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

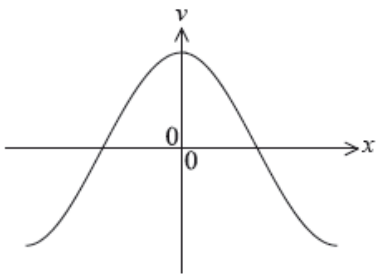
B. The maximum speed

C. The maximum acceleration

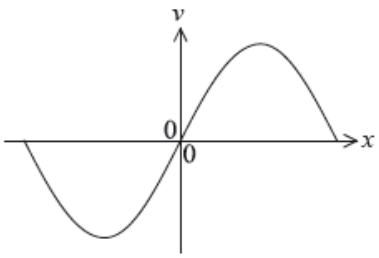
D. The period

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

A.



B.



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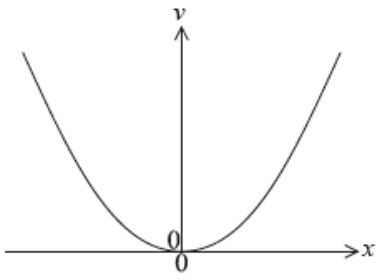
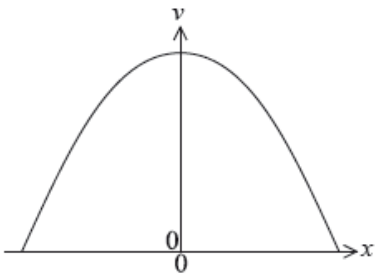


D.



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

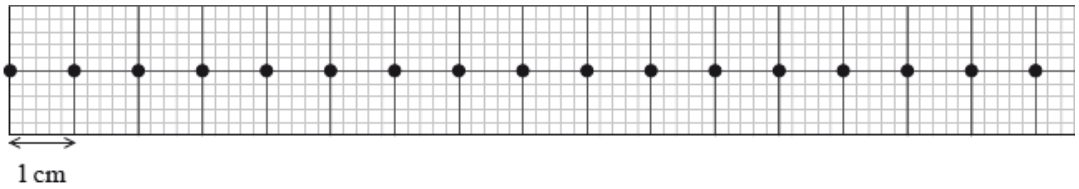
B. $\frac{\pi}{2}$

C. π

D. 2π

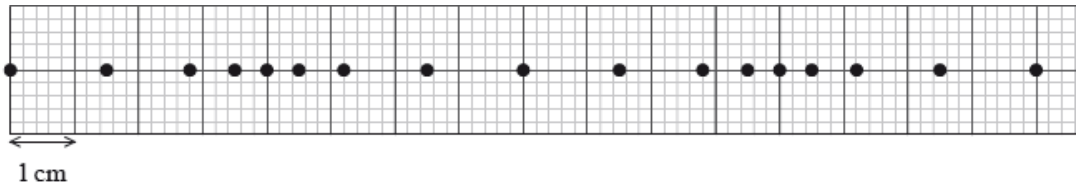
Diagram 1 represents equally spaced beads on a spring. The beads are 1 cm apart.

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

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.

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.

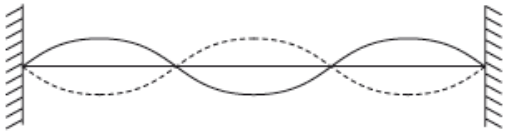
Properties of waves are

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

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?

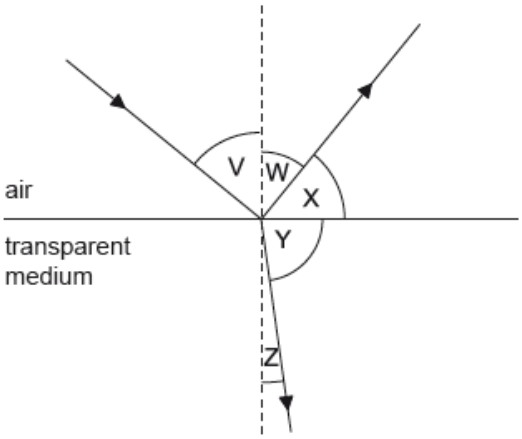
A. 2

B. 3

C. 7

D. 8

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°?

