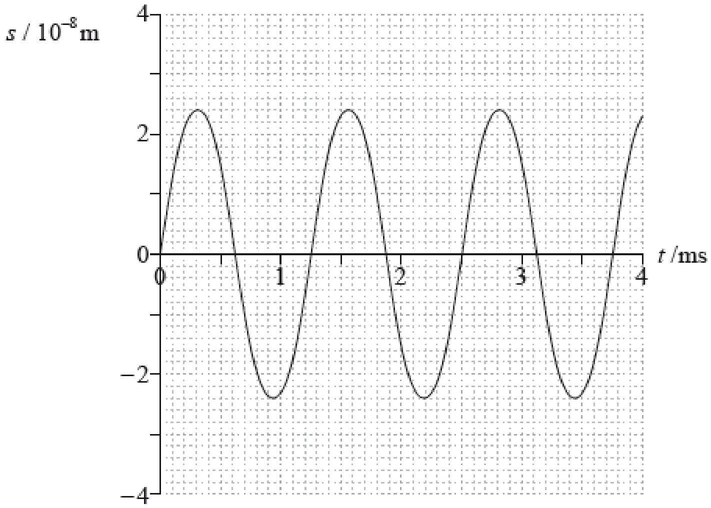
# Waves-practice-2-ShortA *[236 marks]*

This question is about standing (stationary) waves.

The diagram shows a tube that is open at both ends.


Point A shows the position of one air molecule in the tube. A standing sound wave (not shown in the diagram) is set up in the tube.

The graph shows the variation of displacement $s$ with time $t$ for the molecule at point A.



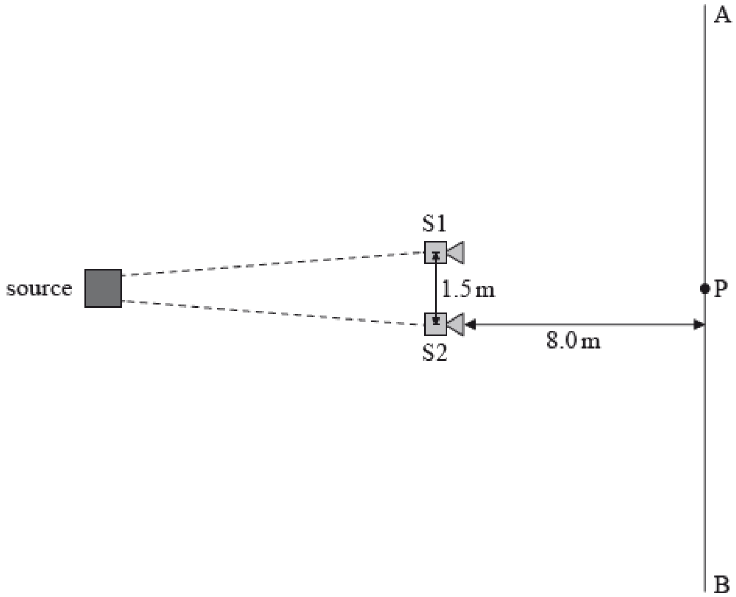

1a. Outline whether the standing wave is transverse **or** longitudinal. *[1 mark]*

1b. The standing wave in the tube corresponds to the fourth harmonic. The speed of sound in the tube is $340\ \mathrm{m\,s^{-1}}$. Using the graph, determine the length of the tube. *[3 marks]*

1c. The tube is now closed at one end and the first harmonic is sounded. Outline why the tube that is open at both ends produces a first harmonic with a wavelength shorter than the first harmonic of the tube that is closed at one end. *[1 mark]*

This question is about the interference of sound waves.

Two loudspeakers, S1 and S2, each emit a musical note of frequency 2.5 kHz with identical signal amplitude. Point P lies on the line AB and is equidistant from S1 and S2. The speakers are placed 1.5 m apart from each other and 8.0 m from line AB. The speed of sound is $330\ \mathrm{m\,s^{-1}}$.




A person walking in a straight line from A to B observes that the intensity of sound alternates between high and low.

2a. With reference to interference, explain why the intensity of sound alternates along line AB. *[3 marks]*

2b. The sound has a maximum intensity at P. Calculate the distance along line AB to the next intensity maximum when S1 and S2 emit a musical note of frequency 2.5 kHz. *[2 marks]*

2c. S1 and S2 are moved so that they are now 3.0 m apart. They remain at the same distance from line AB. Discuss the changes, if any, in the rate at which the intensity of sound alternates when a person is walking along line AB at half the speed. *[2 marks]*

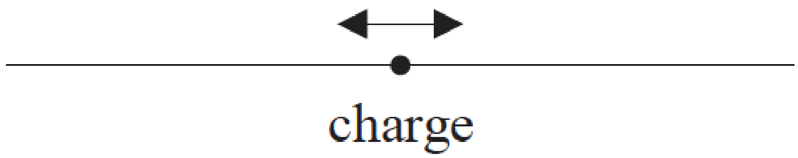
This question is about polarization.

3. Distinguish between polarized light and unpolarized light. *[2 marks]*

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

4a. Electromagnetic waves propagating in a medium suffer dispersion. Describe what is meant by dispersion. *[2 marks]*

4b. A charge moves backwards and forwards along a wire, as shown in the diagram below. *[2 marks]*

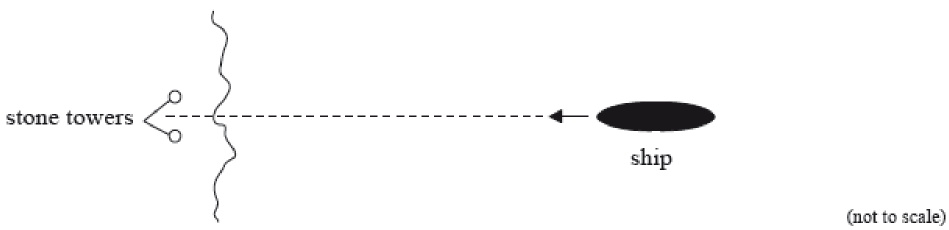



Outline, with reference to the motion of the charge, why electromagnetic radiation is produced by the moving charge.

This question is about resolution and polarization.

5a. State the Rayleigh criterion. *[2 marks]*

A ship sails towards two stone towers built on land.




Emlyn, who is on the ship, views the towers. The pupils of Emlyn's eyes are each of diameter 2.0 mm. The average wavelength of the sunlight is 550 nm.

5b. (i) Calculate the angular separation of the two towers when the images of the towers are just resolved by Emlyn. *[3 marks]*

(ii) Emlyn can just resolve the images of the two towers when his distance from the towers is 11 km. Determine the distance between the two towers.

5c. Emlyn puts on a pair of polarizing sunglasses. Explain how these sunglasses reduce the intensity of the light, reflected from the sea, that enters Emlyn's eyes. *[2 marks]*

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

6a. 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]*

6b. The particle P in (b) is a particle in medium $M_1$ through which a transverse wave is travelling. *[5 marks]*

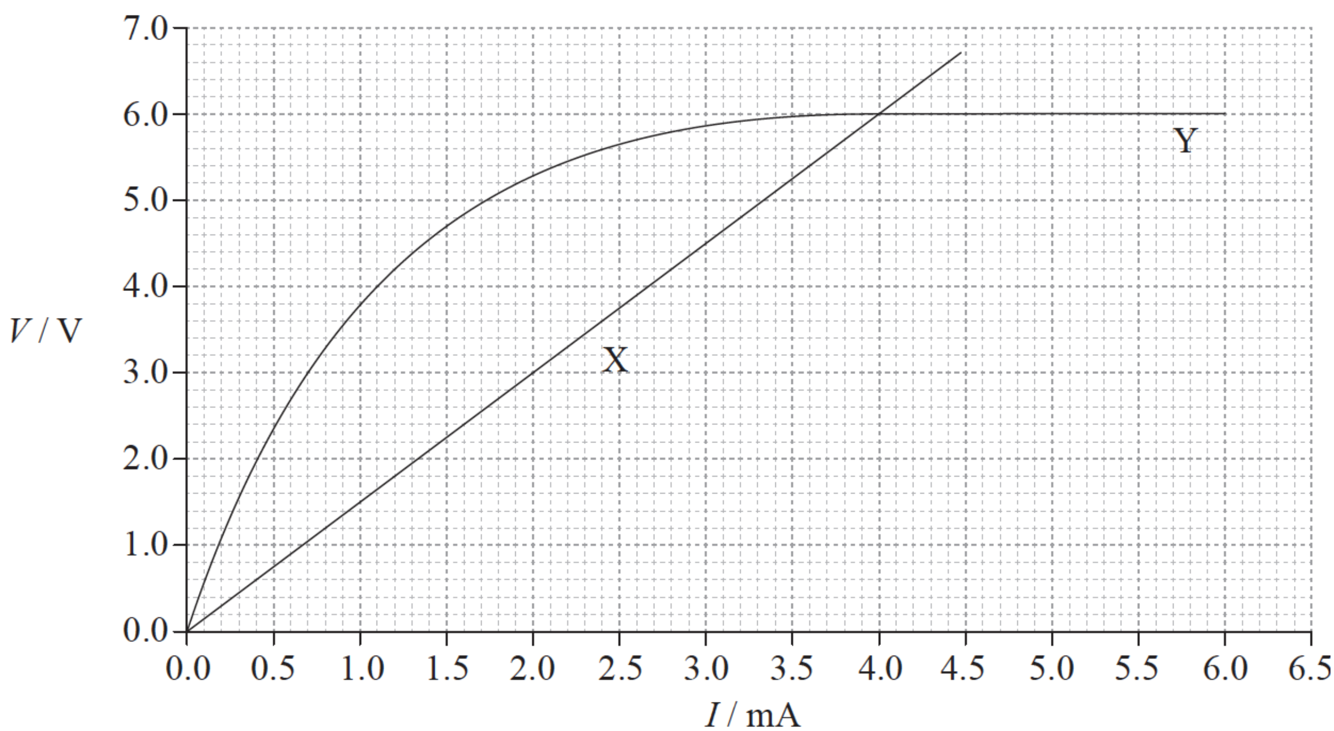
(i) Describe, in terms of energy propagation, what is meant by a transverse wave.

(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 $M_2$.

