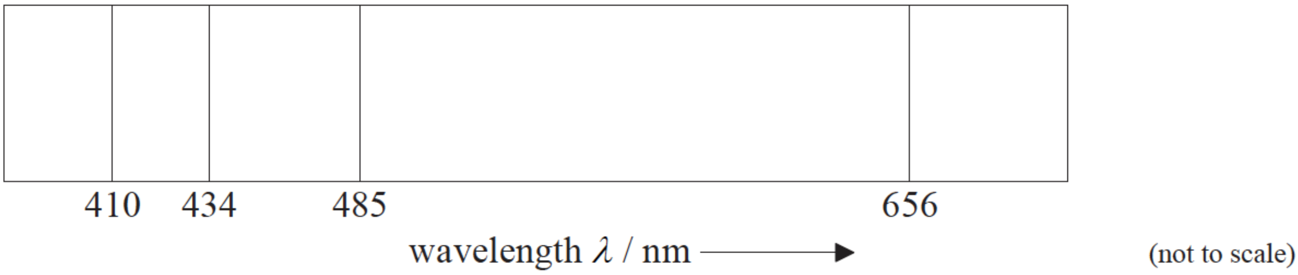
Part 1 Simple harmonic motion (SHM) and waves

45a. A particle P moves with simple harmonic motion. *[3 marks]*

(i) State, with reference to the motion of P, what is meant by simple harmonic motion.

(ii) State the phase difference between the displacement and the velocity of P.

45b. The diagram shows four spectral lines in the visible line emission spectrum of atomic hydrogen. *[6 marks]*



(i) Outline how such a spectrum may be obtained in the laboratory.

(ii) Explain how such spectra give evidence for the existence of discrete atomic energy levels.

45c. The energies of the principal energy levels in atomic hydrogen measured in eV are given by the expression *[4 marks]*

$E_n = -\frac{13.6}{n^2}$ where n=1, 2, 3 ....

The visible lines in the spectrum correspond to electron transitions that end at n=2.

(i) Calculate the energy of the level corresponding to n=2.

(ii) Show that the spectral line of wavelength λ=485nm is the result of an electron transition from n=4.

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45d. The alpha particles and gamma rays produced in radioactive decay have discrete energy spectra. This suggests that nuclei also possess discrete energy levels. However, beta particles produced in radioactive decay have continuous energy spectra. Describe how the existence of the antineutrino accounts for the continuous nature of beta spectra. *[2 marks]*

