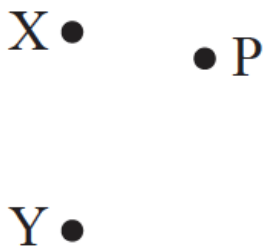
T4-2 *[251 marks]*

1. Waves emitted from sources X and Y have equal wavelengths and are initially in phase. The waves interfere destructively at point P, where the path difference is 0.60m. *[1 mark]*



What is a possible value for the wavelength of the waves?

A. 0.20 m
B. 0.30 m
C. 0.40 m
D. 0.60 m

2. The intensity of radiation from a star at the surface of one of its planets is *I*. The distance between the star and the planet is *d*. *[1 mark]*

What is the intensity at the surface of another planet which is a distance $\frac{d}{4}$ from the star?

A. 4*I*
B. 8*I*
C. 16*I*
D. 64*I*

3. Progressive (travelling) waves *S* and *T* have the same frequency and are in the same medium. *S* has amplitude 2.0 m and *T* has amplitude 4.0 m. What is the ratio of the intensity of *T* to the intensity of *S*? *[1 mark]*

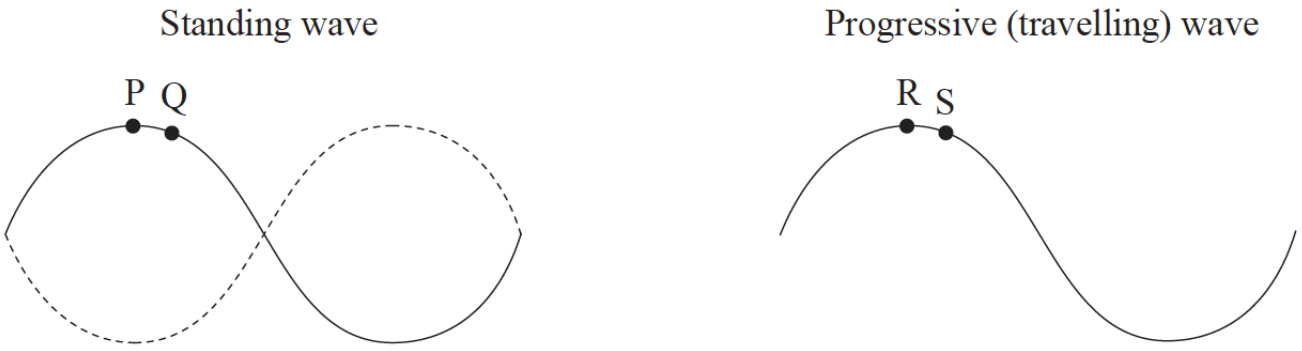
A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 2

D. 4

4. P and Q are two points on a standing wave. R and S are two points on a progressive (travelling) wave. *[1 mark]*



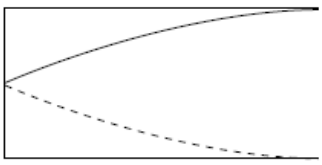
Which of the following gives the relationship between the amplitudes of each pair of points?

	Points P and Q	Points R and S
A.	same amplitude	same amplitude
B.	different amplitude	same amplitude
C.	same amplitude	different amplitude
D.	different amplitude	different amplitude

5. Unpolarized light is incident on the surface of a transparent medium. The reflected light is completely plane polarized. The refracted light will be *[1 mark]*

A. unpolarized.
B. partially plane polarized.
C. completely plane polarized at right angles to the reflected light.
D. completely plane polarized parallel to the reflected light.

6. A standing wave of frequency ƒ is established in air in a pipe open at one end, as shown. *[1 mark]*



Which of the following is the frequency of the next highest harmonic?

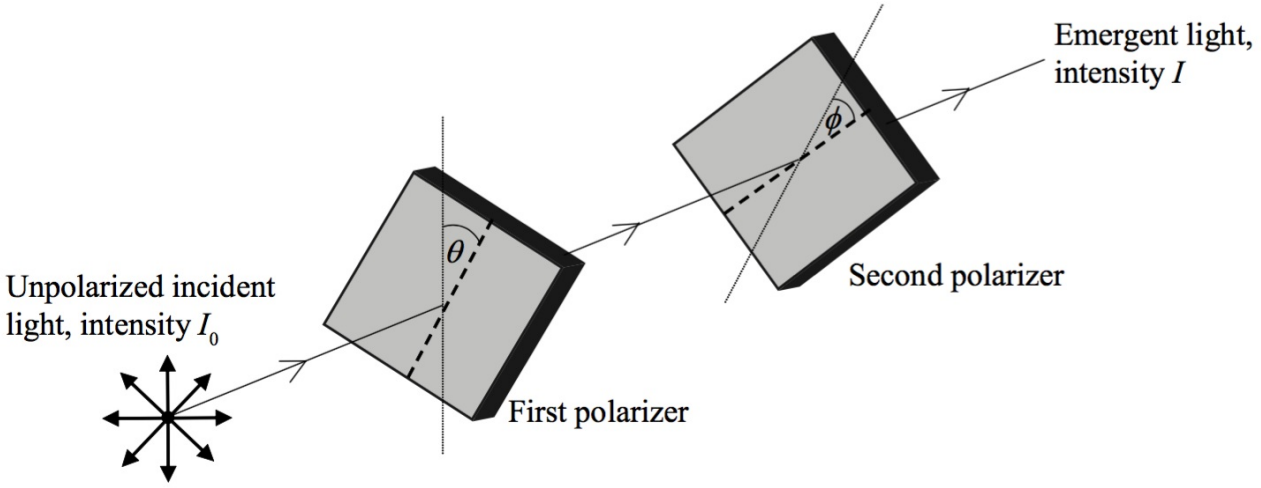
A. $\frac{f}{3}$

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

C. 2ƒ

D. 3ƒ

7. Unpolarized light of intensity I_0 is transmitted through a polarizer which has a transmission axis at an angle θ to the vertical. The light is then incident on a second polarizer with a transmission axis at an angle ϕ to the transmission axis of the first polarizer, as shown below. *[1 mark]*



The intensity of the light that emerges from the second polarizer is I. What is the ratio $\frac{I}{I_0}$?

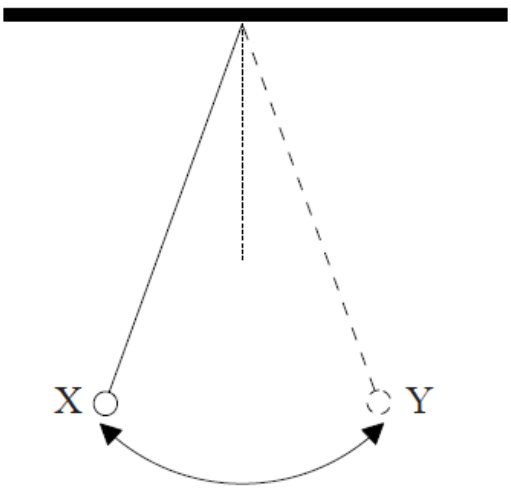
A. 0.25

B. $0.5 \cos^2(\theta+\varphi)$

C. $0.5 \cos^2 \varphi$

D. $\cos^2 \theta \cos^2 \varphi$

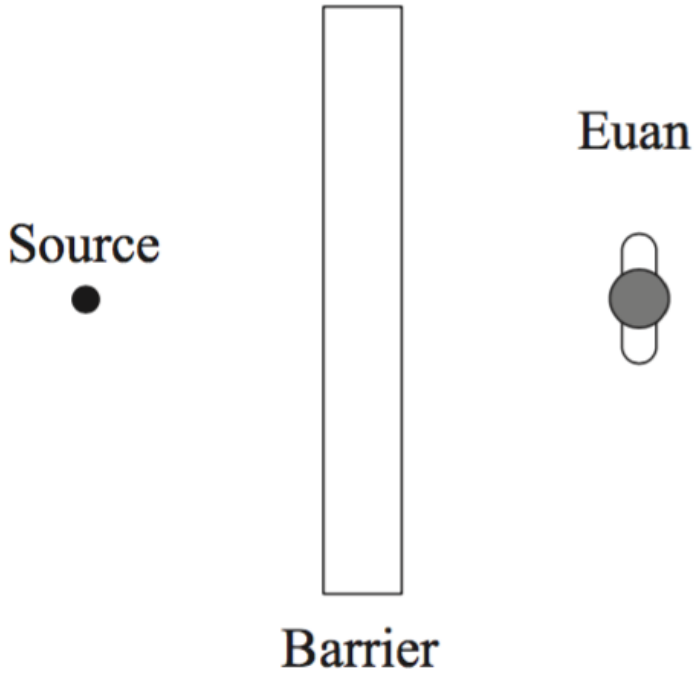
8. A pendulum swings back and forth in a circular arc between X and Y. *[1 mark]*



The pendulum bob is

A. always in equilibrium.
B. only in equilibrium at X and Y.
C. in equilibrium as it passes through the central position.
D. never in equilibrium.

9. A point source of sound is placed behind a soundproof barrier as shown in the diagram. *[1 mark]*



From where Euan is standing he can hear the sound. Which of the following best explains this observation?

A. Diffraction
B. Interference
C. Polarization
D. Refraction

This question is about the superposition of waves.

10a. State what is meant by the principle of superposition of waves. *[1 mark]*

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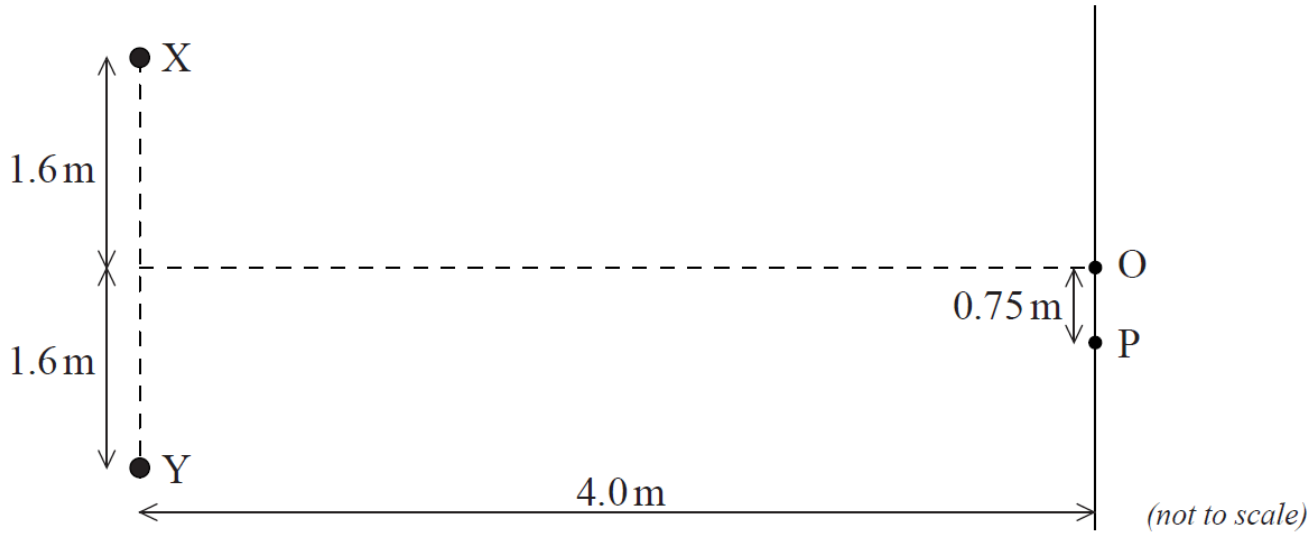
10b. The diagram shows two point sources of sound, X and Y. Each source emits waves of wavelength 1.1 m and amplitude *A*. Over the distances shown, any decrease in amplitude can be neglected. The two sources vibrate in phase. *[5 marks]*



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.

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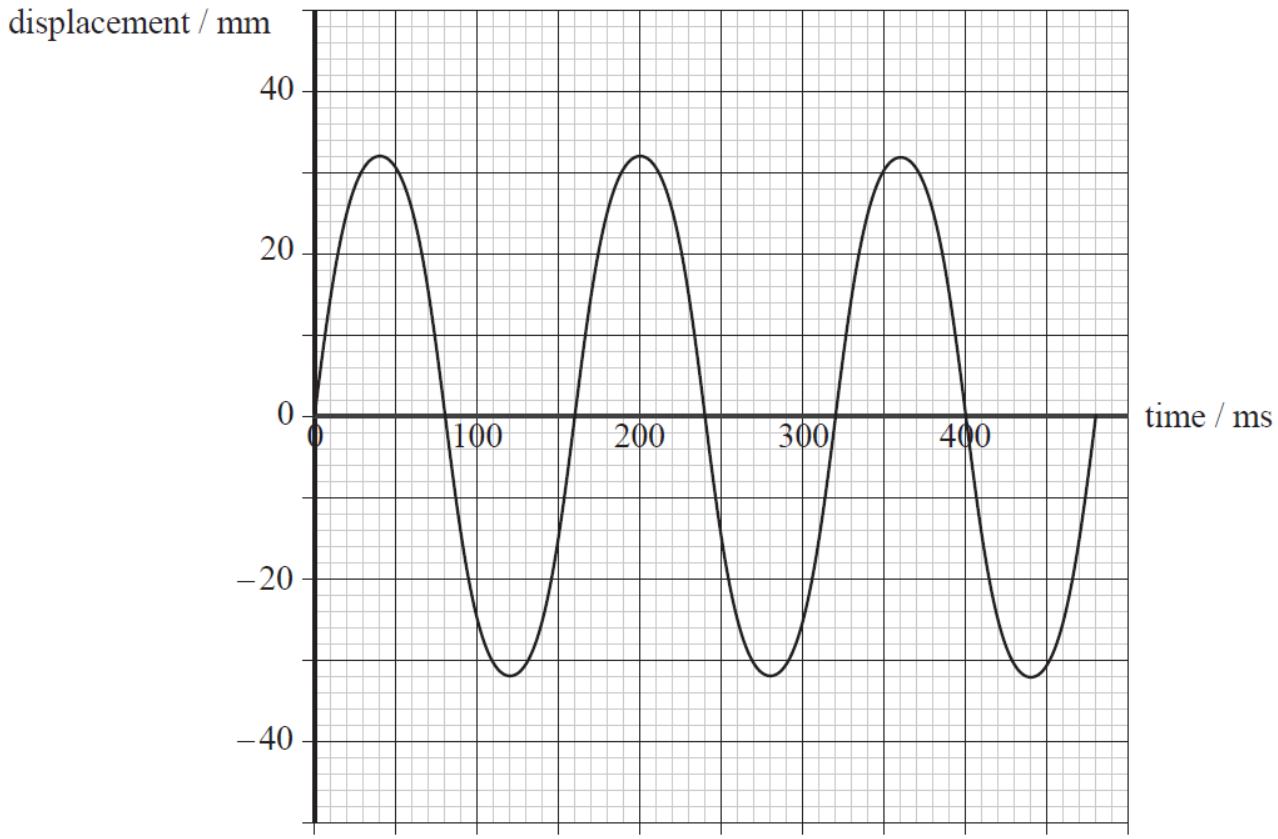
Simple harmonic motion and forced oscillations

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



11a. (i) State the amplitude of the oscillation. *[3 marks]*

(ii) Calculate the frequency of the oscillation.

