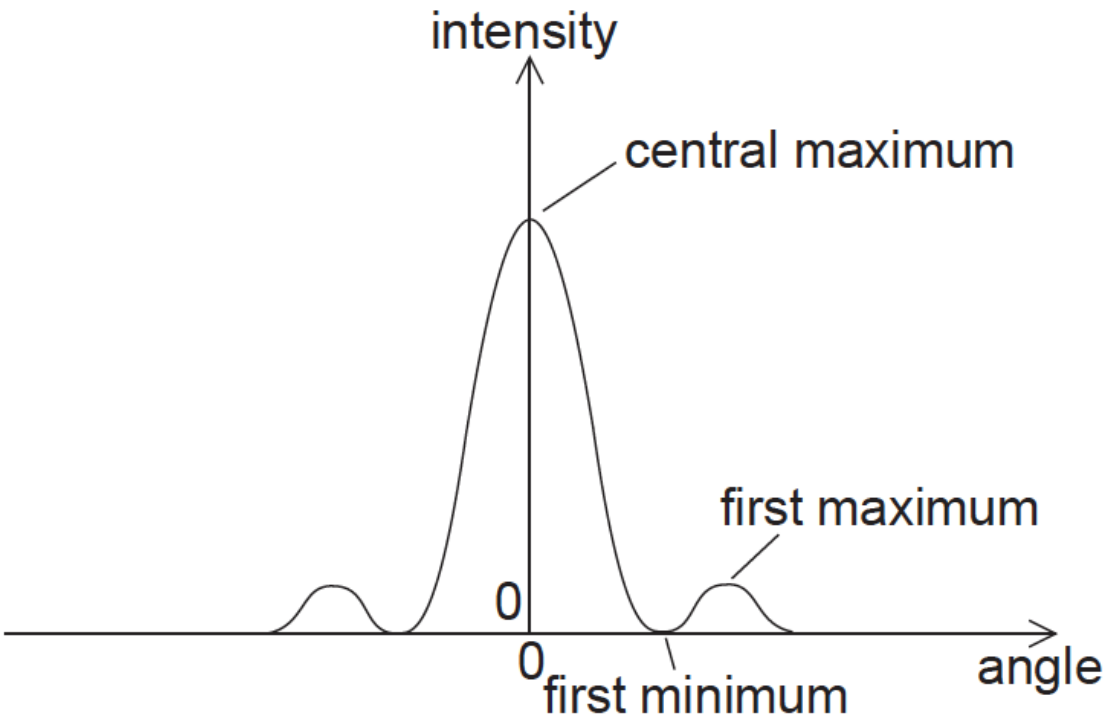
T9-1 *[232 marks]*

1. A car horn emits sound of frequency ƒ. While the horn is sounding, the car moves in a straight line towards a stationary observer. The speed of the car is 0.10*v* where *v* is the speed of sound. What is the frequency of the sound of the horn heard by the observer? *[1 mark]*

   A. $\frac{f}{0.90}$
   B. 1.1 ƒ
   C. $\frac{f}{1.1}$
   D. 0.90 ƒ

2. The graph below shows the variation of the intensity of light with angle for the diffraction pattern produced when light is diffracted by a slit. *[1 mark]*



According to the Rayleigh criterion, when the diffraction patterns of two slits are just resolved

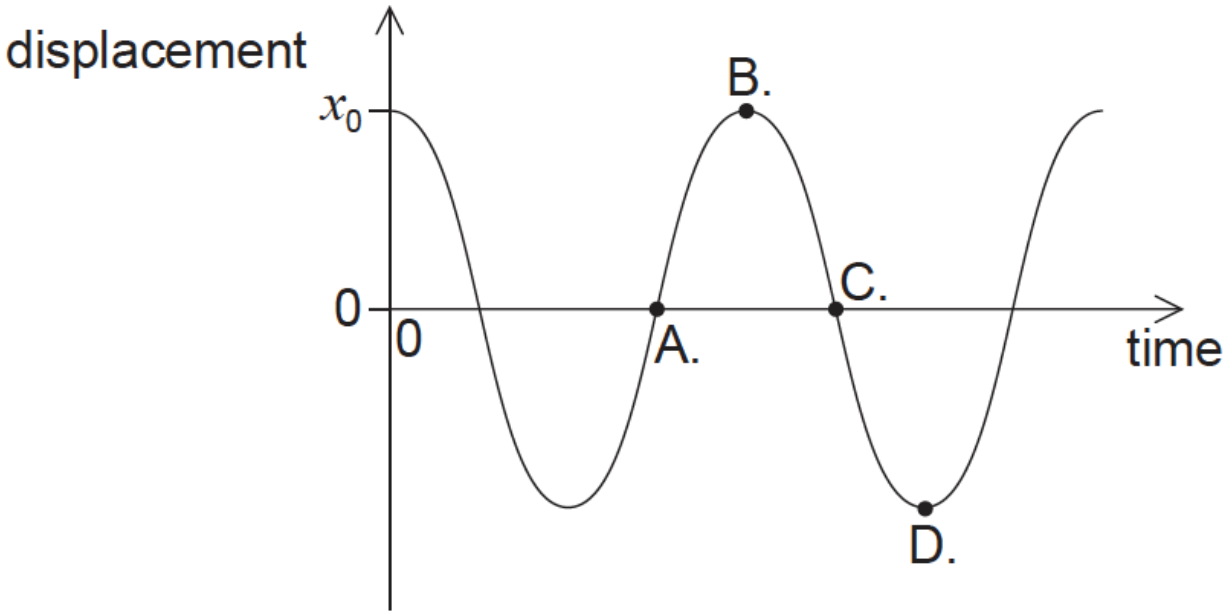
A. the first maximum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.

B. the central maximum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.

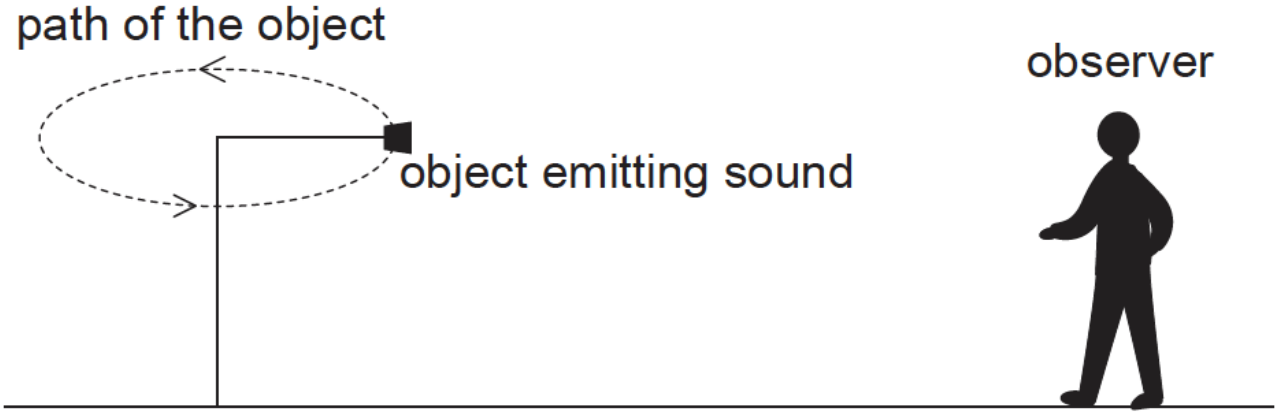
C. the first minimum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.

D. the first minimum of one diffraction pattern coincides with the first minimum of the other diffraction pattern.

3. The bob of a pendulum has an initial displacement x_0 to the right. The bob is released and allowed to oscillate. *[1 mark]*
The graph shows how the displacement varies with time. At which point is the velocity of the bob at maximum towards the right?



4. An object emitting a sound of frequency 100 Hz orbits in a horizontal circle at a rate of two revolutions per second.*[1 mark]*



An observer standing a short distance away from the object is able to hear the sound. Which of the following describes the sound the observer is able to hear?

A. A sound of constant frequency but varying in amplitude

B. A sound of constantly varying frequency

C. A sound with a frequency of 50 Hz

D. A sound with a frequency of 200 Hz

5. Green light is emitted by two point sources. The light passes through a narrow slit and is received by an observer. *[1 mark]*
The images of the two sources just fail to be resolved. Which change allows for the images to be resolved?

A. Replacing the narrow slit with a circular aperture of same size.

B. Moving the two sources further from the aperture.

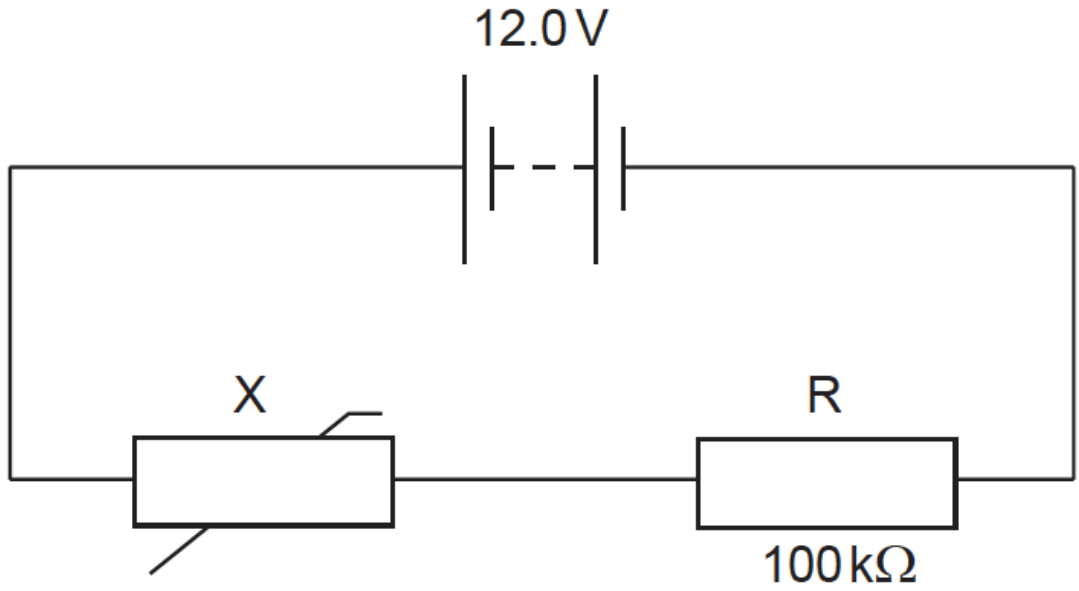
C. Using red light.

D. Using violet light.

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.

6a. (i) Define *electromotive force (emf)*. *[2 marks]*

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

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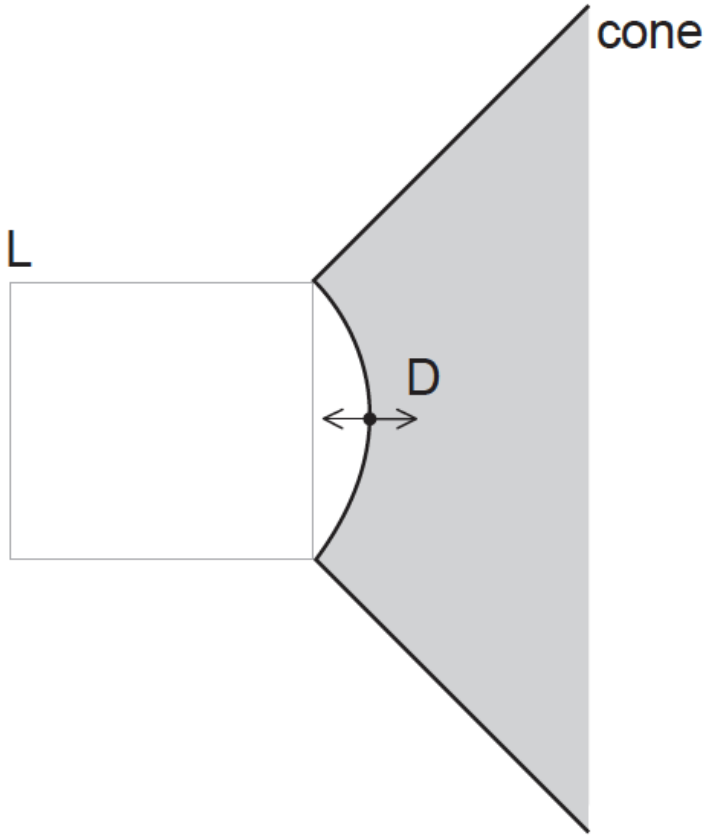
Part 2 Vibrations and waves

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



6b. Define *simple harmonic motion (SHM)*. *[2 marks]*

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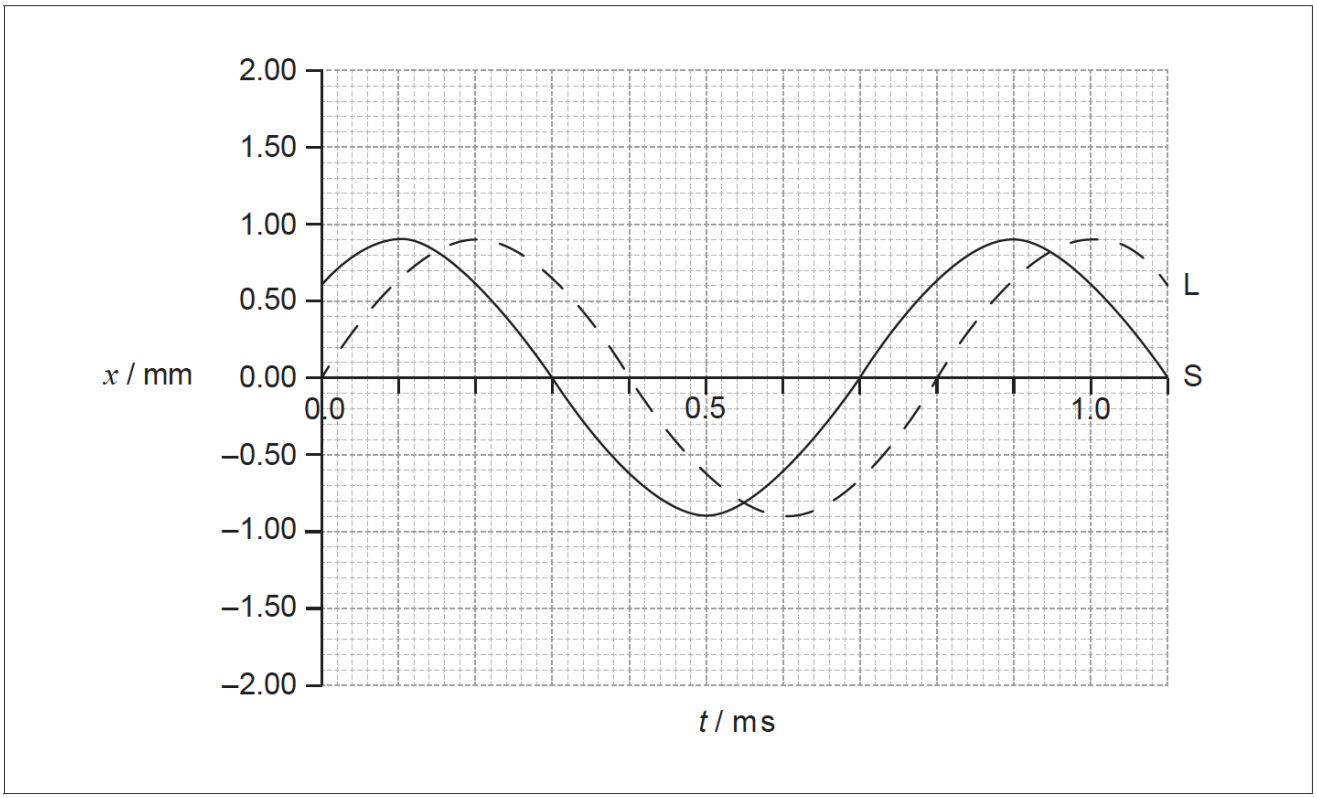
6e. A second loudspeaker S emits the same frequency as L but vibrates out of phase with L. The graph below shows the variation with time *t* of the displacement *x* of the waves emitted by S and L. *[6 marks]*