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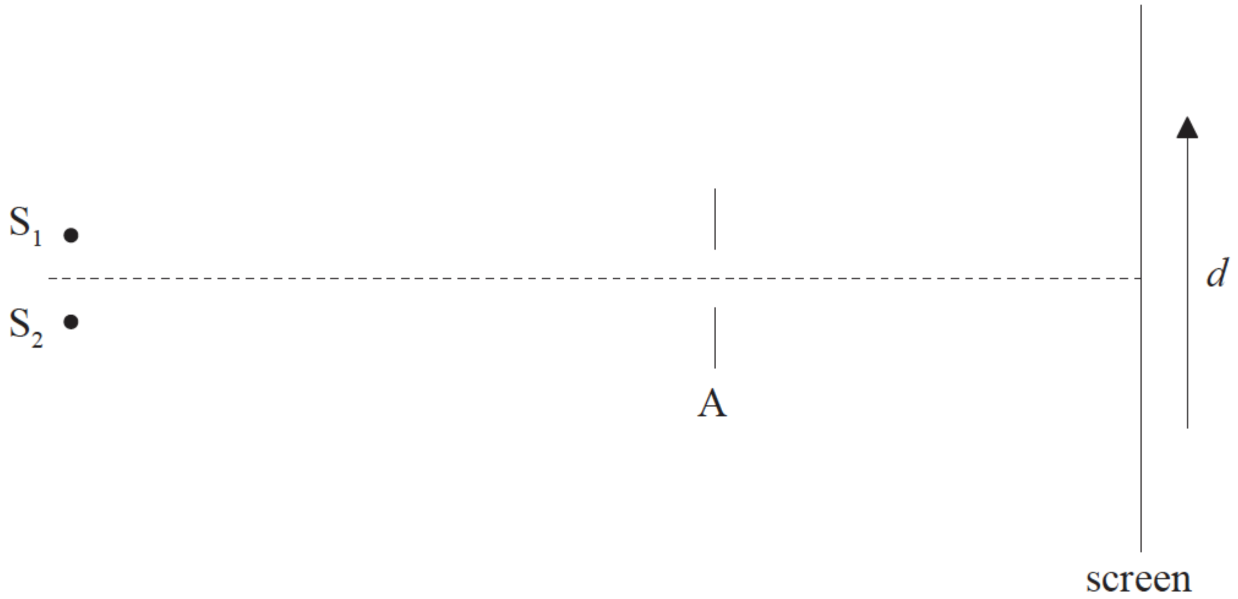
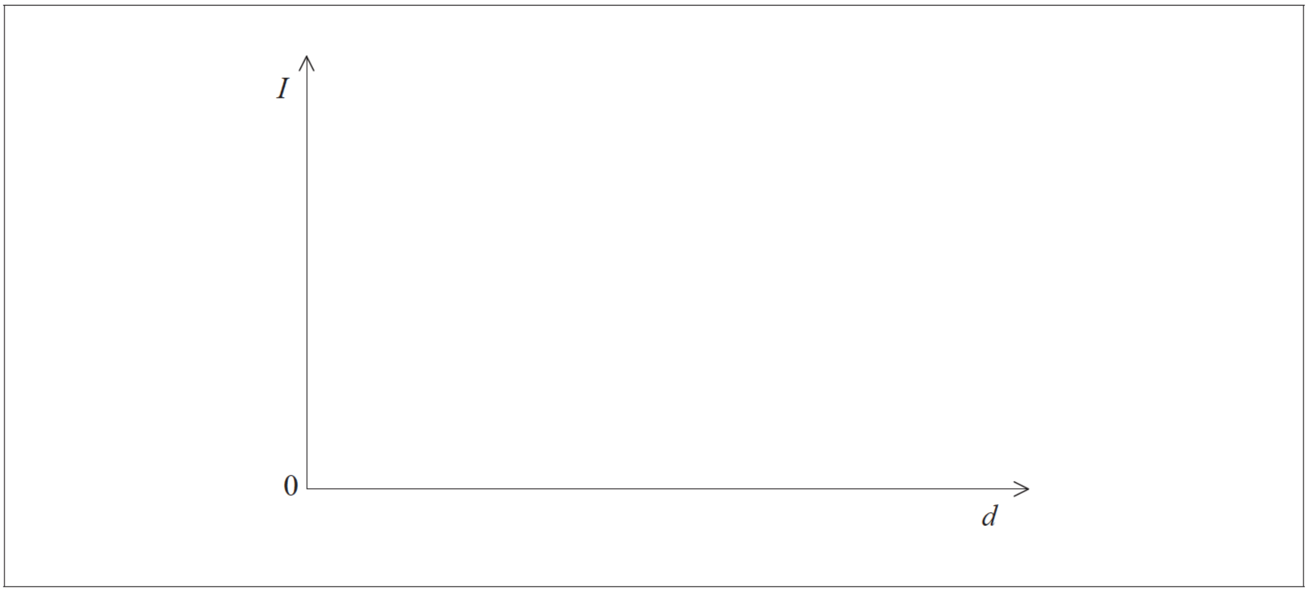
This question is about resolution.

46a. Two point sources S_1 and S_2 emit monochromatic light of the same wavelength. The light is incident on a small aperture A and is then brought to focus on a screen. *[3 marks]*



The images of the two sources on the screen are just resolved according to the Rayleigh criterion. Sketch, using the axes below, how the relative intensity *I* of light on the screen varies with distance along the screen *d*.



46b. A car is travelling at night along a straight road. Diane is walking towards the car. She sees the headlights of the car as one single light. Estimate, using the data below, the separation *d* between Diane and the car at which, according to the Rayleigh criterion, Diane will just be able to see the headlights as two separate sources. *[3 marks]*

Distance between the headlights = 1.4 m
Average wavelength of light emitted by the headlights = 500 nm
Diameter of the pupils of Diane's eyes = 1.9 mm

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46c. The light from the car headlights in (b) is not polarized. State what is meant by polarized light. *[1 mark]*

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This question is about waves.