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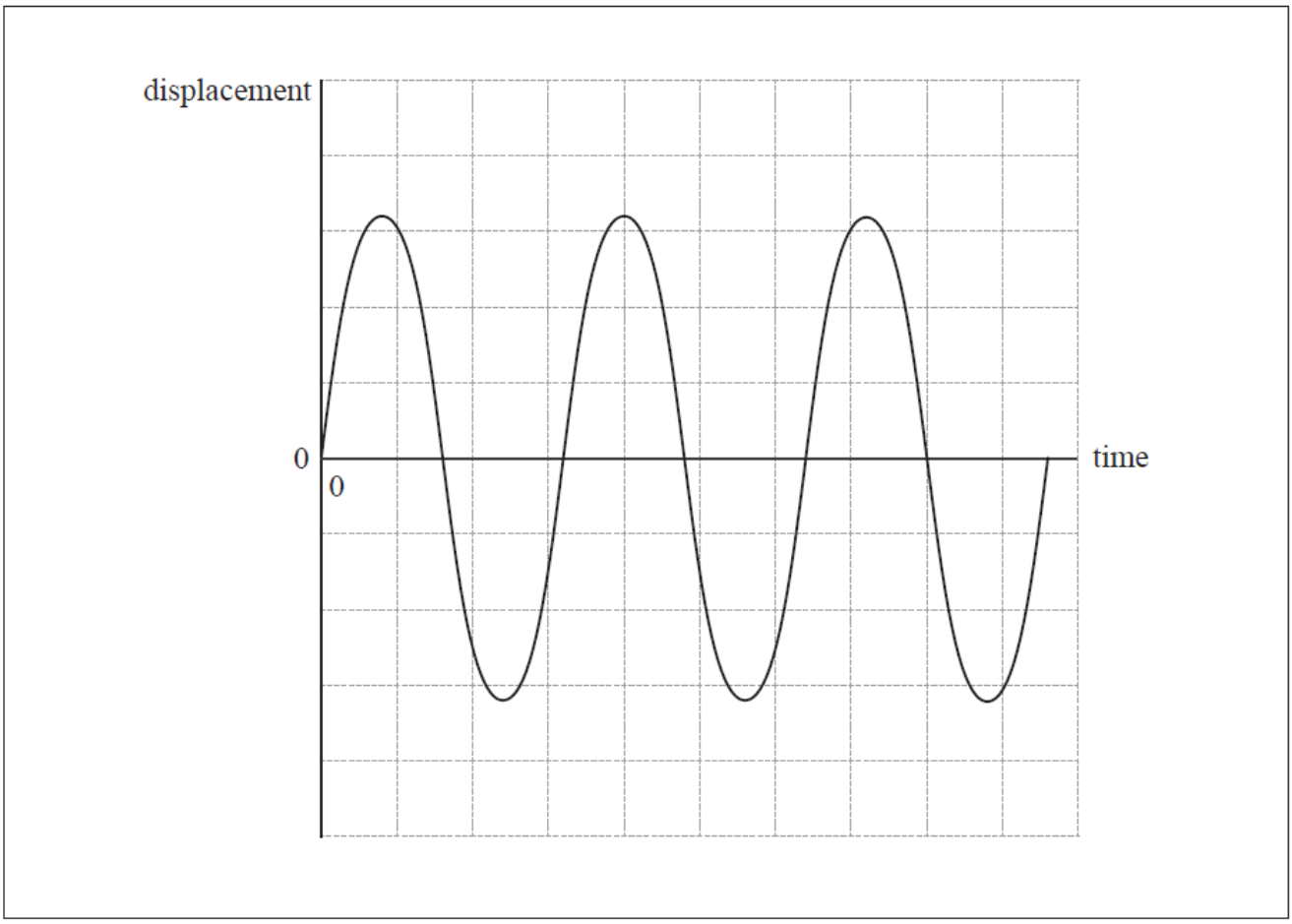
11b. (i) Determine the maximum speed of the object. *[4 marks]*

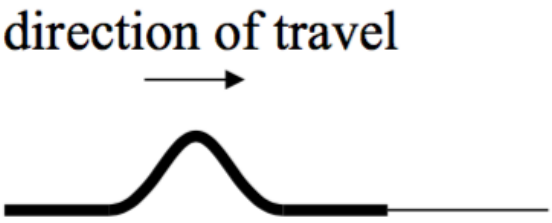
(ii) Determine the acceleration of the object at 140 ms.

11c. 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.



12. A wave pulse is travelling along a dense thick rope which is connected to a less dense thin rope. *[1 mark]*



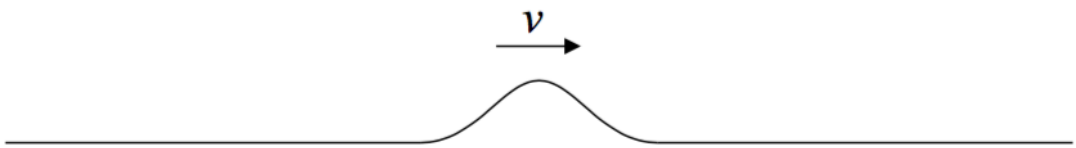
Which of the following is correct regarding the reflected and transmitted wave pulses after the wave pulse reaches the connection of the two ropes?

	Reflected pulse	Transmitted pulse
A.	inverted	inverted
B.	not inverted	inverted
C.	inverted	not inverted
D.	not inverted	not inverted

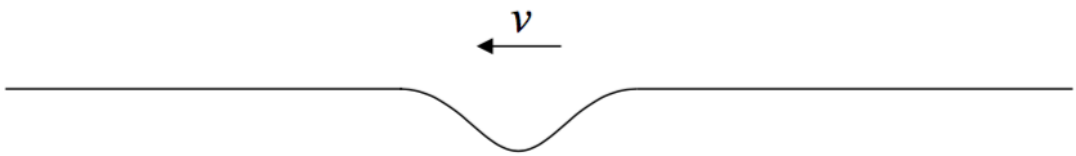
13. Two wave pulses travel along a string towards each other. The diagram shows their positions at a moment in time. *[1 mark]*

Which of the following shows a possible configuration of the pulses at a later time?

A.



B.



C.

D.

14. What region of the electromagnetic spectrum includes waves of wavelength 5×10^{-8} m? *[1 mark]*

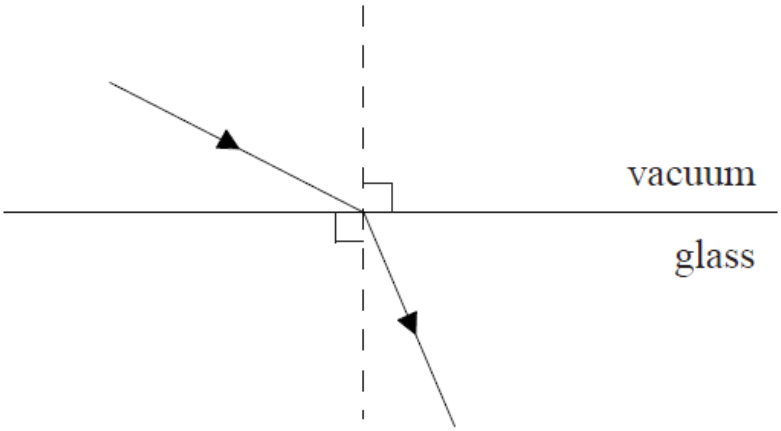
A. X-ray

B. Ultraviolet

C. Infrared

D. Microwave

15. A ray of light travels from a vacuum into glass as shown below. *[1 mark]*



In glass, light has speed v. In a vacuum, light has speed c. Which of the following gives the refractive index of glass?

A. $\frac{c}{v}$

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

C. $\frac{\sin c}{\sin v}$

D. $\frac{\sin v}{\sin c}$

16. A transverse standing wave is established on a string. Consider the following phase differences. *[1 mark]*

I. 0°
II. 90°
III. 180°

Which of the following gives all the possible phase differences between the oscillations of any two particles in the standing wave?

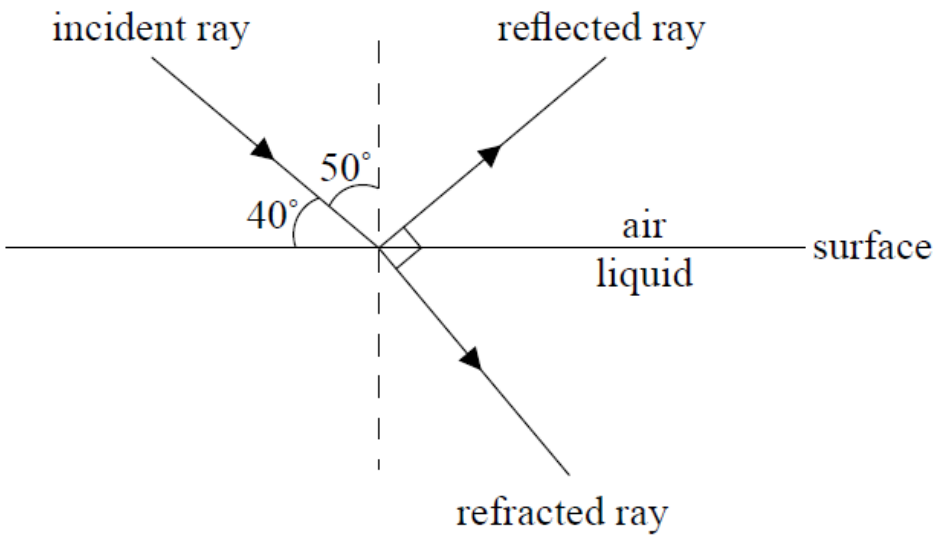
A. I only

B. I and III only

C. II and III only

D. I, II and III

17. A beam of unpolarized light is incident on the surface of a liquid and is partially reflected and partially refracted as shown below. *[1 mark]*



The reflected light is completely horizontally polarized. Which of the following is the refractive index of the liquid?

A. tan 40°

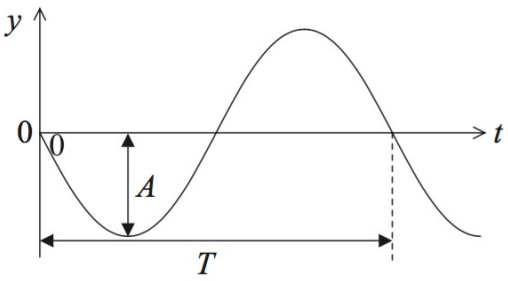
B. tan 50°

C. $\frac{\sin 40^\circ}{\sin 50^\circ}$

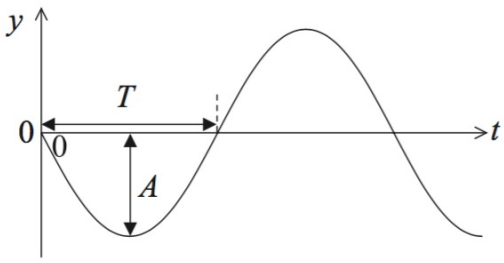
D. $\frac{\sin 40^\circ}{\cos 50^\circ}$

18. The diagrams show the variation with time *t* of the displacement *y* of a particle of a medium through which a wave travels. Which diagram correctly shows the period *T* and amplitude *A* of the wave? *[1 mark]*

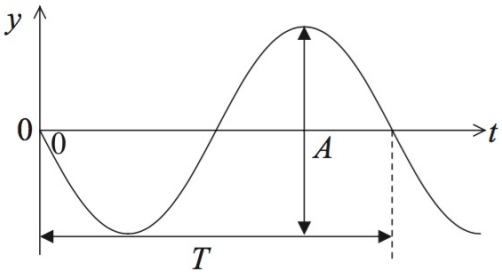
A.



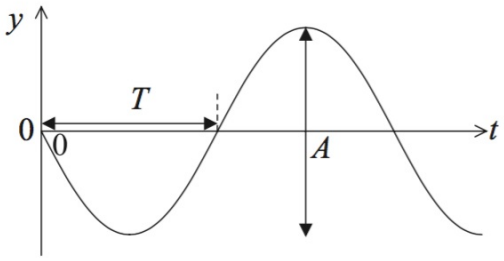
B.



