# HL Paper 1

A particle performs simple harmonic oscillations. Which of the following quantities will be unaffected by a reduction in the amplitude of oscillations?

A. The total energy

B. The maximum speed

C. The maximum acceleration

D. The period

# Markscheme

D

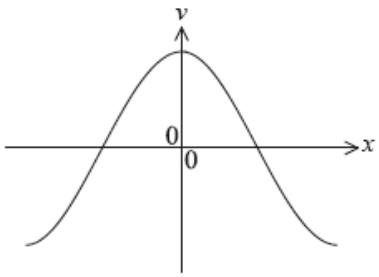
# Examiners report

[N/A]

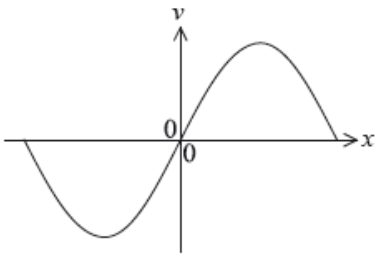
---

Which of the following graphs shows the variation with displacement $x$ of the speed $v$ of a particle performing simple harmonic motion.

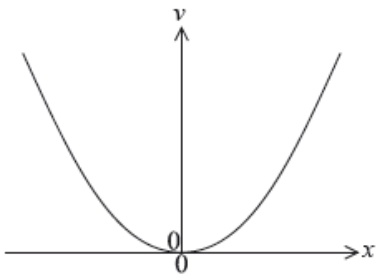
A.



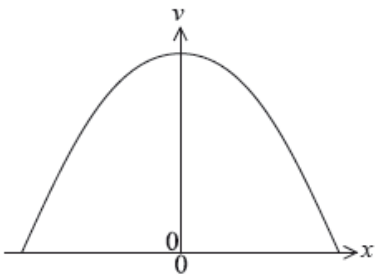

B.




C.




D.




# Markscheme

D

# Examiners report

[N/A]

---

A travelling wave of period 5.0 ms travels along a stretched string at a speed of 40 m $s^{-1}$. Two points on the string are 0.050 m apart.

What is the phase difference between the two points?

A. 0

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

C. $\pi$

D. $2\pi$

# Markscheme

B

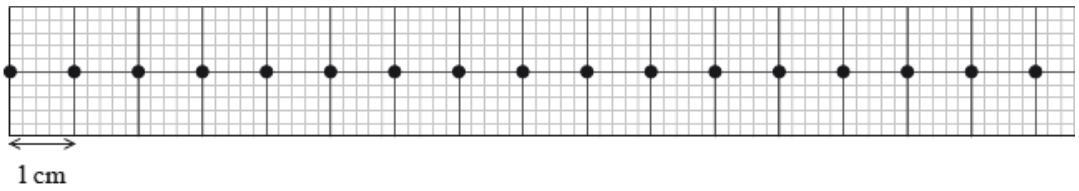
# Examiners report

[N/A]

---

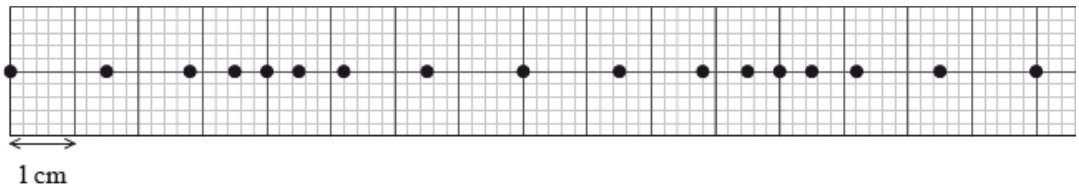
Diagram 1 represents equally spaced beads on a spring. The beads are 1 cm apart.

**Diagram 1**




A longitudinal wave propagates along the spring. Diagram 2 shows the position of the beads at a particular instant.

**Diagram 2**




Which of the following is the best estimate of the wavelength?

A. 2 cm

B. 4 cm

C. 8 cm

D. 16 cm

# Markscheme

C

# Examiners report

The responses to this question showed that students had not been carefully introduced to the physics of longitudinal waves and the meaning of their typical *displacement-distance* graph.

---

The wavelength of a standing (stationary) wave is equal to

A. the distance between adjacent nodes.

B. twice the distance between adjacent nodes.

C. half the distance between adjacent nodes.

D. the distance between a node and an adjacent antinode.

# Markscheme

B

# Examiners report

[N/A]

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Unpolarized light is incident on the surface of a transparent medium. The reflected light is completely plane polarized. The refracted light will be

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.

# Markscheme

B

# Examiners report

Candidates found this question to be the most challenging on the paper. At the Brewster angle the reflected light is plane polarized but that does not mean that the transmitted (refracted) light is plane polarized. There will still be some light in the same plane of vibration as the reflected light but there will now be less of it. The transmitted light is therefore partially plane polarized.

Properties of waves are

I. polarization
II. diffraction
III. refraction

Which of these properties apply to sound waves?

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

# Markscheme

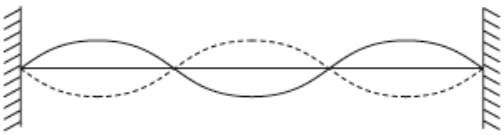
C

# Examiners report

[N/A]

---

A standing (stationary) wave is set up on a string at a particular frequency as shown.



How many nodes will be on the string if the frequency is doubled but nothing else is changed?

A. 2

B. 3

C. 7

D. 8

# Markscheme

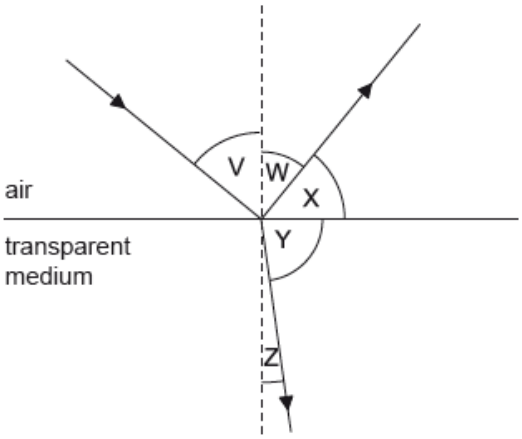
C

# Examiners report

[N/A]

---

Light is incident from air on the surface of a transparent medium.




(angles not drawn to scale)

When V is equal to the Brewster angle, which angle is equal to 90°?

A. $\mathrm{V} + \mathrm{W}$

B. W only

C. $\mathrm{X} + \mathrm{Y}$

D. Z only

# Markscheme

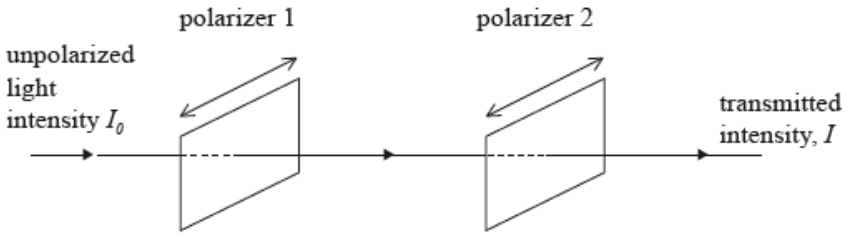
C

# Examiners report

The diagram clearly states that the angles are not drawn to scale. Despite this, many candidates chose response A, presumably as those angles looked as if they added together to make a right angle. But it was good to see that the majority of candidates were not fooled by appearances and selected the correct response of C.

---

Unpolarized light is shone through two identical polarizers whose axes are parallel.




The ratio $\frac{I}{I_0}$ is

A. 100 %.

B. 50 %.

C. 25 %.

D. 0 %.

# Markscheme

B

# Examiners report

[N/A]

---

The phenomenon of diffraction is associated with

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

# Markscheme

D

# Examiners report

[N/A]

---

A standing sound wave is set up inside a narrow glass tube which has both ends open. The first harmonic frequency of the standing wave is 500Hz.

What is the frequency of the sound wave if the length of the tube is halved and one end is closed?

A. 250 Hz

B. 500 Hz

C. 1000 Hz

D. 2000 Hz

# Markscheme

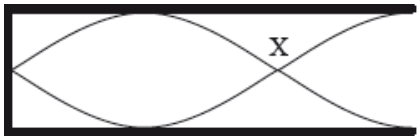
B

# Examiners report

[N/A]

---

A standing wave is established in air in a pipe with one closed and one open end.




The air molecules near X are

A. always at the centre of a compression.

B. always at the centre of a rarefaction.

C. sometimes at the centre of a compression and sometimes at the centre of a rarefaction.

D. never at the centre of a compression or a rarefaction.

# Markscheme

C

# Examiners report

The majority response of A showed a basic misconception of what these standing wave patterns represent. Indeed, the correct response was chosen by the fewest candidates! The standing wave is longitudinal with air molecules moving parallel to the sides of the pipe. At the antinodes they are moving with maximum amplitude, while at the nodes (X) they are not moving (amplitude is zero).

At adjacent antinodes the molecules are out of phase such that when a molecule to the left of X is moving to the left, then a particle to the right of X will be moving to the right creating a rarefaction at X; half a time period later the directions are reversed and a compression will be formed at X.

Teachers should emphasise the dynamic nature of the standing wave with the traditional representation being essentially a graph of amplitude against distance.

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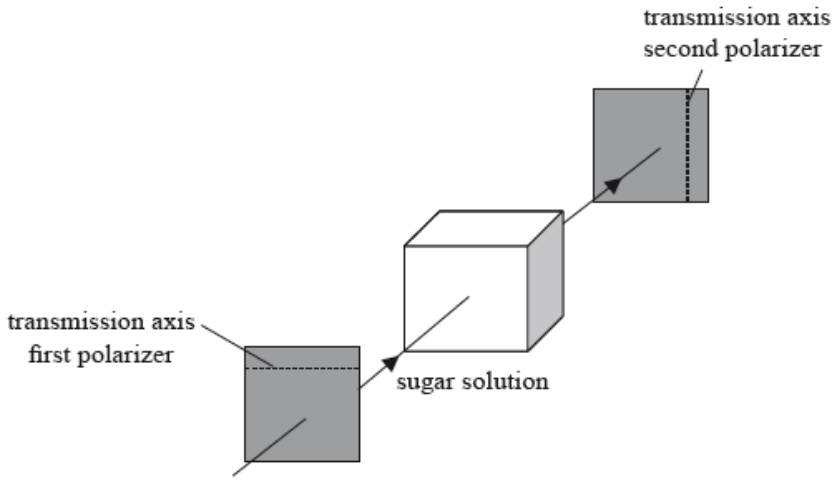
Horizontally polarized light is transmitted through a polarizer whose transmission axis is horizontal. The light enters a container with a sugar solution and is then incident on a second polarizer whose transmission axis is vertical.