(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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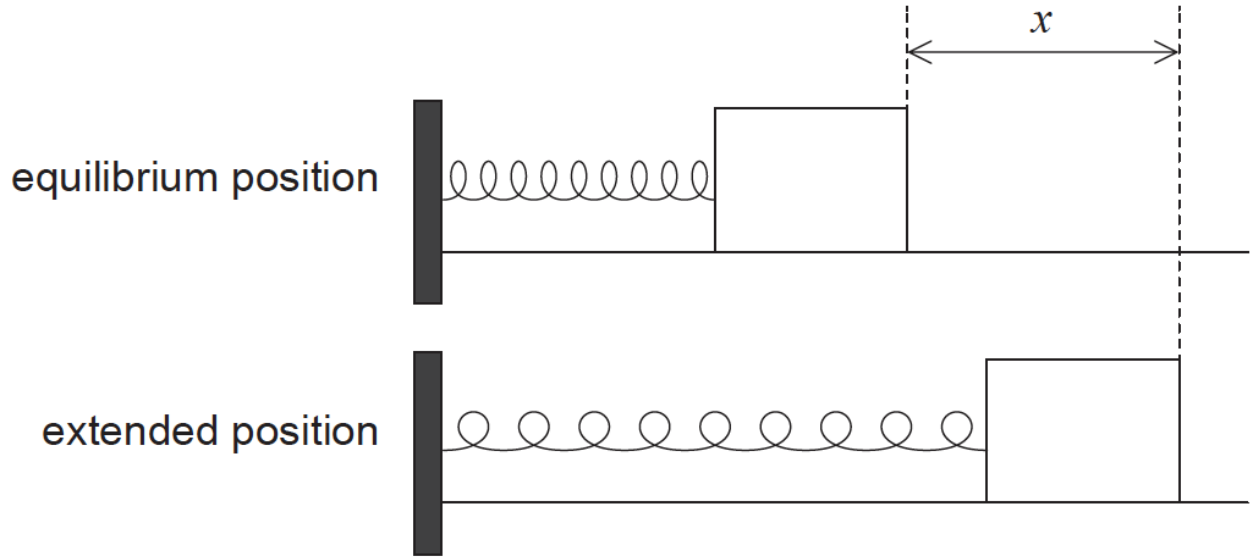
This question is in two parts. **Part 1** is about simple harmonic motion (SHM). **Part 2** is about current electricity.

Part 1 Simple harmonic motion (SHM)

An object is placed on a frictionless surface. The object is attached by a spring fixed at one end and oscillates at the end of the spring with simple harmonic motion (SHM).



The tension F in the spring is given by $F = k\,x$ where x is the extension of the spring and k is a constant.

7a. Show that $\omega^2 = \frac{k}{m}$. *[2 marks]*

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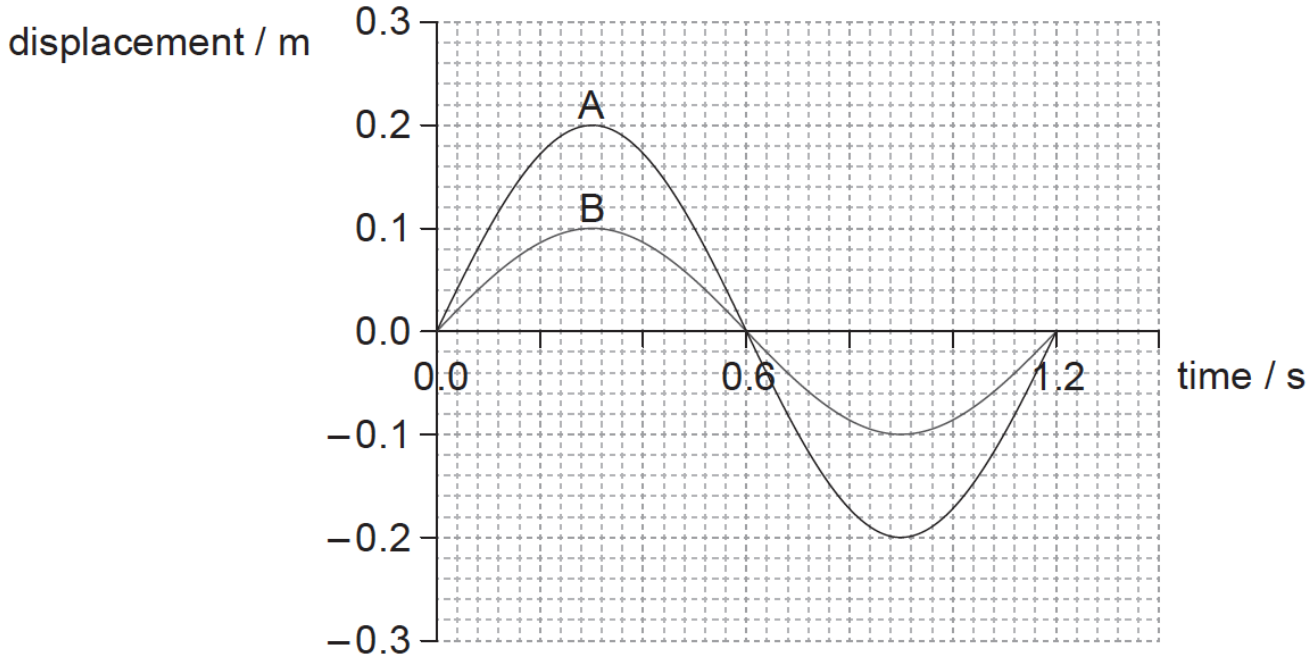
7b. One cycle of the variation of displacement with time is shown for two separate mass–spring systems, A and B. *[3 marks]*



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

(ii) The springs used in A and B are identical. Show that the mass in A is equal to the mass in B.

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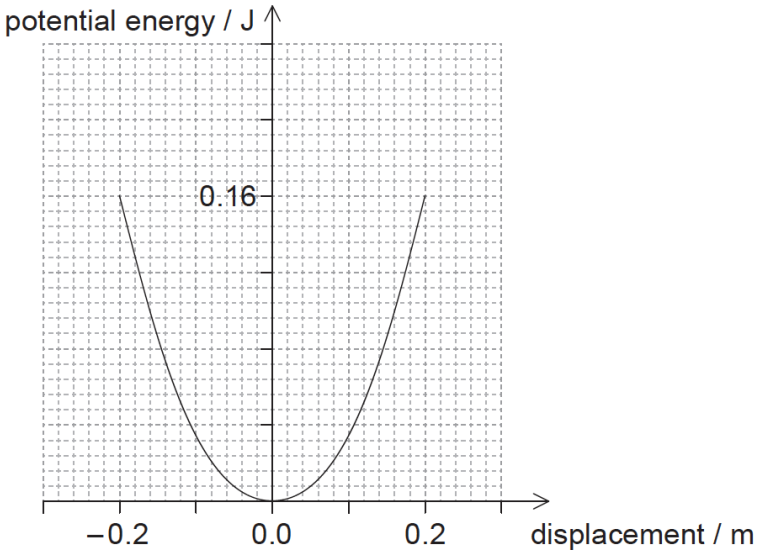
7c. The graph shows the variation of the potential energy of A with displacement. *[5 marks]*



On the axes,

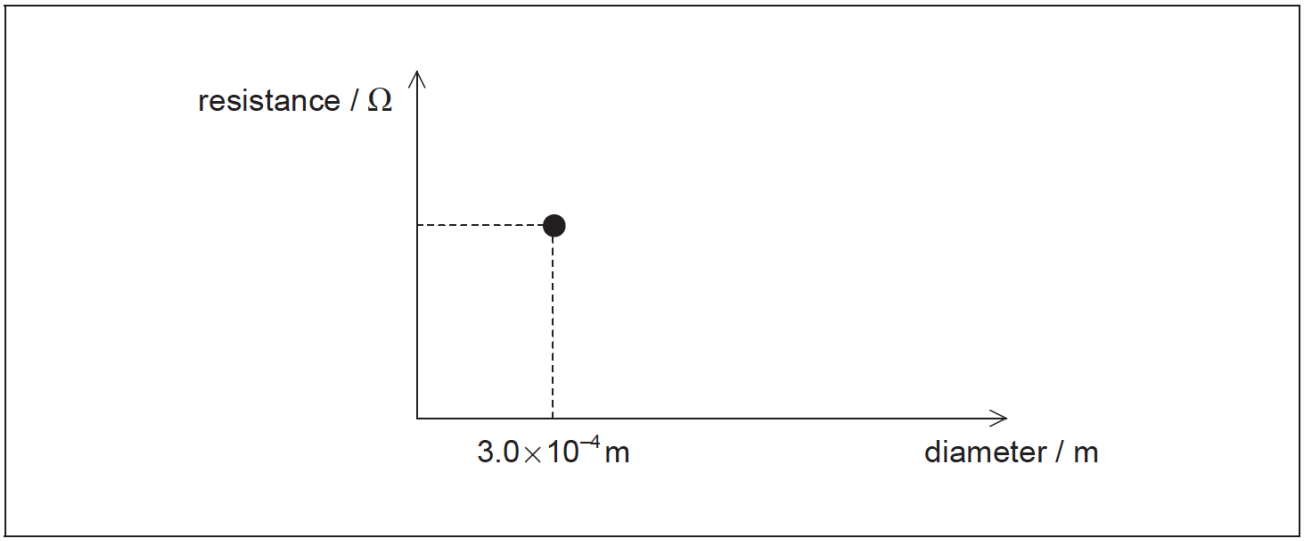
(i) draw a graph to show the variation of kinetic energy with displacement for the mass in A. Label this A.

(ii) sketch a graph to show the variation of kinetic energy with displacement for the mass in B. Label this B.

7d. A 24 Ω resistor is made from a conducting wire. *[4 marks]*

(i) The diameter of the wire is 0.30 mm and the wire has a resistivity of 1.7×10^{-8}Ωm. Calculate the length of the wire.

(ii) On the axes, draw a graph to show how the resistance of the wire in (d)(i) varies with the diameter of the wire when the length is constant. The data point for the diameter of 0.30 mm has already been plotted for you.



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7e. The 24 Ω resistor is covered in an insulating material. Explain the reasons for the differences between the electrical properties of the insulating material and the electrical properties of the wire. *[3 marks]*

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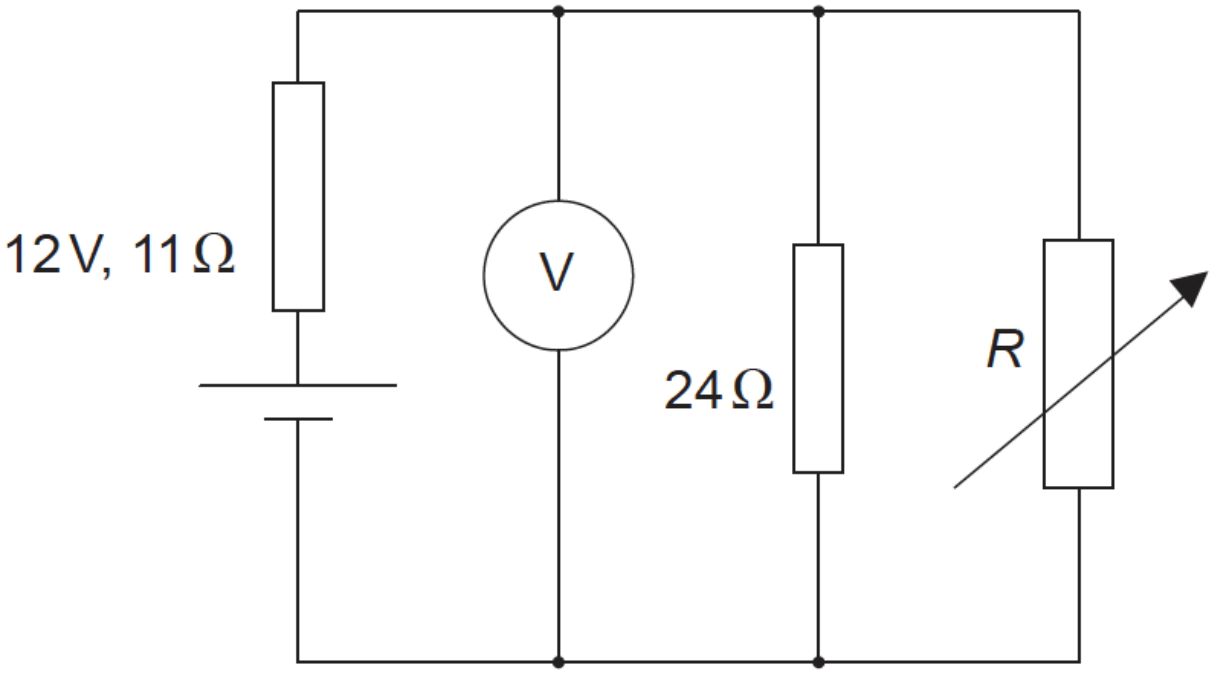
7f. An electric circuit consists of a supply connected to a 24Ω resistor in parallel with a variable resistor of resistance *R*. The supply has an emf of 12V and an internal resistance of 11Ω. *[8 marks]*



Power supplies deliver maximum power to an external circuit when the resistance of the external circuit equals the internal resistance of the power supply.