C.



D.



This question is about standing waves in a vibrating string.

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

19a. Describe the formation of standing waves in a string fixed at both ends. *[2 marks]*

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19b. The length of the string is 0.64 m. Calculate the velocity of the wave in the string. *[2 marks]*

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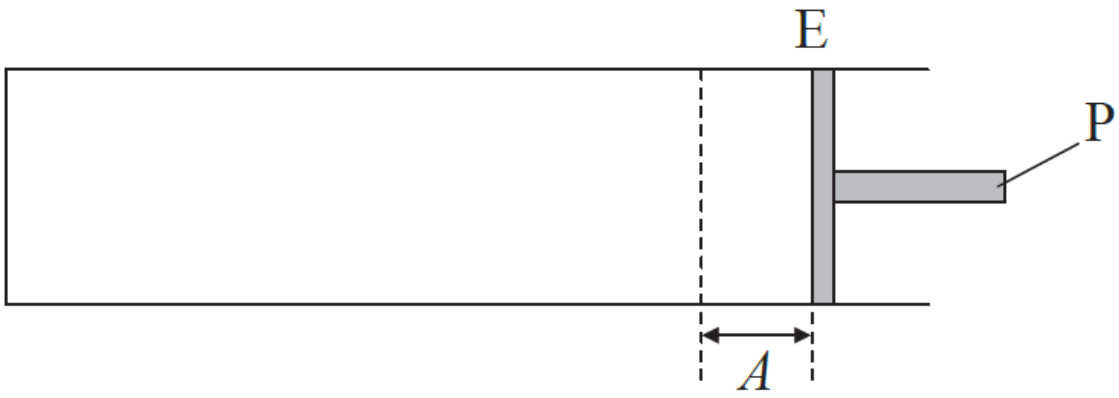
This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about wind power and the greenhouse effect.

Part 1 Simple harmonic motion (SHM) and waves

20a. A gas is contained in a horizontal cylinder by a freely moving piston P. Initially P is at rest at the equilibrium position E. *[2 marks]*



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.

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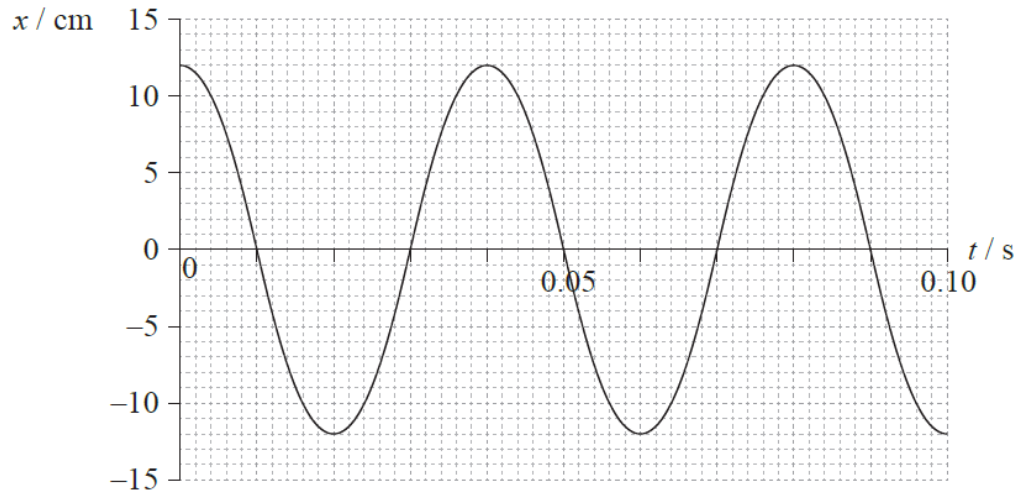
20b. The graph shows how the displacement x of the piston P in (a) from equilibrium varies with time t. *[7 marks]*



(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.

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20c. 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.

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21. The air in a pipe, of length *l* and open at both ends, vibrates with a fundamental frequency *f*. What is the fundamental frequency of a pipe of length 1.5*l* and closed at one end? *[1 mark]*

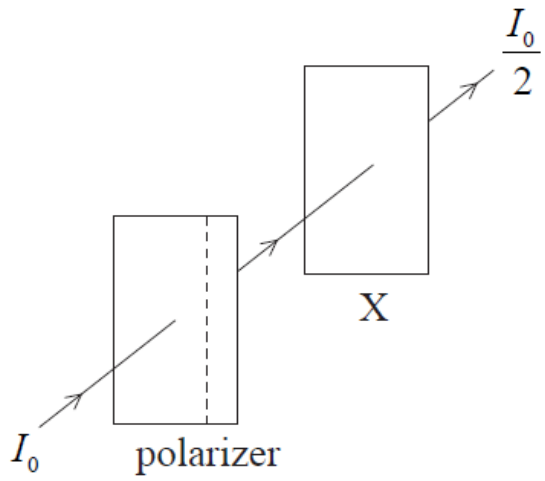
A. $\frac{f}{3}$

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

C. $\frac{3f}{2}$

D. $3f$

22. Unpolarized light of intensity I_0 is incident on a polarizer with a vertical transmission axis. The transmitted light is incident on a sheet of material X. After transmission through X the intensity of the light is $\frac{I_0}{2}$. *[1 mark]*



It is suggested that X could be

I. a polarizer with vertical transmission axis
II. a polarizer with horizontal transmission axis
III. non polarizing glass.

Which of the above suggestions is/are correct?

A. I and III only
B. I only
C. II only
D. II and III only

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

23a. State what is meant by the terms ray and wavefront and state the relationship between them. *[3 marks]*

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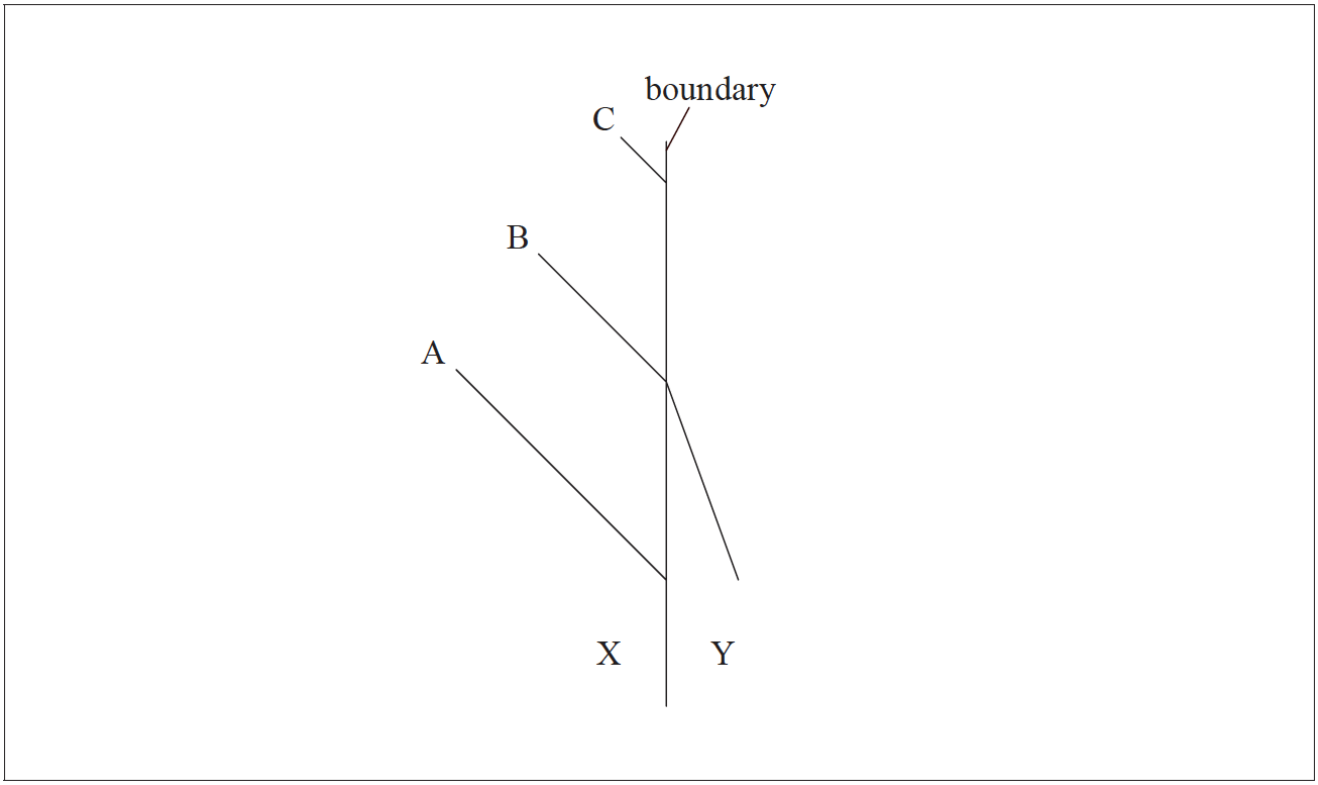
23b. The diagram shows three wavefronts, A, B and C, of a wave at a particular instant in time incident on a boundary between media X and Y. Wavefront B is also shown in medium Y. *[4 marks]*



(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 $\frac{n_X}{n_Y}$.

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23c. Describe the difference between transverse waves and longitudinal waves. *[2 marks]*

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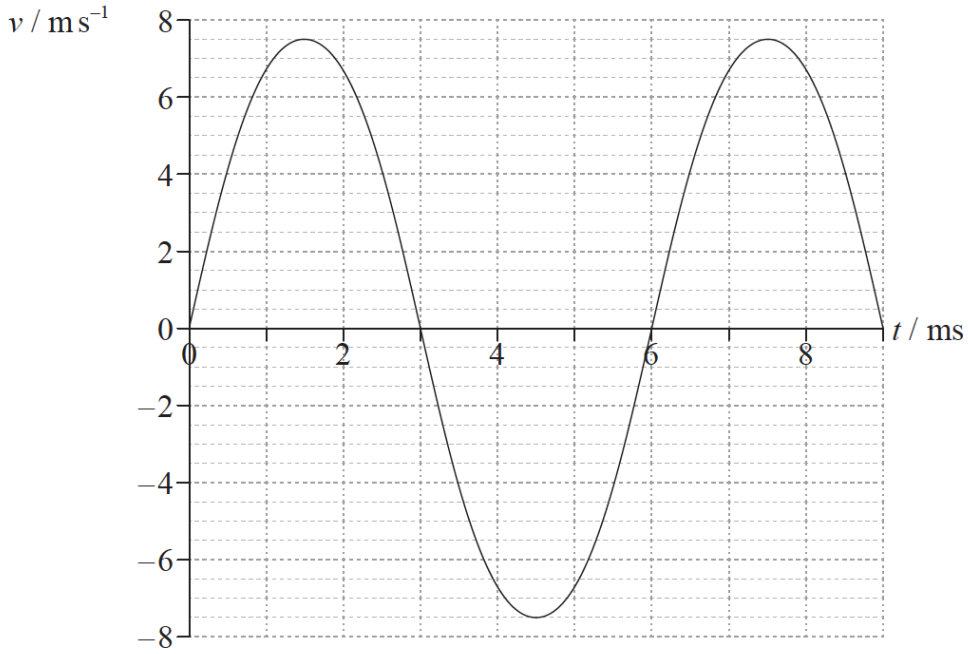
23d. The graph below shows the variation of the velocity *v* with time *t* for one oscillating particle of a medium. *[3 marks]*



(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.

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This question is about polarized light.

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

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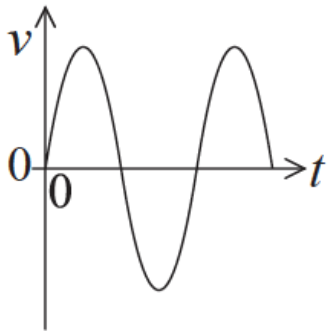
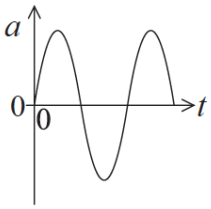
25. The diagram shows the variation of velocity v with time t for an object performing simple harmonic motion. *[1 mark]*

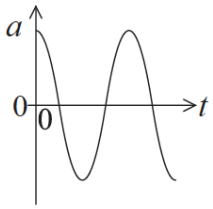


Which of the following shows how the acceleration a varies with t?

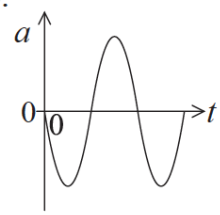
A.



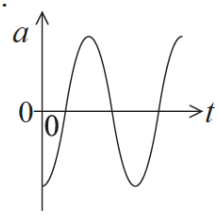
B.



C.



D.