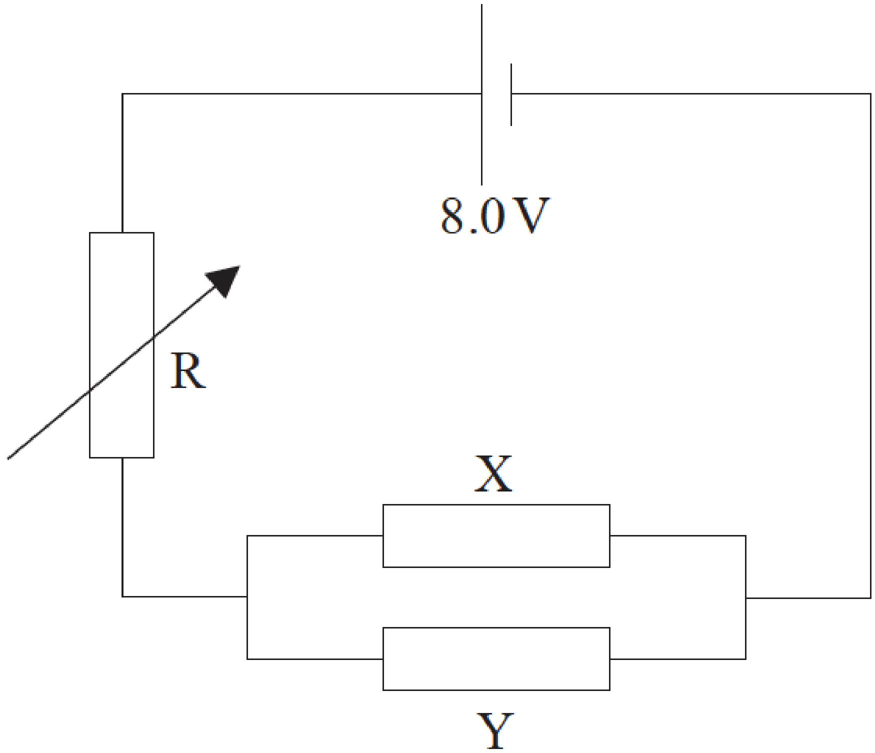
**Part 2** Voltage–current (*V*–*I*) characteristics

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




6c. Outline, with reference to the graph and to Ohm’s law, whether or not each component is ohmic. *[3 marks]*

6d. 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.

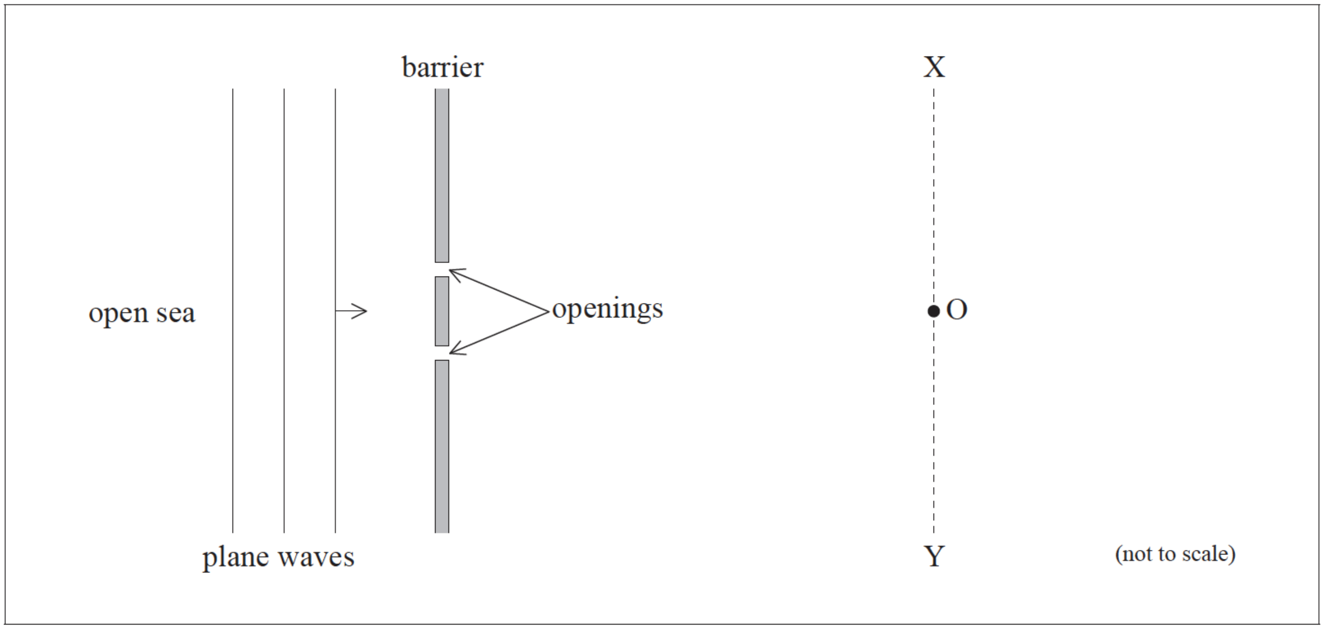
(ii) Using your answer to (e)(i), determine the resistance of R.

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

This question is about waves.

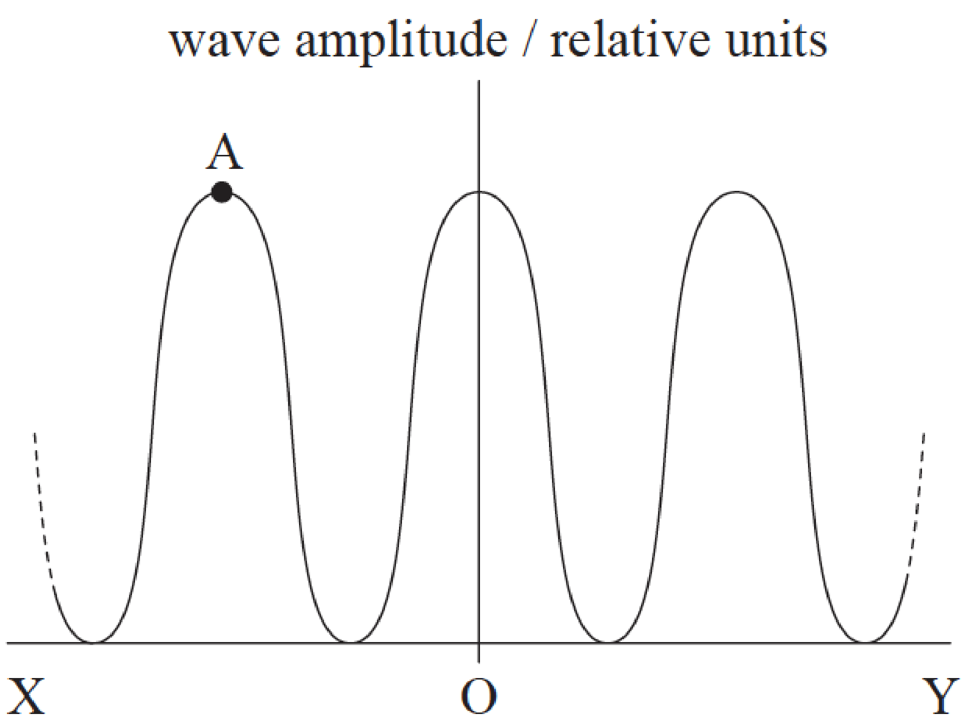
7a. State the principle of superposition. *[2 marks]*

7b. 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.

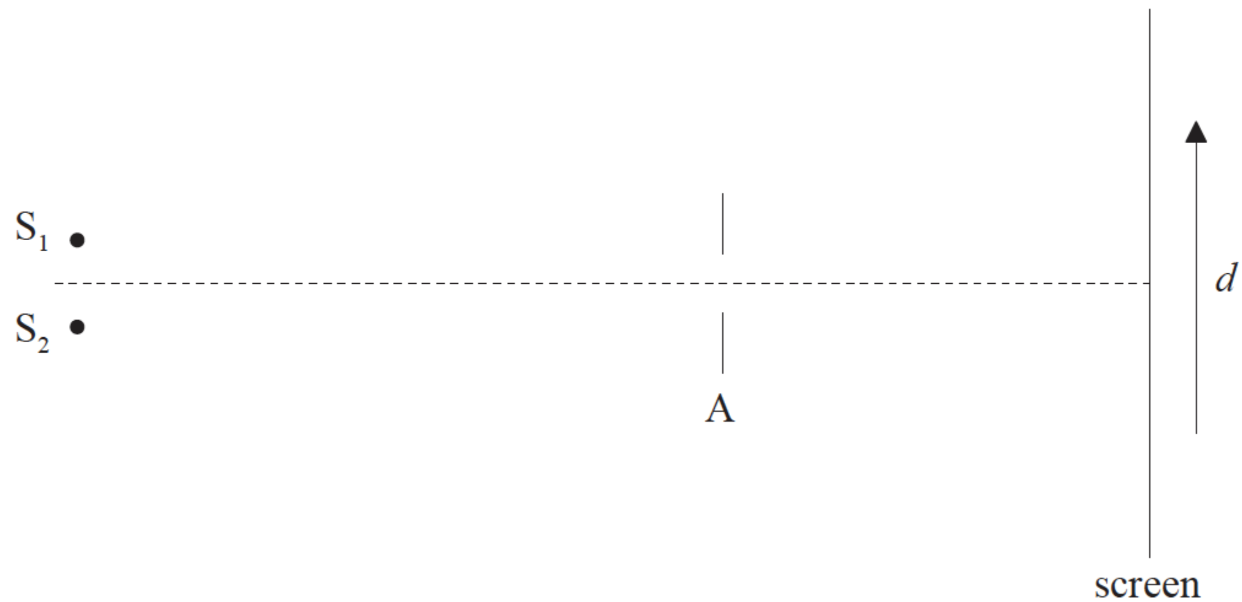
(ii) Explain how the disturbance at point A arises. You may draw on the diagram **of the harbour** to illustrate your answer.

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

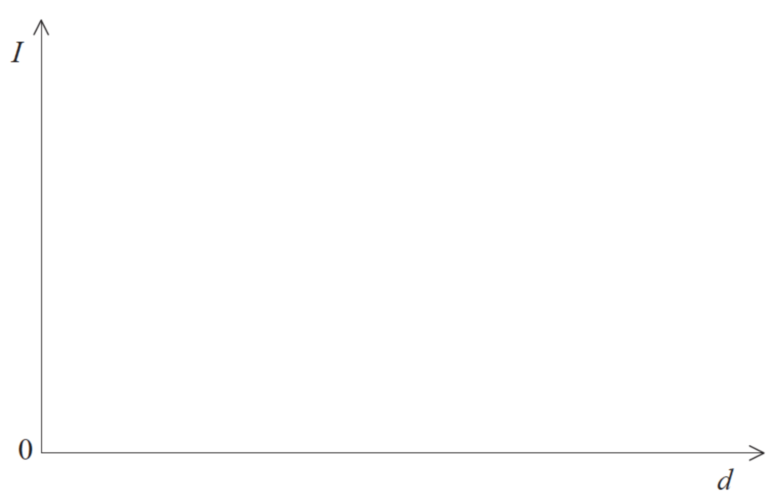
7c. The harbour in (b) is modified to have many narrower openings. The total width of the openings remains the same. Outline **two** ways in which the variation of wave amplitude along XY changes from that shown on the graph in (b). *[2 marks]*

This question is about resolution.

8a. 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*.