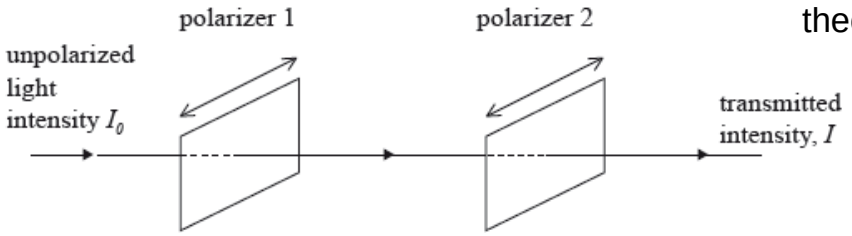
A. $\mathrm{V} + \mathrm{W}$

B. W only

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

D. Z only

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 %.

The phenomenon of diffraction is associated with

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

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?

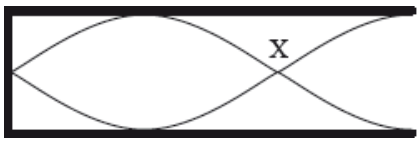
A. 250 Hz

B. 500 Hz

C. 1000 Hz

D. 2000 Hz

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



The air molecules near X are

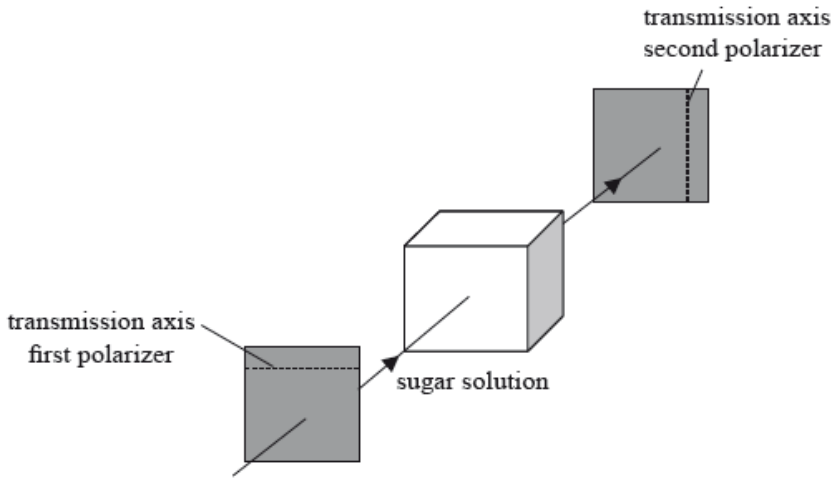
A. always at the centre of a compression.

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.

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

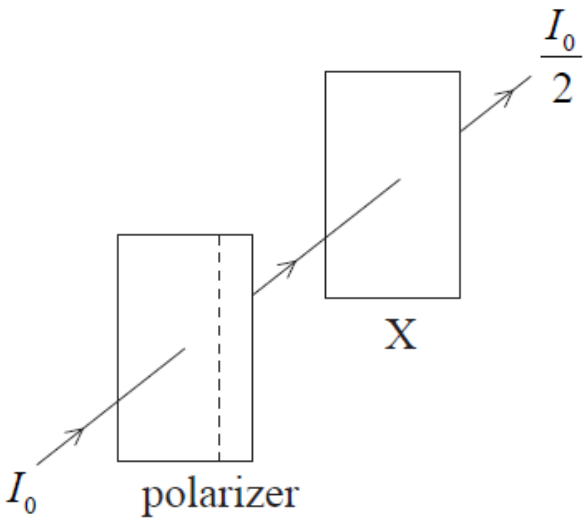
A. causes destructive interference.

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.

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

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. $4f$

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. $8A_0$

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

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*?

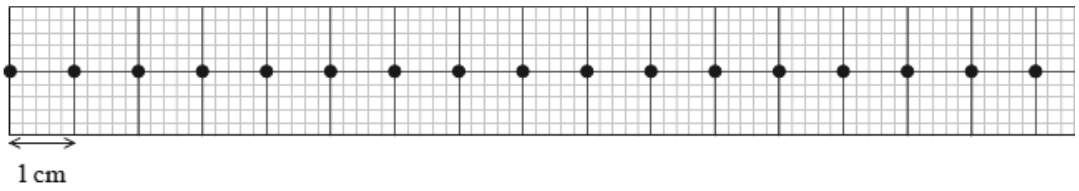
A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 2

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

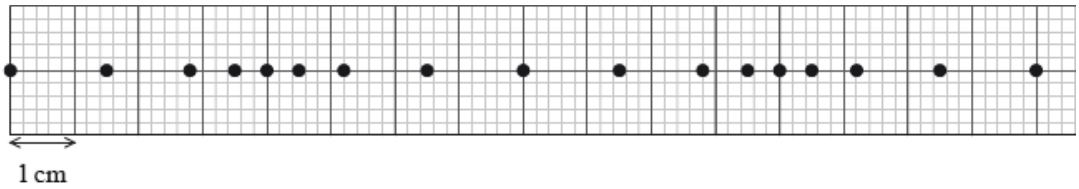
Diagram 1 represents equally spaced beads on a spring. The beads are 1 cm apart.