When the second polarizer is rotated by a small angle, no light is transmitted through the second polarizer. The explanation for this observation is that the sugar solution

A. causes destructive interference.

B. rotates the plane of polarization of light.

C. can only transmit vertically polarized light.

D. refracts light so no light is incident on the second polarizer.

# Markscheme

B

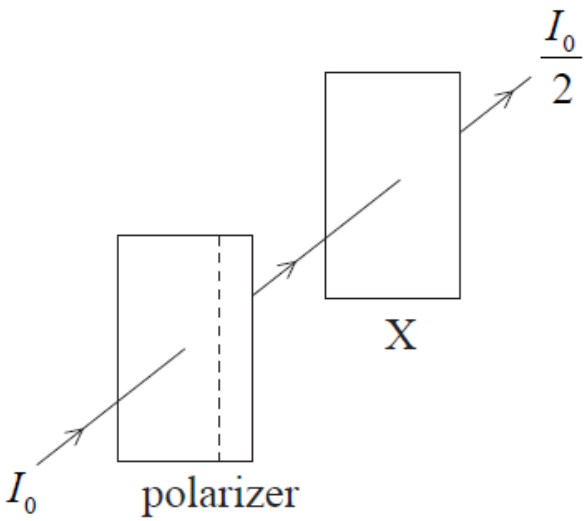
# Examiners report

[N/A]

---

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 $\frac{I_0}{2}$.




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

# Markscheme

A

# Examiners report

This was another question that elicited a number of critical comments from teachers, although the statistics showed two-thirds of the candidates choosing the response A. The amount of light reflected from a glass surface is negligible (and unquantifiable within the parameters of the question), so clearly A was the best response.

---

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

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

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

C. $2f$

D. $4f$

# Markscheme

B

# Examiners report

[N/A]

---

A point source of light of amplitude $A_0$ gives rise to a particular light intensity when viewed at a distance from the source. When the amplitude is increased and the viewing distance is doubled, the light intensity is doubled. What is the new amplitude of the source?

A. $2A_0$

B. $2\sqrt{2}\,A_0$

C. $4A_0$

D. $8A_0$

# Markscheme

B

# Examiners report

[N/A]

---

An unpolarized ray of light in air is incident on the surface of water. The reflected ray is completely polarized. Which of the following are separated by an angle of 90°?

A. The incident ray and the reflected ray

B. The reflected ray and the refracted ray

C. The refracted ray and the incident ray

D. The refracted ray and the surface of the water

# Markscheme

B

# Examiners report

[N/A]

---

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*?

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

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

C. 2

D. 4

# Markscheme

D

# Examiners report

Not enough candidates recognized that intensity depends upon the square of the amplitude. Option C was nearly as popular as the key D.

---

Which of the following is a correct comparison between standing waves and travelling waves?

| | Standing waves | Travelling waves |
|---|---|---|
| A. | wave amplitude is constant at all points along the wave | wave amplitude depends upon the position along the wave |
| B. | energy is always transferred | energy is not transferred |
| C. | the wavelength is twice the distance between consecutive nodes | the wavelength is the distance between consecutive crests |
| D. | phase varies continuously along the wave | phase is constant between consecutive crests |

# Markscheme

C

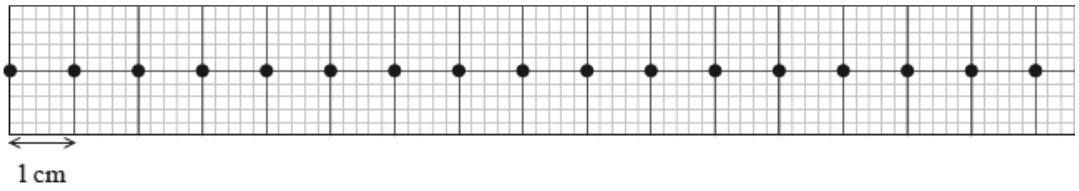
# Examiners report

[N/A]

---

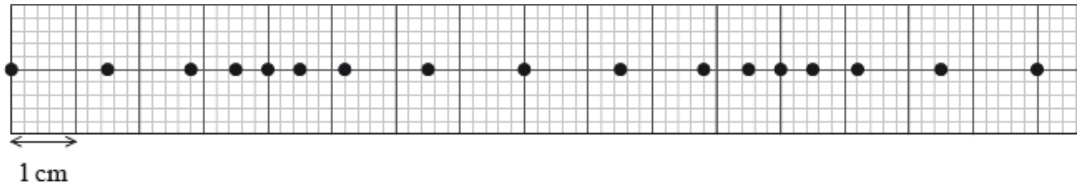
Diagram 1 represents equally spaced beads on a spring. The beads are 1 cm apart.

**Diagram 1**




A longitudinal wave propagates along the spring. Diagram 2 shows the position of the beads at a particular instant.

**Diagram 2**




Which of the following is the best estimate of the amplitude?

A. 0.4 cm

B. 0.8 cm

C. 1.6 cm

D. 3.2 cm

# Markscheme

B

# Examiners report

The responses to this question showed that students had not been carefully introduced to the physics of longitudinal waves and the meaning of their typical *displacement-distance* graph.

---

A string stretched between two fixed points sounds its second harmonic at frequency *f*.

Which expression, where *n* is an integer, gives the frequencies of harmonics that have a node at the centre of the string?

A. $\frac{n+1}{2} f$

B. $nf$

C. $2nf$

D. $(2n + 1)f$

# Markscheme

B

# Examiners report

[N/A]

---

In two separate experiments monochromatic light is incident on a single slit. The diagrams show the diffraction patterns obtained on a screen far from the slit. In the top diagram the wavelength of light is $\lambda_1$ and the slit width is $b_1$. In the bottom diagram the wavelength of light is $\lambda_2$ and the slit width is $b_2$.

In each experiment the distance between the slit and the screen is the same. Which of the following may be deduced?

A. $\frac{\lambda_1}{b_1} < \frac{\lambda_2}{b_2}$

B. $\frac{\lambda_1}{b_1} > \frac{\lambda_2}{b_2}$

C. $b_1 < b_2$

D. $\lambda_1 > \lambda_2$

# Markscheme

A

# Examiners report

[N/A]

---

An optically active substance is a substance that

A. has a refractive index that depends on the plane of polarization of incident light.

B. completely absorbs incident unpolarized light.

C. rotates the plane of polarization of incident polarized light.

D. polarizes unpolarized light.

# Markscheme

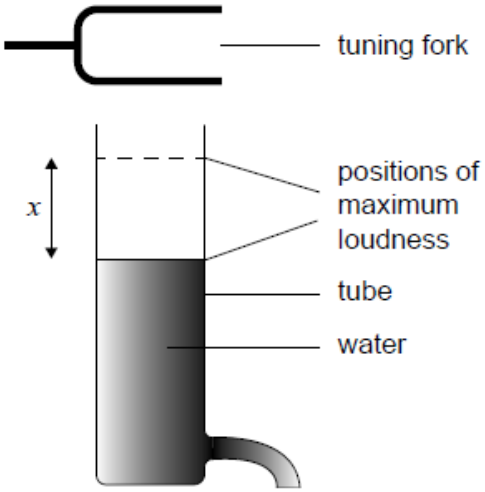
C

# Examiners report

[N/A]

---

Water is draining from a vertical tube that was initially full. A vibrating tuning fork is held near the top of the tube. For two positions of the water surface only, the sound is at its maximum loudness.




The distance between the two positions of maximum loudness is *x*.

What is the wavelength of the sound emitted by the tuning fork?

A. $\frac{x}{2}$

B. *x*

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

D. 2*x*

# Markscheme

D

# Examiners report

[N/A]

---

Which of the following gives regions of the electromagnetic spectrum in the order of **decreasing** frequency?

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

# Markscheme

C

# Examiners report

[N/A]

---

Electromagnetic waves pass through a slit in a metal plate with minimal diffraction. The slit has a width of 0.25 m. What is the wavelength of the waves?

A. Much less than 0.25 m

B. Between 0.10 m and 0.40 m

C. Equal to 0.25 m

D. Much greater than 0.25 m

# Markscheme

A

# Examiners report

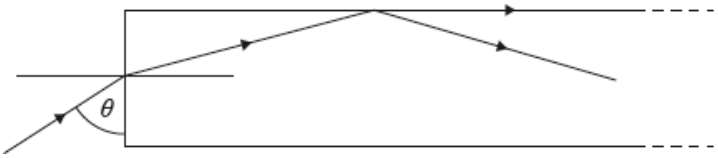
Look at the responses given before trying to work out the answer.

If there is “minimal” diffraction then candidates should know that the wavelength is less than the width of the slit. The only response that fits this requirement is A. There is a reminder on the first page of the paper that candidates should give the most appropriate or closest answer.

The closest alternative response is C, but candidates should know that if the slit is the same size as the wavelength then there will be noticeable diffraction.

---

A ray of light passes from the air into a long glass plate of refractive index $n$ at an angle $\theta$ to the edge of the plate.




The ray is incident on the internal surface of the glass plate and the refracted ray travels along the external surface of the plate.

What change to $n$ and what change to $\theta$ will cause the ray to travel entirely within the plate after incidence?

| | Change to $n$ | Change to $\theta$ |
|---|---|---|
| A. | increase | increase |
| B. | increase | decrease |
| C. | decrease | increase |
| D. | decrease | decrease |

# Markscheme

A

# Examiners report

[N/A]

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?

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

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

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

D. 3*f*

# Markscheme

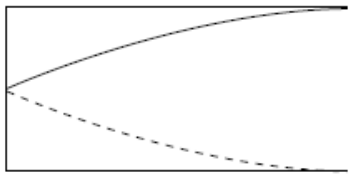
A

# Examiners report

Around the same number of candidates opted for A, B and C. The better candidates clearly favored the correct response, A. A quick and simple sketch reveals the answer immediately – this should be the candidates' natural reaction given a resonance problem of this nature.

---

A standing wave of frequency $f$ is established in air in a pipe open at one end, as shown.



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

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

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

C. $2f$

D. $3f$

# Markscheme

D

# Examiners report

[N/A]

---

A transverse standing wave is established on a string. Consider the following phase differences.

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

# Markscheme

B

# Examiners report

This question concerned itself with phase difference in a standing wave. It appears not to be well known that particles within any one loop are in phase with each other and that two particles in *adjacent* loops differ in phase by 180°.

---

The diagrams show four different organ pipes drawn to scale. Standing waves in the fundamental (first harmonic) mode are set up inside each pipe.

Which pipe produces a fundamental note with the lowest frequency?

A.

B.

C.

D.

## Markscheme

C

## Examiners report

[N/A]

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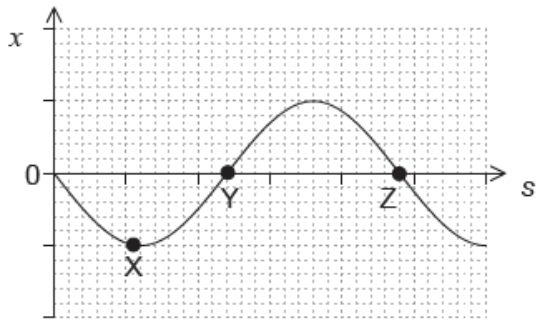
The graph shows the variation with position *s* of the displacement *x* of a wave undergoing simple harmonic motion (SHM).