47a. State the principle of superposition. *[2 marks]*

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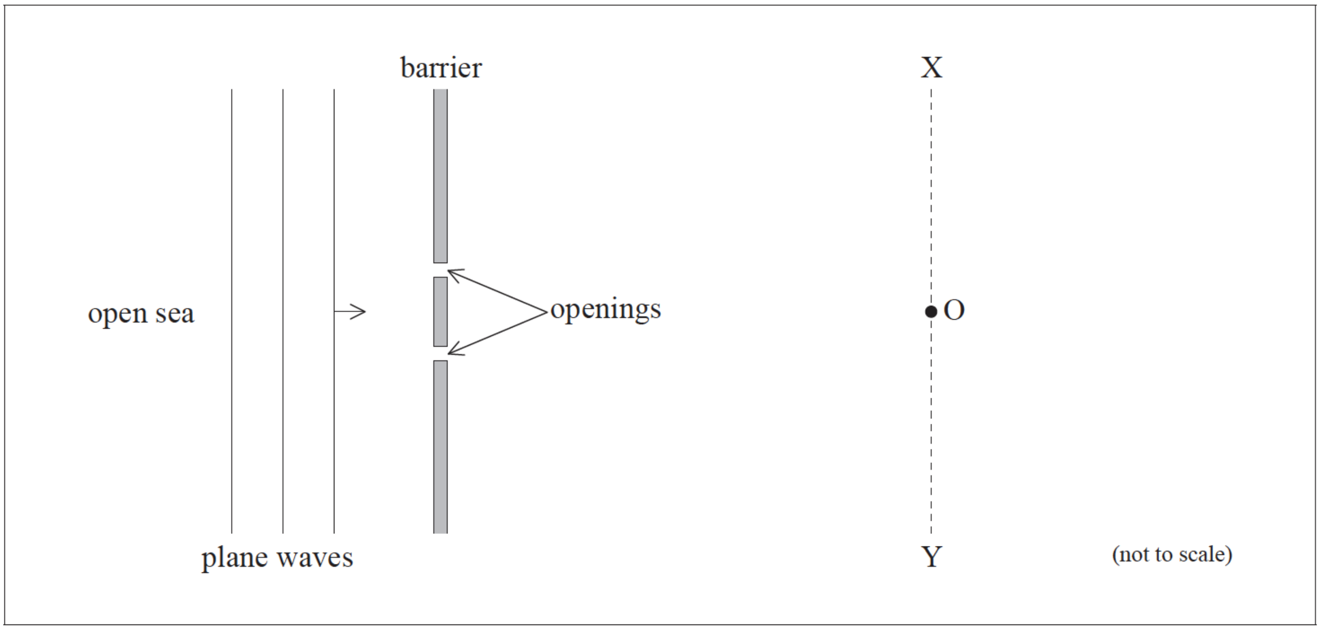
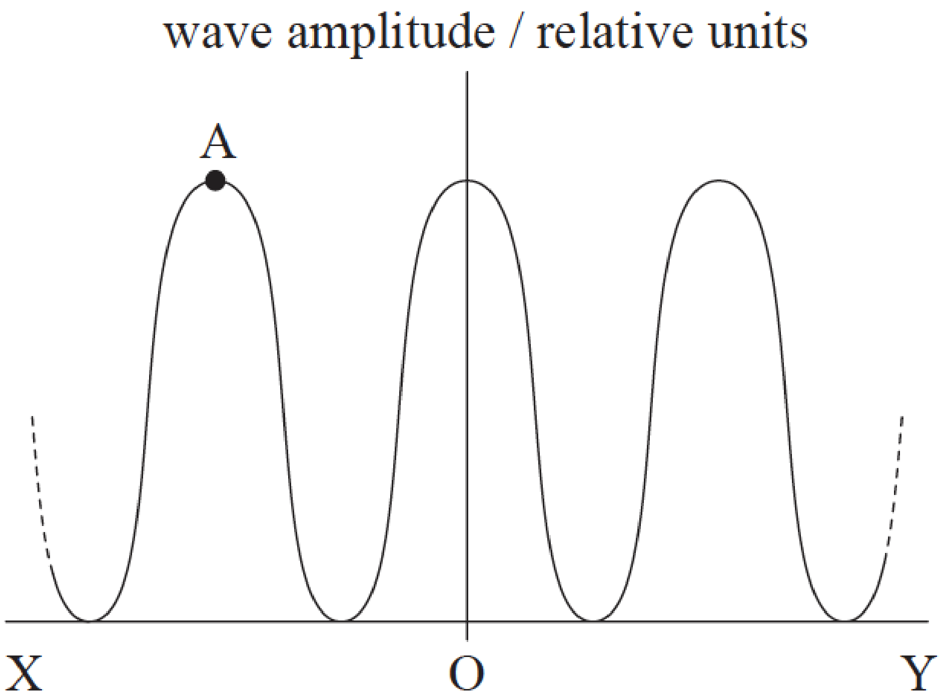
47b. The diagram shows a plan view of a harbour with a floating barrier that has two openings of equal width. *[7 marks]*