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

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. 2*nf*

D. (2*n* + 1)*f*

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 λ_1 and the slit width is b_1. In the bottom diagram the wavelength of light is λ_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. $\lambda_1 > \lambda_2$

An optically active substance is a substance that

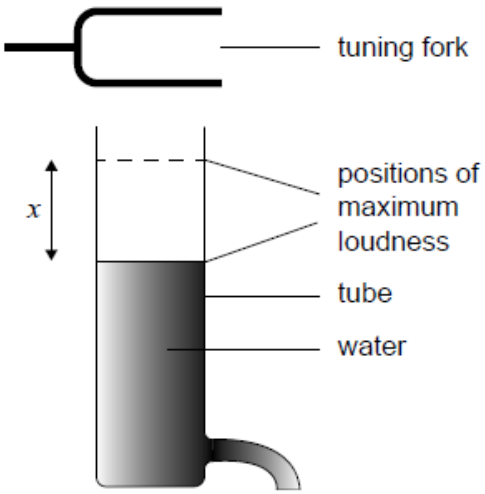
A. has a refractive index that depends on the plane of polarization of incident light.

B. completely absorbs incident unpolarized light.

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

D. polarizes unpolarized light.

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*

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

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?

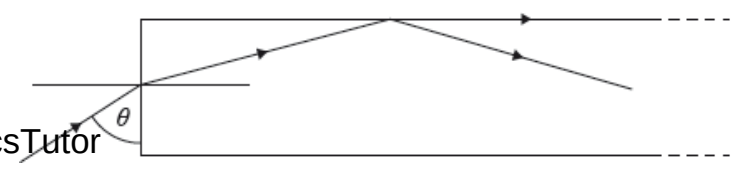
A. Much less than 0.25 m

B. Between 0.10 m and 0.40 m

C. Equal to 0.25 m

D. Much greater than 0.25 m

A ray of light passes from the air into a long glass plate of refractive index *n* at an angle θ 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 θ will cause the ray to travel entirely within the plate after incidence?

	Change to n	Change to θ
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

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 $1.5l$ and closed at one end?

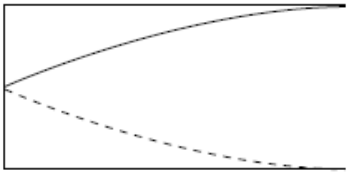
A. $\frac{f}{3}$

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

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

D. $3f$

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. $3f$

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

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?

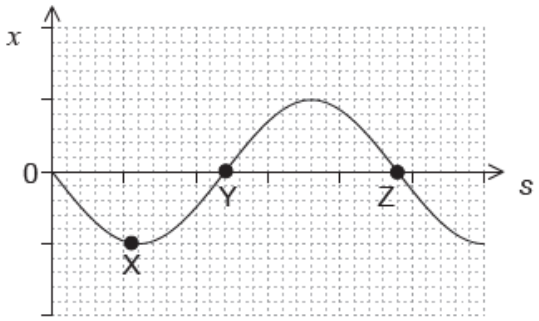
A.

B.

C.

D.

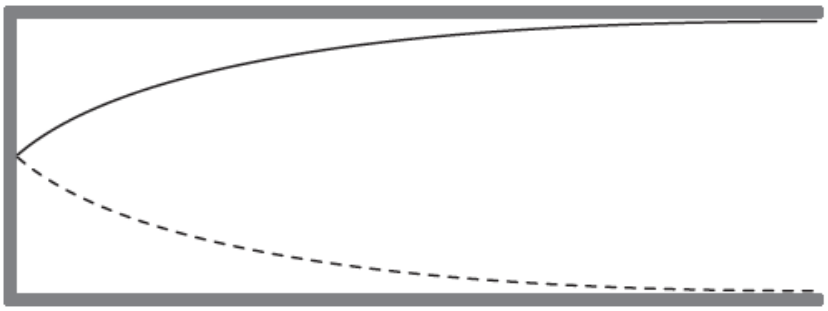
The graph shows the variation with position *s* of the displacement *x* of a wave undergoing simple harmonic motion (SHM).