26. Which of the following gives regions of the electromagnetic spectrum in the order of **decreasing** frequency? *[1 mark]*

A. gamma-ray, microwave, visible
B. radio wave, infrared, microwave
C. ultraviolet, infrared, microwave
D. visible, gamma-ray, radio wave

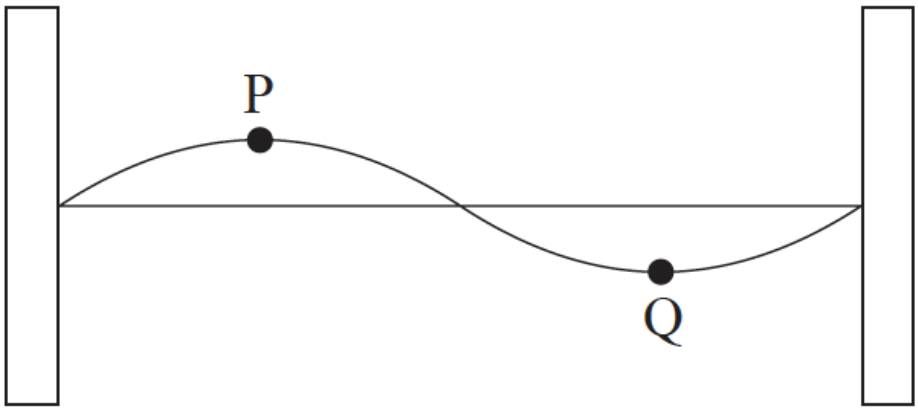
27. The power emitted as electromagnetic radiation by the Sun is approximately 4×10^{26} W. The radius of the orbit of Mars around the Sun is approximately 2×10^{11} m. What is the best estimate for the power incident on an area of 1 m^2 at the radius of Mars' orbit? *[1 mark]*

A. 10^3 W
B. 10^7 W
C. 10^{11} W
D. 10^{15} W

28. Which of the following gives regions of the electromagnetic spectrum in the order of **decreasing** frequency? *[1 mark]*

A. gamma-ray, microwave, visible
B. radio wave, infrared, microwave
C. ultraviolet, infrared, microwave
D. visible, gamma-ray, radio wave

29. A standing wave is established on a string between two fixed points. *[1 mark]*



What is the phase difference in radians between point P and point Q on the string?

A. zero

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

C. π

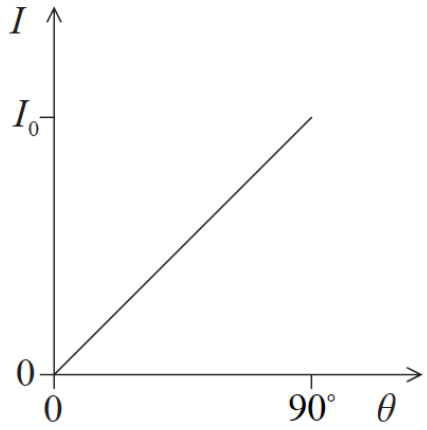
D. 2π

30. The phenomenon of diffraction is associated with *[1 mark]*

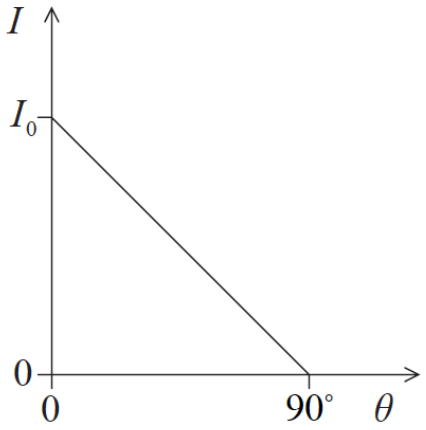
A. sound waves only.
B. light waves only.
C. water waves only.
D. all waves.

31. Polarized light of intensity I_0 is incident on a polarizing filter. The angle between the plane of polarization of the incident light and the transmission plane of the polarizer is θ. Which graph shows how the intensity I of the light transmitted through the polarizer varies with θ? *[1 mark]*

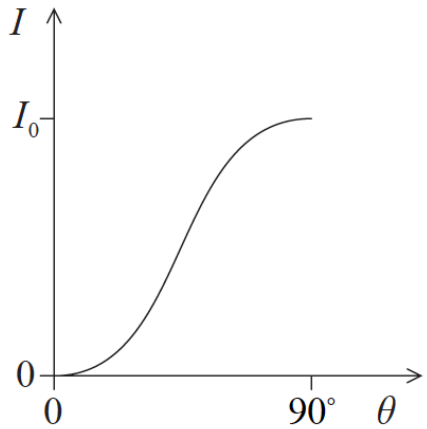
A.



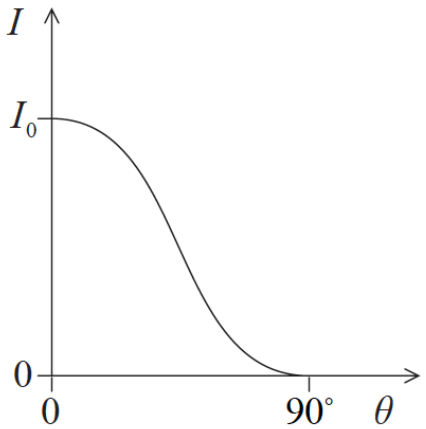
B.



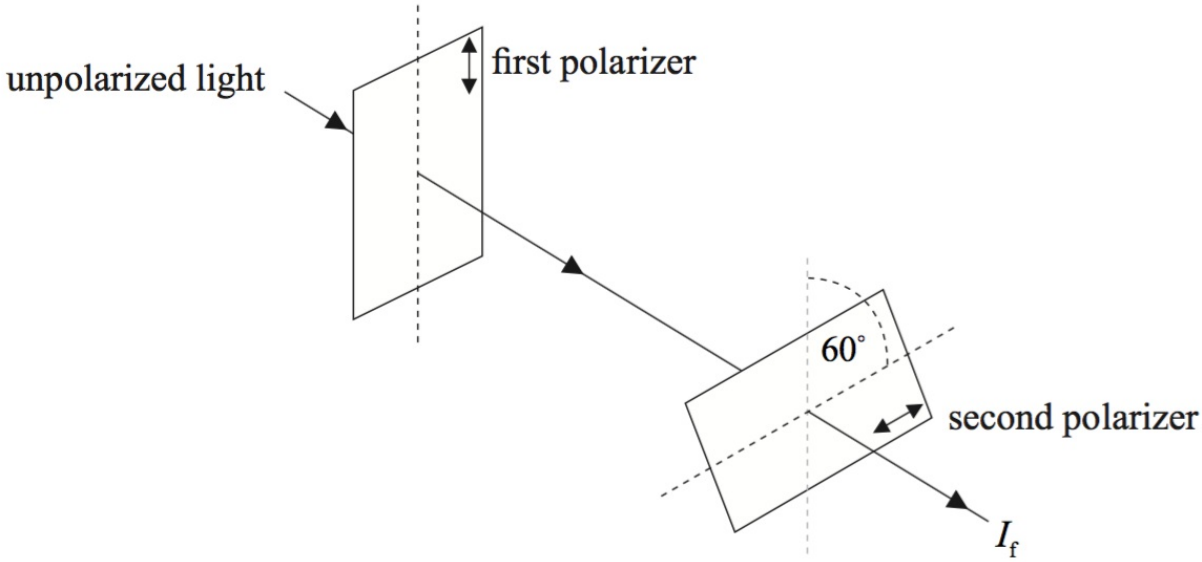
C.



D.



32. Unpolarized light is incident on a polarizer. The light transmitted by the first polarizer is then incident on a second polarizer. The polarizing axis of the second polarizer is at 60º to that of the first polarizer. *[1 mark]*



The intensity emerging from the second polarizer is I_f.

Which of the following correctly gives the intensity incident on the first polarizer?

A. $\frac{I_f}{8}$

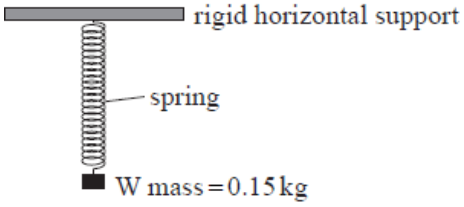
B. $\frac{I_f}{4}$

C. $4I_f$

D. $8I_f$

Part 2 Simple harmonic motion and waves

33a. One end of a light spring is attached to a rigid horizontal support. *[8 marks]*



An object W of mass 0.15 kg is suspended from the other end of the spring. The extension x of the spring is proportional to the force F causing the extension. The force per unit extension of the spring k is 18 Nm^{-1}.

A student pulls W down such that the extension of the spring increases by 0.040 m. The student releases W and as a result W performs simple harmonic motion (SHM).

(i) State what is meant by the expression “W performs SHM”.

(ii) Determine the maximum acceleration of W.

(iii) Determine the period of oscillation of the spring.

(iv) Determine the maximum kinetic energy of W.

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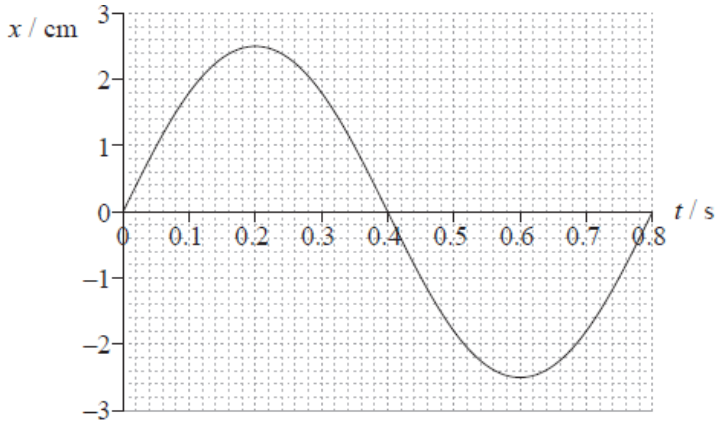
33b. A light spring is stretched horizontally and a longitudinal travelling wave is set up in the spring, travelling to the right. *[6 marks]*

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

(ii) The graph shows how the displacement x of one coil C of the spring varies with time t.



The speed of the wave is 3.0 cms^{-1}. Determine the wavelength of the wave.

(iii) Draw, on the graph in (c)(ii), the displacement of a coil of the spring that is 1.8 cm away from C in the direction of travel of the wave, explaining your answer.

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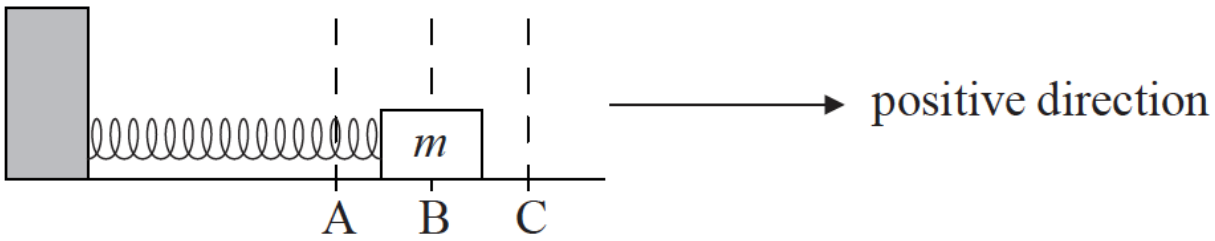
This question is in **two** parts. **Part 1** is about simple harmonic motion and the superposition of waves. **Part 2** is about gravitational fields.

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.

34a. Define *simple harmonic motion*. *[2 marks]*

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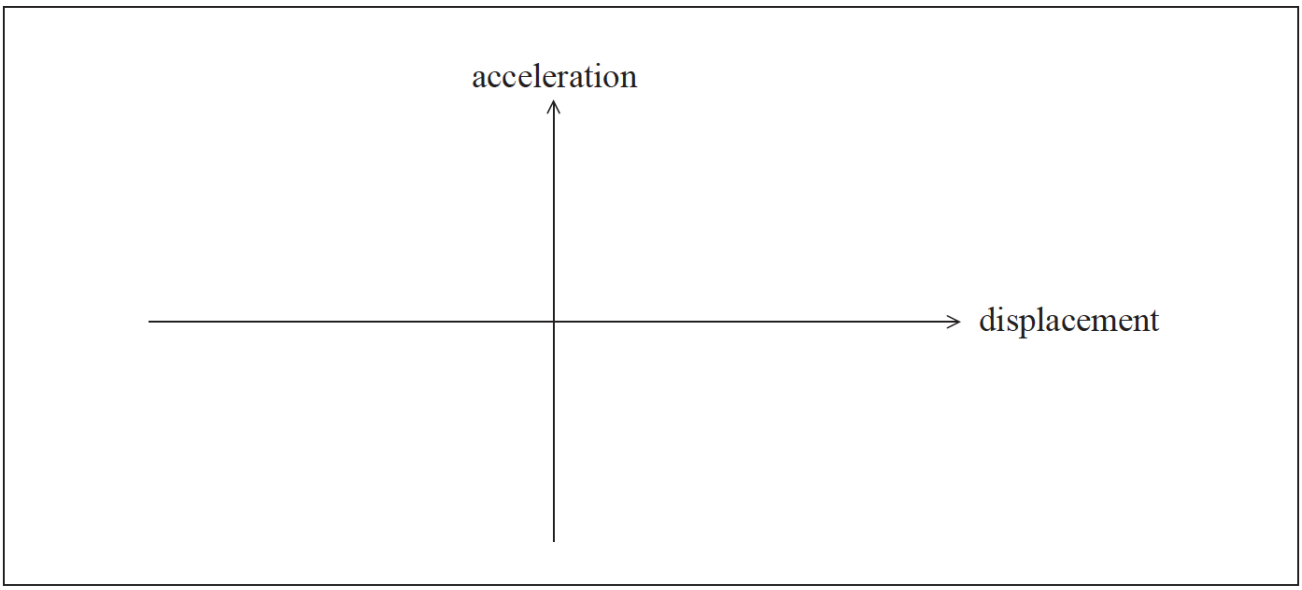
34b. (i) On the axes below, sketch a graph to show how the acceleration of the mass varies with displacement from the equilibrium position B. *[3 marks]*



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

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34c. (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]*

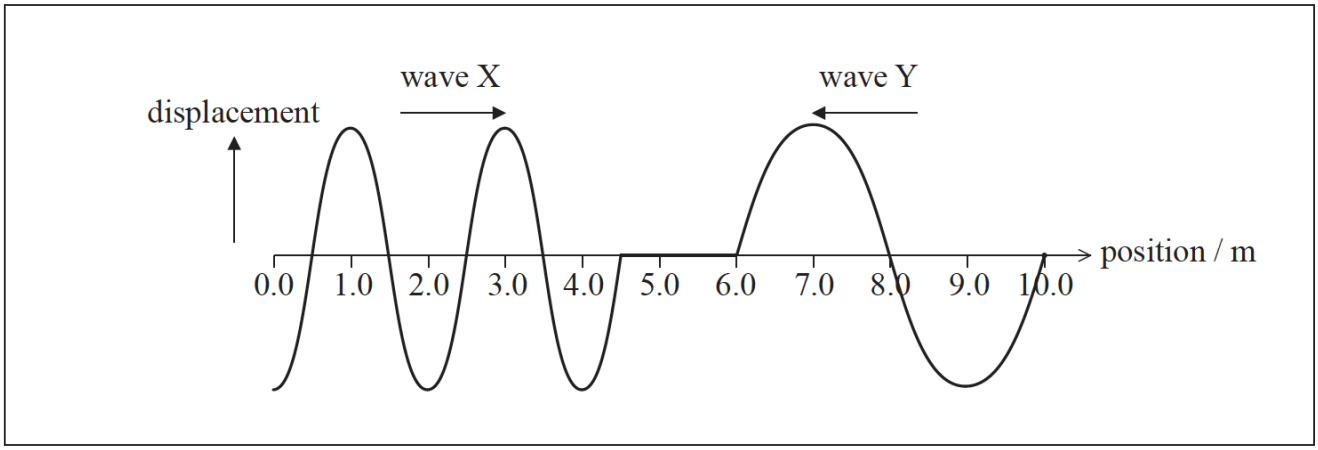
(ii) On your graph, label the points that correspond to the positions A, B and C.