(i) Determine the value of *R* for this circuit at which maximum power is delivered to the external circuit.

(ii) Calculate the reading on the voltmeter for the value of *R* you determined in (f)(i).

(iii) Calculate the total power dissipated in the circuit when the maximum power is being delivered to the external circuit.

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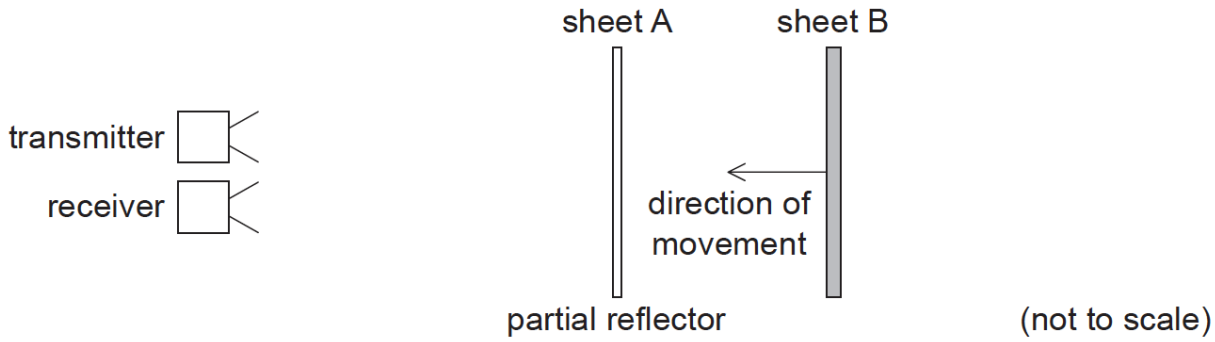
This question is about the properties of waves.

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.

8a. Outline why a minimum in the intensity occurs for certain positions of sheet B. *[3 marks]*

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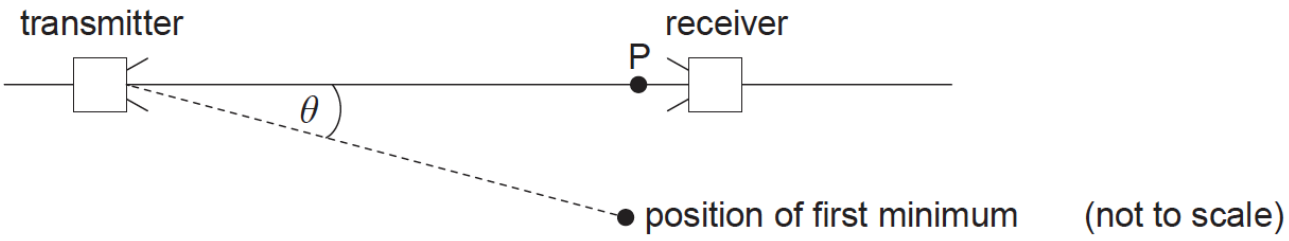
8b. The apparatus is arranged to demonstrate diffraction effects. *[3 marks]*



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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8c. 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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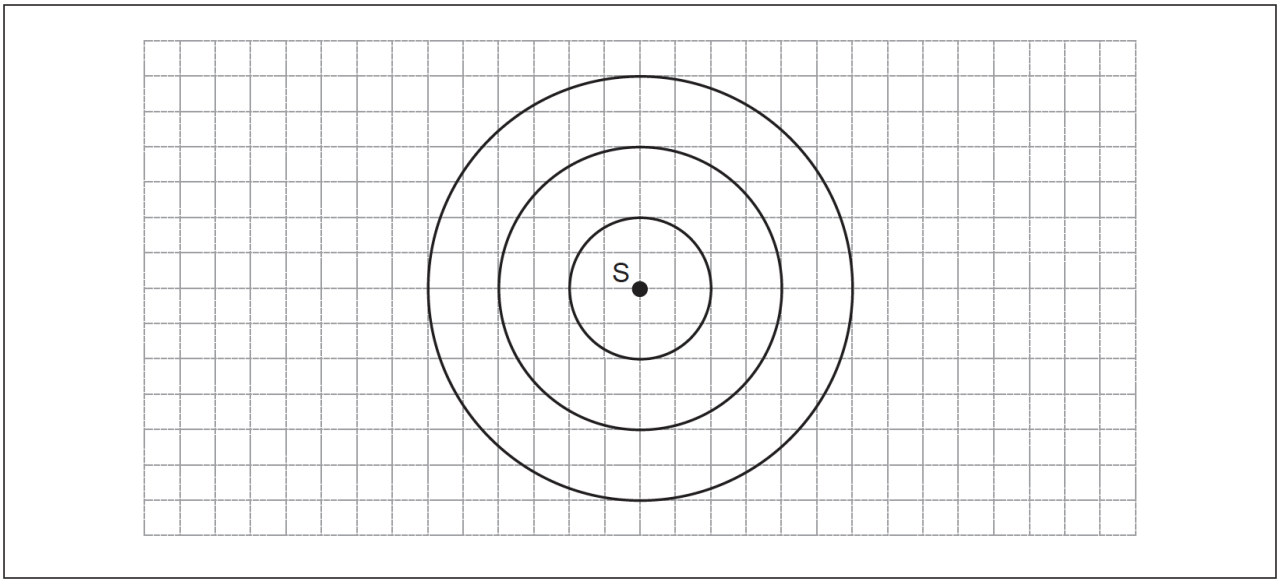
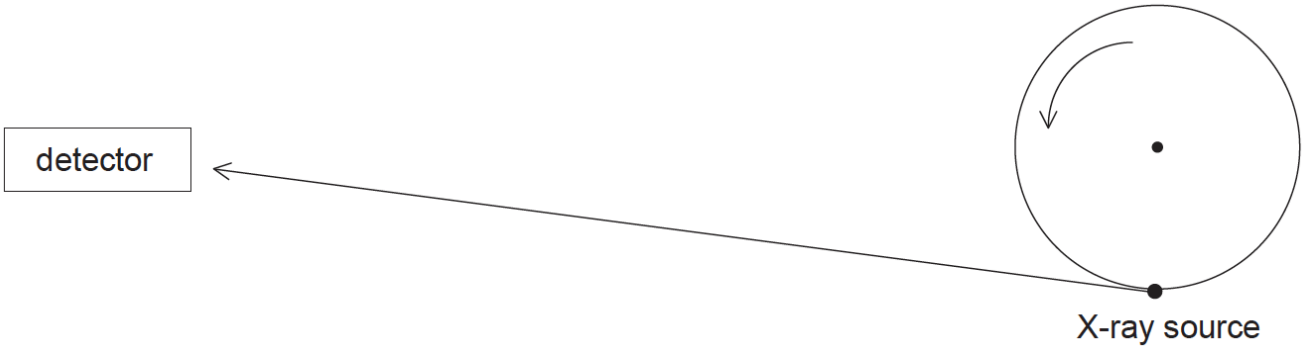
This question is about the Doppler effect.

The diagram shows wavefronts in air produced by a stationary source S of sound. The distance between successive wavefronts is equal to the wavelength of the sound. The speed of sound is *c*.



9a. On the diagram, sketch three successive wavefronts produced when S is moving to the left at a speed of 0.5*c*. *[2 marks]*

9b. A source of X-rays rotates on a turntable. Radiation of wavelength 7.5 nm is emitted by the source and undergoes a maximum shift of 0.50 fm. The distance between the source and the detector is large in comparison to the diameter of the turntable. *[3 marks]*



(i) Determine the speed of a point on the edge of the turntable.

(ii) State the assumption you made in your answer to (b)(i).

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This question is about thin-film interference.

A thin film of oil lies on a puddle of water. White light from above shines on the film at normal incidence.

10a. Outline the process by which coloured fringes are formed. *[3 marks]*

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10b. The following data are available: *[2 marks]*

Refractive index of oil = 1.4
Refractive index of water = 1.3
Thickness of the oil film = 250 nm

Calculate the maximum wavelength of the incident light for which **destructive** interference occurs.

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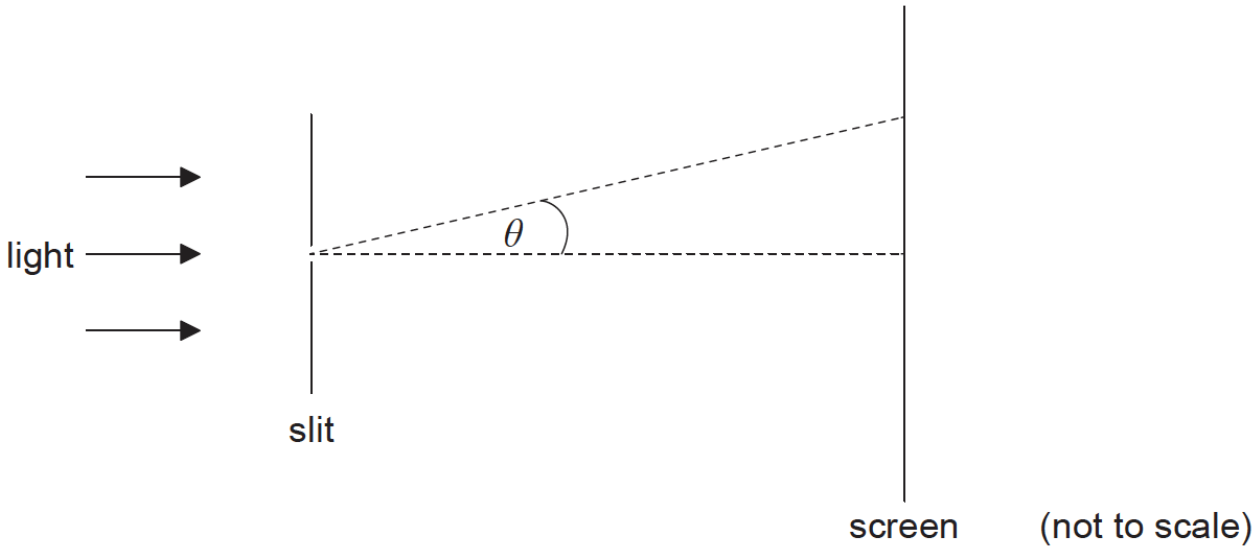
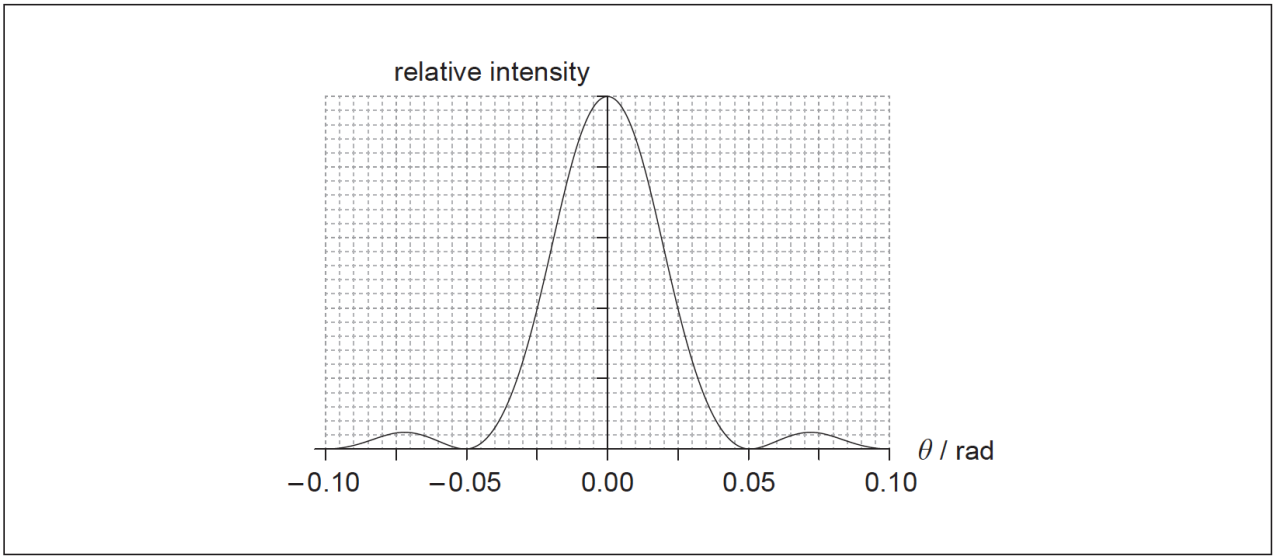
This question is about diffraction and resolution.
Monochromatic light is incident on a narrow rectangular slit.



The light is observed on a screen far from the slit. The graph shows the variation with angle θ of the relative intensity for light of wavelength 7.0×10^{-7}m.



11a. Estimate the width of the slit. *[2 marks]*

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11b. On the graph, sketch the variation of the relative intensity with θ when the wavelength of the light is reduced. *[1 mark]*

11c. State and explain, with reference to your sketch in (b), whether it is easier to resolve two objects in blue light **or** in red light. *[2 marks]*

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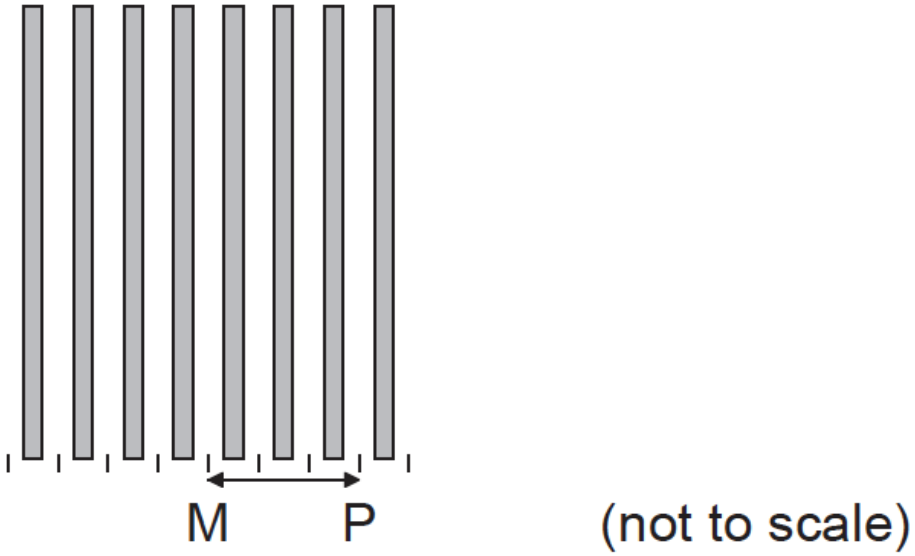
This question is about a double-slit experiment.

Coherent monochromatic light is incident on two narrow rectangular slits. The diagram shows the fringes produced on a screen that is some distance from the slits. M is the middle of the central bright fringe and P is the middle of the third bright fringe.