What is the magnitude of the velocity at the displacements X, Y and Z?

| | X | Y | Z |
|---|---|---|---|
| A. | maximum | zero | maximum |
| B. | zero | maximum | maximum |
| C. | maximum | maximum | zero |
| D. | zero | maximum | zero |

# Markscheme

B

# Examiners report

[N/A]

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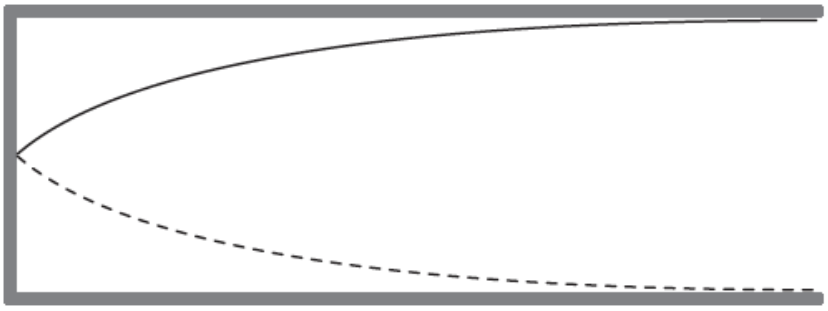
The diagram shows the fundamental (first harmonic) of a standing (stationary) sound wave in a pipe open at one end.



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

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

# Markscheme

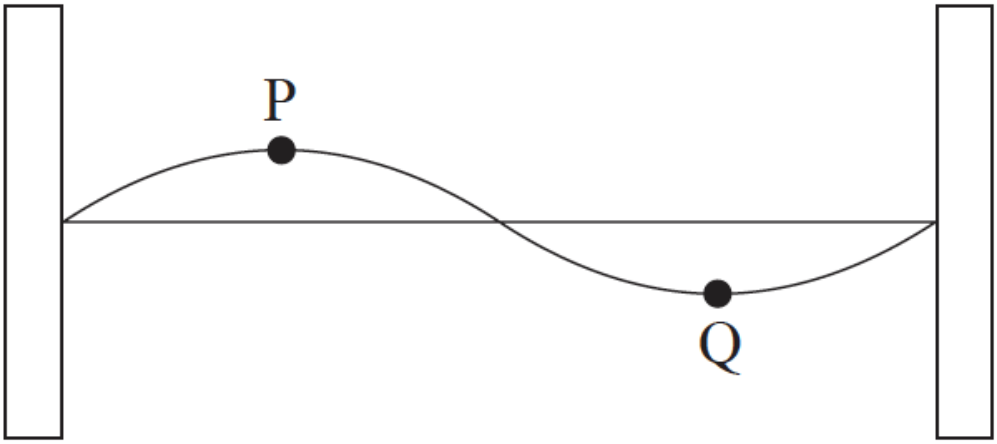
A

# Examiners report

[N/A]

---

A standing wave is established on a string between two fixed points.




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

A. zero

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

C. $\pi$

D. $2\pi$

# Markscheme

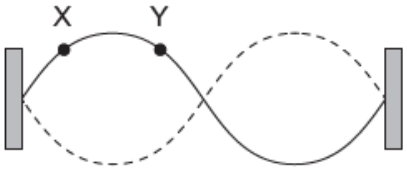
C

# Examiners report

B was a popular distractor indicating that some candidates thought that being „in phase" represented a phase difference of π rather than 2π.

---

The diagram shows a second harmonic standing wave on a string fixed at both ends.




What is the phase difference, in rad, between the particle at X and the particle at Y?

A. 0

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

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

D. $\frac{3\pi}{4}$

# Markscheme

A

# Examiners report

[N/A]

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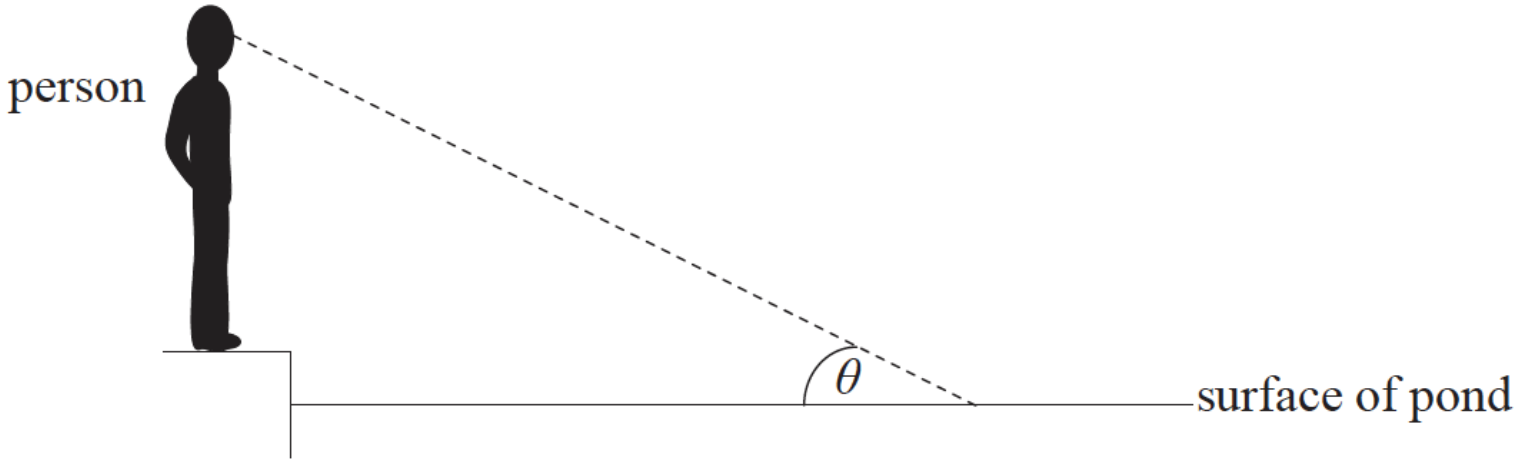
A person wearing polarizing sunglasses stands at the edge of a pond in bright sunlight.




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

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

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

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

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

# Markscheme

D

# Examiners report

This was very poorly done with over half of the candidates opting for A. Simple recall of the Brewster angle, which involves tan of an angle, should cause candidates to eliminate B and C (which most of them did). To choose between A and D, though, it is required to look at the situation as depicted (rather than jumping to conclusions based upon familiar diagrams). θ is the angle to the surface – not the angle of incidence. So A must be incorrect.

---

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?

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

# Markscheme

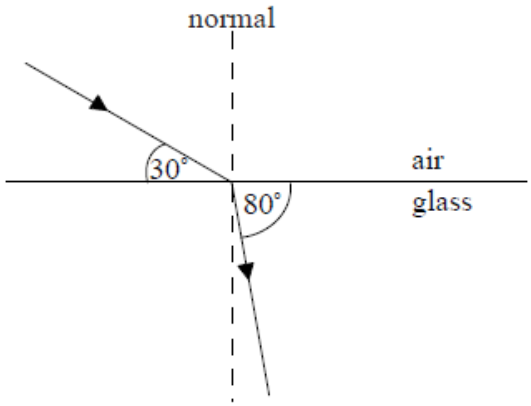
D

# Examiners report

[N/A]

---

Light travels from air into glass as shown below.




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

# Markscheme

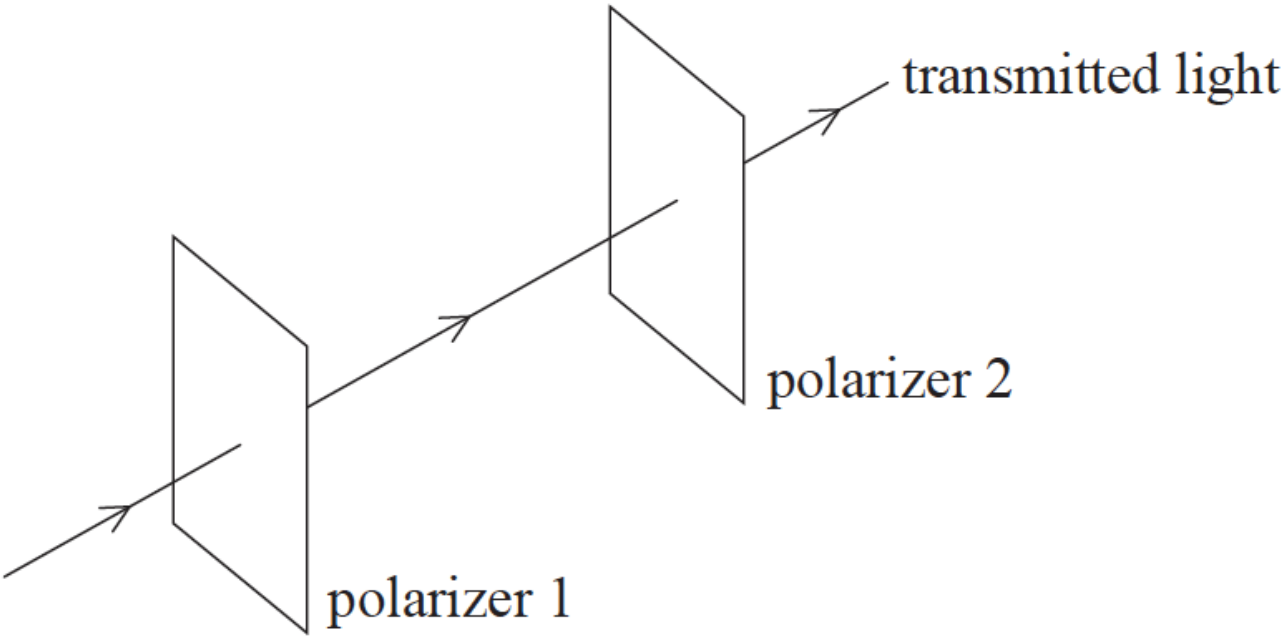
C

# Examiners report

[N/A]

---

Two polarizing filters are set up so the transmitted light is at a maximum intensity.




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

A. 45 °
B. 60 °
C. 90 °
D. 180°

# Markscheme

C

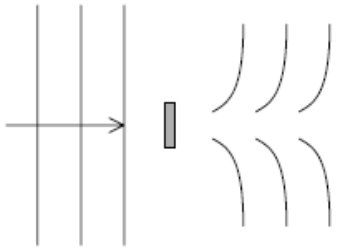
# Examiners report

[N/A]

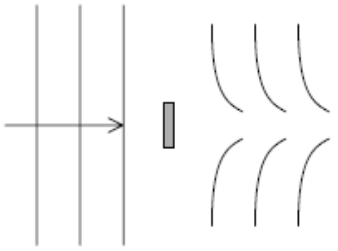
---

Which diagram shows the shape of the wavefront as a result of the diffraction of plane waves by an object?

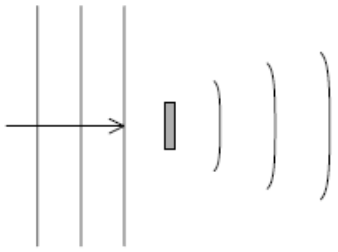
A.