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

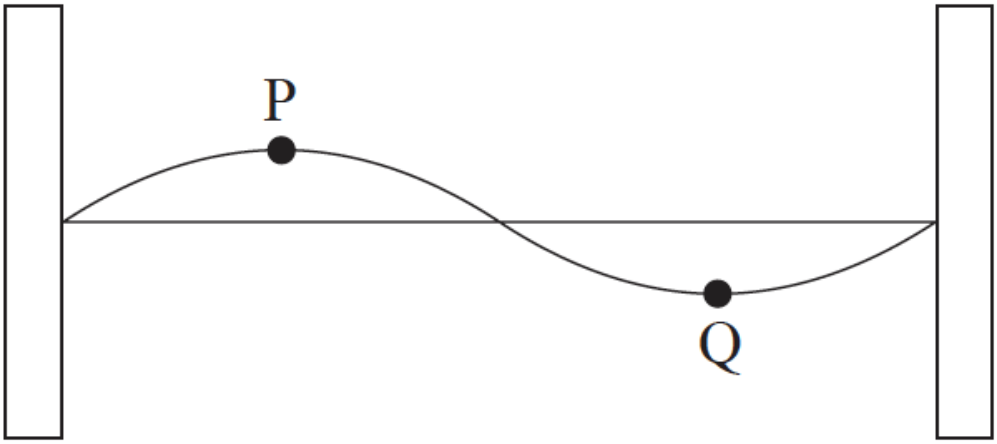
The diagram shows the fundamental (first harmonic) of a standing (stationary) sound wave in a pipe open at one end.



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

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

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?