8b. 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]*

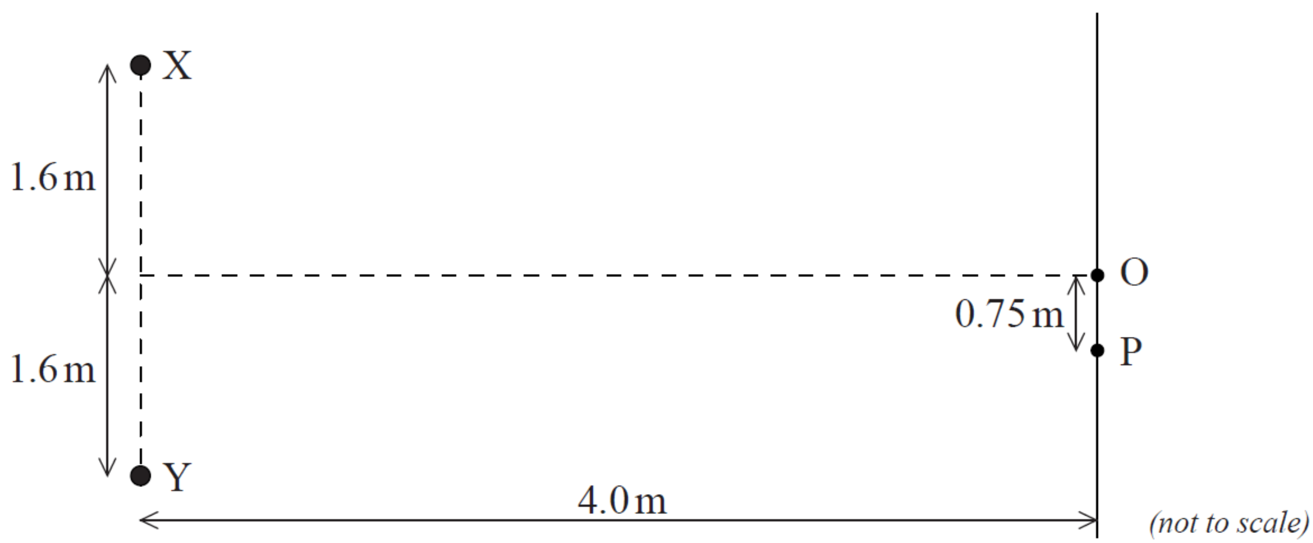
Distance between the headlights = 1.4 m
Average wavelength of light emitted by the headlights = 500 nm
Diameter of the pupils of Diane’s eyes = 1.9 mm

8c. The light from the car headlights in (b) is not polarized. State what is meant by polarized light. *[1 mark]*

This question is about the superposition of waves.

9a. State what is meant by the principle of superposition of waves. *[1 mark]*

9b. The diagram shows two point sources of sound, X and Y. Each source emits waves of wavelength 1.1 m and amplitude *A*. Over the distances shown, any decrease in amplitude can be neglected. The two sources vibrate in phase. *[5 marks]*



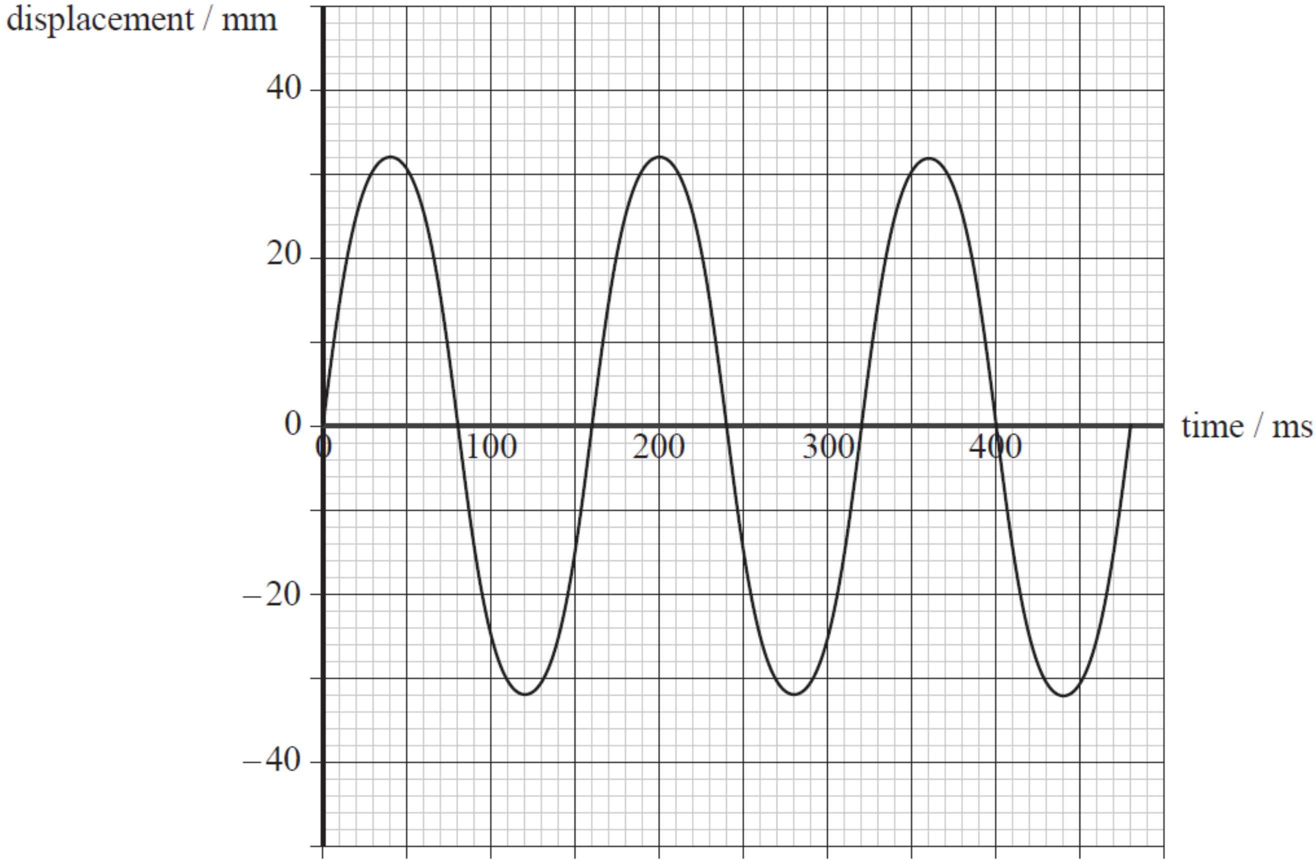

Points O and P are on a line 4.0 m from the line connecting X and Y. O is opposite the midpoint of XY and P is 0.75 m from O.

(i) Explain why the intensity of the sound at O is $4A^2$.

(ii) Deduce that no sound is detected at P.

Simple harmonic motion and forced oscillations

The graph shows the variation with time of the displacement of an object undergoing simple harmonic motion.




10a. (i) State the amplitude of the oscillation. *[3 marks]*

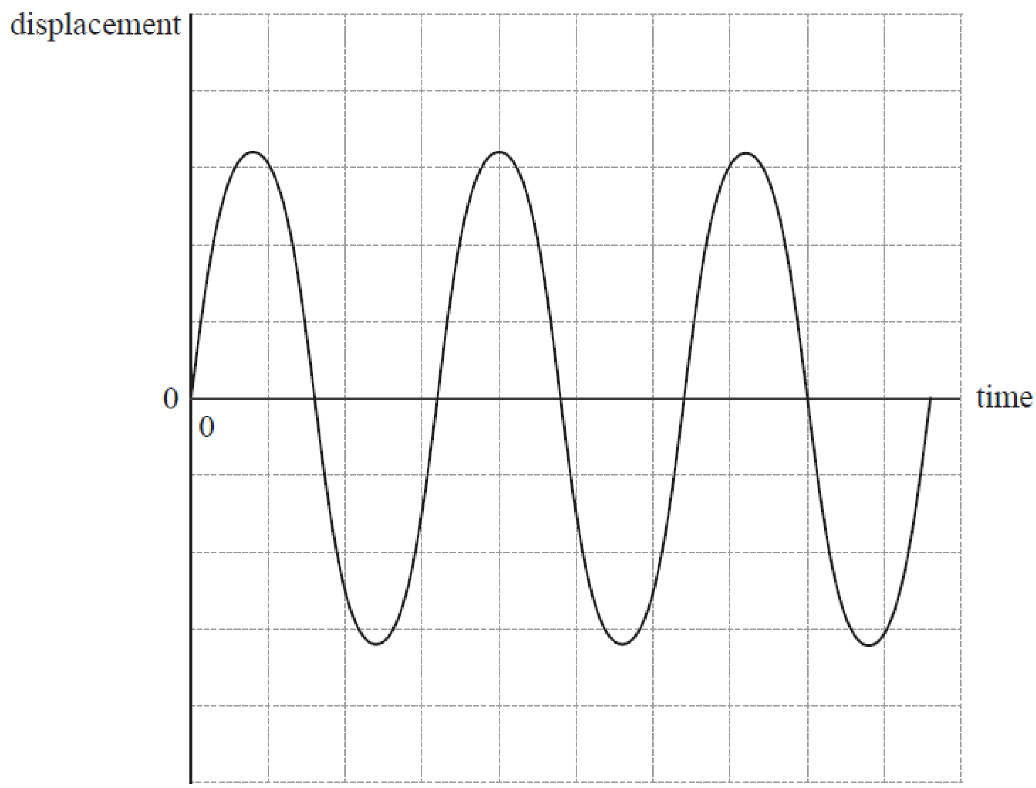
(ii) Calculate the frequency of the oscillation.

10b. (i) Determine the maximum speed of the object. *[4 marks]*

(ii) Determine the acceleration of the object at 140 ms.

10c. The graph below shows how the displacement of the object varies with time. Sketch on the same axes a line indicating how the kinetic energy of the object varies with time. *[3 marks]*

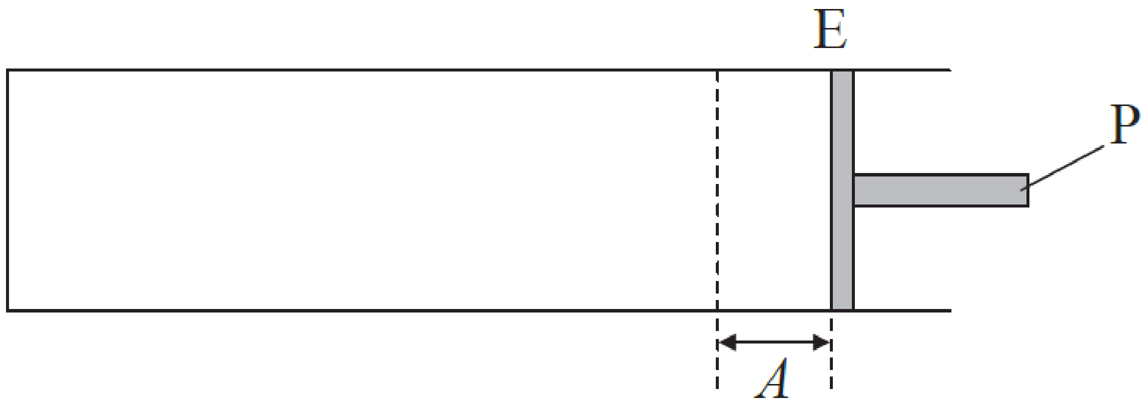
You should ignore the actual values of the kinetic energy.