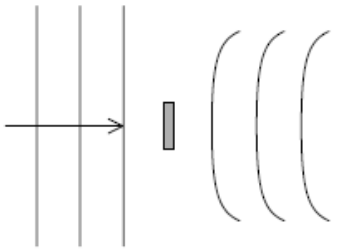
B.



C.



D.



# Markscheme

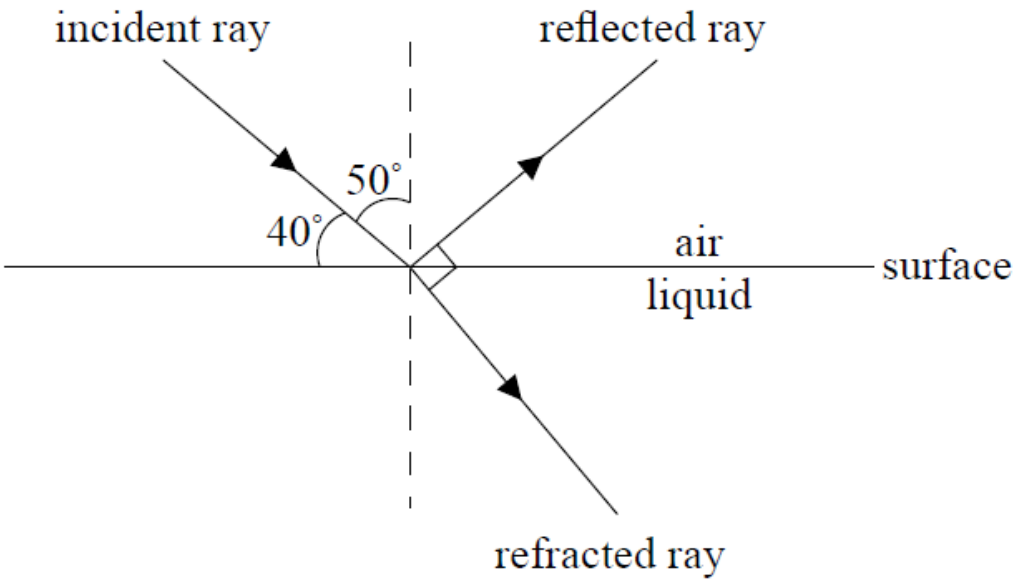
A

# Examiners report

[N/A]

---

A beam of unpolarized light is incident on the surface of a liquid and is partially reflected and partially refracted as shown below.




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

# Markscheme

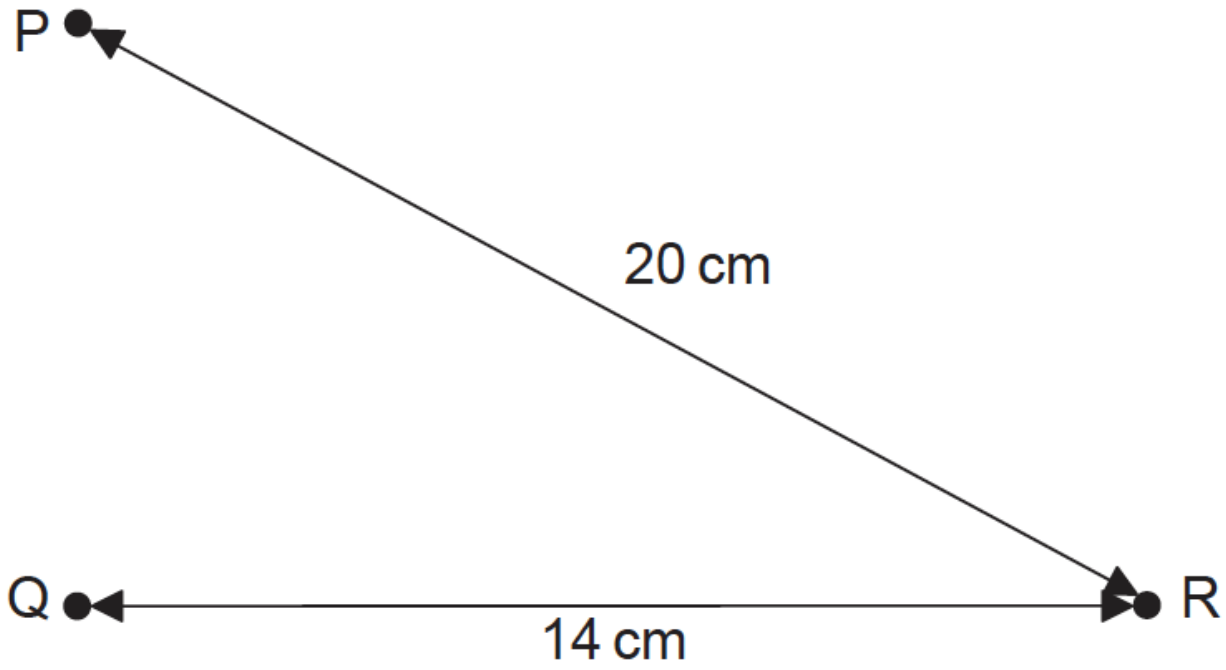
B

# Examiners report

The majority of the candidates got the answer to this question but an almost equal number thought that the refractive index was given by the ratio of sines in option C. This shows clearly that candidates thought they were dealing with Snell's law and not Brewster's law.

---

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




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

A. 0

B. *A*

C. $A^2$

D. 2*A*

# Markscheme

A

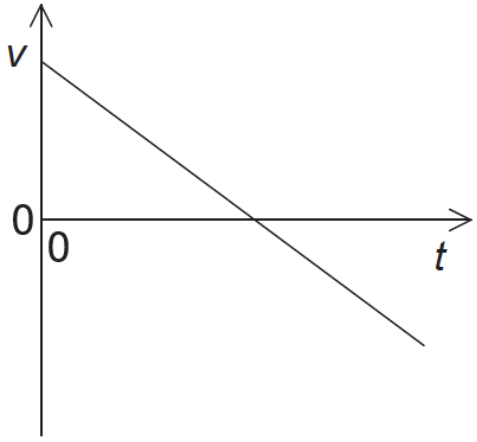
# Examiners report

[N/A]

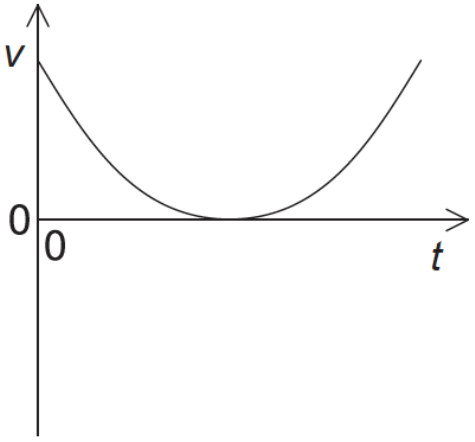
---

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

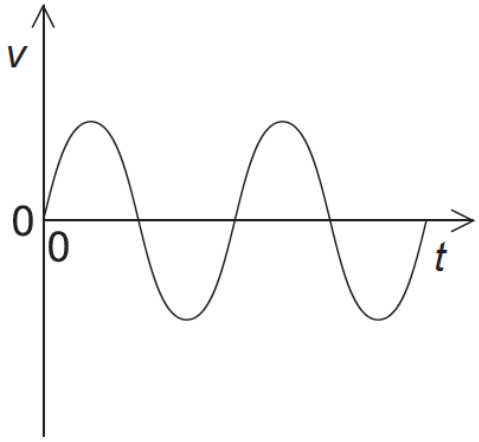
A.



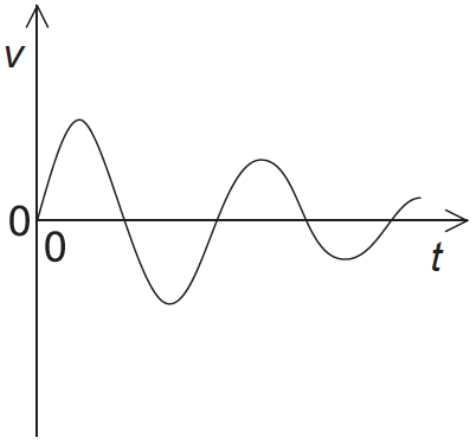

B.




C.




D.




# Markscheme

D

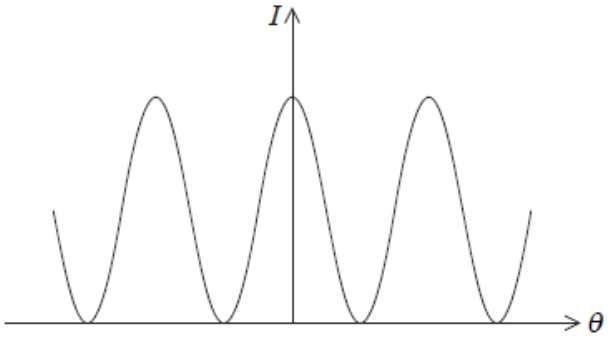
# Examiners report

[N/A]

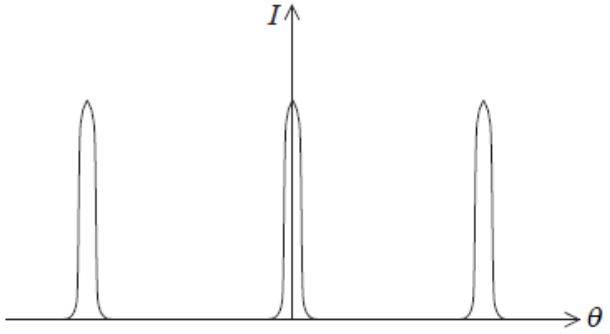
---

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 $\theta$?

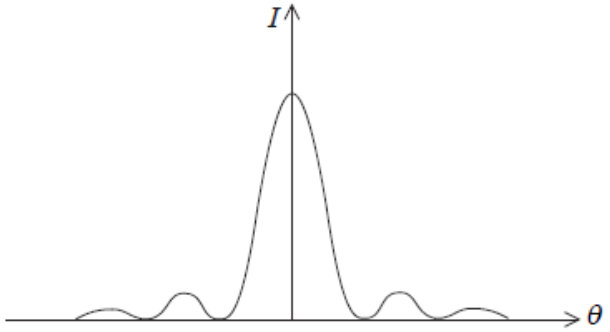
A.



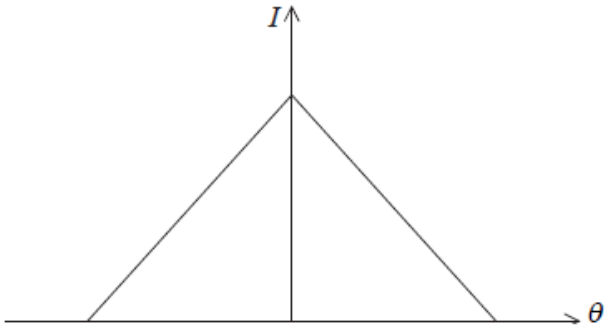

B.