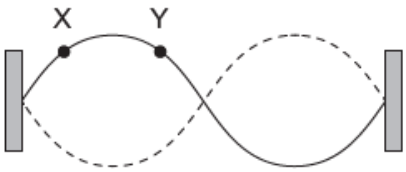
A. zero

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

C. π

D. 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?

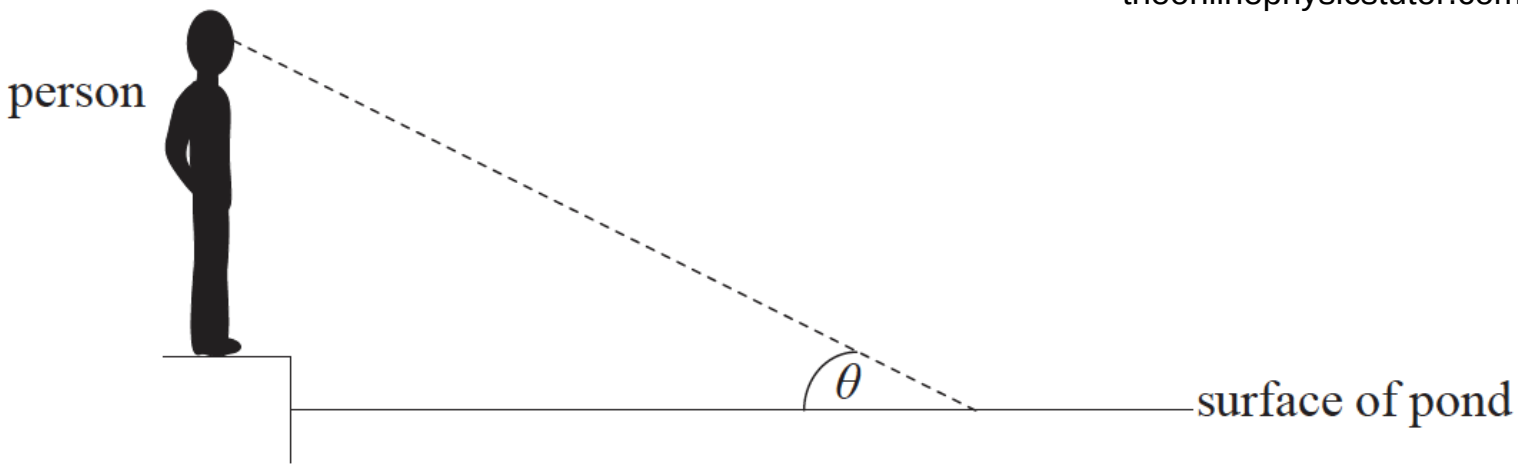
A. 0

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

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

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

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

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

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

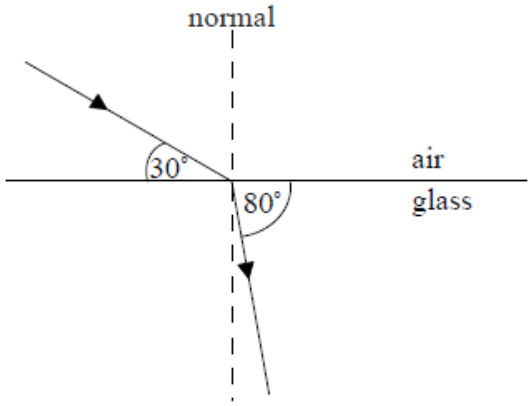
C. $\cos^{-1}(n)$

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

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

Light travels from air into glass as shown below.



The refractive index of the glass is

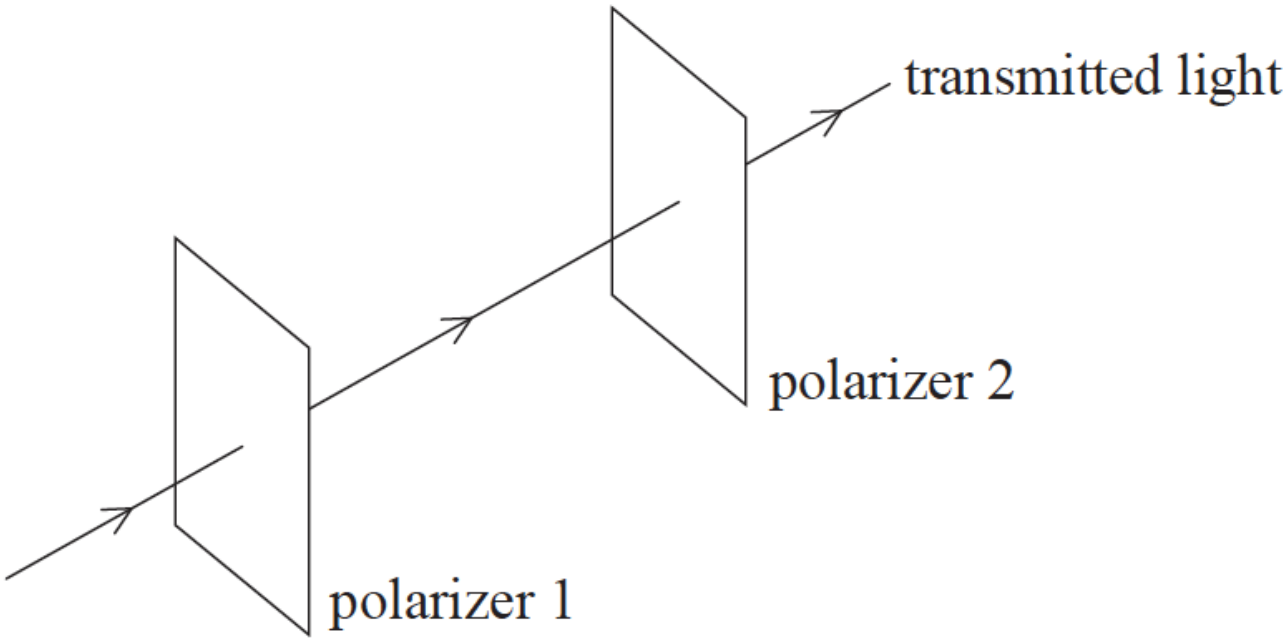
A. $\frac{\sin 30^\circ}{\sin 80^\circ}$

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

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

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

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

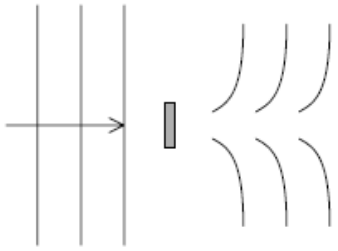


Through which angle should polarizer 2 be rotated so that no light is transmitted?