This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about wind power and the greenhouse effect.

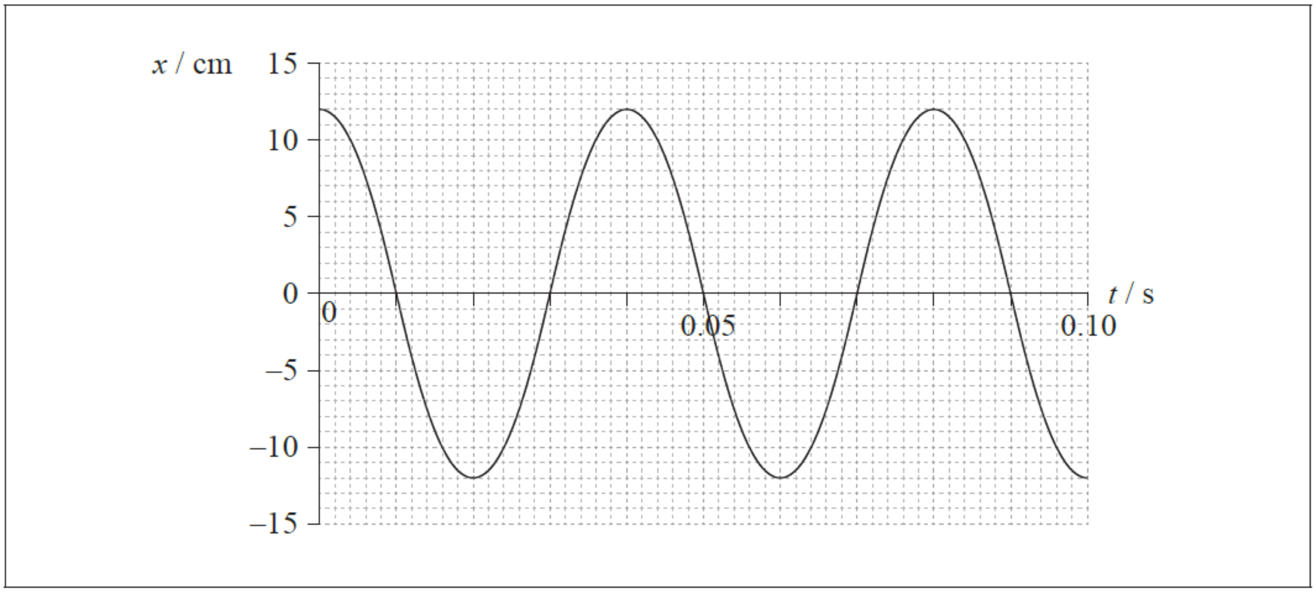
**Part 1** Simple harmonic motion (SHM) and waves

11a. A gas is contained in a horizontal cylinder by a freely moving piston P. *[2 marks]*
Initially P is at rest at the equilibrium position E.




The piston P is displaced a small distance *A* from E and released. As a result, P executes simple harmonic motion (SHM).
Define *simple harmonic motion* as applied to P.

11b. The graph shows how the displacement *x* of the piston P in (a) from equilibrium varies with time *t*. *[7 marks]*




(i) State the value of the displacement *A* as defined in (a).

(ii) On the graph identify, using the letter M, a point where the magnitude of the acceleration of P is a maximum.

(iii) Determine, using data from the graph and your answer to (b)(i), the magnitude of the maximum acceleration of P.

(iv) The mass of P is 0.32 kg. Determine the kinetic energy of P at $t$=0.052 s.

11c. The oscillations of P initially set up a longitudinal wave in the gas. *[4 marks]*

(i) Describe, with reference to the transfer of energy, what is meant by a longitudinal wave.

(ii) The speed of the wave in the gas is 340 m $s^{-1}$. Calculate the wavelength of the wave in the gas.

This question is about standing waves in a vibrating string.

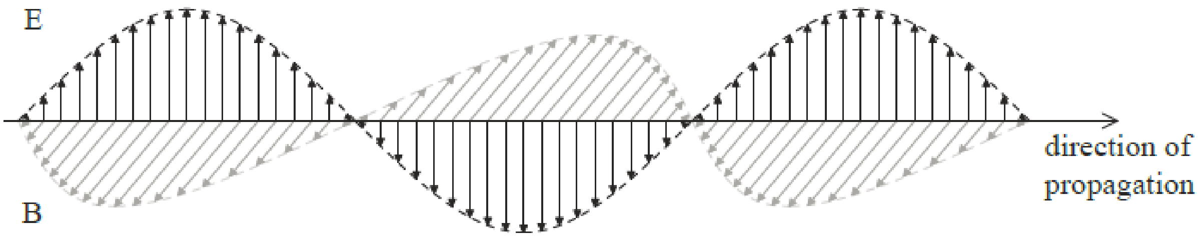
A guitar string vibrates at 330 Hz in its fundamental mode.

12a. Describe the formation of standing waves in a string fixed at both ends. *[2 marks]*

12b. The length of the string is 0.64 m. Calculate the velocity of the wave in the string. *[2 marks]*

This question is about light.

13a. The diagram is a representation of the oscillating electric (E) and magnetic (B) fields in an electromagnetic wave in vacuum. The fields are perpendicular to each other. *[2 marks]*



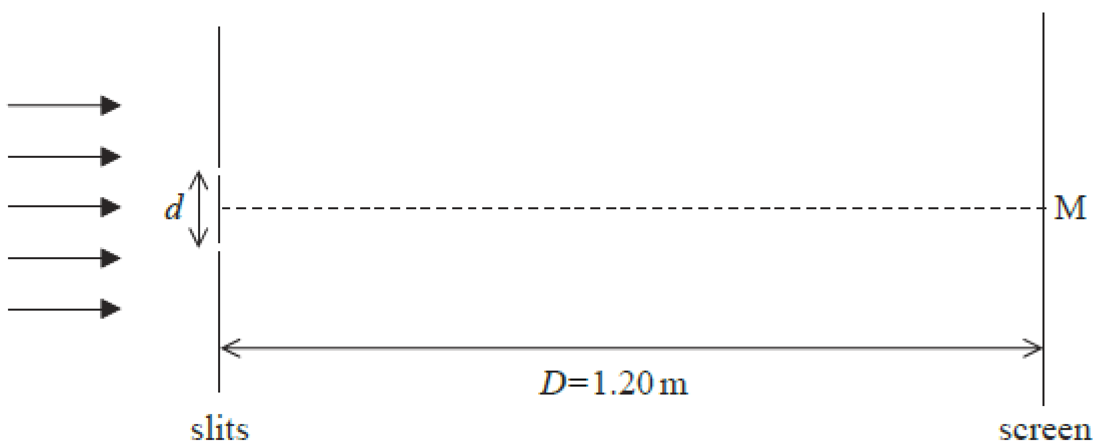

(i) State the change, if any, in the angle between E and B when the wave enters a transparent medium from vacuum.

(ii) On the diagram, label a distance that is equal to one wavelength of this electromagnetic wave.

13b. State **one** common property of all electromagnetic waves. *[1 mark]*

This question is about interference.

14a. Coherent monochromatic light is incident normally on two very narrow, parallel slits whose width is small compared to their separation. After the light passes through the slits it is incident on a screen. The mid-point of the screen is at M. *[4 marks]*

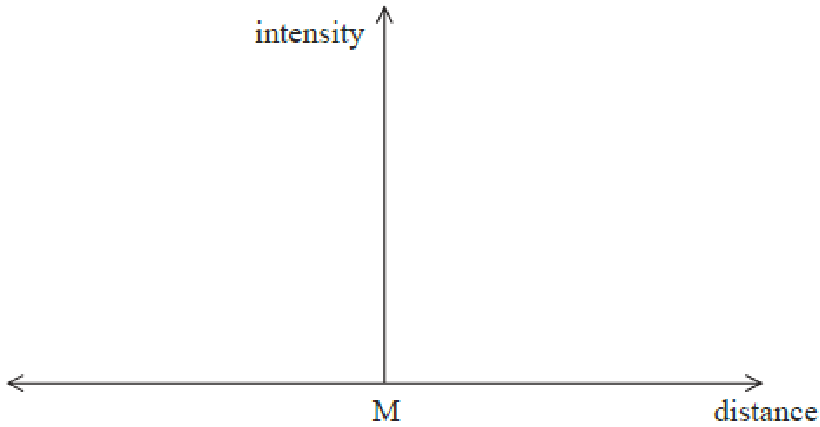



The distance *D* between the slits and the screen is 1.20 m. The slit separation *d* is 0.150 mm.

(i) Explain why the intensity of the light at M is a maximum.

(ii) Point P is the closest point to M on the screen where the light intensity is a minimum. The distance MP is 2.62 mm. Calculate the wavelength of light.

14b. Using the axes below, sketch a graph to show the variation with distance along the screen of the light intensity. *[2 marks]*



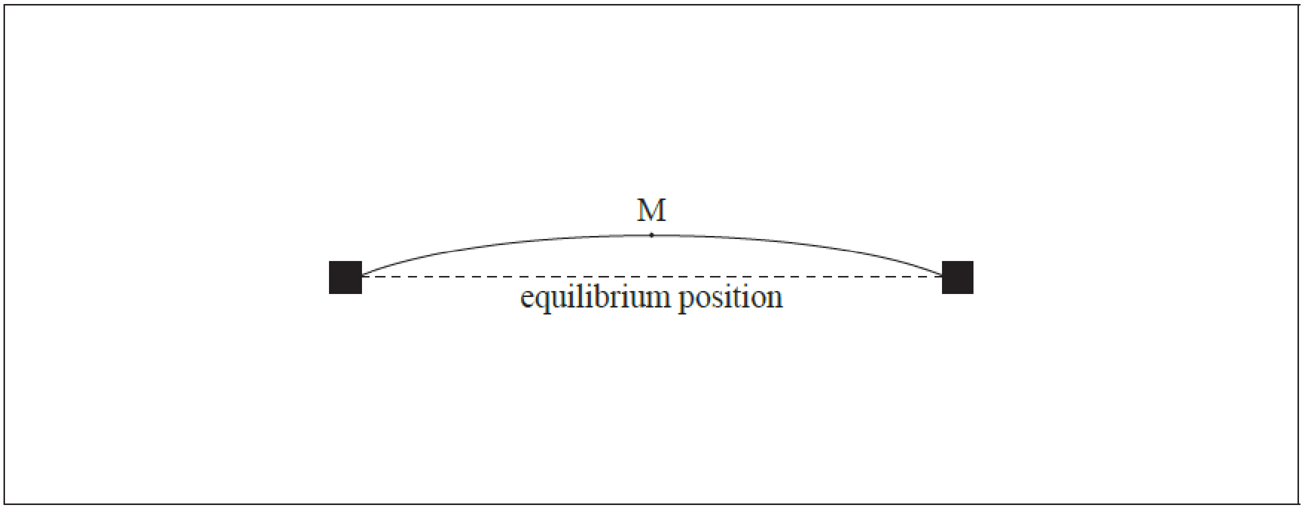

14c. The number of slits is greatly increased, each with the same separation as in (a). Describe the differences, if any, in the intensity distribution in (b). *[2 marks]*

This question is about standing waves.