34d. 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]*

34e. 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.

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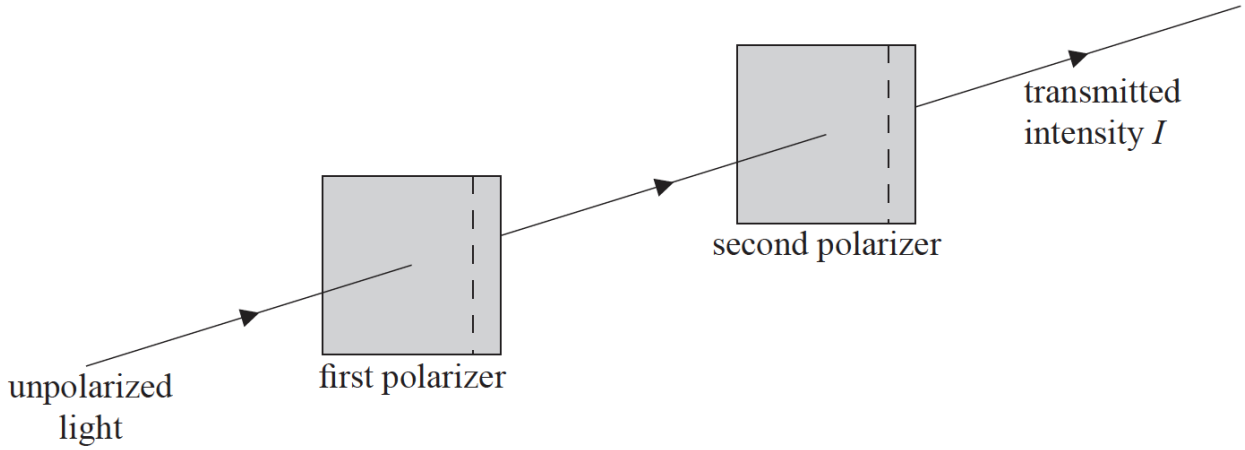
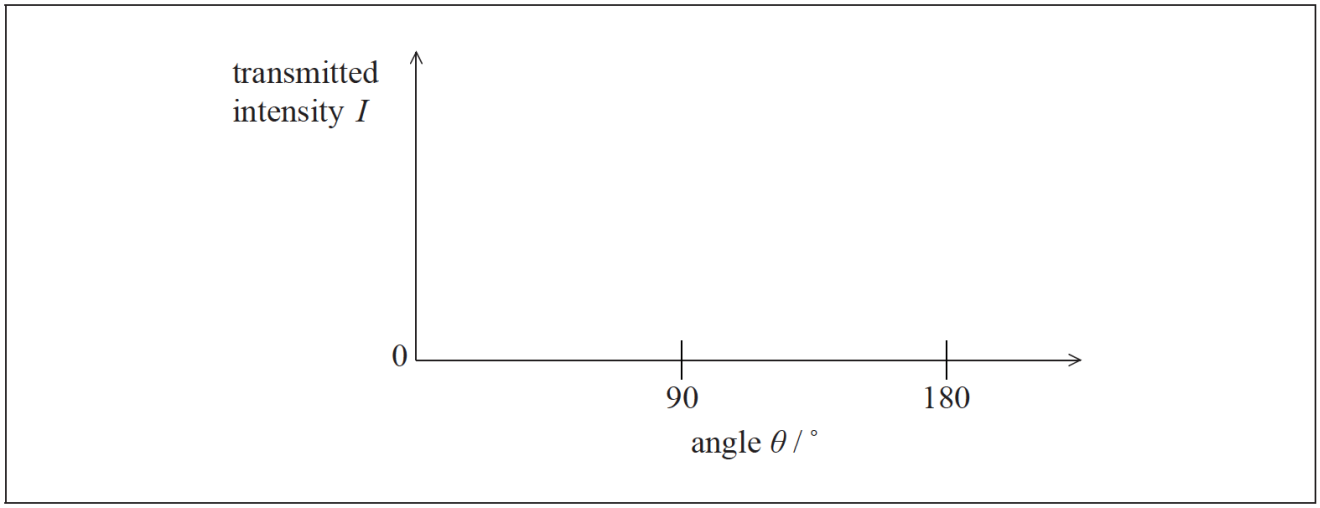
This question is about polarization.

Unpolarized light is directed towards two polarizers. The dashed lines represent the transmission axes of the polarizers. The angle θ between the transmission axes of the polarizers is initially 0º.



35. On the axes below, sketch a graph to show how the intensity I of the light emerging from the second polarizer varies with θ. *[2 marks]*



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This question is about standing waves on strings.

36a. A string is fixed at one end and the other free end is moved up and down. Explain how a standing wave can be formed on the string. *[3 marks]*

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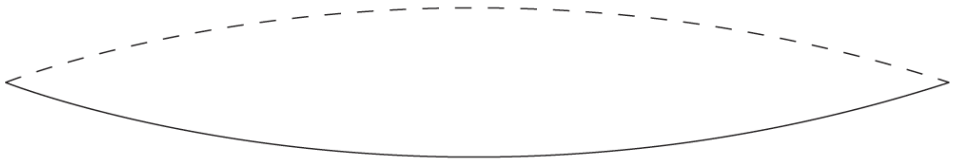
36b. The diagram shows a string vibrating in its first harmonic mode. Both ends of the string are fixed. *[5 marks]*



(i) Label an antinode on the diagram.

(ii) The length of the string is 0.85 m and its first harmonic frequency is 73 Hz. Calculate the speed of the waves on the string.

(iii) Sketch how the string will appear if it is vibrated at a frequency three times that of the first harmonic frequency.

(iv) State the speed of the wave when the string is vibrated at a frequency three times that of the first harmonic frequency.

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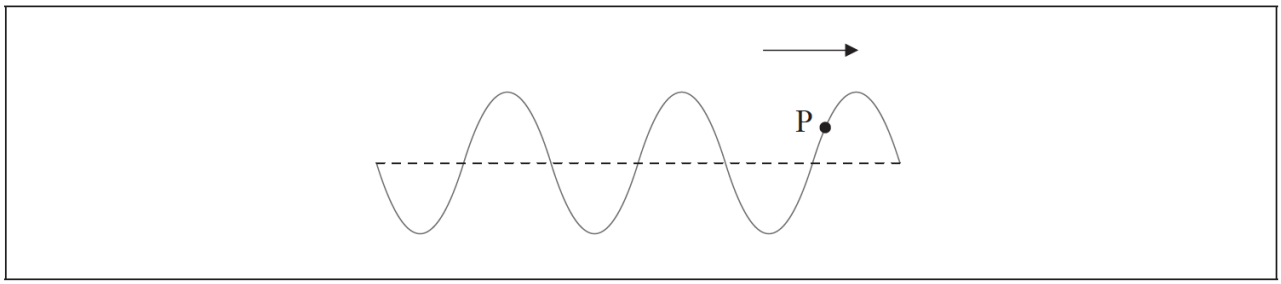
This question is in **two** parts. **Part 1** is about wave motion. **Part 2** is about renewable energy sources.

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.

37a. 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.

37b. The wavelength of the wave is 25mm and its speed is 18mms^{-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.

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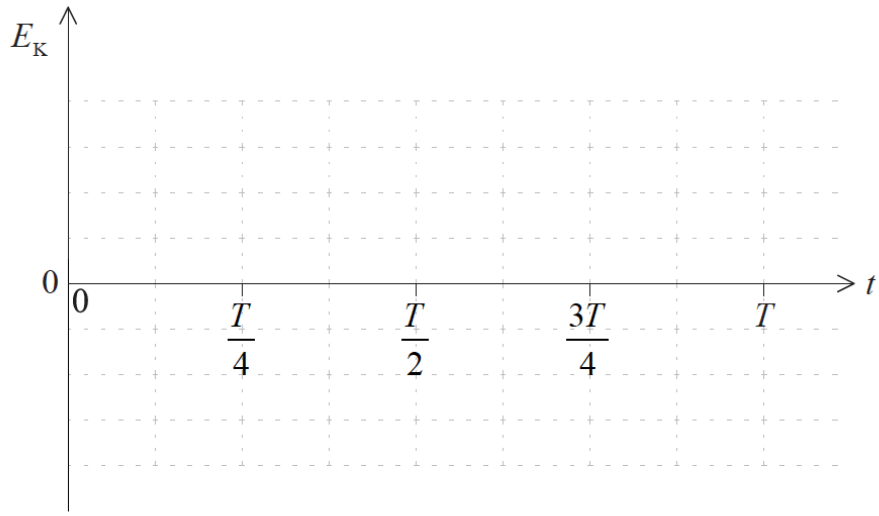
37c. Marker P undergoes simple harmonic motion. The amplitude of the wave is 1.7×10^{-2}m and the mass of marker P is 3.5×10^{-3}kg. *[5 marks]*

(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.



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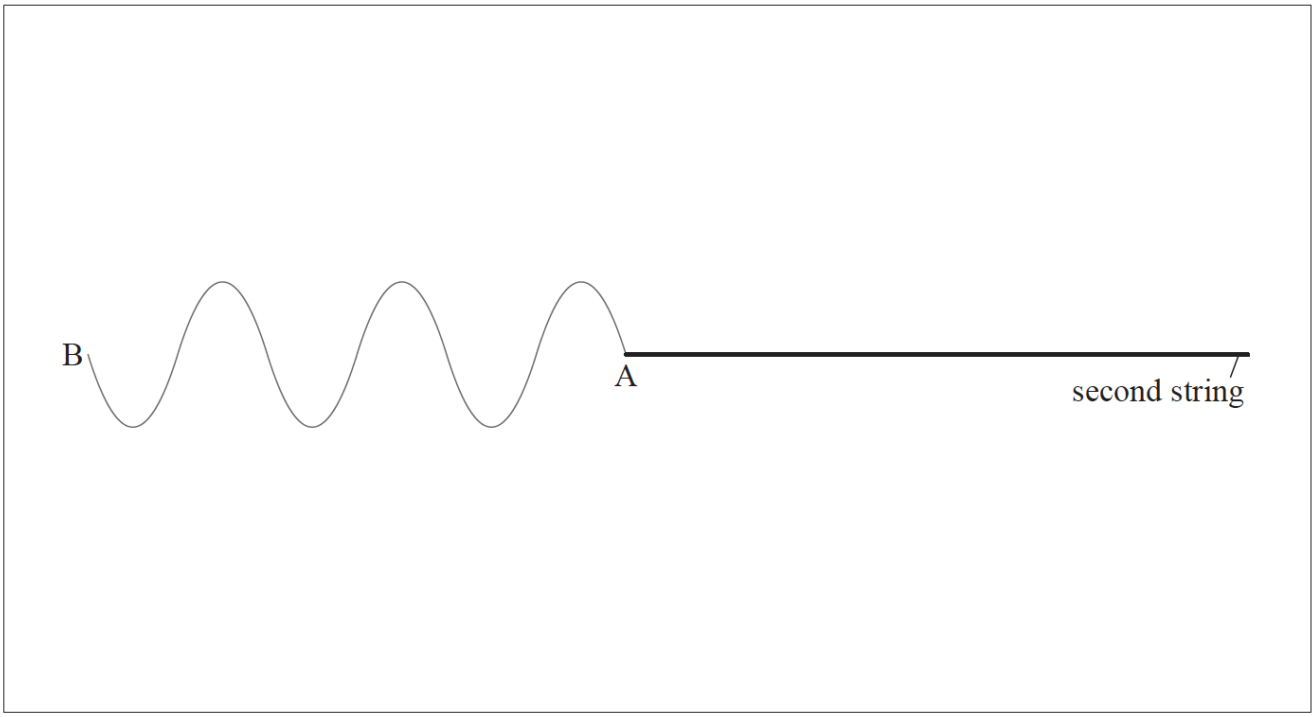
37d. The right-hand edge of the wave AB reaches a point where the string is securely attached to a second string in which the speed of waves is smaller than that of the first string. *[5 marks]*



(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).