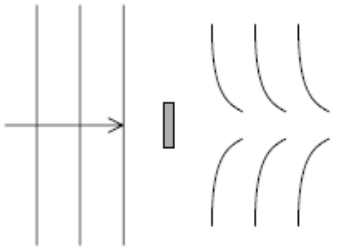
A. 45 °
B. 60 °
C. 90 °
D. 180°

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

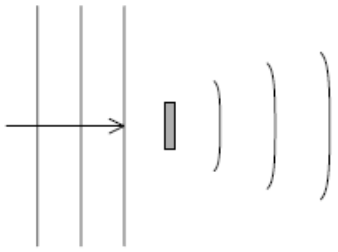
A.



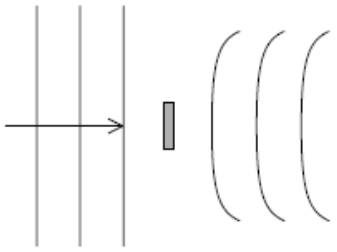
B.



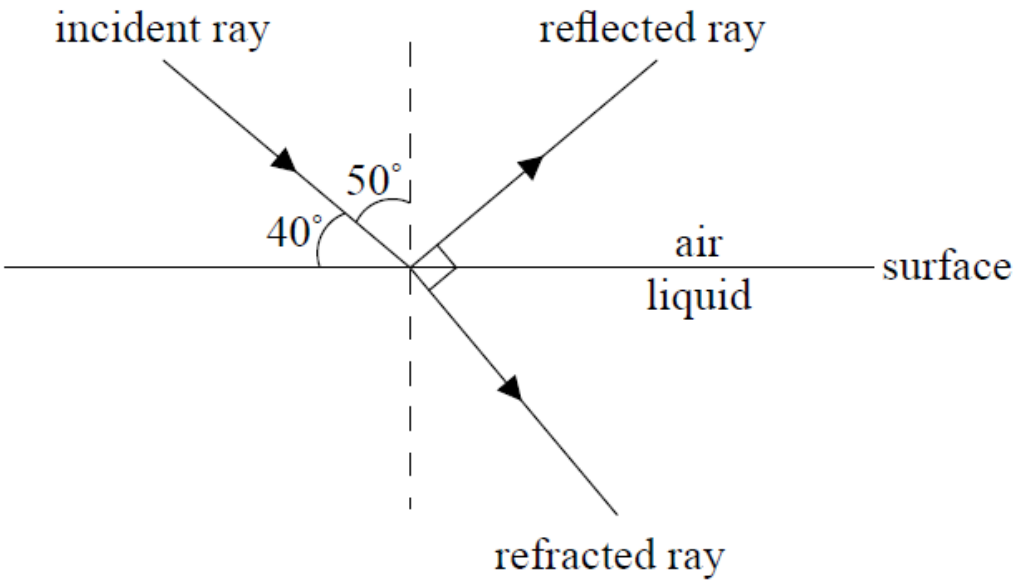
C.



D.



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?