12a. Explain why an interference pattern is produced on the screen. *[2 marks]*

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12b. The two slits are separated by 2.2 mm and the distance from the slits to the screen is 1.8 m. The wavelength of the light is 650 nm. Calculate the distance MP. *[2 marks]*

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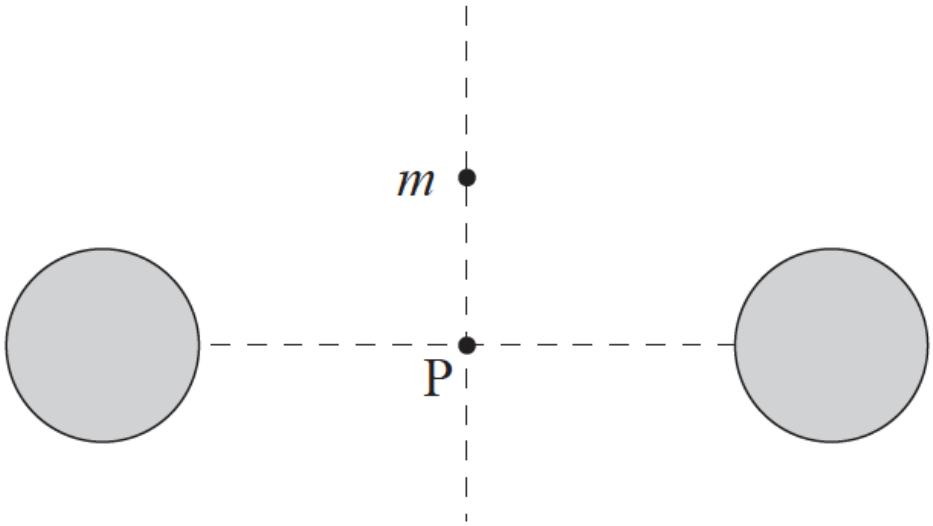
13. A small point mass m is placed at the same distance from two identical fixed spherical masses far from any other masses. *[1 mark]*



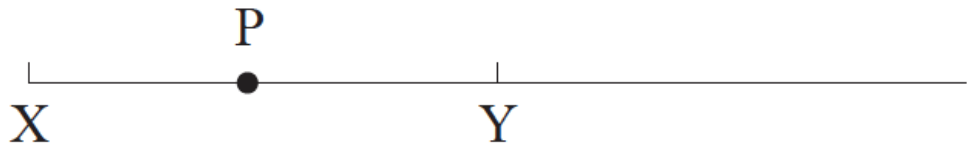
The point mass is released from rest. The point mass will

A. move upwards.
B. stay where it is.
C. move towards P and stop there.
D. oscillate about point P.

14. Light of wavelength λ_0 is emitted from a nearby galaxy. The light is received on Earth and the wavelength is measured to be λ where $\lambda<\lambda_0$. Which of the following correctly describes the speed and direction of motion of the galaxy? *[1 mark]*

	Speed	Direction
A.	$\frac{\lambda_0-\lambda}{\lambda_0}c$	towards earth
B.	$\frac{\lambda_0-\lambda}{\lambda}c$	towards earth
C.	$\frac{\lambda_0-\lambda}{\lambda_0}c$	away from earth
D.	$\frac{\lambda_0-\lambda}{\lambda}c$	away from earth

15. A particle P executes simple harmonic motion (SHM) about its equilibrium position Y. *[1 mark]*



The amplitude of the motion is XY.

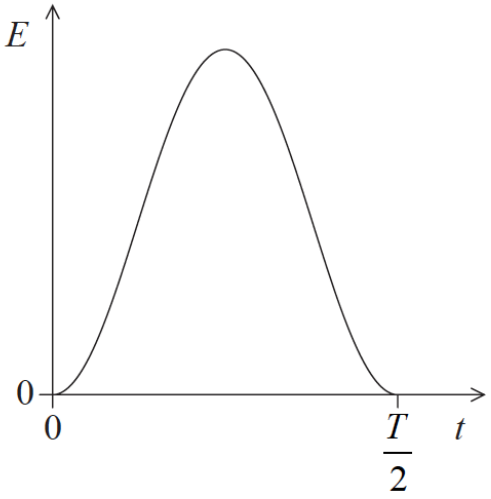
At which of the positions shown on the diagram is the acceleration of P equal to zero and the kinetic energy of P equal to zero?

	Acceleration	Kinetic energy
A.	Y	X
B.	X	X
C.	Y	Y
D.	X	Y

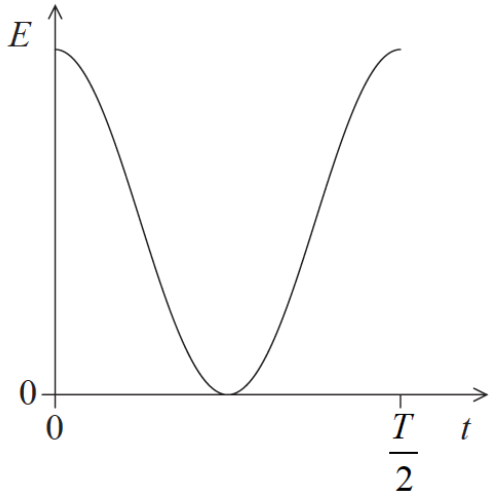
16. A particle executes simple harmonic motion (SHM) with period T. *[1 mark]*

Which sketch graph correctly shows how the total energy E of the particle varies with time t from $t = 0$ to $t = \frac{T}{2}$?

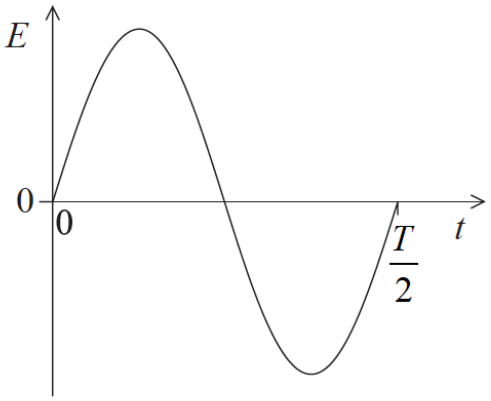
A.



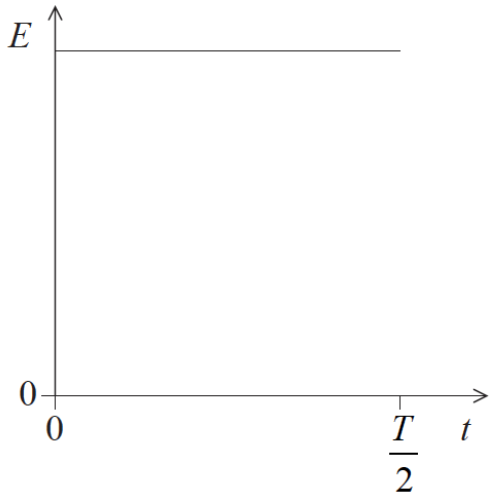
B.



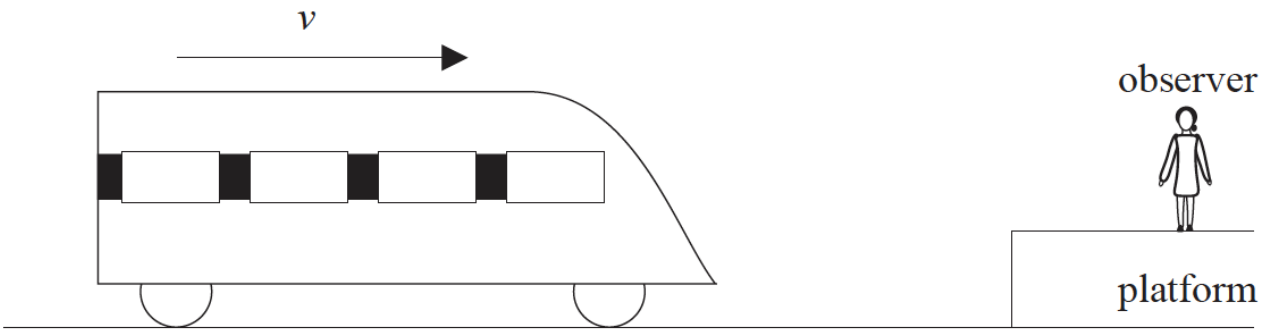
C.



D.



17. The diagram shows a train travelling in a straight line at constant speed v, as it approaches the platform of a station. *[1 mark]*



The whistle of the engine is emitting a sound of constant frequency. Which of the following is **not** true for the sound of the whistle heard by an observer on the platform?

A. A sudden change in frequency of the sound as the train passes the observer.
B. A sound of constant frequency as the train approaches the observer.
C. A sound of increasing frequency as the train approaches the observer and of decreasing frequency after the train has passed the observer.
D. A sound of constant frequency after the train has passed the observer.

18. A parallel beam of coherent light of wavelength λ is incident on a rectangular slit of width d. After passing through the slit the light is incident on a screen a distance D from the slit where D is much greater than d. What is the width of the central maximum of the diffraction pattern as measured on the screen? *[1 mark]*

A. $\frac{2D\lambda}{d}$

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

C. $\frac{D\lambda}{d}$

D. $\frac{d}{D\lambda}$

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'.

19a. (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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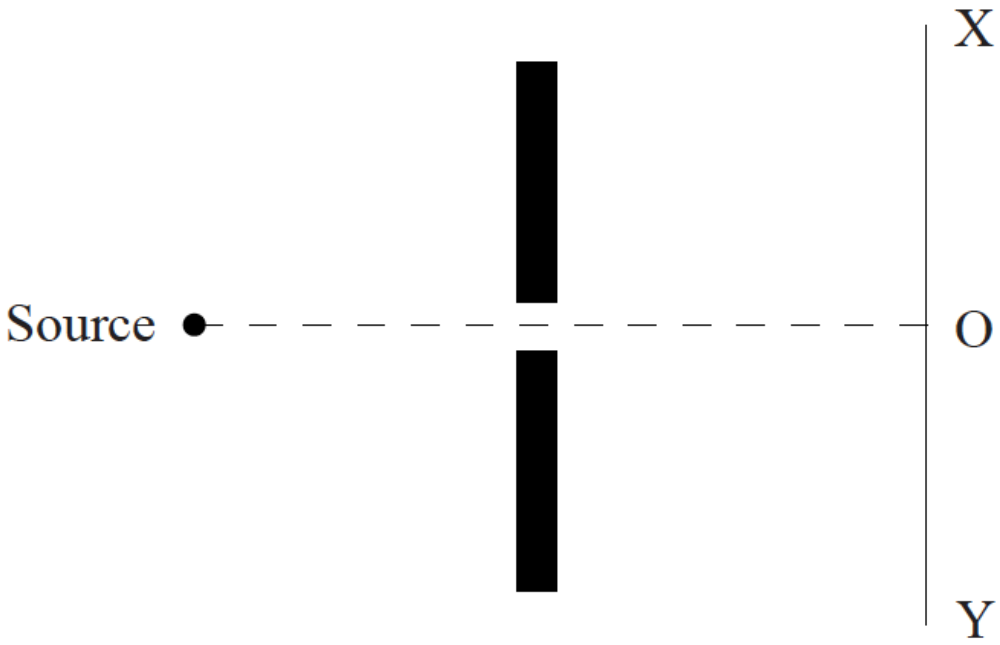
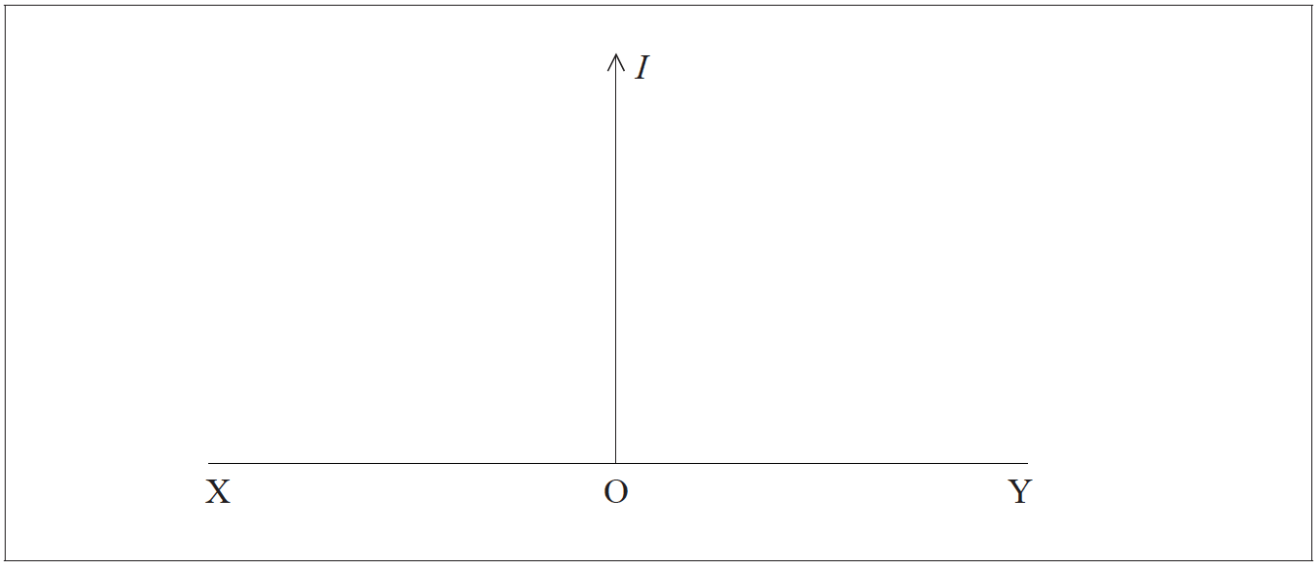
19b. A source of sound is placed in front of a barrier that has an opening of width comparable to the wavelength of the sound. *[4 marks]*



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.

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19c. (i) Outline the difference between a polarized wave and an unpolarized wave. *[3 marks]*

(ii) State why sound waves cannot be polarized.

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20. A particle undergoes simple harmonic motion (SHM) of maximum kinetic energy E_{max} and amplitude x_0. The particle is released from rest at its maximum displacement amplitude. *[1 mark]*

What is the change in the kinetic energy when the particle has travelled a distance of $\frac{x_0}{3}$?