15a. State **one** difference between a standing wave and a travelling wave. *[1 mark]*

15b. A string fixed at both ends oscillates in its fundamental (first harmonic) mode. The diagram shows the displacement of the string at time *t=0*. *[3 marks]*

Point M is the point at the middle of the string.




At *t = 0* point M is moving upwards. The frequency of oscillation is 250 Hz. On the diagram, draw

(i) an arrow to indicate the direction of acceleration of point M.

(ii) a line to show the position of the string at a time of 2.0 ms

15c. Describe how the string in (b) was made to oscillate in its fundamental mode. *[1 mark]*

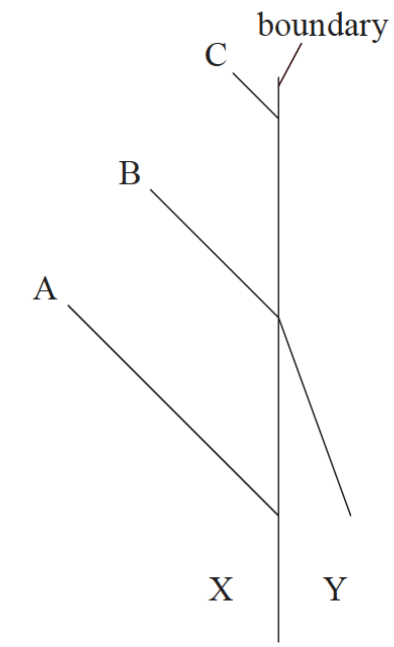
15d. State the frequency of oscillation of the string when it oscillates in its second harmonic. *[1 mark]*

This question is in **two** parts. **Part 1** is about wave motion. **Part 2** is about the melting of the Pobeda ice island.

**Part 1** Wave motion

16a. State what is meant by the terms ray and wavefront and state the relationship between them. *[3 marks]*

16b. The diagram shows three wavefronts, A, B and C, of a wave at a particular instant in time incident on a boundary between media X and Y. Wavefront B is also shown in medium Y. *[4 marks]*

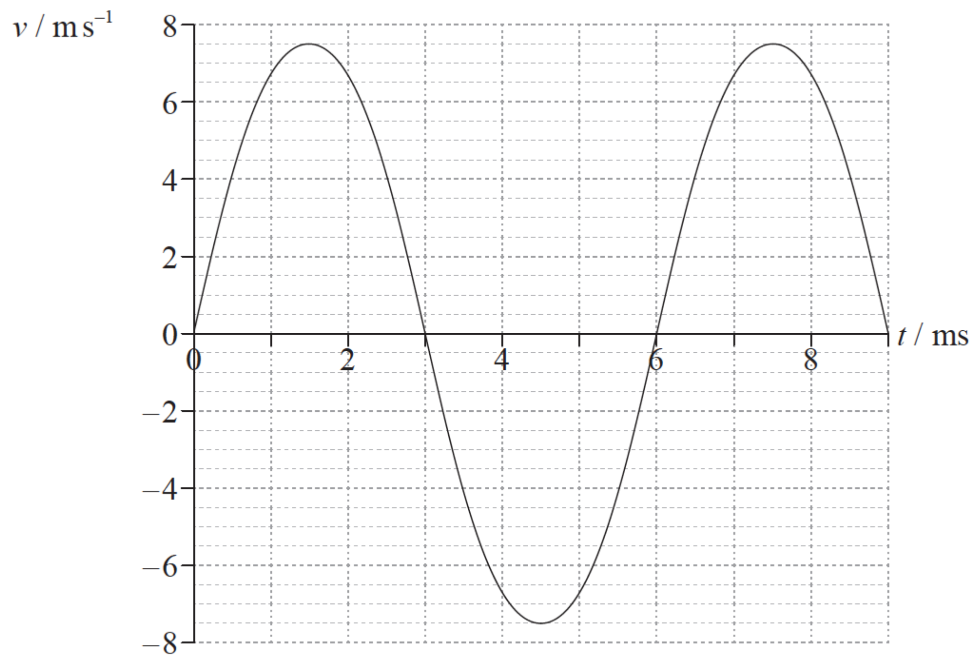



(i) Draw a line to show wavefront C in medium Y.

(ii) The refractive index of X is $n_X$ and the refractive index of Y is $n_Y$. By making appropriate measurements, calculate $\frac{n_X}{n_Y}$.

16c. Describe the difference between transverse waves and longitudinal waves. *[2 marks]*

16d. The graph below shows the variation of the velocity *v* with time *t* for one oscillating particle of a medium. *[3 marks]*




(i) Calculate the frequency of oscillation of the particle.

(ii) Identify on the graph, with the letter M, a time at which the displacement of the particle is a maximum.

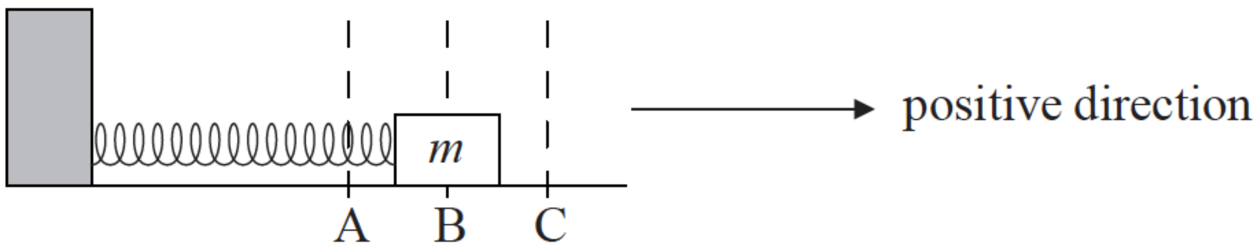
This question is about polarized light.

17. Describe what is meant by polarized light. *[1 mark]*

This question is in **two** parts. **Part 1** is about simple harmonic motion and the superposition of waves. **Part 2** is about gravitational fields.

**Part 1** Simple harmonic motion and the superposition of waves

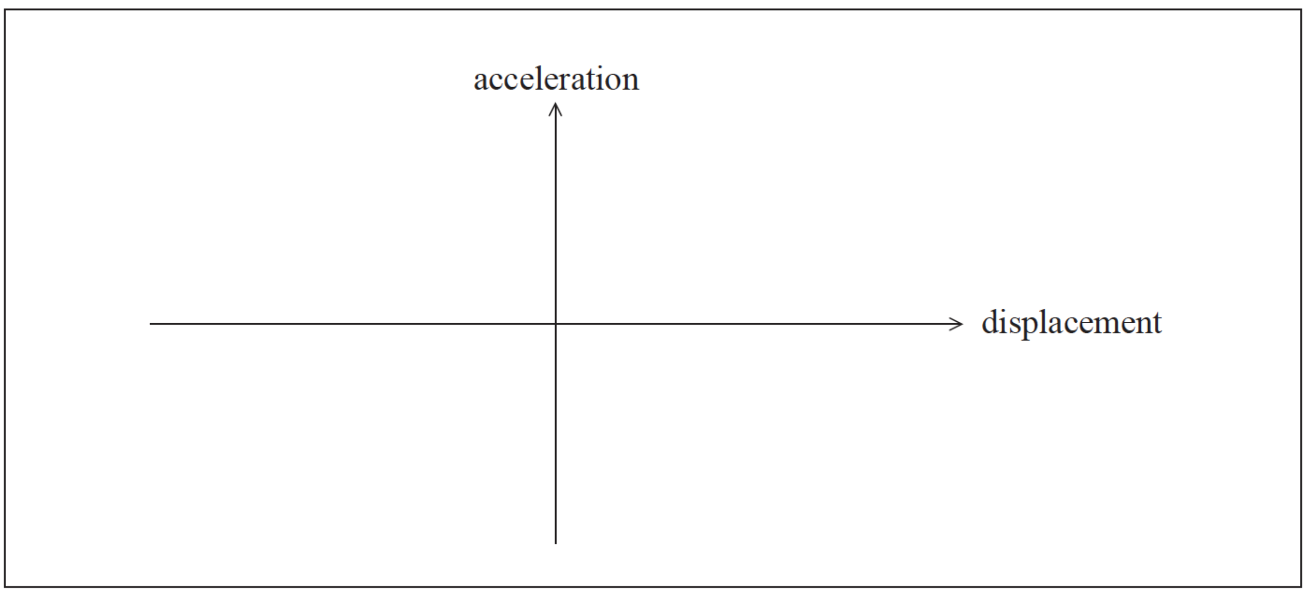
An object of mass *m* is placed on a frictionless surface and attached to a light horizontal spring. The other end of the spring is fixed.




The equilibrium position is at B. The direction B to C is taken to be positive. The object is released from position A and executes simple harmonic motion between positions A and C.

18a. Define *simple harmonic motion*. *[2 marks]*

18b. (i) On the axes below, sketch a graph to show how the acceleration of the mass varies with displacement from the equilibrium position B. *[3 marks]*




(ii) On your graph, label the points that correspond to the positions A, B and C.

18c. (i) On the axes below, sketch a graph to show how the velocity of the mass varies with time from the moment of release from A until the mass returns to A for the first time. *[3 marks]*

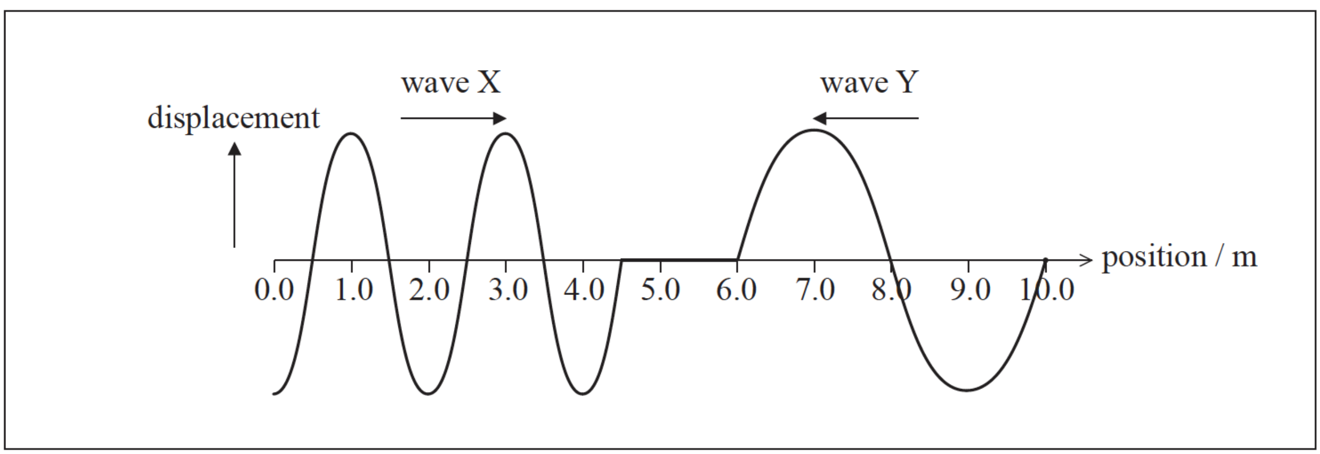

(ii) On your graph, label the points that correspond to the positions A, B and C.