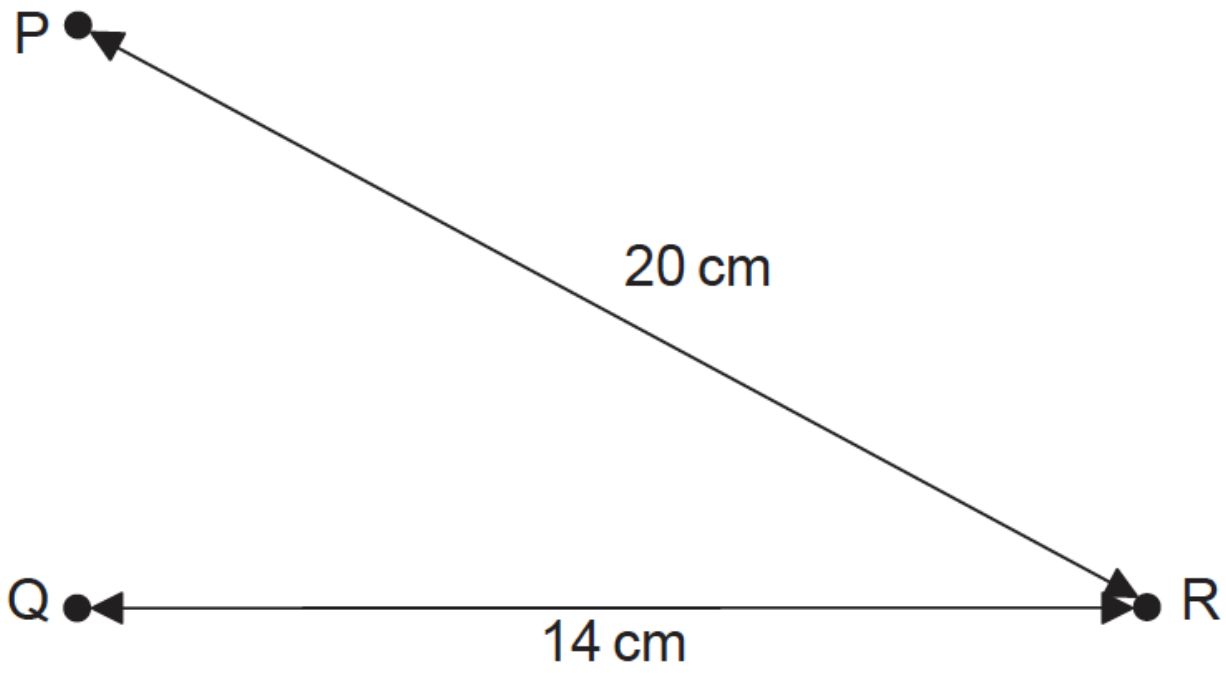
A. tan 40°

B. tan 50°

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

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

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

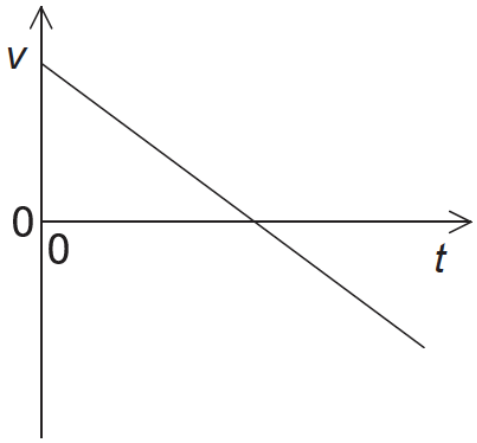
B. *A*

C. A^2

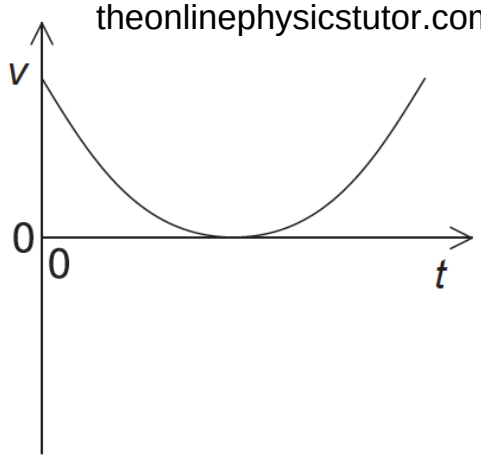
D. 2*A*

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?

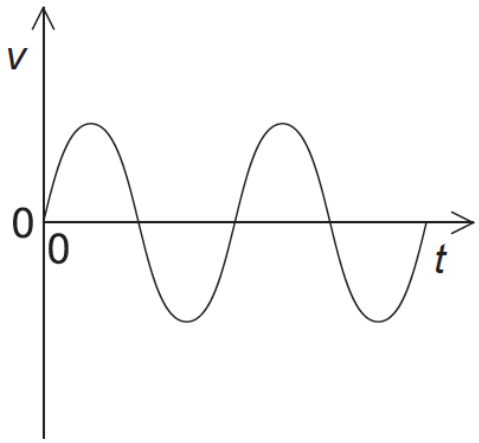
A.



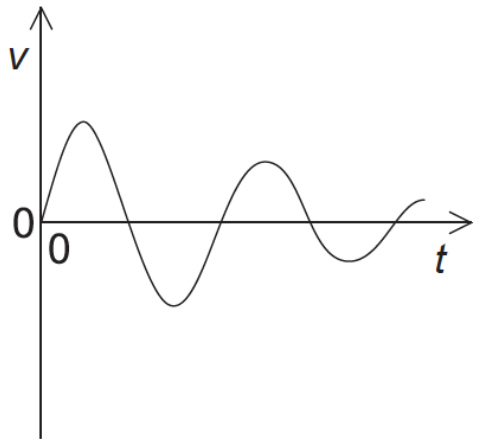
B.



C.