C.




D.




# Markscheme

C

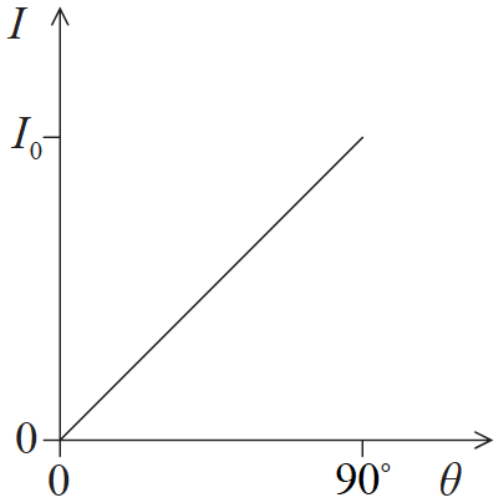
# Examiners report

[N/A]

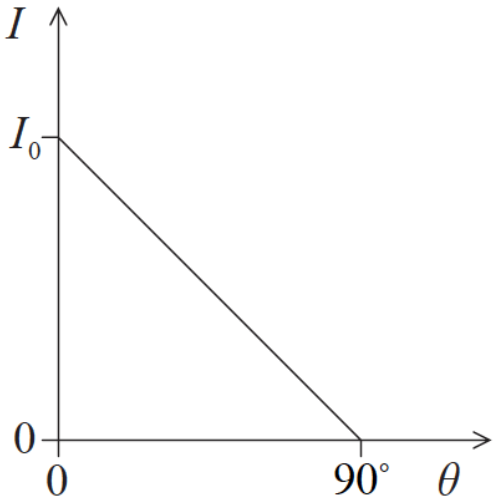
---

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 $\theta$. Which graph shows how the intensity $I$ of the light transmitted through the polarizer varies with $\theta$?

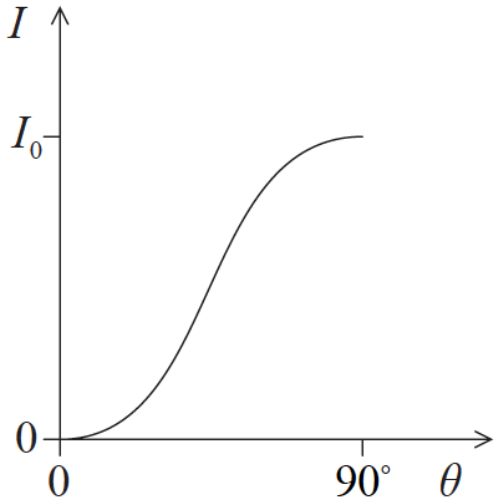
A.



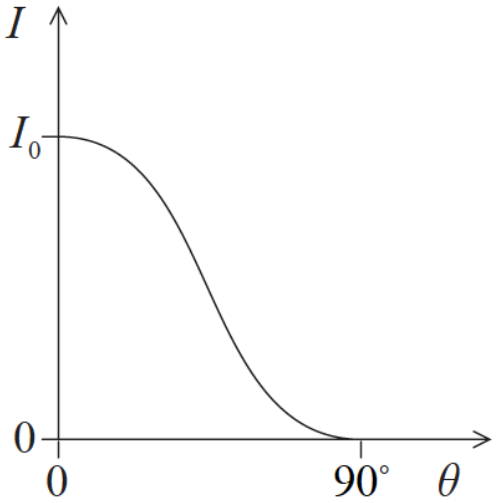

B.




C.




D.




# Markscheme

D

# Examiners report

[N/A]

---

Plane-polarized light is incident normally on a polarizer which is able to rotate in the plane perpendicular to the light as shown below.

**Diagram 1**

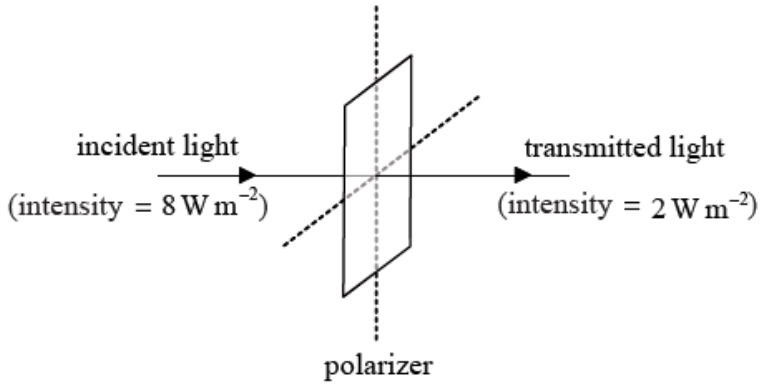
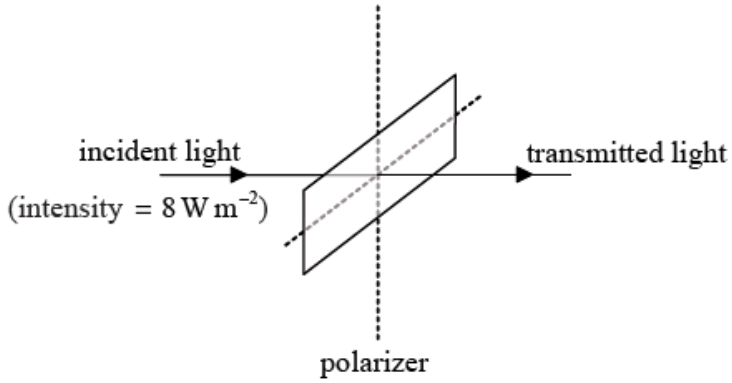



**Diagram 2**




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$^{-2}$

# Markscheme

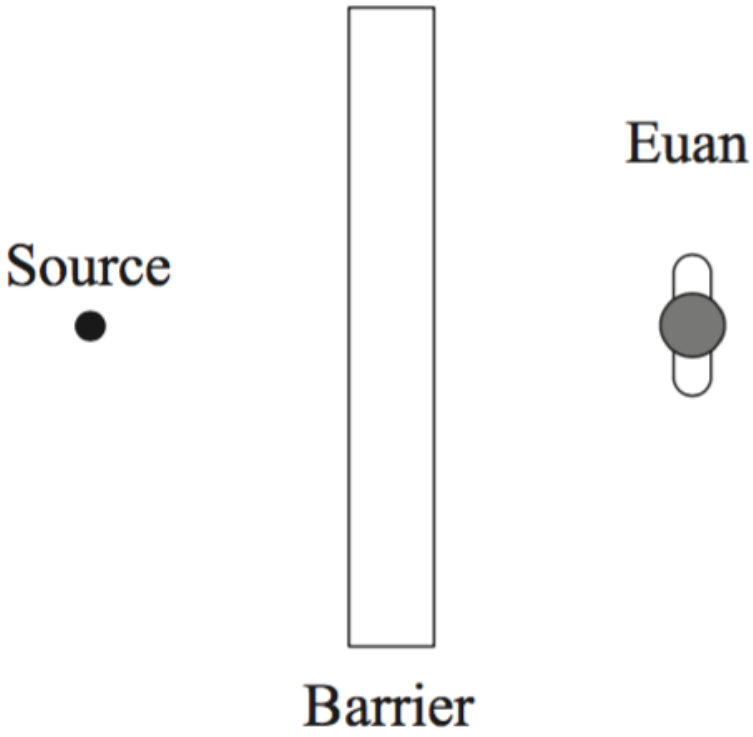
C

# Examiners report

[N/A]

---

A point source of sound is placed behind a soundproof barrier as shown in the diagram.




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

# Markscheme

A

# Examiners report

[N/A]

---

A string vibrates with fundamental frequency *f*. The wavelength of the sound produced in air is $\lambda$. 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?

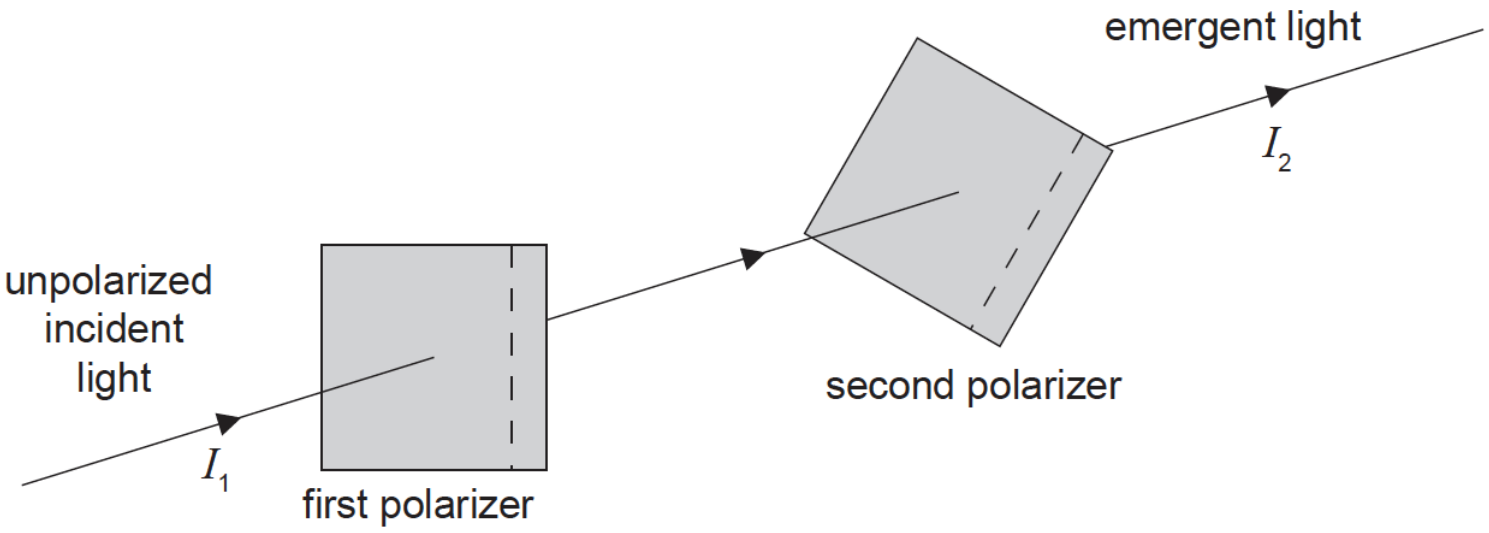
| | Frequency | Wavelength |
|---|---|---|
| A. | $\frac{f}{2}$ | $\frac{\lambda}{4}$ |
| B. | $4f$ | $4\lambda$ |
| C. | $\frac{f}{2}$ | $4\lambda$ |
| D. | $4f$ | $\frac{\lambda}{4}$ |