A. $\frac{E_{max}}{9}$

B. $\frac{4E_{max}}{9}$

C. $\frac{5E_{max}}{9}$

D. $\frac{8E_{max}}{9}$

21. A body moves with simple harmonic motion (SHM) with period T and total energy E_T. What is the total energy when the period of the motion is changed to $5T$ and the amplitude of the motion remains constant? *[1 mark]*

A. 0.04 E_T

B. 0.2 E_T

C. 5 E_T

D. 25 E_T

22. A source of sound moves away from an observer. The observed frequency of the sound differs from the frequency emitted by the source because the *[1 mark]*

A. observed wavelength of the sound is less than the emitted wavelength.
B. observed wavelength of the sound is greater than the emitted wavelength.
C. speed of sound relative to the observer has decreased.
D. speed of sound relative to the observer has increased.

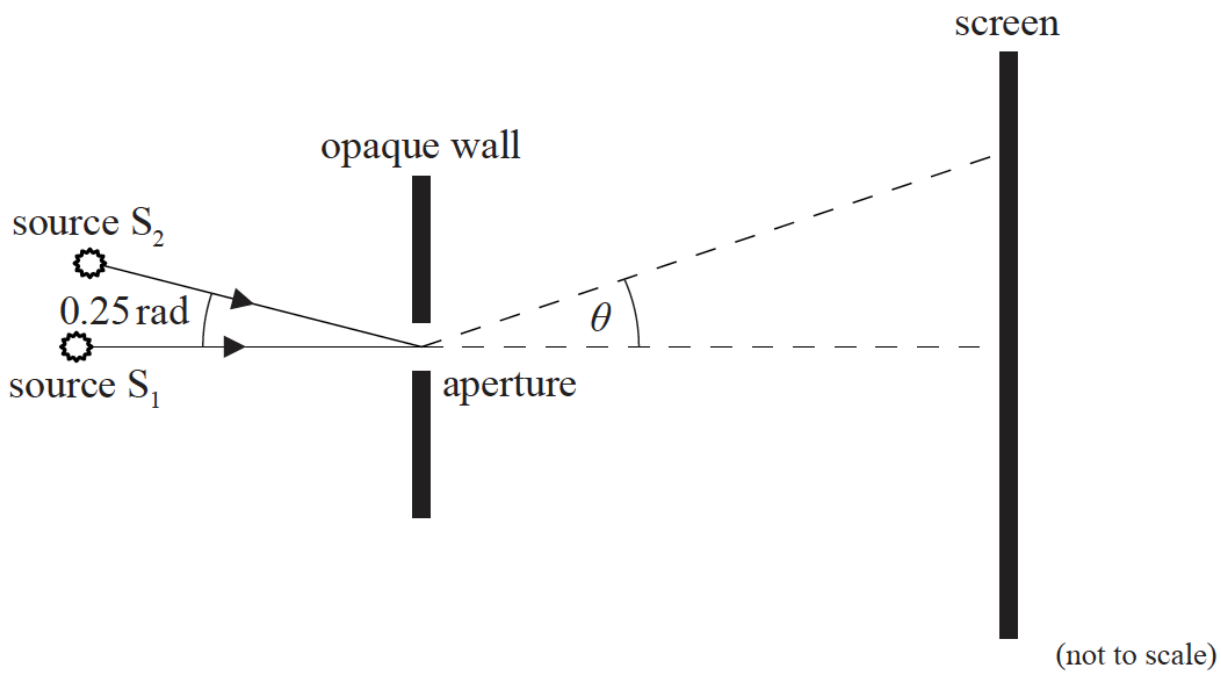
23. Radiation is incident on a single rectangular slit. The diffracted beam that emerges from the slit is incident on a screen. The slit width is then doubled and the wavelength of the radiation is also doubled. The intensity of the radiation remains the same. *[1 mark]*

Which of the following correctly describes the angular width of the central maximum of the diffracted beam and the total number of photons incident every second on the screen?

	Angular width of the central maximum	**Number of photons incident every second on the screen**
A.	unchanged	unchanged
B.	changed	unchanged
C.	unchanged	changed
D.	changed	changed

This question is about diffraction and resolution.

Two identical sources of electromagnetic radiation, S_1 and S_2, emit monochromatic coherent waves of wavelength 59 μm. The waves pass through a circular aperture and are incident on a screen.

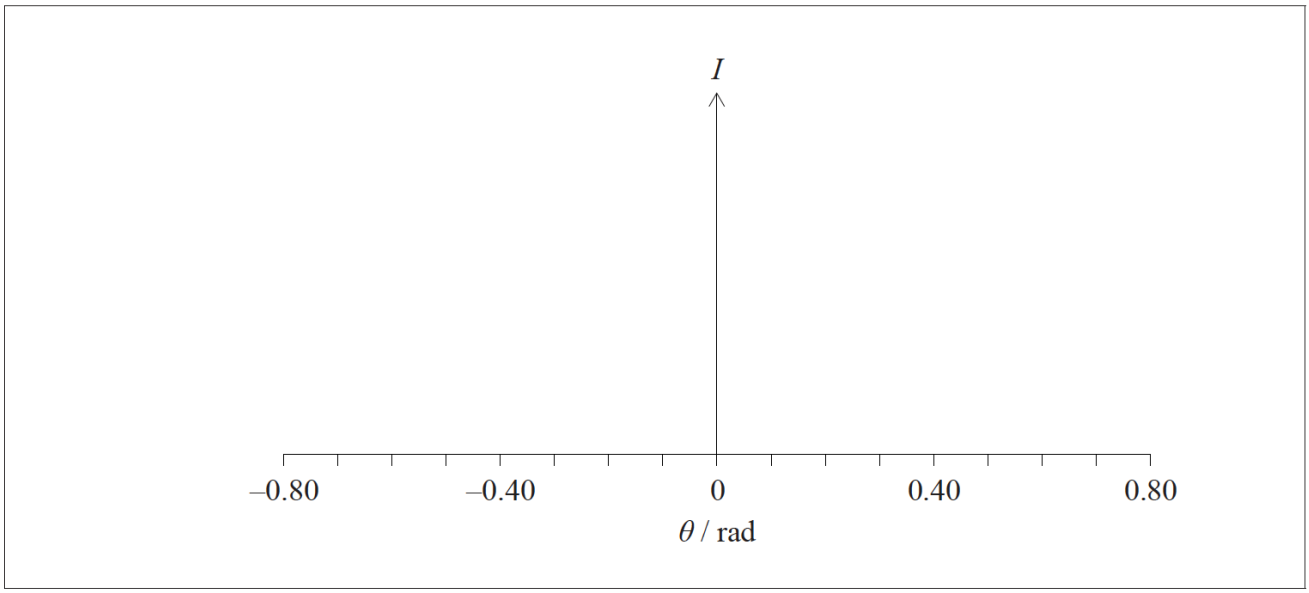


S_1 and S_2 are at the same distance from the aperture. The diameter of the aperture is 0.18 mm. The angle between the lines joining the sources to the aperture is 0.25 rad.

24. S_1 is turned on and S_2 is turned off. *[4 marks]*

(i) Show that the angle at which the first minimum of the diffraction pattern occurs is 0.40 rad.

(ii) On the axes below, sketch a graph to show how the intensity I of the radiation from S_1 varies with the diffraction angle θ.



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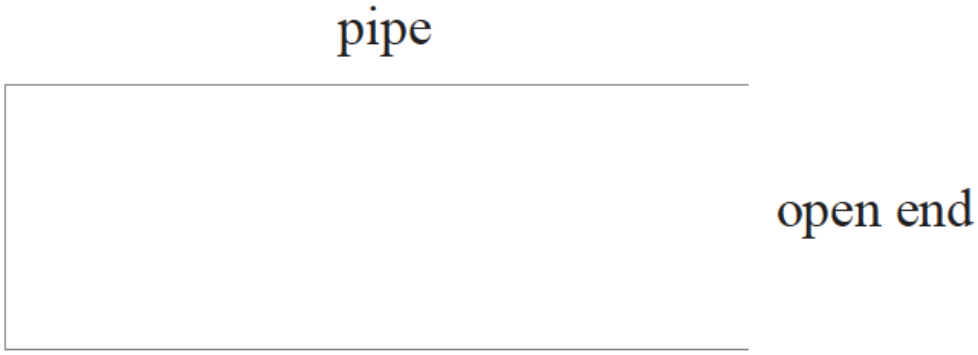
This question is about standing waves and the Doppler effect.

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 $330 ms^{-1}$.



25a. 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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25b. (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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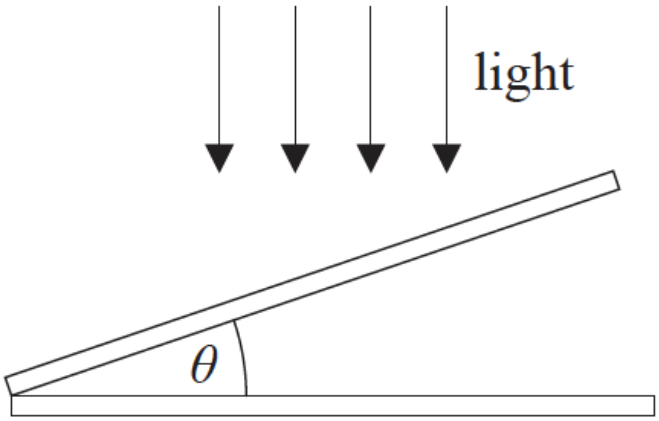
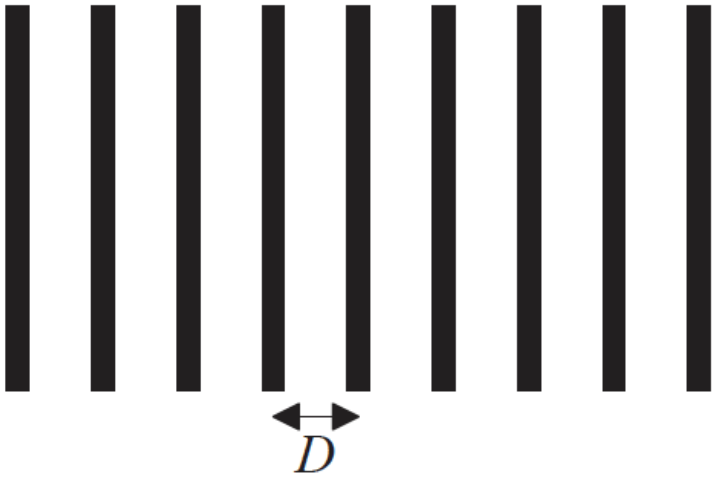
This question is about thin-film interference.

A thin air wedge consists of two flat glass plates that form an angle θ of 1.0×10^{-3}rad.



(not to scale)

When illuminated with monochromatic light from above, the fringe pattern below is observed in the reflected light. The distance D between two consecutive fringes is 0.30mm.



(not to scale)

26a. Calculate the wavelength of the light. *[2 marks]*

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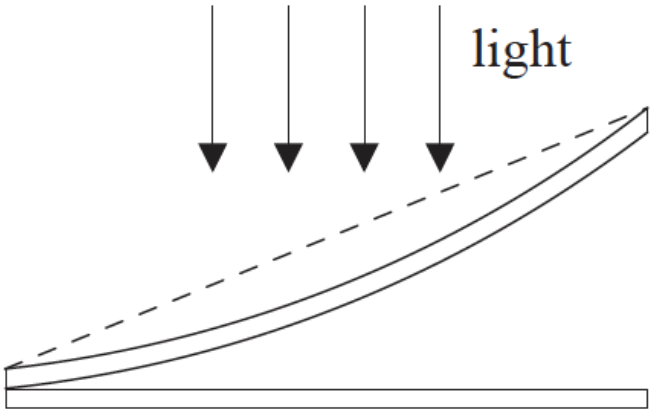
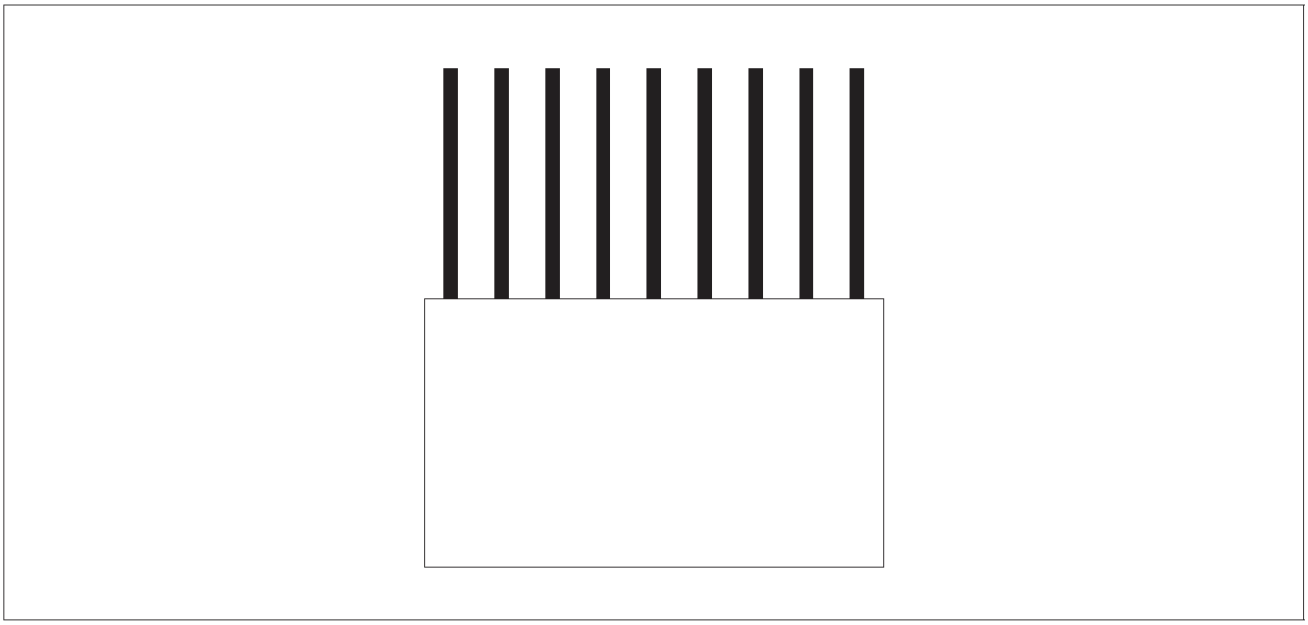
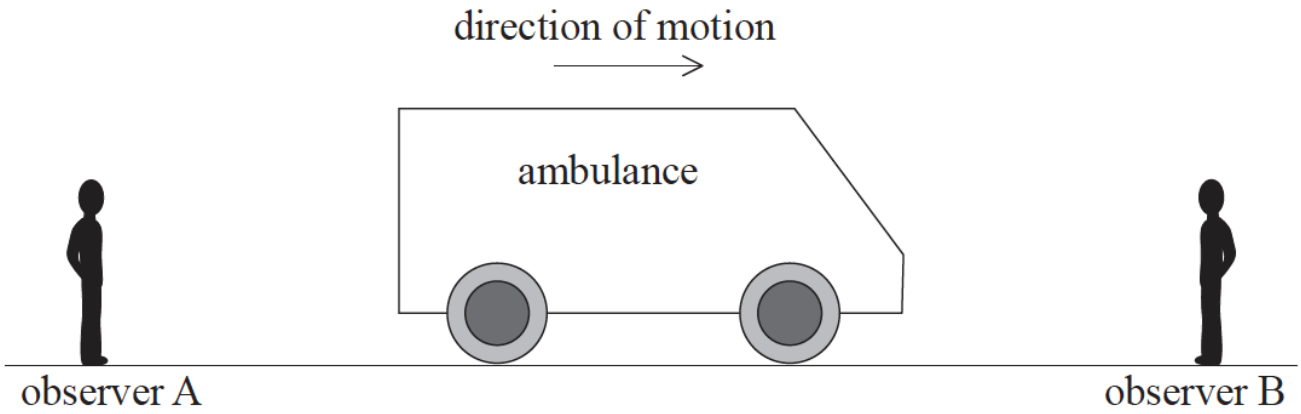
26b. The upper glass plate is now replaced with a curved glass plate. The dotted line represents the upper glass plate used in (a). *[2 marks]*



Sketch the new fringe pattern in the space below. The fringe pattern of (a) is given for comparison.