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

Part 1 Greenhouse effect

38a. Describe what is meant by the greenhouse effect in the Earth's atmosphere. *[3 marks]*

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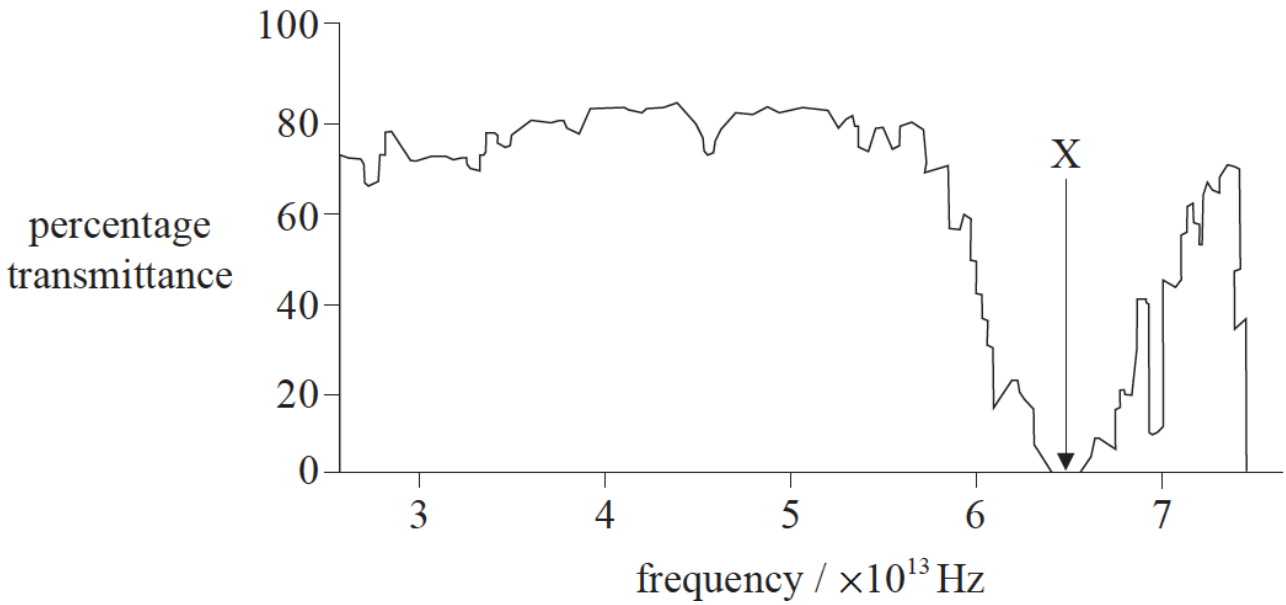
38b. The graph shows the variation with frequency of the percentage transmittance of electromagnetic waves through water vapour in the atmosphere. *[9 marks]*



(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.

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This question is about standing (stationary) waves.

39a. State **one** way in which a standing wave differs from a travelling (progressive) wave. *[1 mark]*

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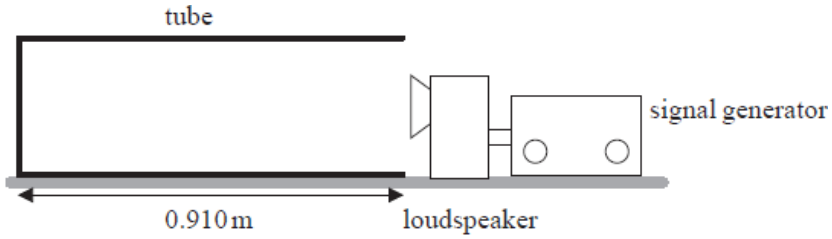
39b. A loudspeaker connected to a signal generator is placed in front of the open end of a tube. *[3 marks]*



The frequency of the sound is slowly increased from zero. At a frequency of 92.0 Hz the first large increase in the intensity of the sound is heard.

(i) On the diagram above, draw a representation of the wave in the tube for the frequency of 92.0 Hz.

(ii) The length of the tube is 0.910 m. Determine the speed of sound in the tube.

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39c. The frequency of sound is continuously increased above 92.0Hz. *[2 marks]*

Calculate the frequency at which the next large increase in the intensity of the sound is heard.

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This question is about polarization.

40a. State what is meant by polarized light. *[1 mark]*

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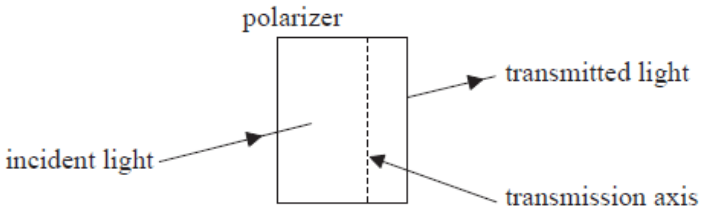
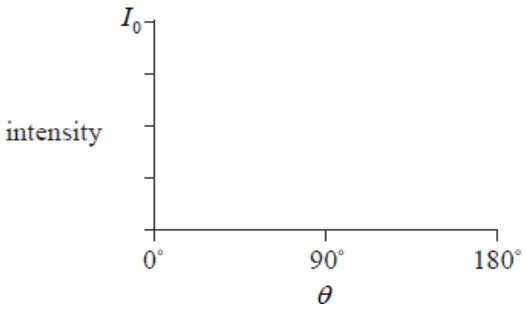
40b. Light of intensity I_0 is incident on a polarizer. The transmission axis of the polarizer is vertical. The polarizer is rotated by an angle θ about the direction of the incident light. The intensity of the transmitted light is measured for various angles θ. *[4 marks]*

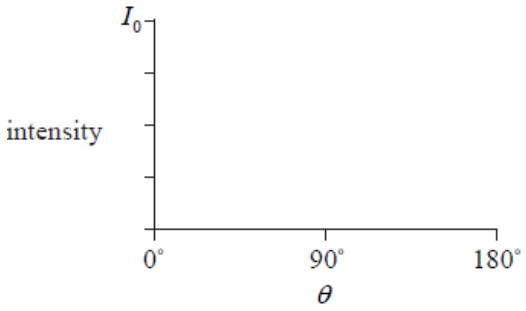


On the axes below, sketch graphs to show the variation of the transmitted intensity I with θ when the incident light is

(i) horizontally polarized.

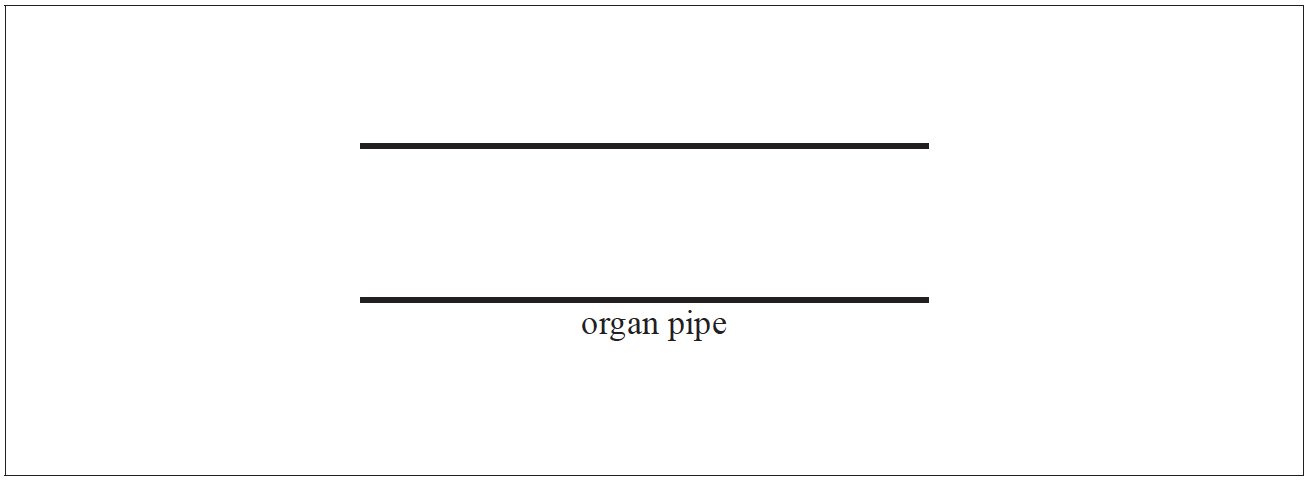


(ii) unpolarized.



This question is about standing waves in an organ pipe.

41a. 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.

41b. 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.

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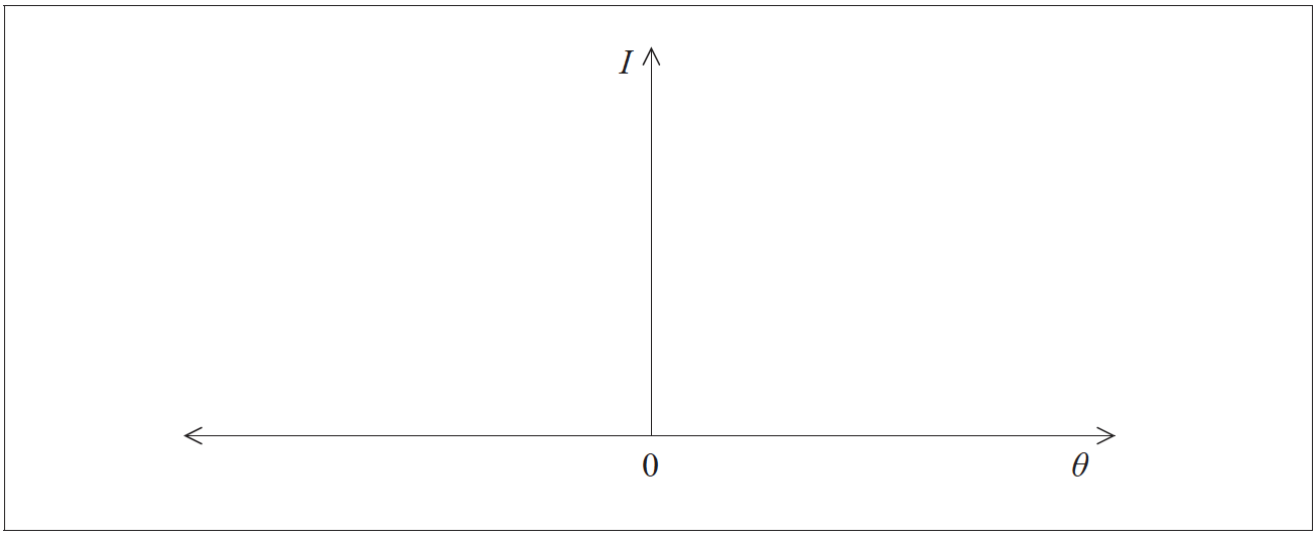
This question is about diffraction and polarization.

42a. 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 θ 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.

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42b. 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.

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42c. 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.

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This question is about the electromagnetic spectrum.

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

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This question is about the nature of electromagnetic waves.

44a. Outline what is meant by an electromagnetic wave. *[2 marks]*

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44b. State **two** cases in which electrons may produce electromagnetic waves. *[2 marks]*

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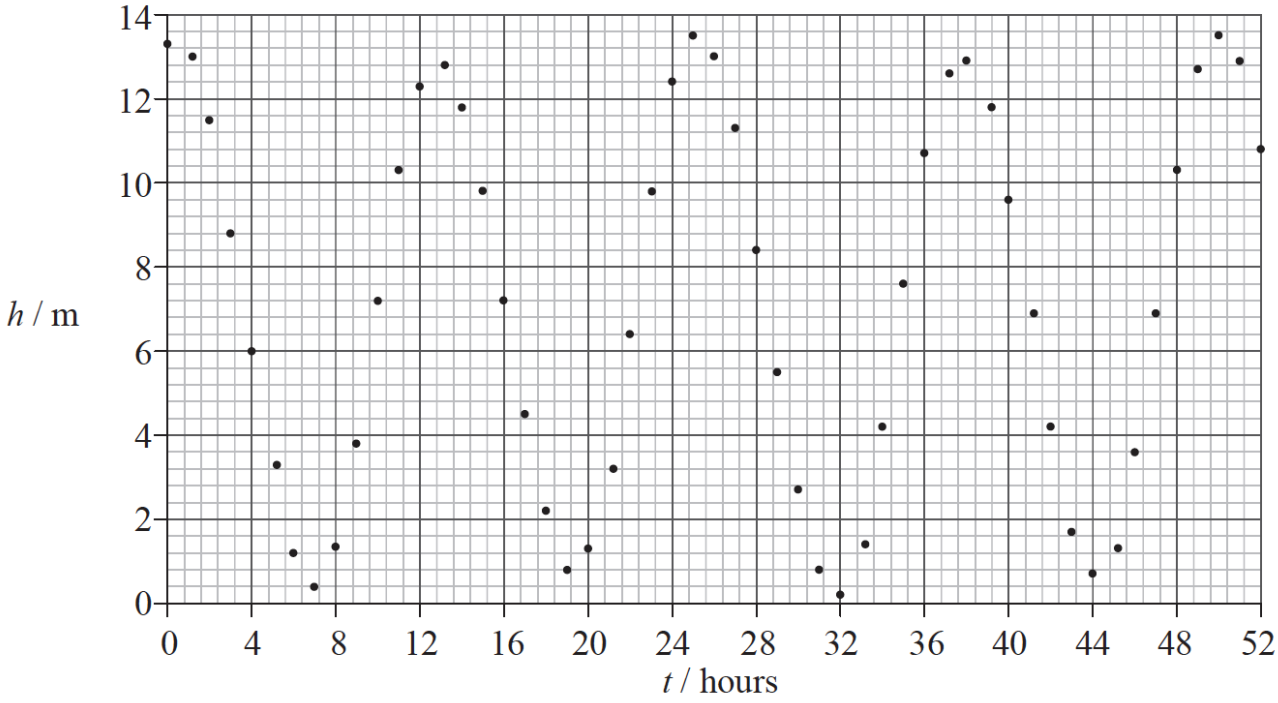
45. The graph shows measurements of the height h of sea level at different times t in the Bay of Fundy. *[1 mark]*



Which of the following gives the approximate amplitude and period of the tides?