## Markscheme

D

## Examiners report

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




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

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

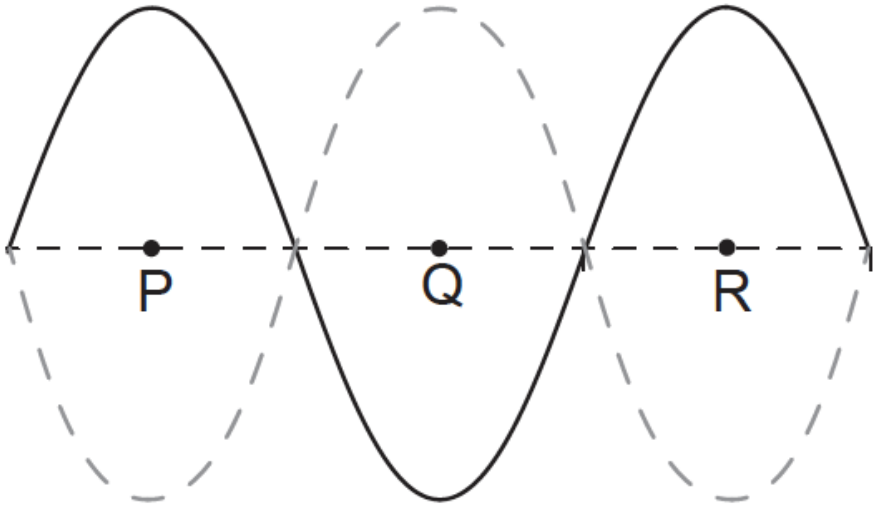
# Markscheme

D

# Examiners report

[N/A]

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




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

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

# Markscheme

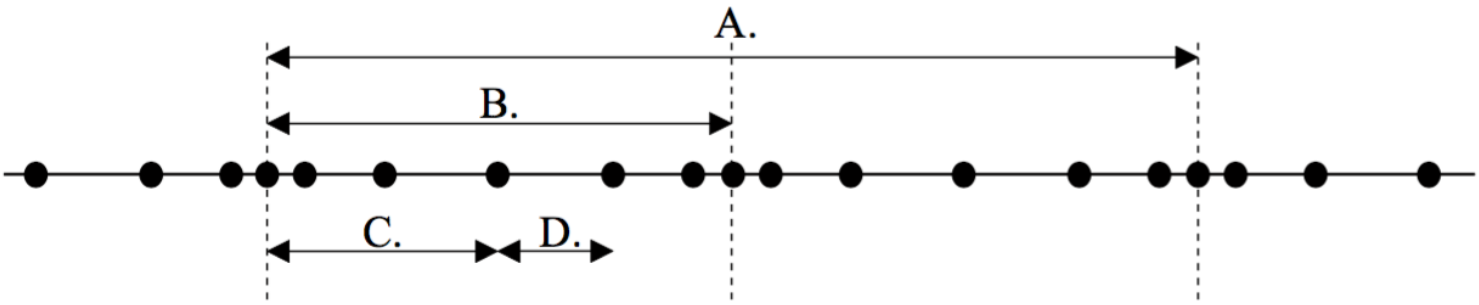
B

# Examiners report

[N/A]

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

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




# Markscheme

B

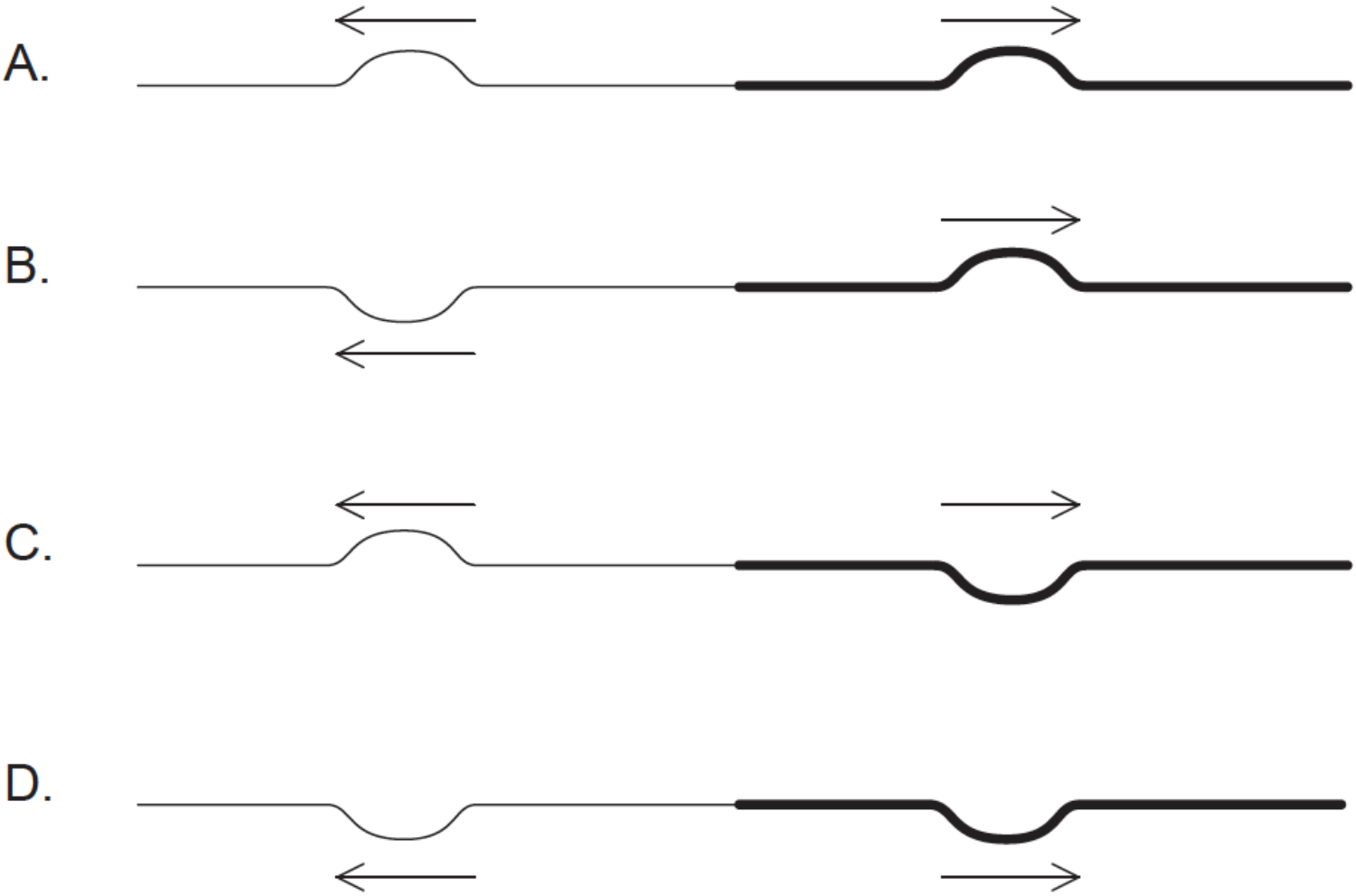
# Examiners report

[N/A]

---

A wave pulse is sent along a light string which is attached to a heavy rope as shown. The diagrams are not to scale.


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




# Markscheme

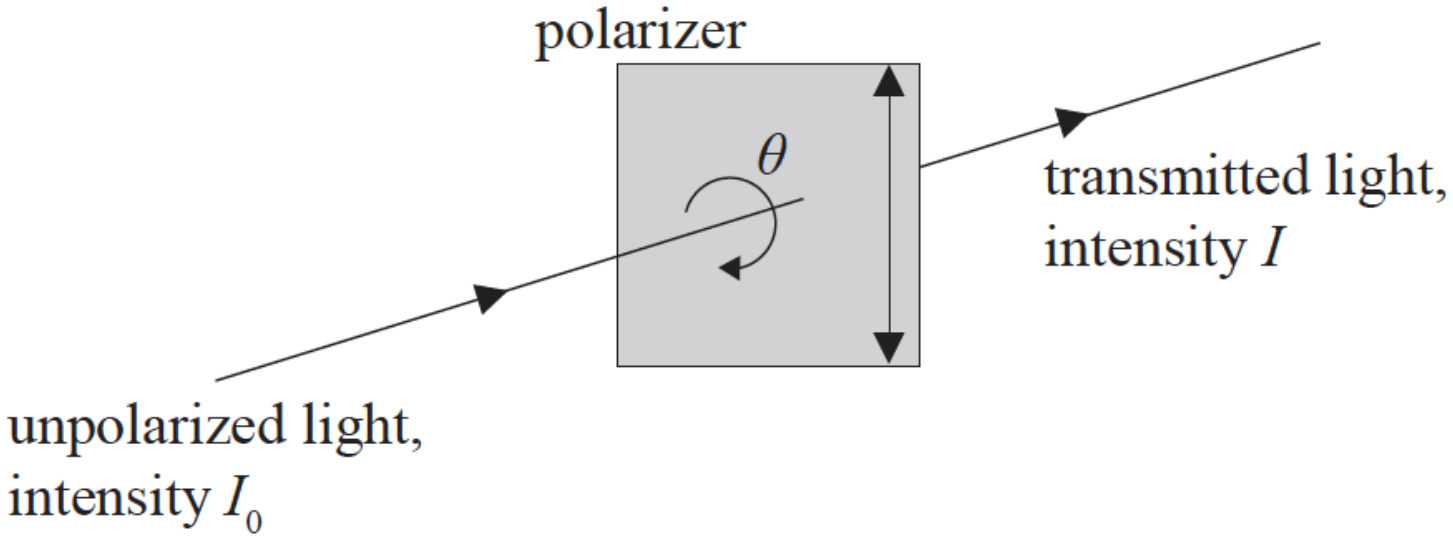
B

# Examiners report

[N/A]

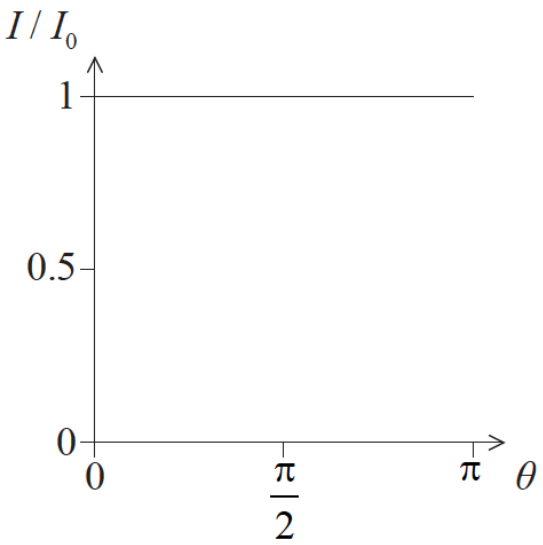
---

Unpolarized light of intensity $I_0$ is incident on a polarizer that has a vertical transmission axis.