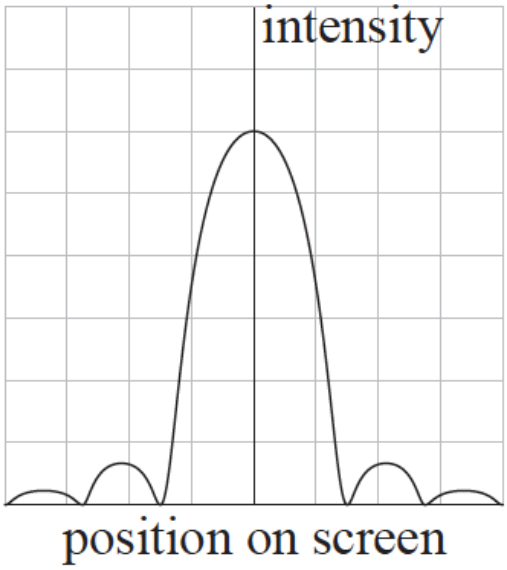
27. An ambulance emits a sound of frequency *f* as it travels along a straight road between stationary observers A and B. *[1 mark]*



Which of the following shows how the frequency of the sound heard by each observer compares with *f*?

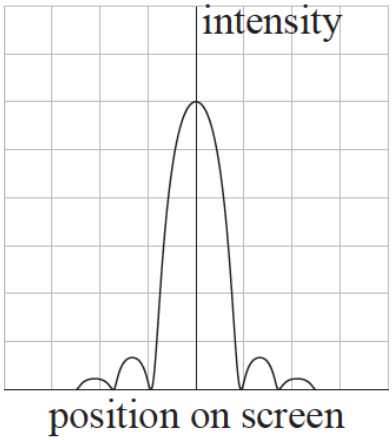
	Observer A	Observer B
A.	greater than *f*	greater than *f*
B.	greater than *f*	less than *f*
C.	less than *f*	greater than *f*
D.	less than *f*	less than *f*

28. The intensity distribution of monochromatic light passing through a narrow slit and then incident on a screen is shown below. *[1 mark]*

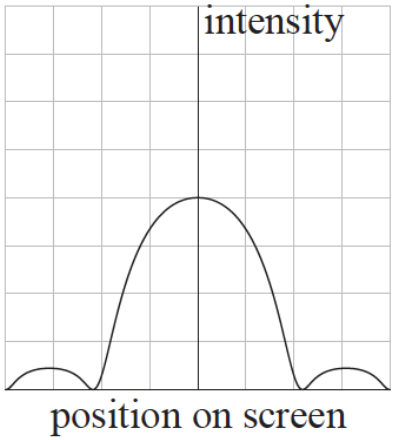


When the slit width is reduced which diagram shows the new intensity distribution? Diagrams are drawn to the same scale as the original.

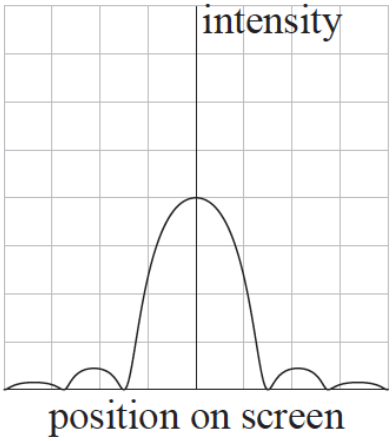
A.



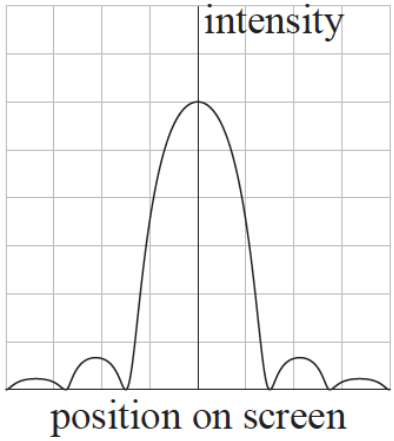
B.



C.



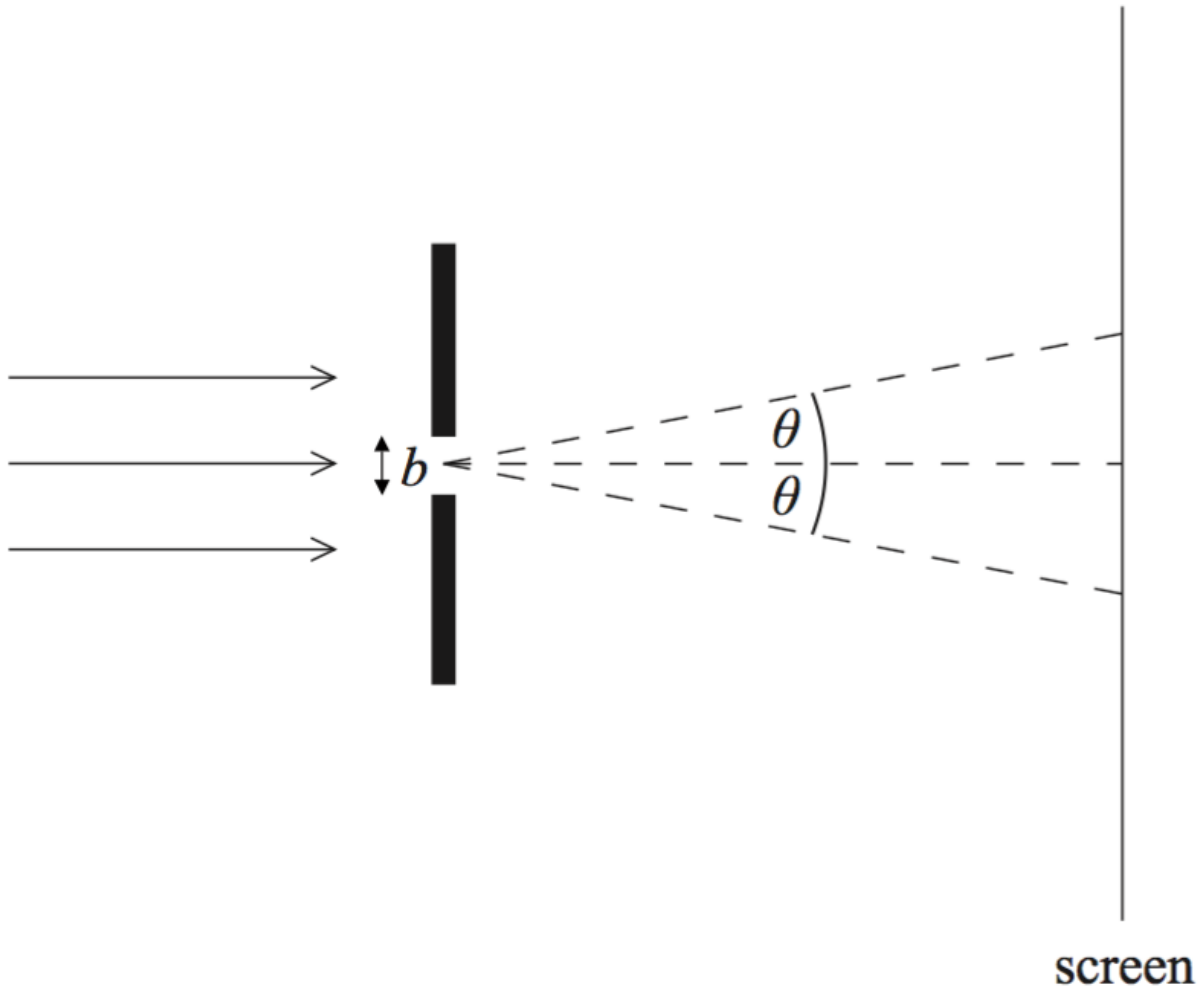
D.



29. A sample of hydrogen on Earth emits a spectral line that is measured by an Earth observer to have wavelength 500 nm. The same spectral line is emitted by a galactic source that is moving away from Earth at speed of 0.1c. What is the wavelength of the galactic spectral line that will be measured by the Earth observer? *[1 mark]*

A. 50 nm
B. 450 nm
C. 550 nm
D. 5000 nm

30. A parallel beam of monochromatic light of wavelength λ passes through a slit of width *b* and forms a diffraction pattern on a screen far from the slit. The angle at which the first diffraction minimum is formed is θ. *[1 mark]*



Which of the following changes in λ and *b*, carried out separately, will increase the value of θ?

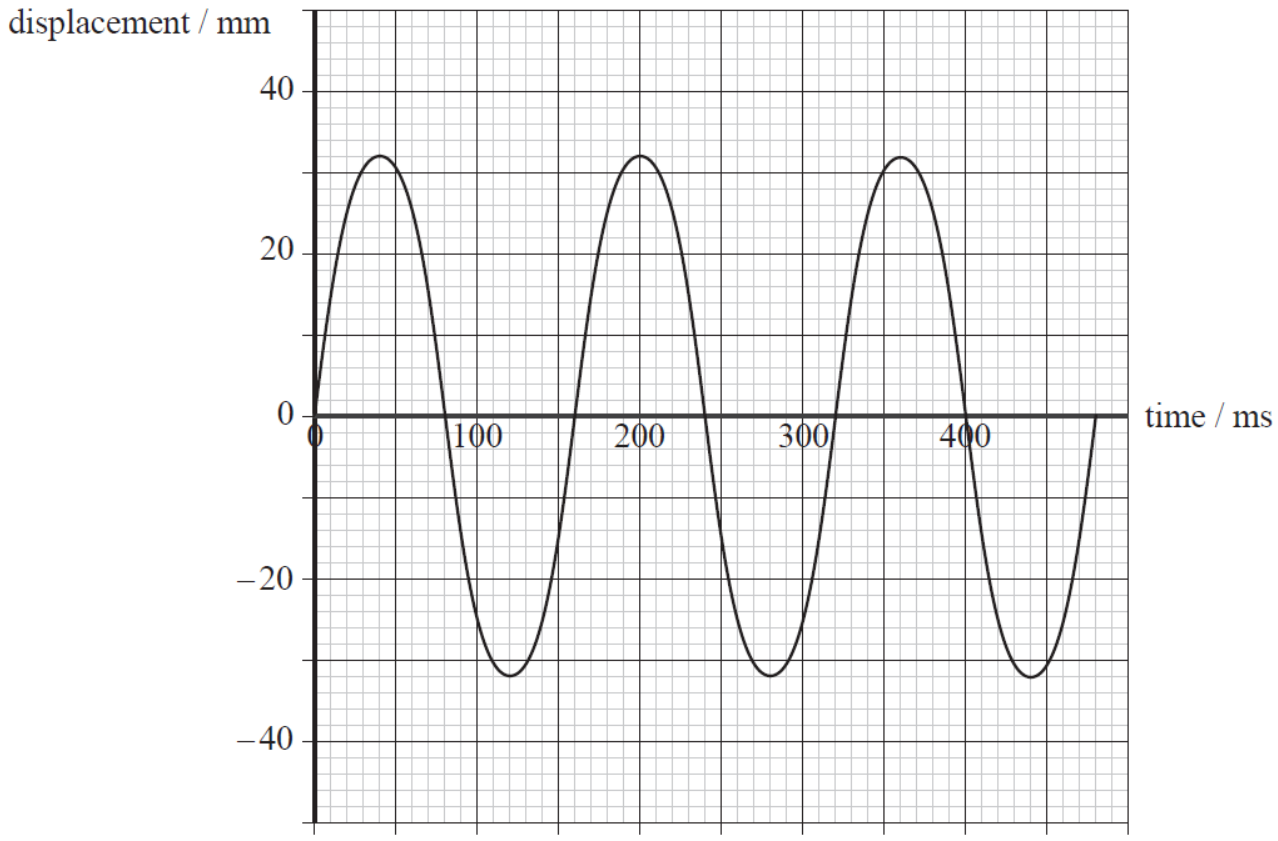
	λ	*b*
A.	decrease	increase
B.	increase	increase
C.	decrease	decrease
D.	increase	decrease

31. Two coloured point sources are observed through an optical telescope. Which of the following colours for the sources would best allow their images to be resolved? *[1 mark]*

A. Blue
B. Green
C. Red
D. Yellow

Simple harmonic motion and forced oscillations

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



32a. (i) State the amplitude of the oscillation. *[3 marks]*

(ii) Calculate the frequency of the oscillation.