Plane water waves from the open sea are incident on the barrier and the openings act as point sources of waves. The distance from the openings to XOY is much greater than the wavelength of the wave. O is equidistant from the openings.

The graph shows the variation of the magnitude of the wave amplitude that is observed along the line XOY.



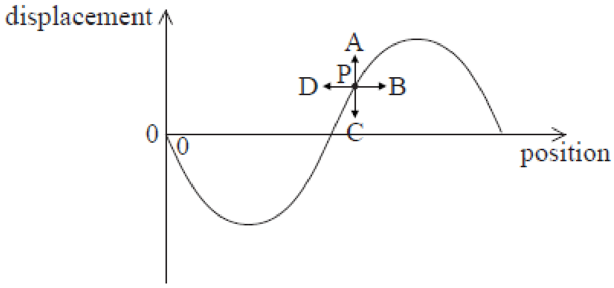
(i) State why the two sets of waves emerging from the openings are coherent.

(ii) Explain how the disturbance at point A arises. You may draw on the diagram **of the harbour** to illustrate your answer.

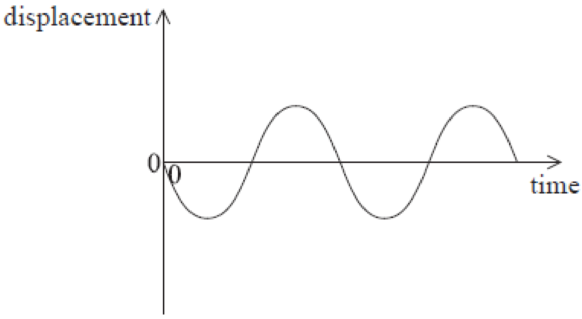
(iii) The wavelength of the waves is doubled. State and explain the effect that this change will have on the graph.

47c. The harbour in (b) is modified to have many narrower openings. The total width of the openings remains the same. Outline **two** ways in which the variation of wave amplitude along XY changes from that shown on the graph in (b). *[2 marks]*

48. A transverse wave travels from left to right. The diagram below shows how, at a particular instant of time, the displacement of particles in the medium varies with position. Which arrow represents the direction of the velocity of the particle marked P? *[1 mark]*



49. The graph shows how the displacement varies with time for an object undergoing simple harmonic motion. *[1 mark]*



Which graph shows how the object's acceleration *a* varies with time *t*?

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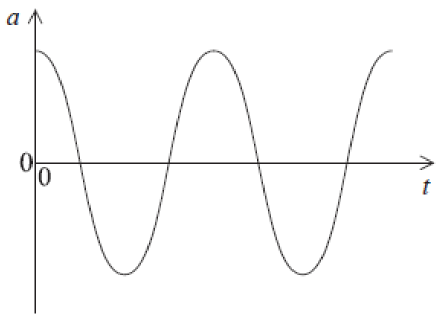

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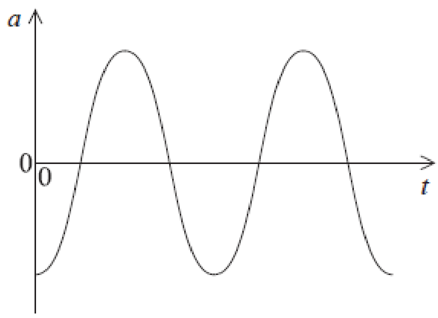

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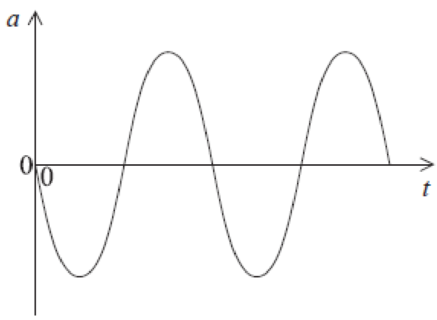

D.