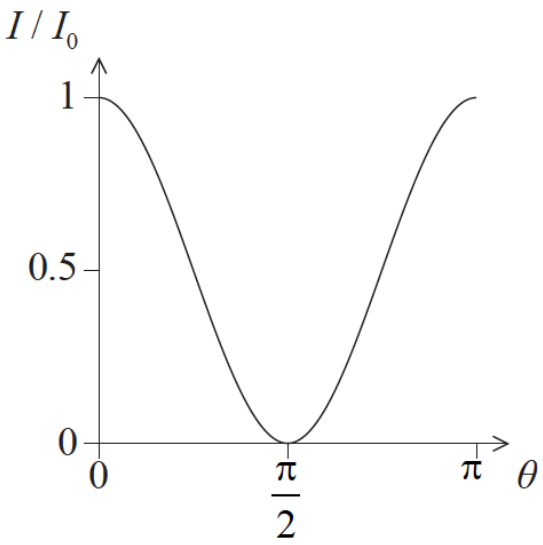



The polarizer is rotated by an angle $\theta$ about the direction of the incident light. The intensity of the transmitted light is $I$. Which graph correctly shows the variation with the angle $\theta$ of the ratio $\frac{I}{I_0}$?

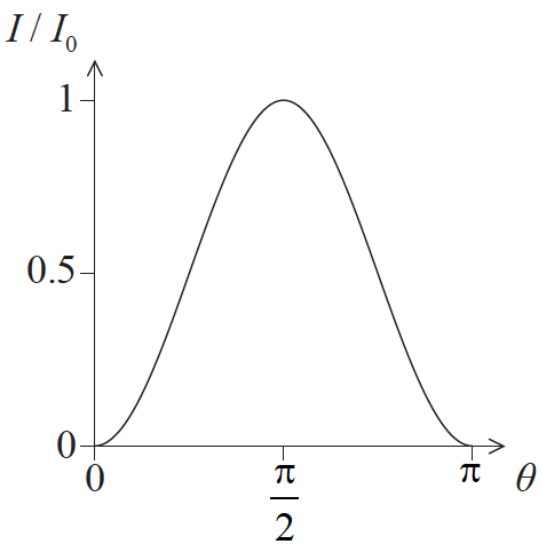
A.



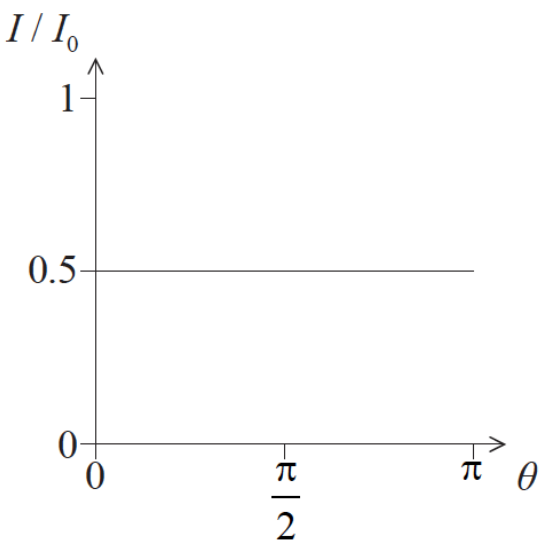

B.




C.




D.




# Markscheme

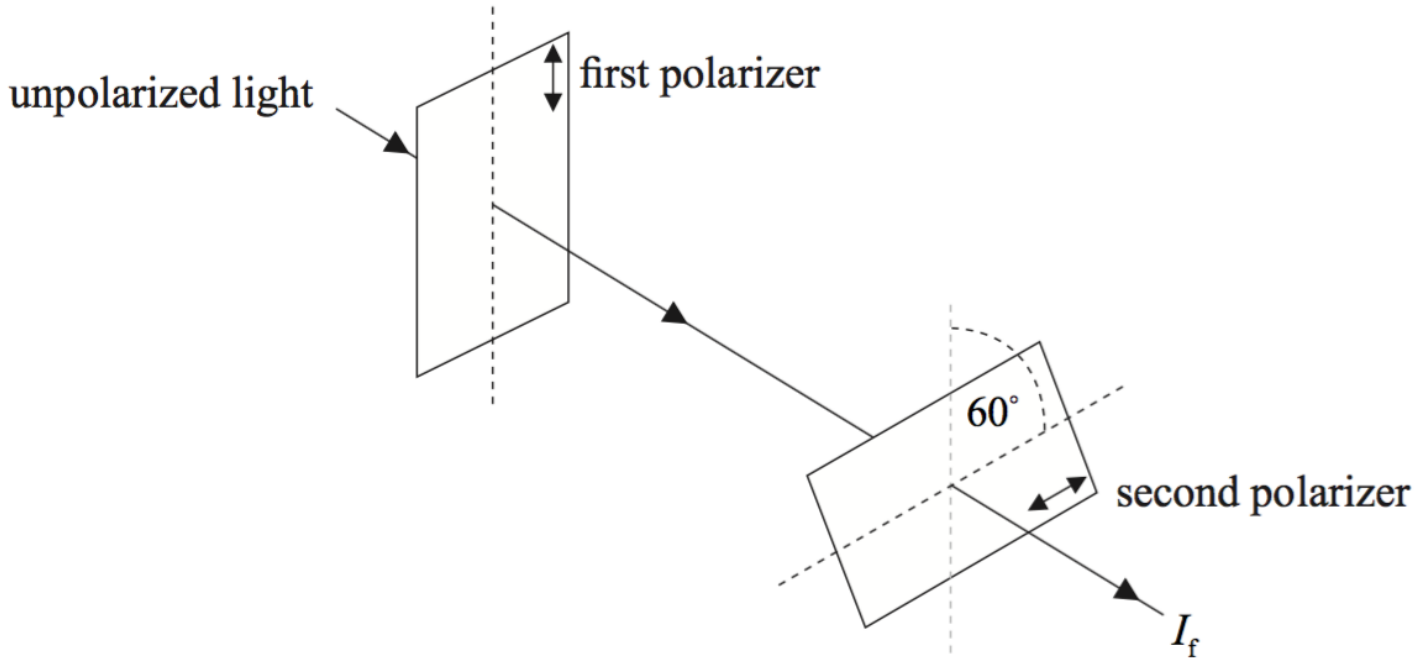
D

# Examiners report

It would seem that candidates had not read this question carefully and were trying to remember similar past questions. The incoming light is unpolarized, hence B and C must be incorrect. As the polarizer will reduce the intensity, A must also be incorrect.

---

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 60° to that of the first polarizer.




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. $8I_f$

# Markscheme

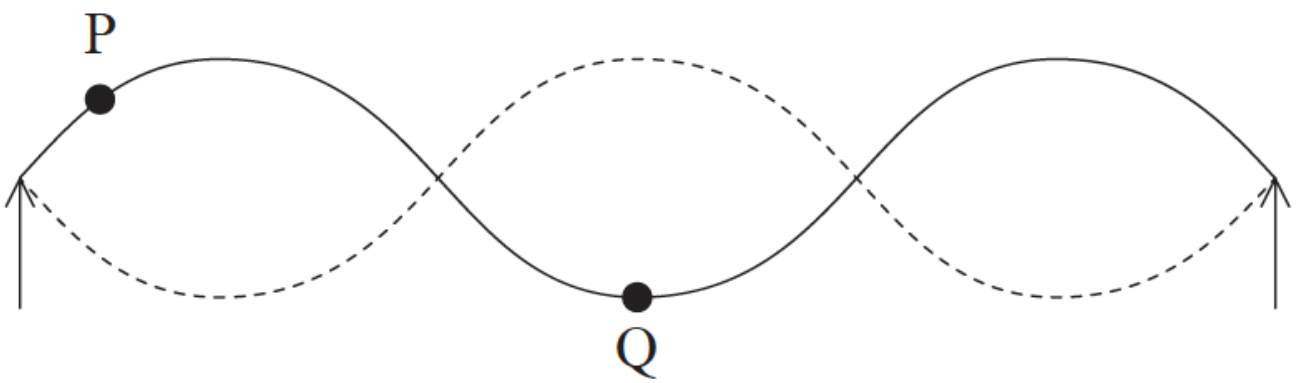
D

# Examiners report

It is reasonable to expect higher level physics candidates to know the value of cos30°, and if they do not, they can always sketch the relevant triangle. The evidence from the statistics, though, would suggest that the majority of candidates either omitted to factor in the effect of the light passing through the first polarizer, or that they thought the intensity was reduced by the factor cos60° (rather than $\cos^2 60°$) on passing through the second polarizer.

---

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




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

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

# Markscheme

B

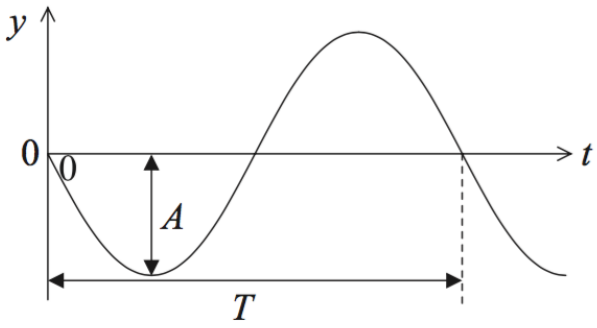
# Examiners report

[N/A]

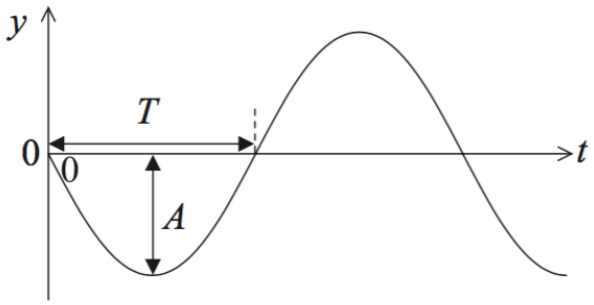
---

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?

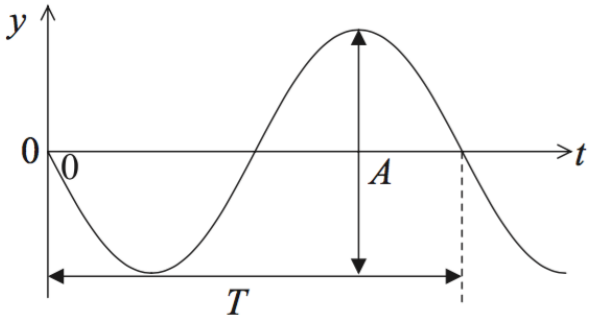
A.



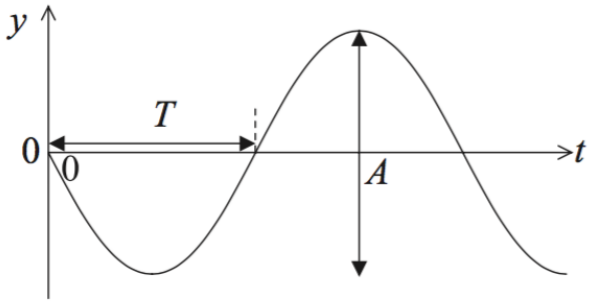

B.




C.




D.