18d. The period of oscillation is 0.20s and the distance from A to B is 0.040m. Determine the maximum speed of the mass. *[3 marks]*

18e. A long spring is stretched so that it has a length of 10.0 m. Both ends are made to oscillate with simple harmonic motion so that transverse waves of equal amplitude but different frequency are generated. *[4 marks]*

Wave X, travelling from left to right, has wavelength 2.0 m, and wave Y, travelling from right to left, has wavelength 4.0 m. Both waves move along the spring at speed 10.0 m $s^{-1}$.

The diagram below shows the waves at an instant in time.




(i) State the principle of superposition as applied to waves.

(ii) By drawing on the diagram or otherwise, calculate the position at which the resultant wave will have maximum displacement 0.20 s later.

This question is about the nature of electromagnetic waves.

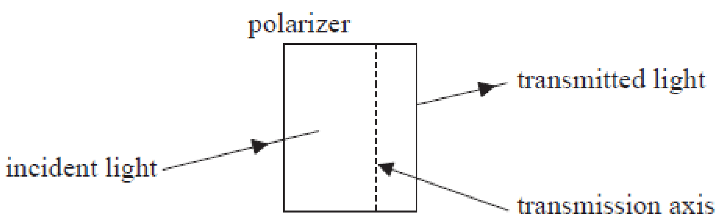
19a. Outline what is meant by an electromagnetic wave. *[2 marks]*

19b. State **two** cases in which electrons may produce electromagnetic waves. *[2 marks]*

This question is about polarization.

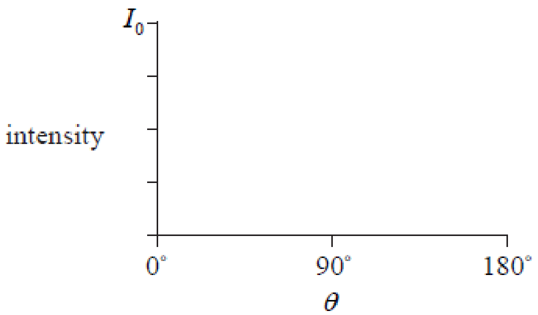
20a. State what is meant by polarized light. *[1 mark]*

20b. Light of intensity $I_0$ is incident on a polarizer. The transmission axis of the polarizer is vertical. The polarizer is rotated by an angle $\theta$ about the direction of the incident light. The intensity of the transmitted light is measured for various angles $\theta$. *[4 marks]*

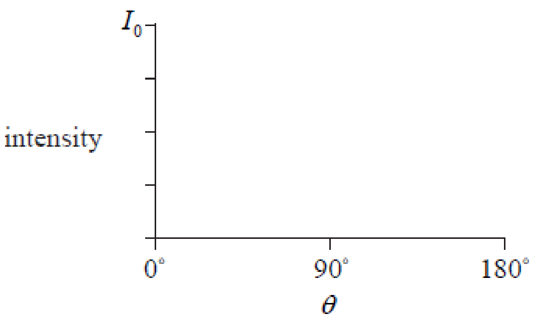



On the axes below, sketch graphs to show the variation of the transmitted intensity $I$ with $\theta$ when the incident light is

(i) horizontally polarized.



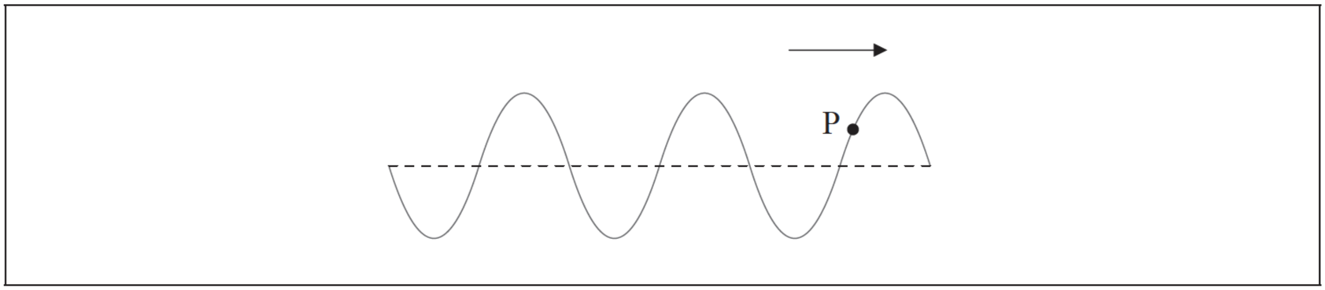

(ii) unpolarized.



This question is in **two** parts. **Part 1** is about wave motion. **Part 2** is about renewable energy sources.

**Part 1** Wave motion

The diagram shows a wave that is travelling to the right along a stretched string at a particular instant.




The dotted line shows the position of the stretched string when it is undisturbed. P is a small marker attached to the string.

21a. On the diagram above, identify *[2 marks]*

(i) with an arrow, the direction of movement of marker P at the instant in time shown.

(ii) the wavelength of the wave.

21b. The wavelength of the wave is 25mm and its speed is $18 mms^{-1}$. *[2 marks]*

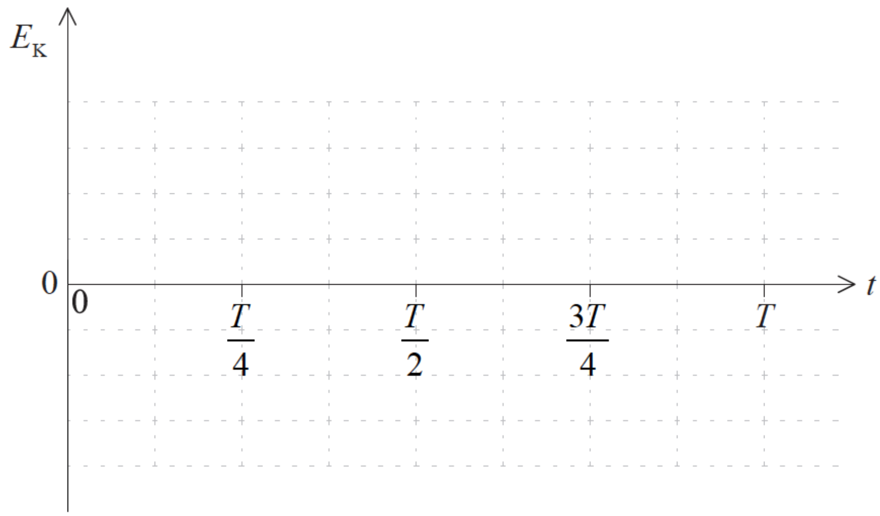
(i) Calculate the time period $T$ of the oscillation of the wave.

(ii) On the diagram above, draw the displacement of the string at a time $\frac{T}{3}$ later than that shown in the diagram.

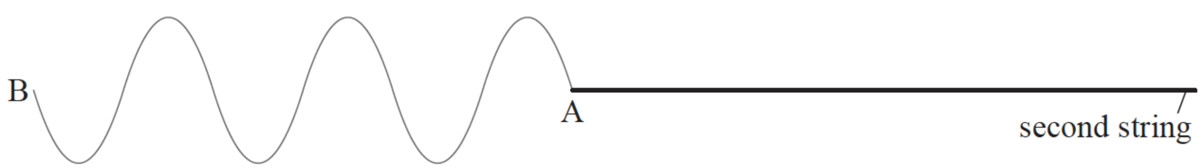
21c. Marker P undergoes simple harmonic motion. The amplitude of the wave is $1.7\times10^{-2}$m and the mass of marker P is $3.5\times10^{-3}$kg. *[5 marks]*

(i) Calculate the maximum kinetic energy of marker P.

(ii) Sketch a graph to show how the kinetic energy $E_K$ of marker P varies with time $t$ from $t$=0 to $t$=$T$, where $T$ is the time period of the oscillation calculated in (b). Annotate the axes of the graph with numerical values.




21d. The right-hand edge of the wave AB reaches a point where the string is securely attached to a second string in which the speed of waves is smaller than that of the first string. *[5 marks]*




(i) On the diagram above, draw the shape of the second string after the complete wave AB is travelling in it.

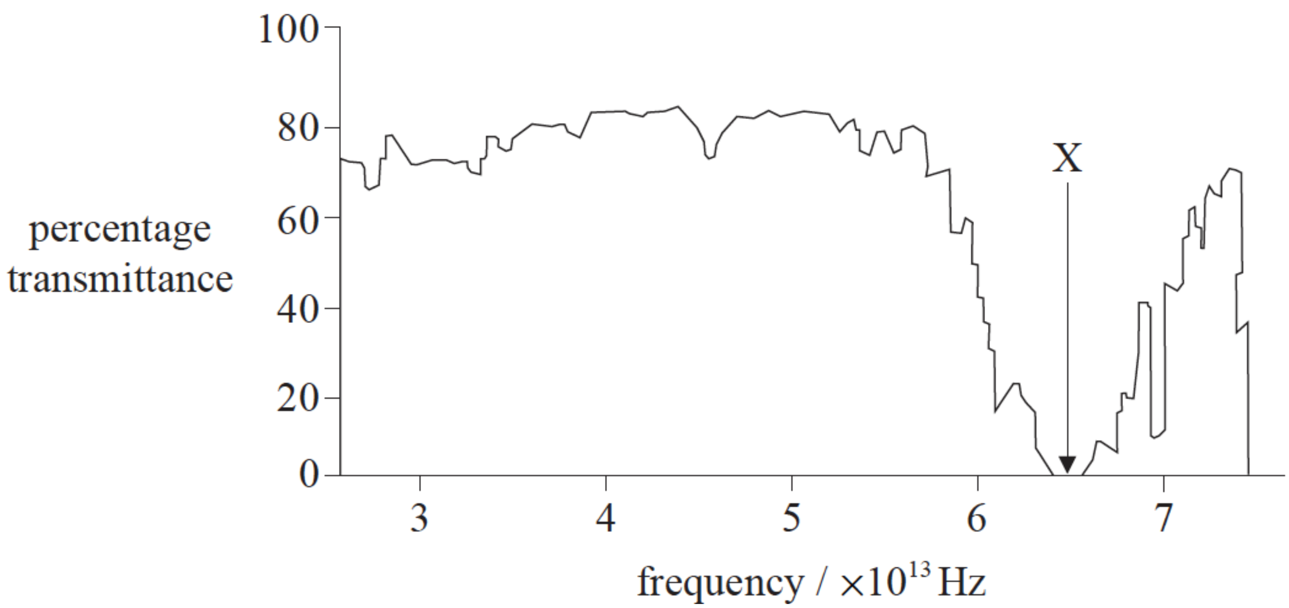
(ii) Explain the shape you have drawn in your answer to (d)(i).