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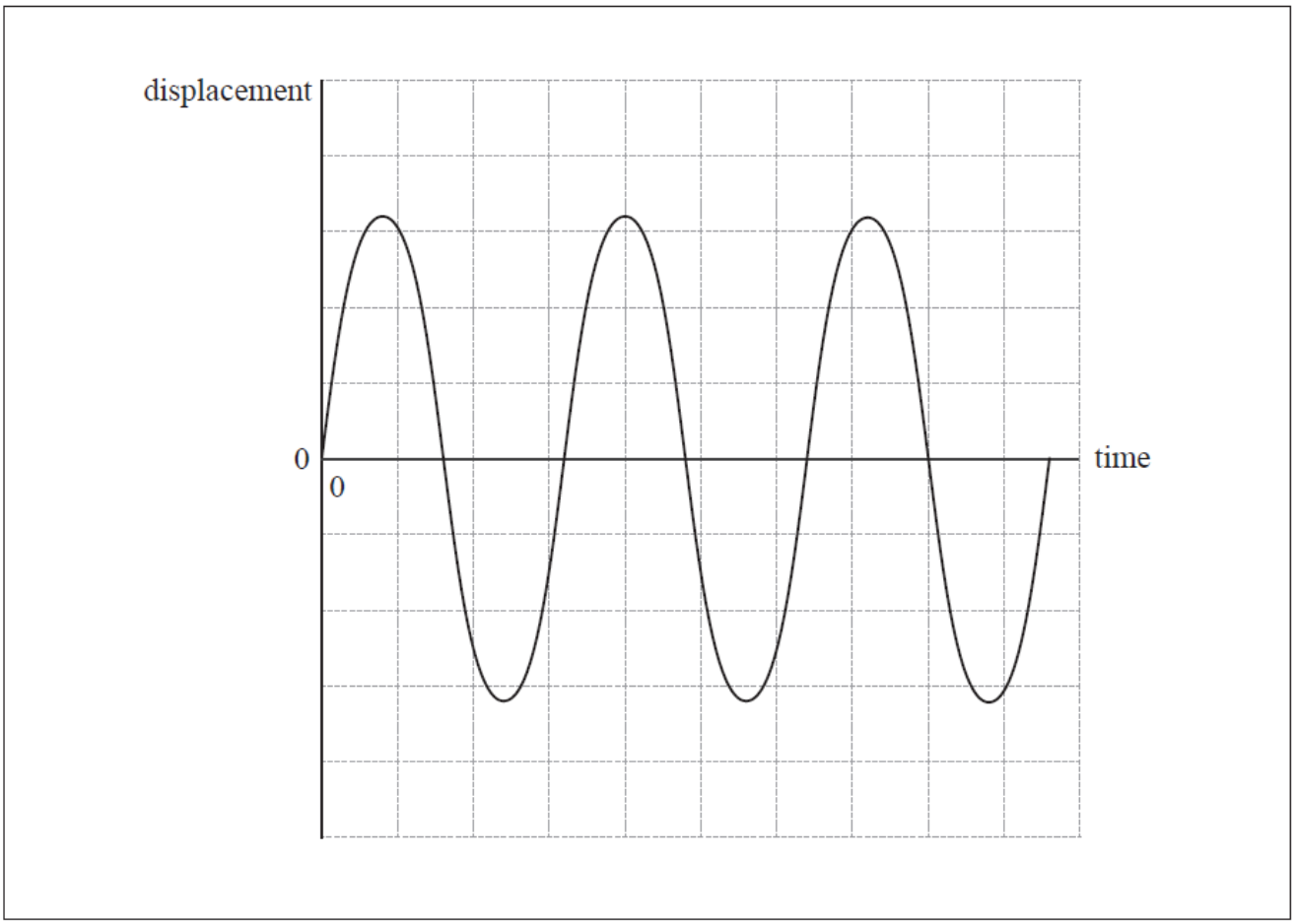
32b. (i) Determine the maximum speed of the object. *[4 marks]*

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

32c. 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 about radio telescopes.

A distant galaxy emits radio waves of frequency 6.0×10^{9} Hz and is moving with speed 6.0×10^{6} ms^{-1} directly away from an observer on Earth.

33a. Determine the wavelength of the radio wave as measured by the observer on Earth. *[3 marks]*

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33b. The radio signals from two stars on opposite sides of the galaxy are detected on Earth using a radio telescope. *[4 marks]*
The telescope has a circular receiving dish.

(i) State the Rayleigh criterion for the images of two point sources to be just resolved.

(ii) The galaxy is 2.0×10^{21}m from Earth and the stars are separated by 5.0×10^{19}m. Determine the minimum size of the telescope dish required to resolve the images of the two stars at a wavelength of 5.1×10^{-2}m.

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This question is about the Ω^- particle.

The Ω^- particle is a baryon which contains only strange quarks.

34a. Deduce the strangeness of the Ω^- particle. *[1 mark]*

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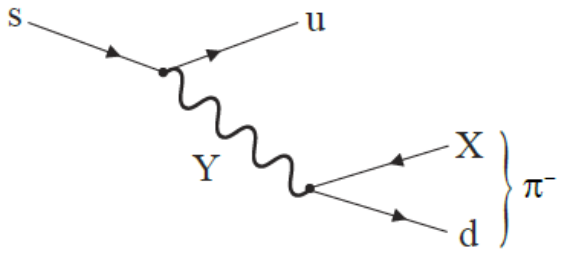
34b. The Feynman diagram shows a quark change that gives rise to a possible decay of the Ω^- particle. *[2 marks]*



(i) Identify X.

(ii) Identify Y.

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This question is about laser light.

34c. The number of lines per millimetre in the diffraction grating in (b) is reduced. Describe the effects of this change on the fringe pattern in (b). *[2 marks]*

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35a. Laser light is monochromatic and coherent. Explain what is meant by *[3 marks]*

(i) monochromatic.

(ii) coherent.

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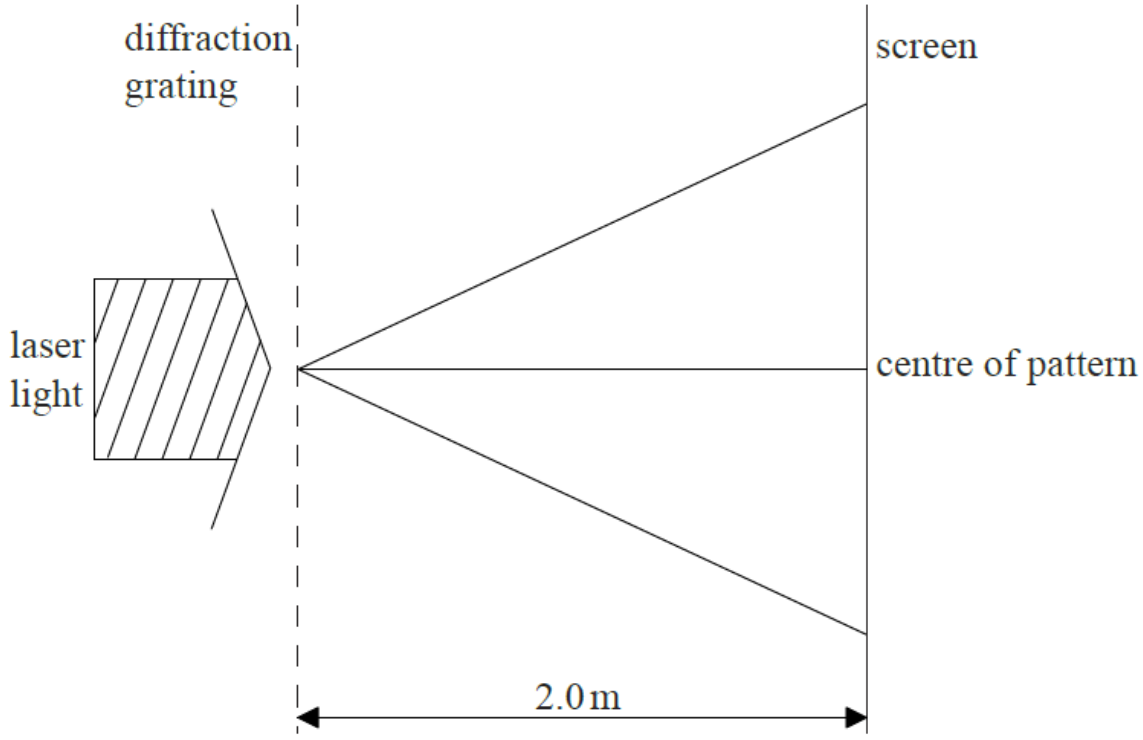
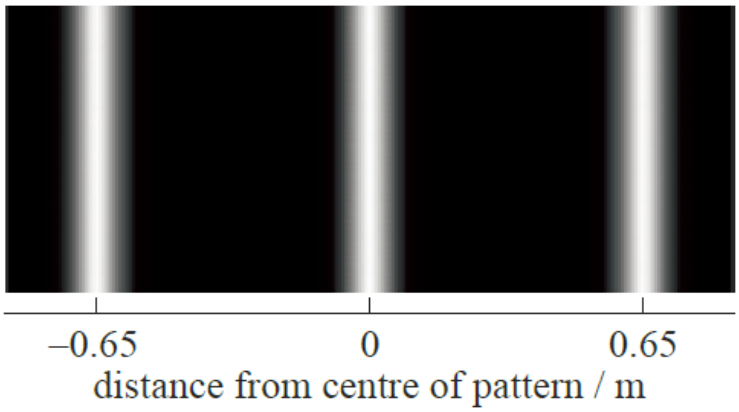
35b. A beam of laser light is incident normally on a diffraction grating which has 600 lines per millimetre. A fringe pattern is formed on a screen 2.0 m from the diffraction grating. *[4 marks]*



The fringe pattern formed on the screen is shown below.



Determine the wavelength of the laser light.

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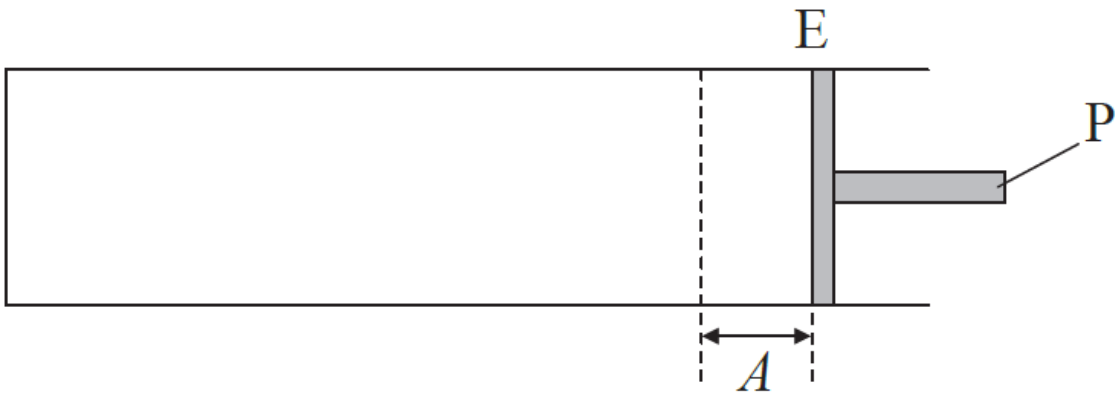
This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about wind power and the greenhouse effect.

Part 1 Simple harmonic motion (SHM) and waves

36a. 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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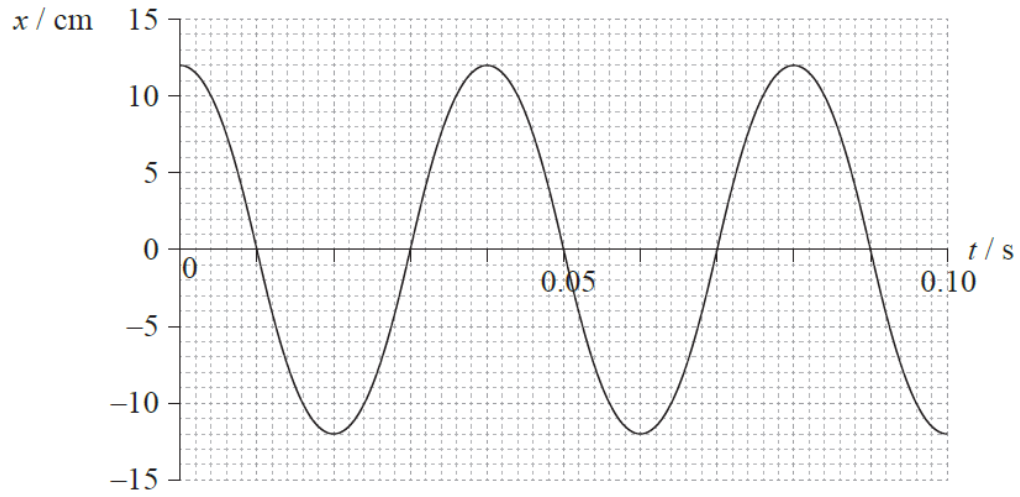
36b. The graph shows how the displacement x of the piston P in (a) from equilibrium varies with time t. *[7 marks]*



(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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36c. 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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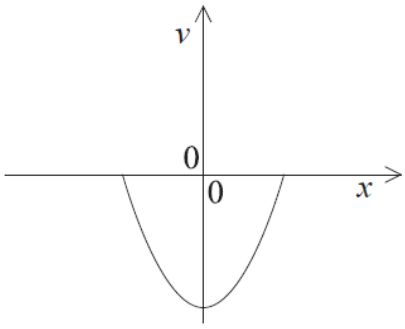
37. Which graph shows how velocity *v* varies with displacement *x* of a system moving with simple harmonic motion? *[1 mark]*

A.



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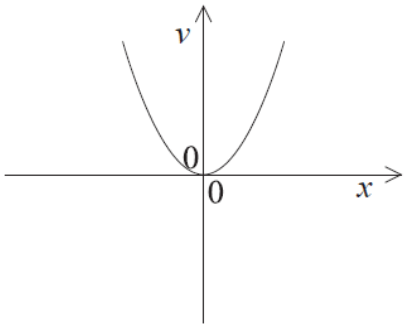

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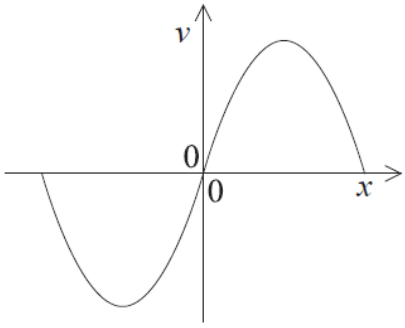
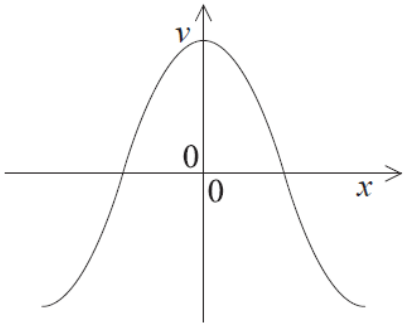


D.



38. An object undergoes simple harmonic motion with time period *T* and amplitude 0.5 m. At time *t* = 0 s the displacement of the object is a maximum. *[1 mark]*

What is the displacement of the object at time $t = \frac{3T}{4}$?

A. -0.50 m
B. 0.50 m
C. 0.25 m
D. 0 m

39. A stationary source of sound emits sound of frequency *f*. A moving observer measures the sound as having the frequency *f ′*. The observer is moving directly away from the source at a speed that is 30% of the speed of sound in air. *[1 mark]*

Which of the following gives the correct value for $\frac{f'}{f}$?