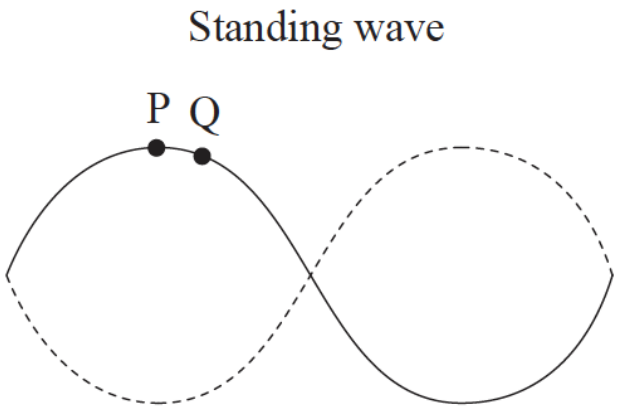

# Markscheme

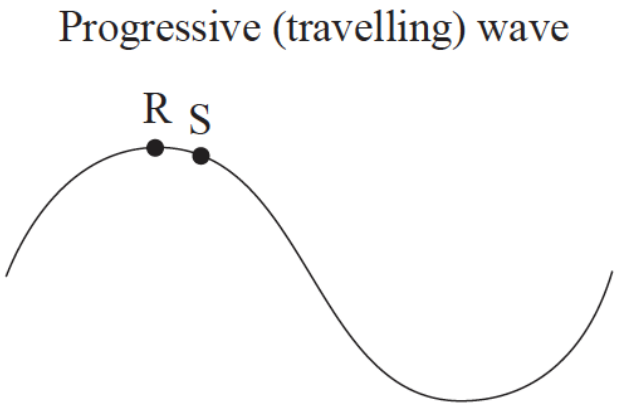
A

# Examiners report

---

P and Q are two points on a standing wave. R and S are two points on a progressive (travelling) wave.




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 |

# Markscheme

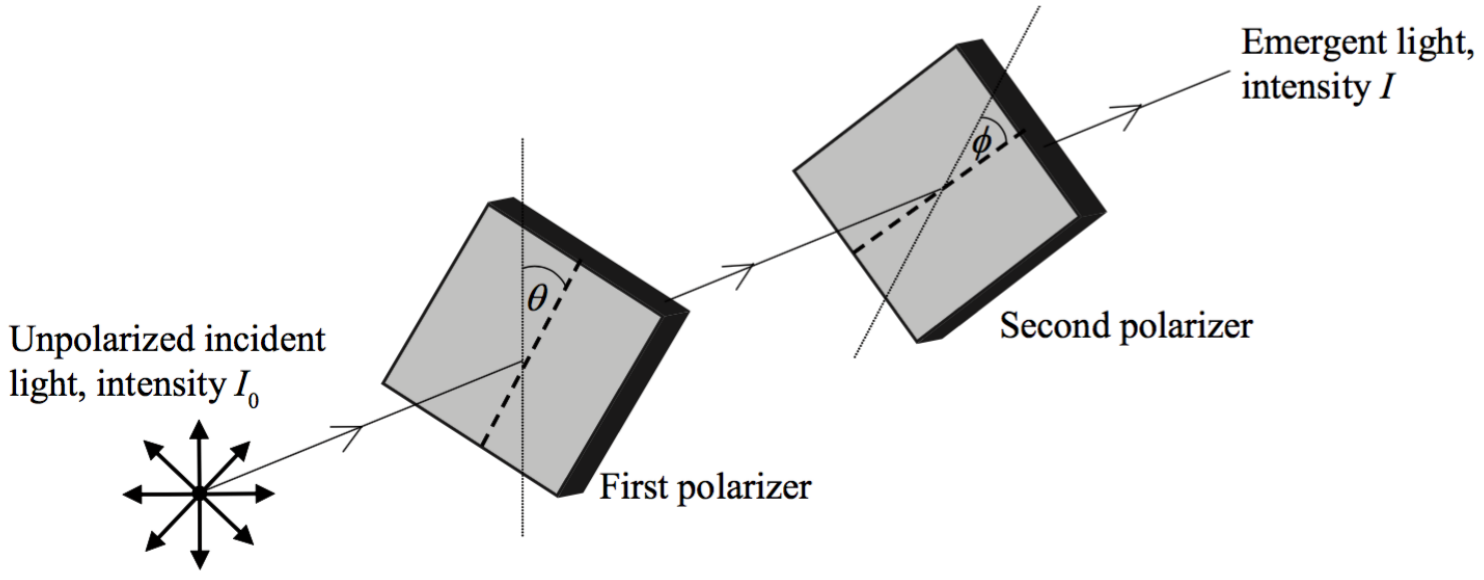
B

# Examiners report

Candidates often find this to be difficult. In a standing wave each particle has its own amplitude with that at the nodes being zero and that at the antinodes being a maximum. For a progressive wave all particles follow on from their neighbours and have the same amplitude.

---

Unpolarized light of intensity $I_0$ is transmitted through a polarizer which has a transmission axis at an angle $\theta$ to the vertical. The light is then incident on a second polarizer with a transmission axis at an angle $\phi$ to the transmission axis of the first polarizer, as shown below.



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 $\cos^2(\theta+\phi)$

C. 0.5 $\cos^2\phi$

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

# Markscheme

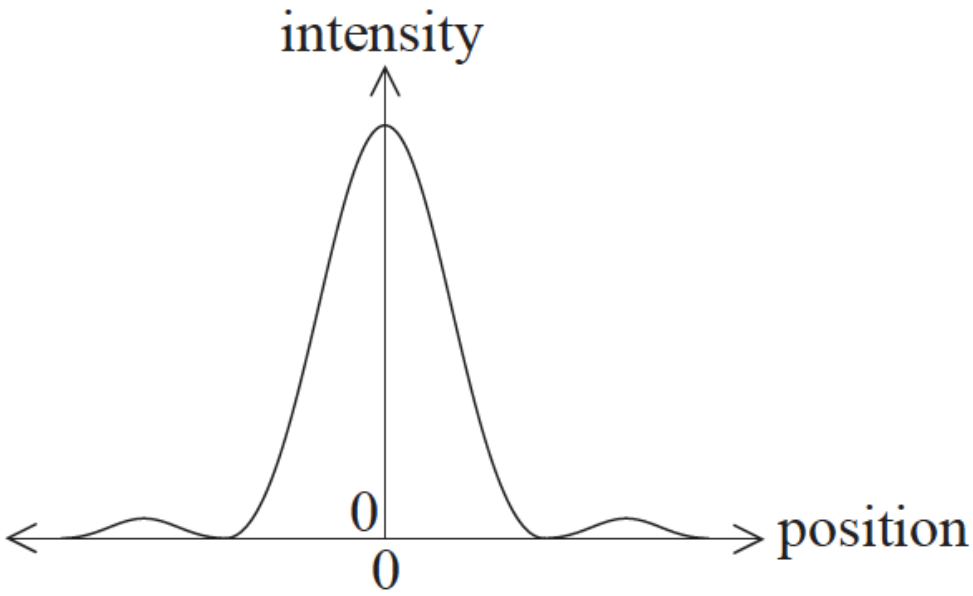
C

# Examiners report

When unpolarized light passes through a polarising filter its intensity halves. Clearly all angles of the polarising filter are logically equivalent and therefore immaterial. However, when polarized light passes through a polarizing filter its intensity is reduced depending upon the angle of the filter to the plane of polarization. Hence C is the only logically possible answer. The most popular response, however, was D, presumably since the candidates referred to their formula booklets before thinking through the situation illustrated.

---

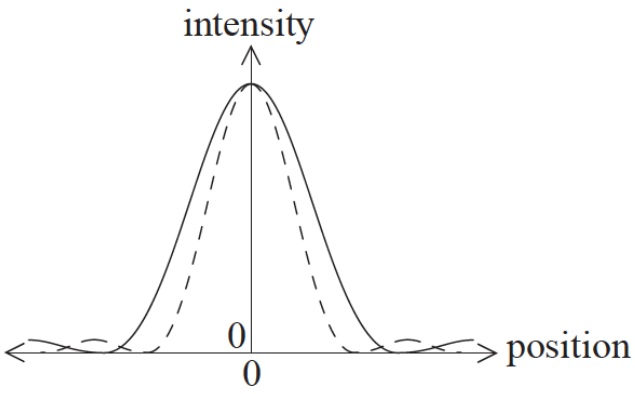
Monochromatic coherent light is incident on a narrow rectangular slit. The diffracted light is observed on a distant screen. The graph below shows how the intensity of the light varies with position on the screen.



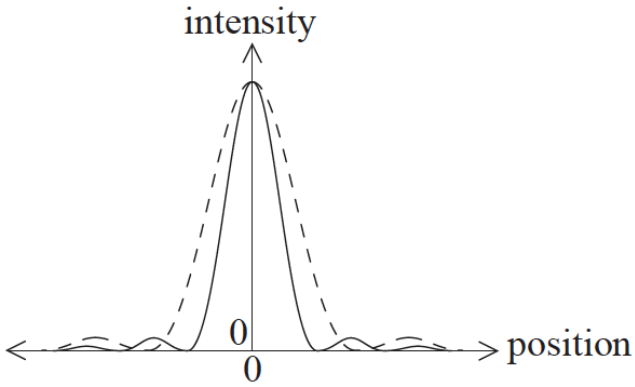

The width of the slit is reduced.

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

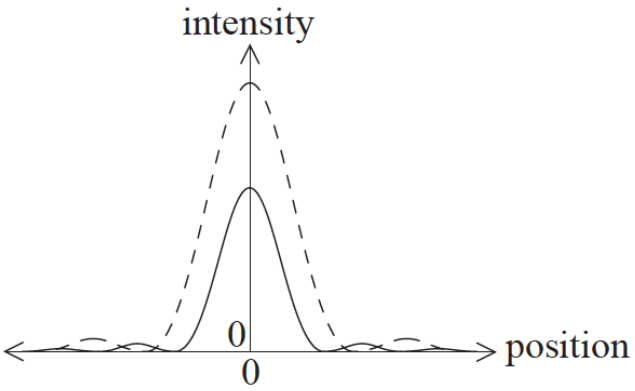
A.



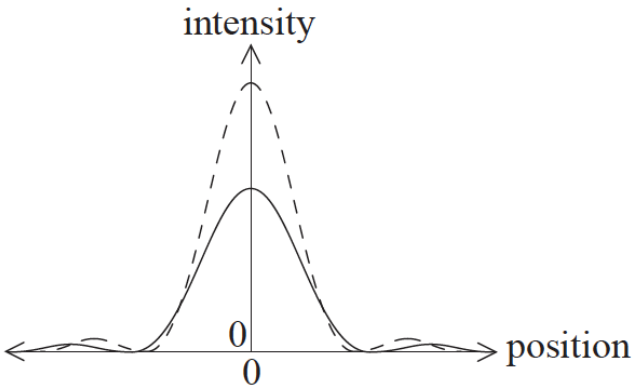

B.




C.




D.




# Markscheme

D

# Examiners report

70% of the candidates assumed the peak intensity does not change and opted for either A or B. But if the slit width is reduced then the energy transmitted (and hence peak intensity) will be reduced.