This question is in **two** parts. **Part 1** is about the greenhouse effect. **Part 2** is about an electric motor.

**Part 1** Greenhouse effect

22a. Describe what is meant by the greenhouse effect in the Earth's atmosphere. *[3 marks]*

22b. The graph shows the variation with frequency of the percentage transmittance of electromagnetic waves through water vapour in the atmosphere. *[9 marks]*




(i) Show that the reduction in percentage transmittance labelled X occurs at a wavelength equal to approximately 5 µm.

(ii) Suggest, with reference to resonance, the possible reasons for the sharp reduction in percentage transmittance at a wavelength of 5 µm.

(iii) Explain how the reduction in percentage transmittance, labelled X on the graph opposite, accounts for the greenhouse effect.

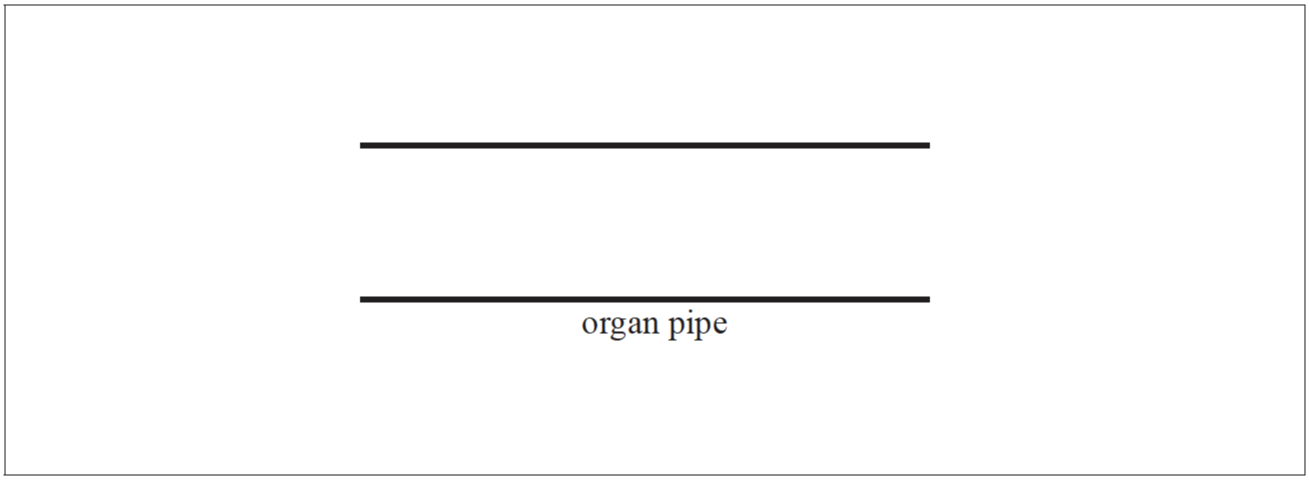
(iv) Outline how an increase in the concentration of greenhouse gases in the atmosphere may lead to global warming.

This question is about the electromagnetic spectrum.

23. Outline the nature of electromagnetic waves. *[2 marks]*

This question is about standing waves in an organ pipe.

24a. The diagram shows an organ pipe that is open at both ends. *[3 marks]*




The pipe is emitting its lowest frequency note.

On the diagram above,

(i) sketch a representation of the standing wave set up in the pipe.

(ii) label with the letter P, the point or points within the pipe where the air pressure is a maximum.

(iii) label with the letter A, the displacement antinodes.

24b. The length of the pipe in (a) is 1.5 m. An organ pipe that is closed at one end has the same lowest frequency note as the pipe in (a). *[3 marks]*

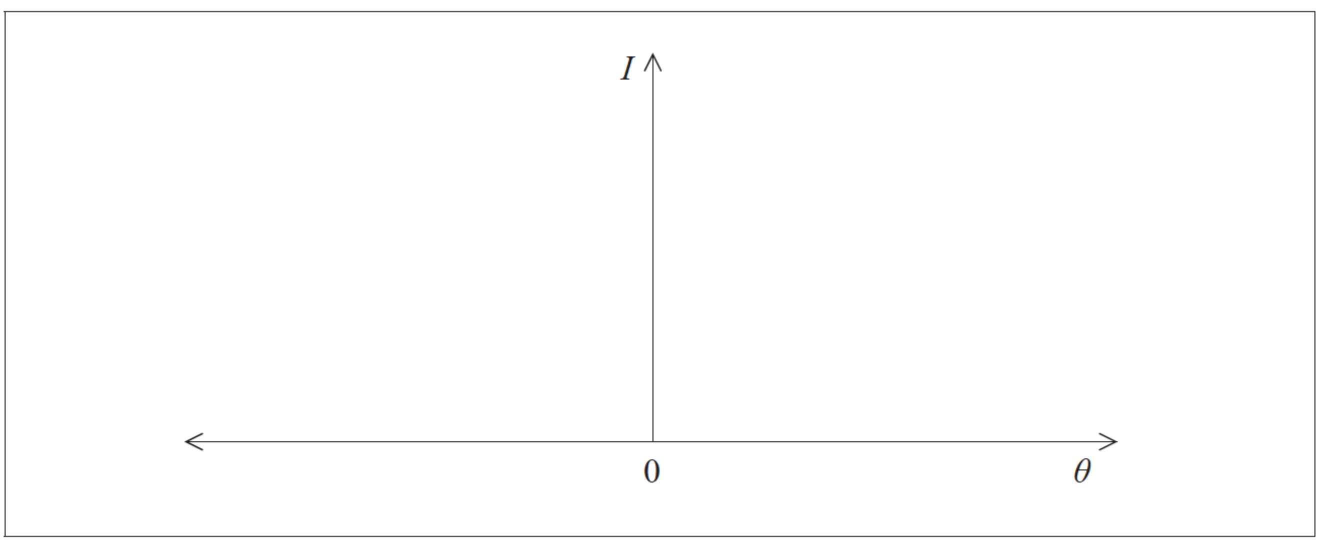
Show that the length of this pipe is 0.75 m.

This question is about diffraction and polarization.

25a. Light from a monochromatic point source $S_1$ is incident on a narrow, rectangular slit. *[5 marks]*


After passing through the slit the light is incident on a screen. The distance between the slit and screen is very large compared with the width of the slit.

(i) On the axes below, sketch the variation with angle of diffraction $\theta$ of the relative intensity $I$ of the light diffracted at the slit.




(ii) The wavelength of the light is 480 nm. The slit width is 0.1 mm and its distance from the screen is 1.2 m. Determine the width of the central diffraction maximum observed on the screen.

25b. Judy looks at two point sources identical to the source $S_1$ in (a). The distance between the sources is 8.0 mm and Judy's eye is at a distance *d* from the sources. *[3 marks]*

Estimate the value of *d* for which the images of the two sources formed on the retina of Judy's eye are just resolved.

25c. The light from a point source is unpolarized. The light can be polarized by passing it through a polarizer. *[3 marks]*

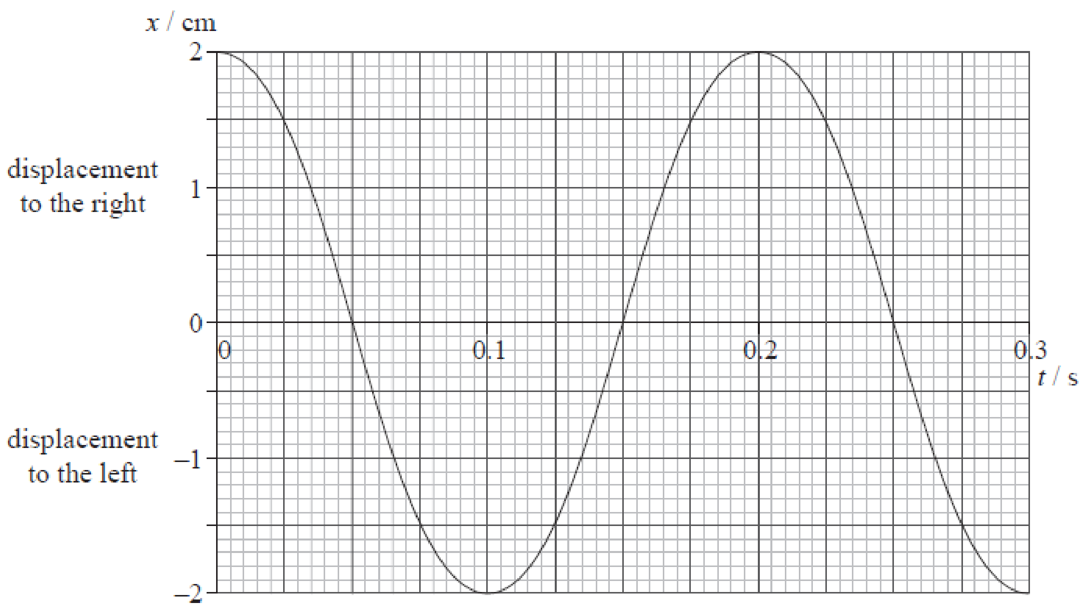
Explain, with reference to the electric (field) vector of unpolarized light and polarized light, the term polarizer.

**Part 2** Simple harmonic oscillations

A longitudinal wave travels through a medium from left to right.

Graph 1 shows the variation with time *t* of the displacement *x* of a particle P in the medium.

**Graph 1**




26a. For particle P, *[6 marks]*

(i) state how graph 1 shows that its oscillations are not damped.

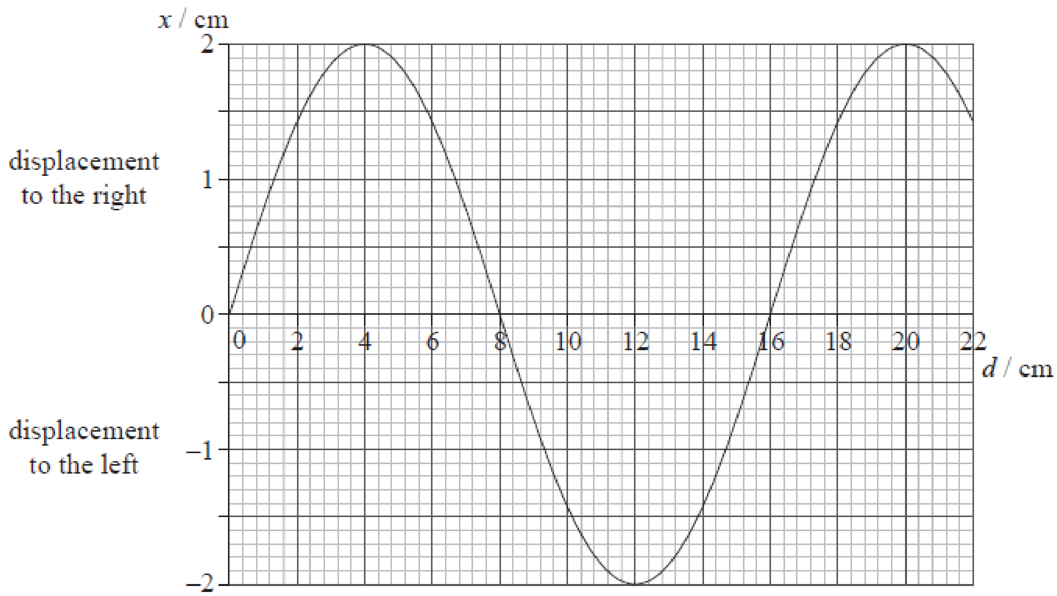
(ii) calculate the magnitude of its maximum acceleration.