A. $\frac{7}{10}$

B. $\frac{10}{13}$

C. $\frac{13}{10}$

D. $\frac{10}{7}$

40. An optical instrument is used to observe an object illuminated with monochromatic light. Which of the following changes to the frequency of the light and to the aperture diameter of the optical instrument will increase the resolution of the image of the object formed by the instrument? *[1 mark]*

	Frequency	Aperture diameter
A.	increase	decrease
B.	decrease	decrease
C.	increase	increase
D.	decrease	increase

Part 2 The Doppler effect and optical resolution

The Doppler effect can be used to deduce that a particular star X is moving towards Earth.

41a. Describe what is meant by the Doppler effect. *[2 marks]*

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41b. One of the lines in the spectrum of atomic hydrogen has a frequency of 4.6×10^{16}Hz as measured in the laboratory. The same line in the spectrum of star X is observed on Earth to be shifted by 1.3×10^{12}Hz. *[4 marks]*

(i) State the direction of the observed frequency shift.

(ii) Determine the speed at which X is moving towards Earth stating any assumption that you have made.

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41c. The star X has a companion star Y. The distance from Earth to the stars is 1.0×10^{18}m. The images of X and Y are just resolved according to the Rayleigh criterion by a telescope on Earth with a circular eyepiece lens of diameter 5.0×10^{-2}m. *[5 marks]*

(i) State what is meant by the statement “just resolved according to the Rayleigh criterion”.

(ii) The average wavelength of the light emitted by the stars is 4.8×10^{-7}m. Determine the separation of X and Y.

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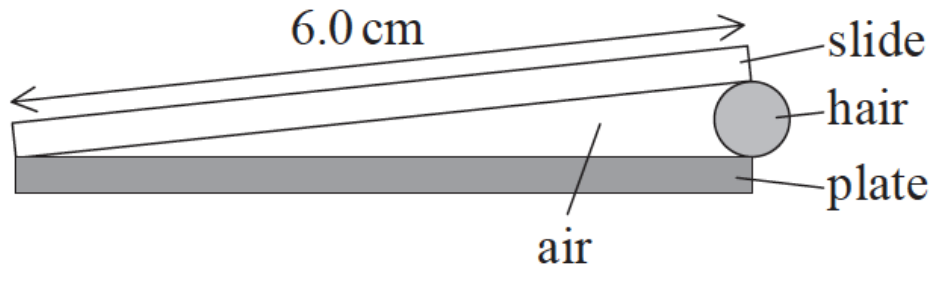
This question is about wedge fringes.

A glass microscope slide of length 6.0cm is placed on a glass plate and illuminated using a monochromatic source of light of wavelength 590nm. A hair is trapped at one end of the slide forming an air wedge between the glass plate and the slide.



(not to scale)

42. An observer viewing the microscope slide at near-normal incidence measures the fringe spacing to be 0.29 mm. *[3 marks]*
Calculate the thickness of the hair.

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This question is about the Doppler effect.

43a. Describe what is meant by the Doppler effect as it relates to sound. *[2 marks]*

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43b. An ambulance is travelling at a speed of 28.0 ms^{-1} along a straight road. Its siren emits a continuous sound of frequency 520 Hz. The ambulance is approaching a stationary observer. The observer measures the frequency of the note to be 566 Hz. Determine the speed of sound. *[3 marks]*

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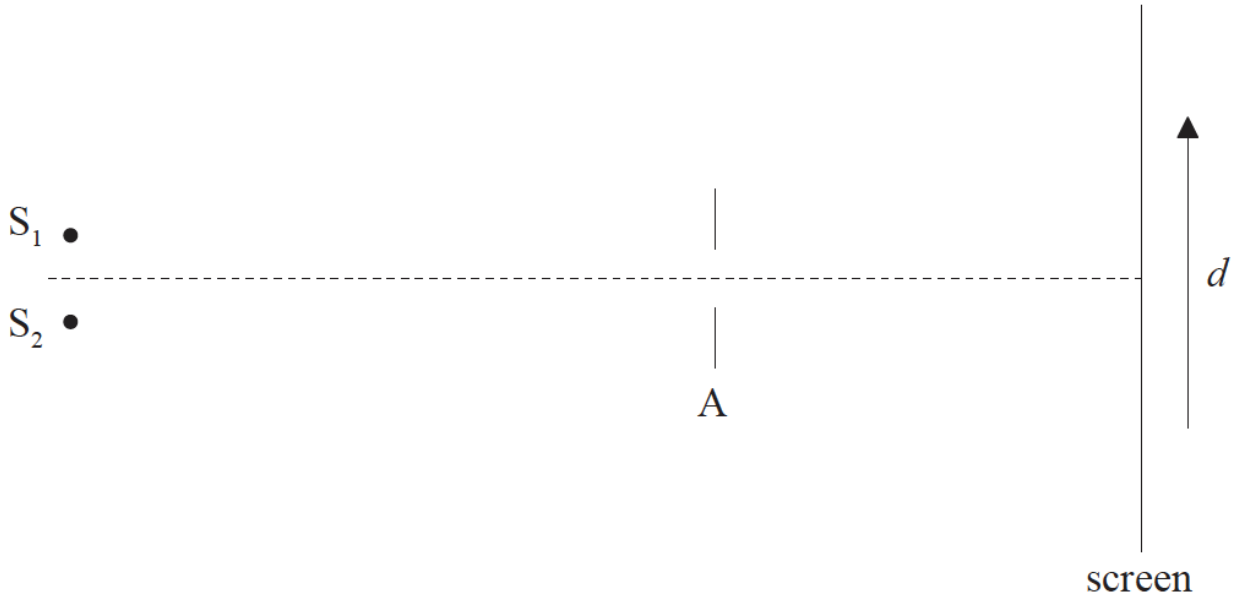
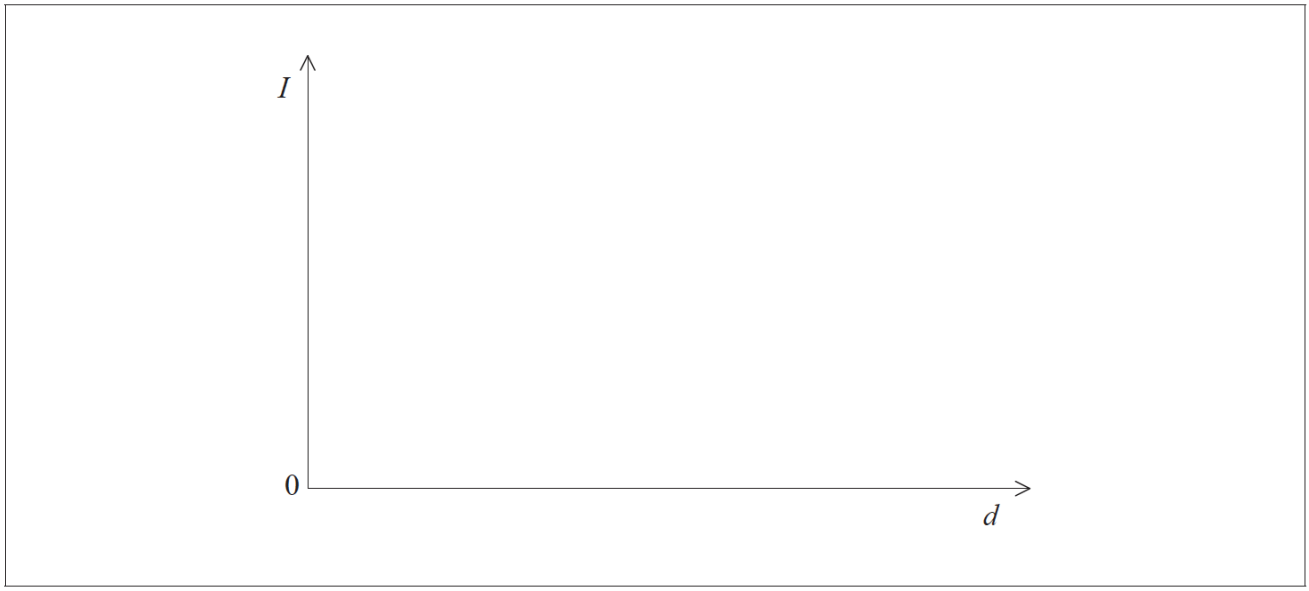
This question is about resolution.

44a. 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*.



44b. 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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44c. 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 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

45a. By reference to simple harmonic motion, state what is meant by amplitude. *[1 mark]*

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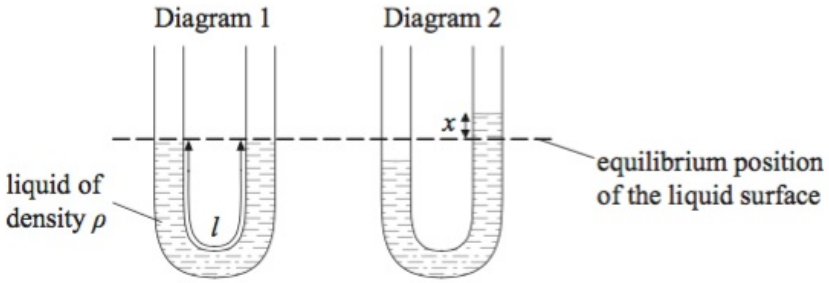
45b. A liquid is contained in a U-tube. *[5 marks]*



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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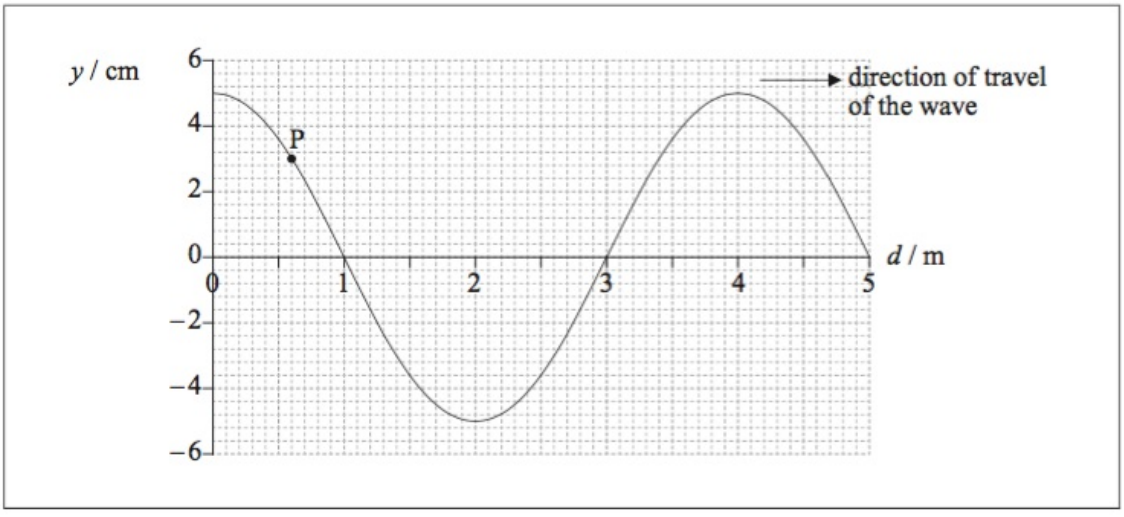
45c. A wave is travelling along a string. The string can be modelled as a single line of particles and each particle executes simple harmonic motion. The period of oscillation of the particles is 0.80s. *[9 marks]*

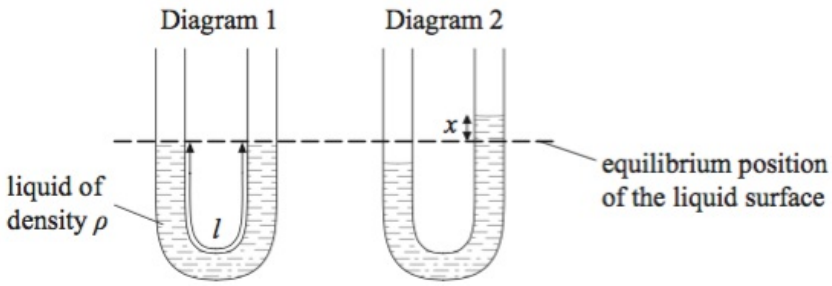
The graph shows the displacement *y* of part of the string at time *t*=0. The distance along the string is *d*.



(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.

46a. 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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46b. 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 the Doppler effect.

The sound emitted by a car's horn has frequency f , as measured by the driver. An observer moves towards the stationary car at constant speed and measures the frequency of the sound to be f'.

47a. Explain, using a diagram, any difference between f and f'. *[3 marks]*

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47b. The frequency f is 3.00×10^{2}Hz. An observer moves towards the stationary car at a constant speed of 15.0ms^{-1}. *[2 marks]*
Calculate the observed frequency f' of the sound. The speed of sound in air is $3.30\times10^{2}\text{ms}^{-1}$.

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This question is about using a diffraction grating to view the emission spectrum of sodium.

Light from a sodium discharge tube is incident normally upon a diffraction grating having 8.00×10^{5} lines per metre. The spectrum contains a double yellow line of wavelengths 589 nm and 590 nm.

48a. Determine the angular separation of the two lines when viewed in the second order spectrum. *[4 marks]*

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48b. State why it is more difficult to observe the double yellow line when viewed in the first order spectrum. *[1 mark]*

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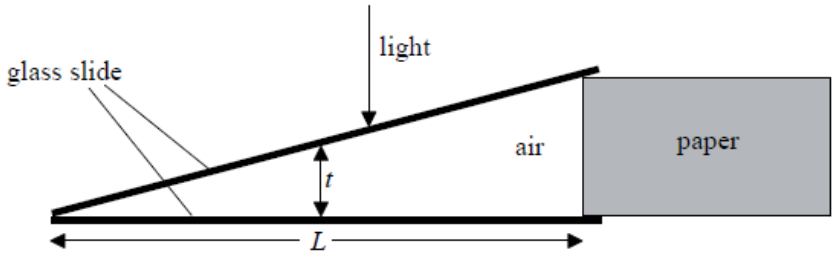
This question is about wedge film interference.

One flat, glass slide is placed at an angle on top of a second identical slide. The slides are in contact along one short edge and are separated at the other edge by a thin piece of paper, as shown below.



(diagram not to scale)

A thin wedge of air of variable thickness, *t* , is trapped between the two slides. The arrangement is viewed normally from above, using light of wavelength 590 nm. The glass plates are coated, so that reflection only takes place at the bottom surface of the top plate and the top surface of the bottom plate.

A series of straight bright and dark fringes, equally separated and parallel to the short edge of the slides, is seen.

49a. Deduce that the thickness of the air wedge *t* that gives rise to a bright fringe, is given by $2t = (m + \frac{1}{2})\lambda$. *[2 marks]*

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49b. The length of the air wedge, *L*, is 8.2 cm. The bright fringes are each separated by a distance of 1.2 mm. Calculate the thickness of the paper. *[3 marks]*

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