	Amplitude	Period
A.	6.5 m	6 hours
B.	13 m	12 hours
C.	6.5 m	12 hours
D.	13 m	6 hours

46. A string vibrates with fundamental frequency f. The wavelength of the sound produced in air is λ. Which of the following correctly gives the frequency of vibration of the fourth harmonic of the string and the wavelength of the sound in air? *[1 mark]*

	Frequency	Wavelength
A.	$\frac{f}{2}$	$\frac{\lambda}{4}$
B.	$4f$	4λ
C.	$\frac{f}{2}$	4λ
D.	$4f$	$\frac{\lambda}{4}$

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

47a. By reference to simple harmonic motion, state what is meant by amplitude. *[1 mark]*

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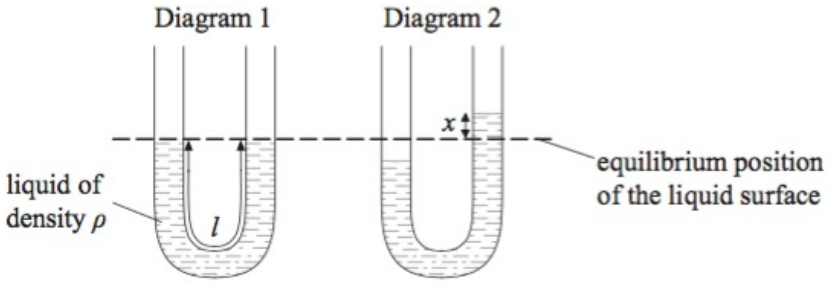
47b. A liquid is contained in a U-tube. *[5 marks]*



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.

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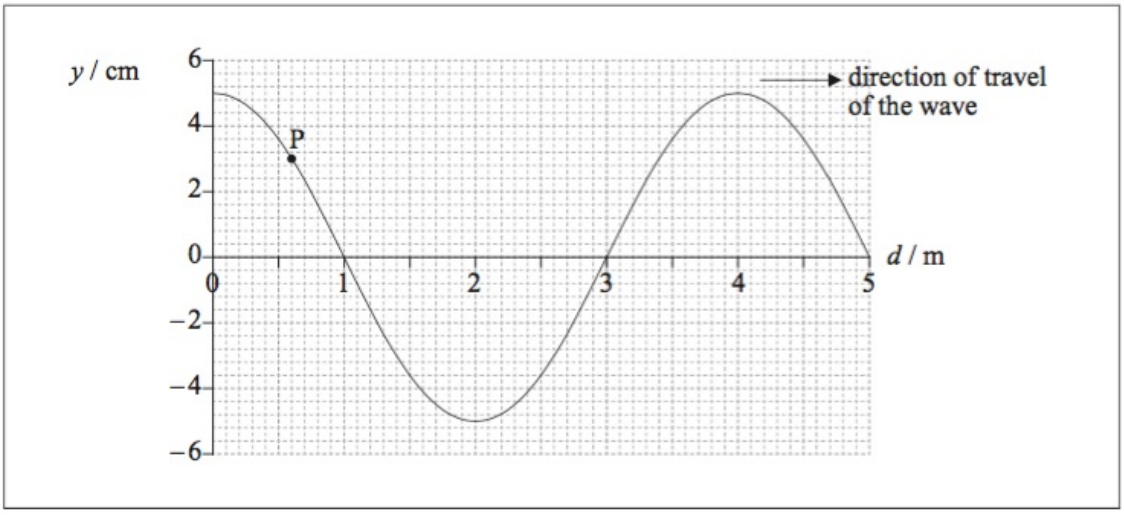
47c. A wave is travelling along a string. The string can be modelled as a single line of particles and each particle executes simple harmonic motion. The period of oscillation of the particles is 0.80s. *[9 marks]*

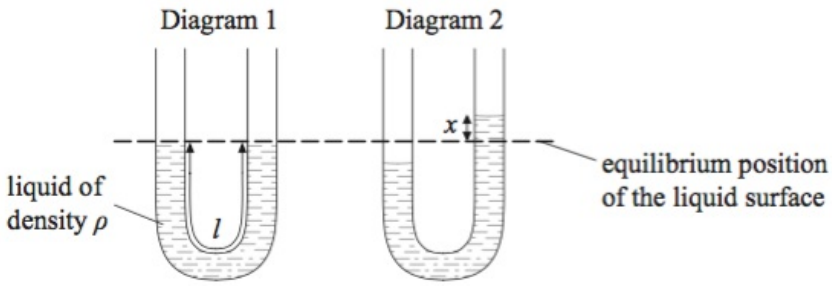
The graph shows the displacement *y* of part of the string at time *t*=0. The distance along the string is *d*.



(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 simple harmonic motion (SHM), wave motion and polarization.

48a. A liquid is contained in a U-tube. *[7 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. Explain, with reference to the motion of the liquid, the significance of the minus sign.

(iii) The total length of the liquid column in the tube is 0.32m. Determine the period of oscillation.

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48b. The string in (c) is fixed at both ends and is made to vibrate in a vertical plane in its first harmonic. *[6 marks]*

(i) Describe how the standing wave in the string gives rise to the first harmonic.
(ii) Outline how a travelling wave in a string can be used to describe the nature of polarized light.

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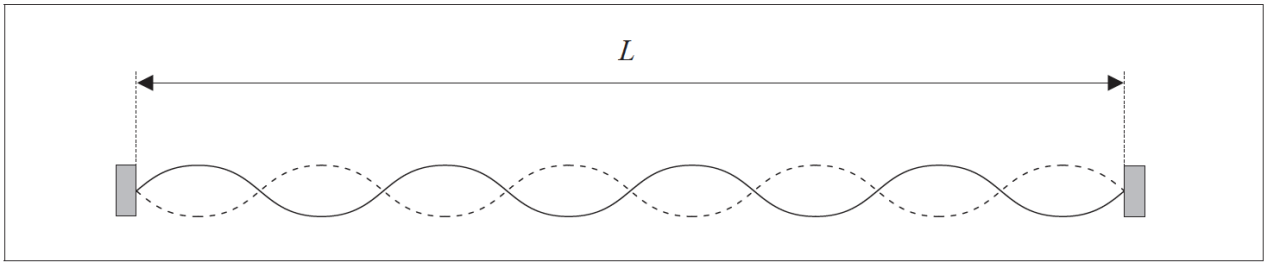
This question is about standing (stationary) waves.

The diagram represents a standing wave of wavelength λ set up on a string of length L.



The string is fixed at both ends.

49a. For this standing wave *[3 marks]*

(i) state the relationship between λ and L.

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

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49b. The standing wave has wavelength λ and frequency f. State and explain, with respect to a standing wave, what is represented by the product $f\lambda$. *[3 marks]*

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This question is about properties of electromagnetic waves.

50a. State **two** properties that are common to all electromagnetic waves. *[2 marks]*

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50b. A single lens is used to form a magnified real image of an object. Explain, with reference to the dispersion of light, why the image has coloured edges. *[3 marks]*

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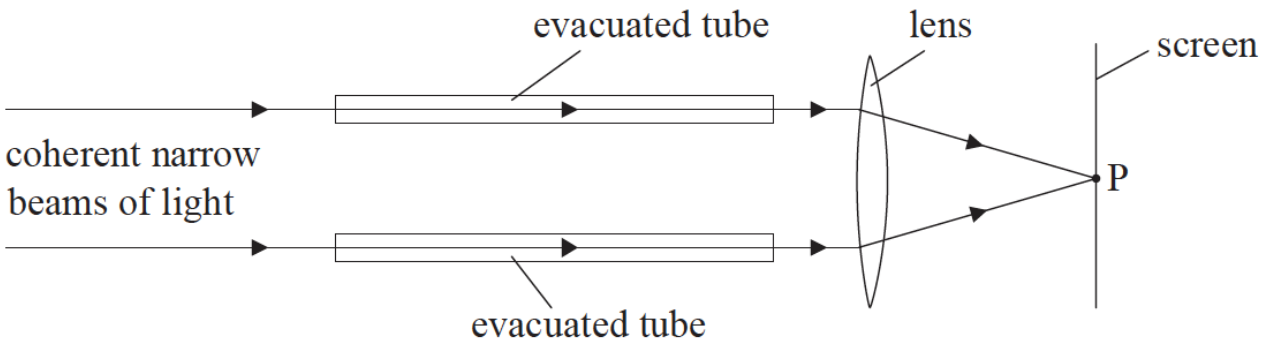
This question is about interference of light.

Two coherent narrow beams of light pass through two identical evacuated tubes, as shown below.



The two coherent narrow beams are brought to a focus at point P on a screen.

51a. State what is meant by coherence. *[1 mark]*

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51b. State, with reference to the wavelength, the condition that must be satisfied for a bright fringe to be formed on the screen at point P. *[1 mark]*

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51c. Air is allowed to enter gradually into one of the evacuated tubes. The brightness of the light at point P is seen to decrease and then increase again repeatedly. *[2 marks]*

(i) State the effect on the wavelength of the light in the evacuated tube as the air is introduced.

(ii) Suggest why there is a variation in the brightness of the light at point P.

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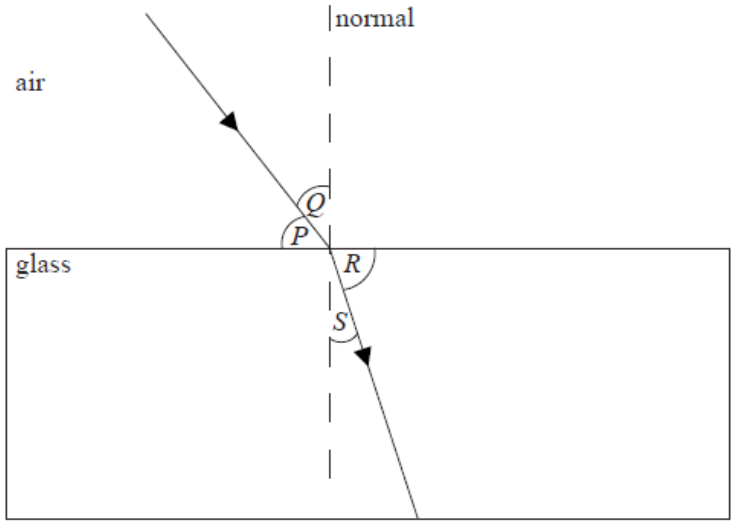
52. Light travels from air into glass as shown below. *[1 mark]*



What is the refractive index of glass?

A. $\frac{\sin P}{\sin S}$

B. $\frac{\sin Q}{\sin R}$

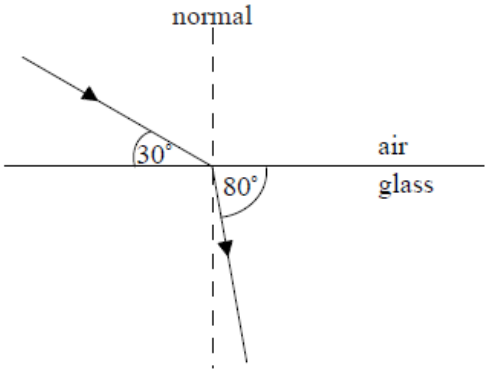
C. $\frac{\sin P}{\sin R}$

D. $\frac{\sin Q}{\sin S}$

53. Which of the following electromagnetic waves has a frequency **greater** than that of visible light? *[1 mark]*

A. Ultraviolet
B. Radio
C. Microwaves
D. Infrared

54. Light travels from air into glass as shown below. *[1 mark]*



The refractive index of the glass is

A. $\frac{\sin 30^\circ}{\sin 80^\circ}$

B. $\frac{\sin 80^\circ}{\sin 30^\circ}$

C. $\frac{\sin 60^\circ}{\sin 10^\circ}$

D. $\frac{\sin 10^\circ}{\sin 60^\circ}$

55. The fundamental (first harmonic) frequency for a particular organ pipe is 330 Hz. The pipe is closed at one end but open at the other. What is the frequency of its next highest harmonic? *[1 mark]*

A. 110 Hz
B. 165 Hz
C. 660 Hz
D. 990 Hz

56. Light is diffracted at a single slit. Which of the following graphs best represents how the intensity I of the diffracted light varies with the diffraction angle θ? *[1 mark]*

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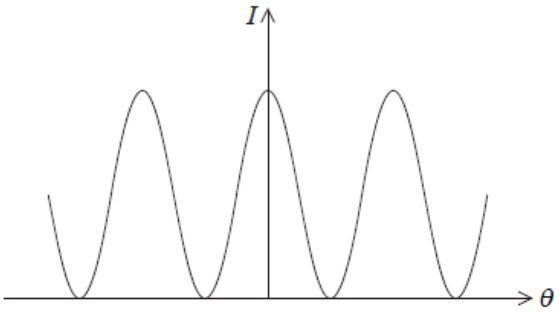
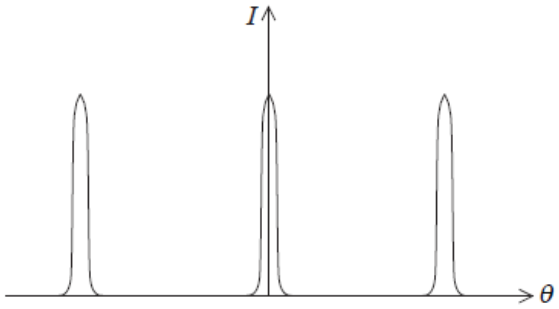
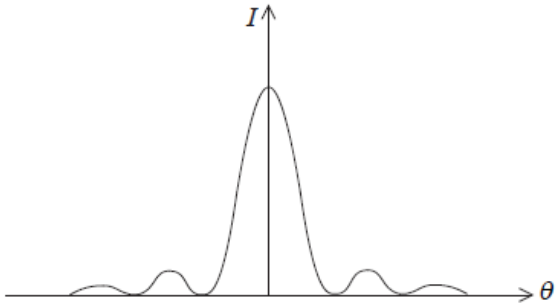


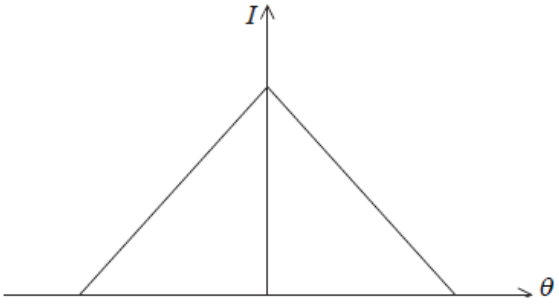
B.