(iii) calculate its speed at $t$=0.12 s.

(iv) state its direction of motion at $t$=0.12 s.

26b. Graph 2 shows the variation with position *d* of the displacement *x* of particles in the medium at a particular instant of time. *[4 marks]*

**Graph 2**

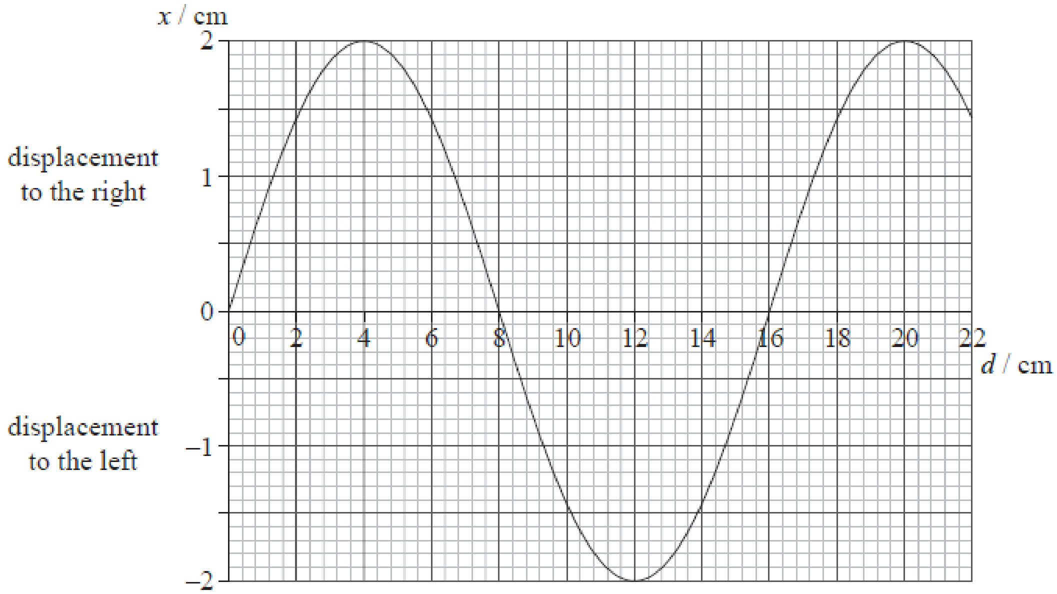



Determine for the longitudinal wave, using graph 1 and graph 2,

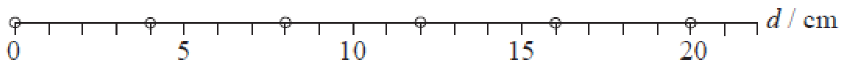
(i) the frequency.

(ii) the speed.

26c. **Graph 2** – reproduced to assist with answering (c)(i). *[4 marks]*




(c) The diagram shows the equilibrium positions of six particles in the medium.




(i) On the diagram above, draw crosses to indicate the positions of these six particles at the instant of time when the displacement is given by graph 2.

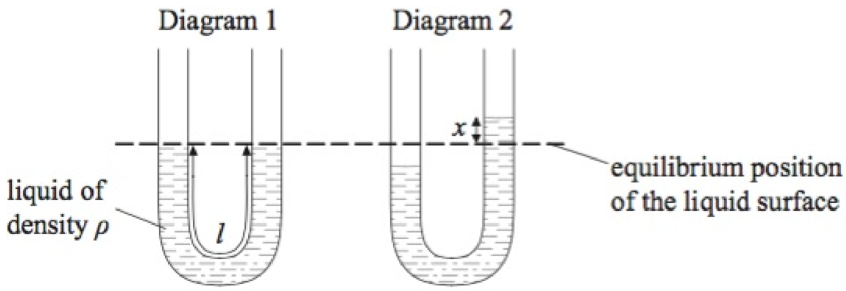
(ii) On the diagram above, label with the letter C a particle that is at the centre of a compression.

This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and a wave in a string. **Part 2** is about the unified atomic mass unit and a nuclear reaction.

**Part 1** Simple harmonic motion and a wave in a string

27a. By reference to simple harmonic motion, state what is meant by amplitude. *[1 mark]*

27b. A liquid is contained in a U-tube. *[5 marks]*




The pressure on the liquid in one side of the tube is increased so that the liquid is displaced as shown in diagram 2. When the pressure is suddenly released the liquid oscillates. The damping of the oscillations is small.

(i) Describe what is meant by damping.

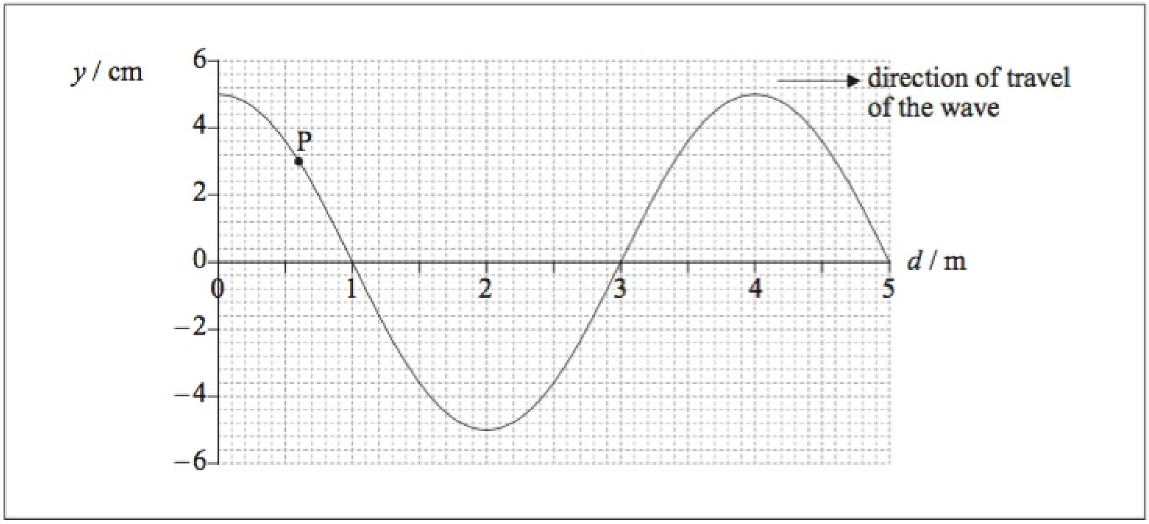
(ii) The displacement of the liquid surface from its equilibrium position is *x*. The acceleration *a* of the liquid in the tube is given by the expression

$$a = -\frac{2g}{l}x$$

where *g* is the acceleration of free fall and *l* is the total length of the liquid column. The total length of the liquid column in the tube is 0.32m. Determine the period of oscillation.

27c. A wave is travelling along a string. The string can be modelled as a single line of particles and each particle executes simple harmonic motion. The period of oscillation of the particles is 0.80s. *[9 marks]*

The graph shows the displacement *y* of part of the string at time *t*=0. The distance along the string is *d*.




(i) On the graph, draw an arrow to show the direction of motion of particle P at the point marked on the string.

(ii) Determine the magnitude of the velocity of particle P.

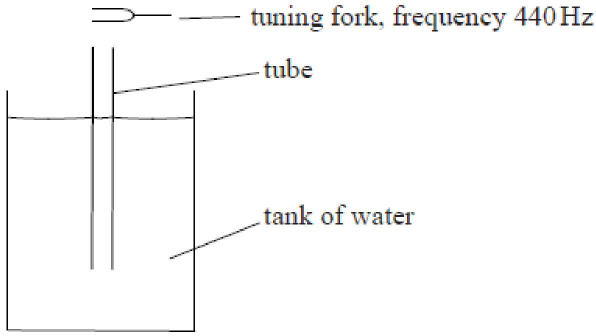
(iii) Show that the speed of the wave is 5.0 $ms^{-1}$.

(iv) On the graph opposite, label with the letter X the position of particle P at *t*=0.40 s.

This question is about standing (stationary) waves.

28a. Describe **two** ways that standing waves are different from travelling waves. *[2 marks]*

28b. An experiment is carried out to measure the speed of sound in air, using the apparatus shown below. *[3 marks]*




A tube that is open at both ends is placed vertically in a tank of water, until the top of the tube is just at the surface of the water. A tuning fork of frequency 440 Hz is sounded above the tube. The tube is slowly raised out of the water until the loudness of the sound reaches a maximum for the first time, due to the formation of a standing wave.

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

(ii) State the position in the tube that is always a node.

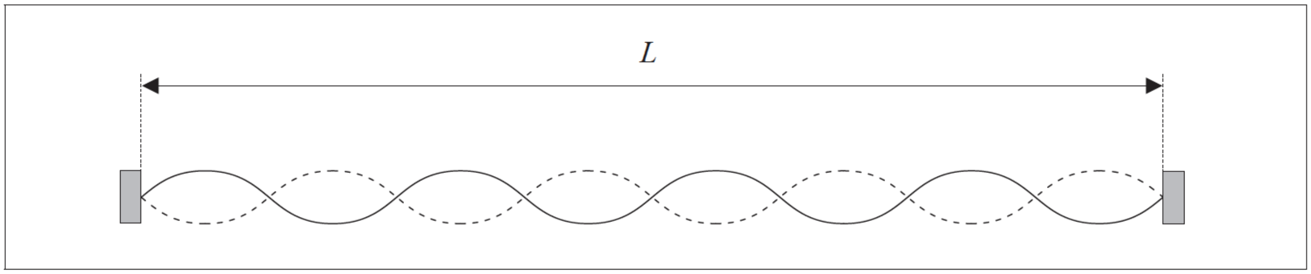
28c. The tube is raised until the loudness of the sound reaches a maximum for a second time. Between the two positions of maximum loudness, the tube has been raised by 36.8 cm. The frequency of the sound is 440 Hz. Estimate the speed of sound in air. *[2 marks]*

This question is about dispersion.

29. State an approximate value for the wavelength of visible light. *[1 mark]*

This question is about standing (stationary) waves.

The diagram represents a standing wave of wavelength $\lambda$ set up on a string of length $L$.




The string is fixed at both ends.

30a. For this standing wave *[3 marks]*

(i) state the relationship between $\lambda$ and $L$.

(ii) label, on the diagram, **two** antinodes where the string is vibrating in phase. Label the antinodes with the letter A.

30b. The standing wave has wavelength $\lambda$ and frequency $f$. State and explain, with respect to a standing wave, what is represented by the product $f\lambda$. *[3 marks]*