C.



D.



57. Plane-polarized light is incident normally on a polarizer which is able to rotate in the plane perpendicular to the light as shown below. *[1 mark]*

Diagram 1

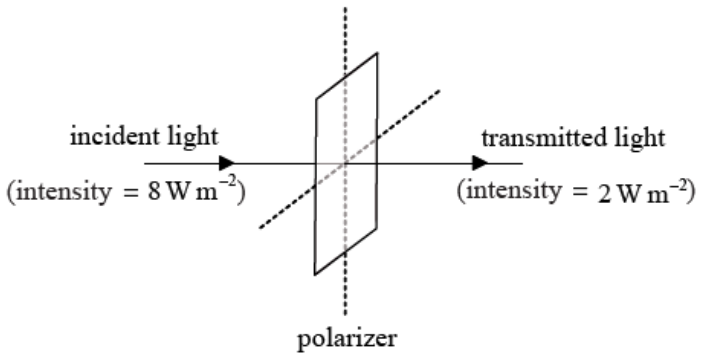
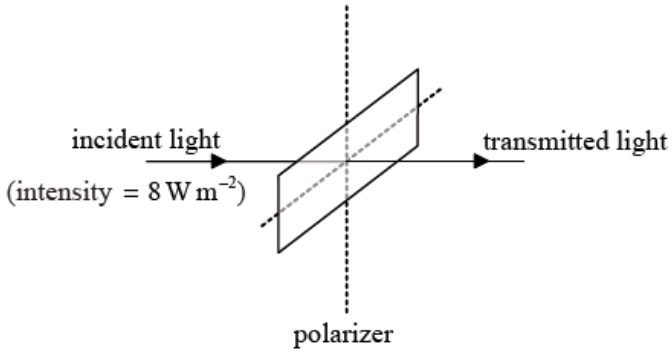


Diagram 2



In diagram 1, the intensity of the incident light is 8 W m^{-2} and the transmitted intensity of light is 2 W m^{-2}. Diagram 2 shows the polarizer rotated 90° from the orientation in diagram 1. What is the new transmitted intensity?

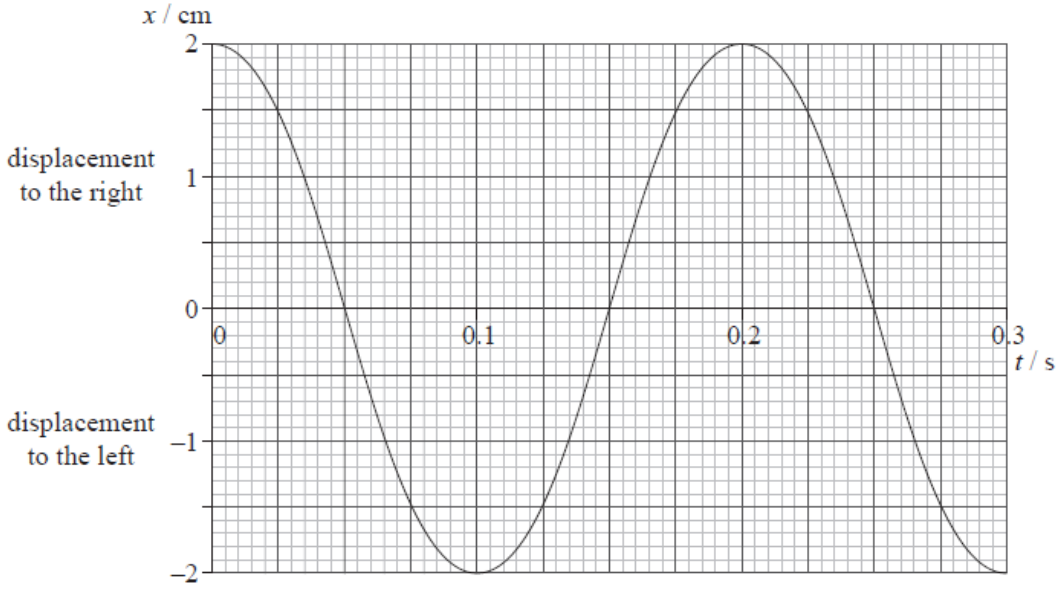
A. 0 W m^{-2}
B. 2 W m^{-2}
C. 6 W m^{-2}
D. 8 W m^{-2}

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



58a. For particle P, *[6 marks]*

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

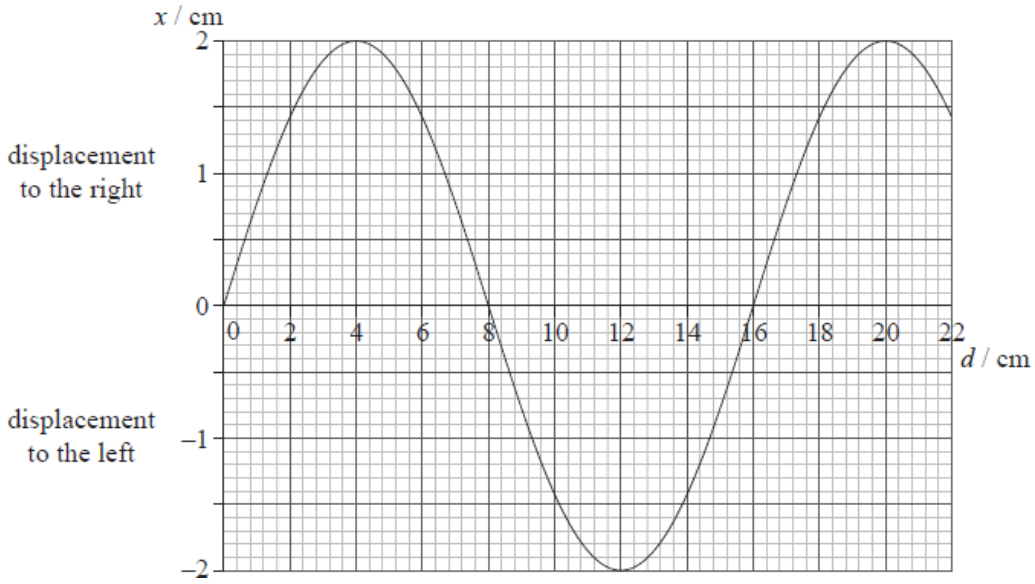
(ii) calculate the magnitude of its maximum acceleration.

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

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

58b. 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.

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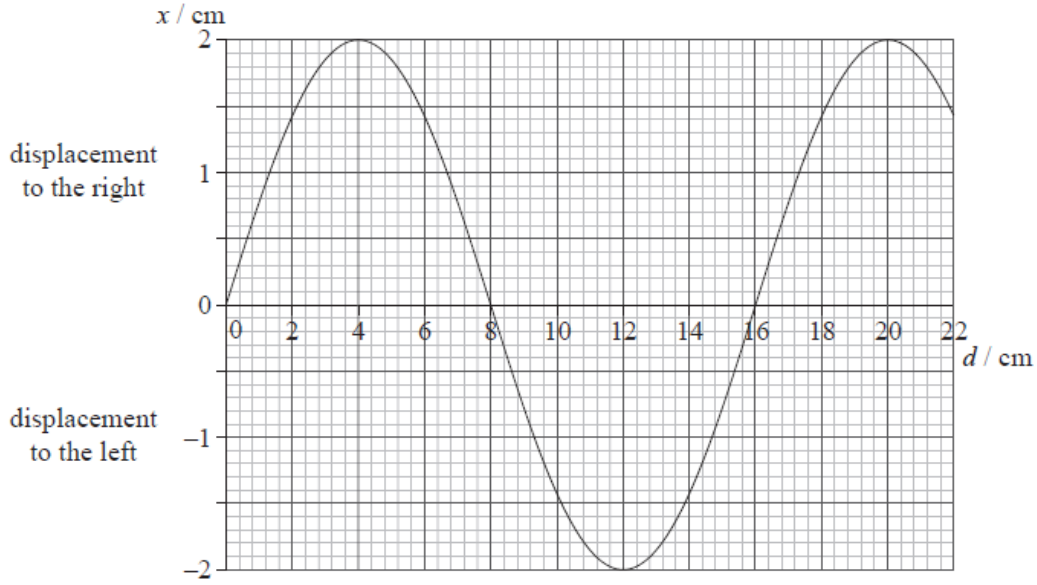
58c. **Graph 2** – reproduced to assist with answering (c)(i). *[4 marks]*



(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 about polarization.

59a. State what is meant by polarized light. *[1 mark]*

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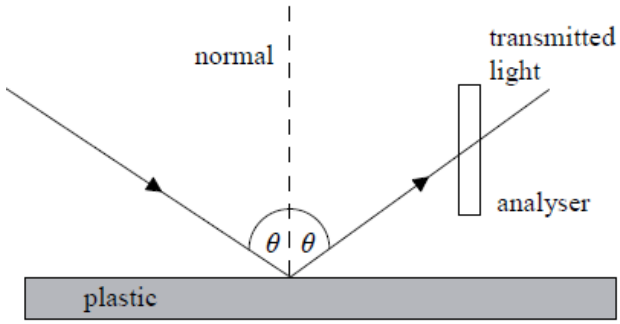
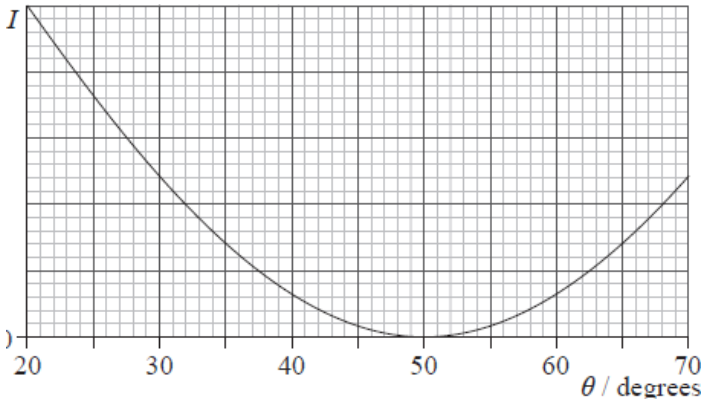
59b. Unpolarized light is incident on the surface of a plastic. The angle of incidence is θ . The reflected light is viewed *[2 marks]* through an analyser whose transmission axis is vertical.



The variation with θ of the intensity I of the transmitted light is shown in the graph.



Explain why there is an angle of incidence, for which the intensity of the transmitted light is zero.

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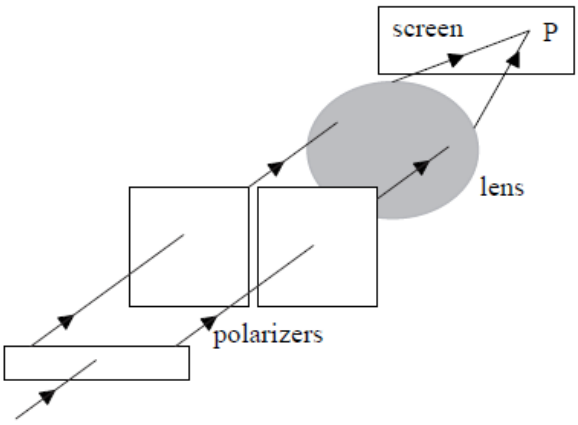
59c. Unpolarized light from a source is split, so that there is a path difference of half a wavelength between the two beams. *[4 marks]*



A lens brings the light to focus at point P on a screen. The lens does not introduce any additional path difference.

State and explain whether any light would be observed at P, in the case in which the polarizers have their transmission axes

(i) parallel.

(ii) at right angles to each other.

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This question is about standing (stationary) waves.

60a. Describe **two** ways that standing waves are different from travelling waves. *[2 marks]*

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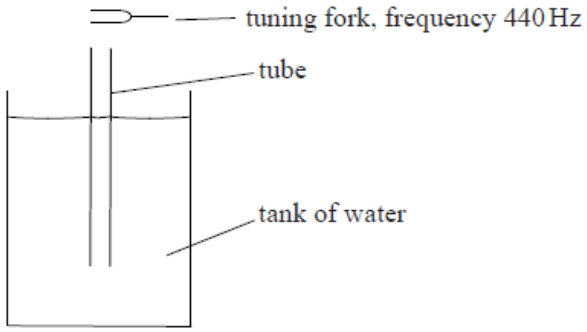
60b. An experiment is carried out to measure the speed of sound in air, using the apparatus shown below. *[3 marks]*



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.

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60c. 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]*

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This question is about dispersion.

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

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