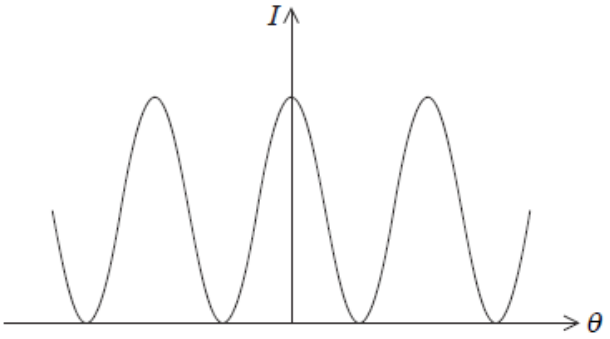


D.

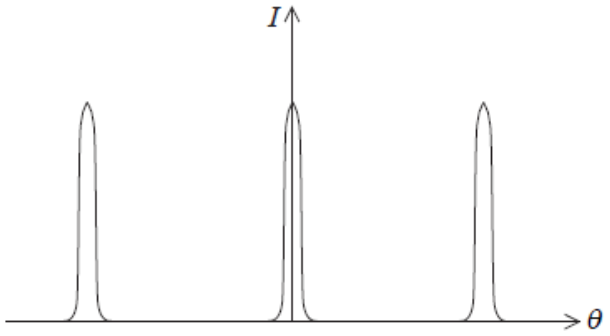


Light is diffracted at a single slit. Which of the following graphs best represents how the intensity I of the diffracted light varies with the diffraction angle θ?

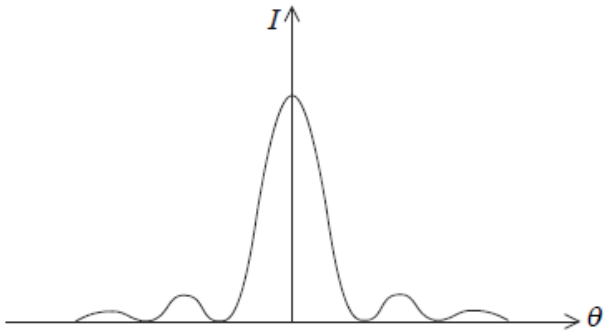
A.



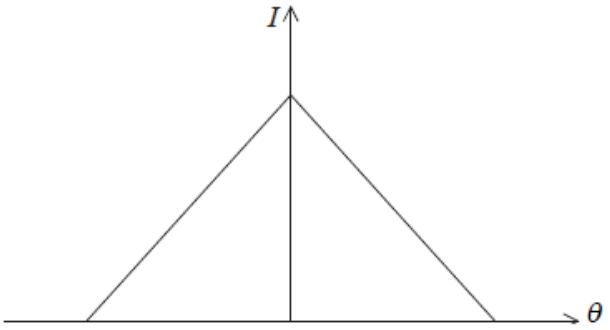
B.



C.

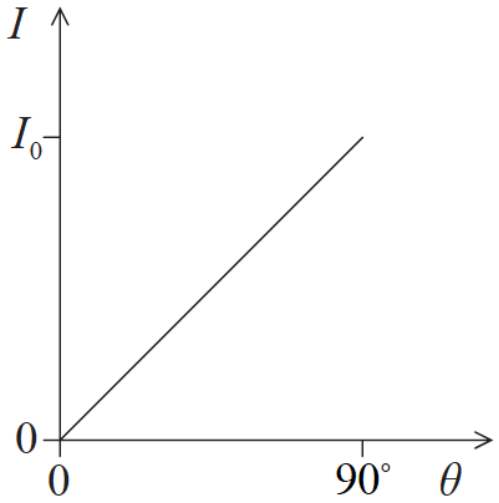


D.

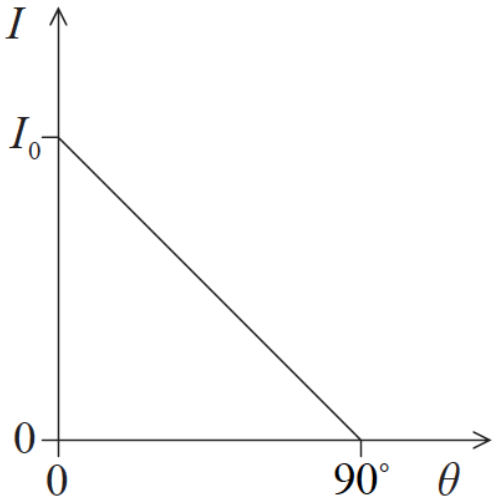


Polarized light of intensity I_0 is incident on a polarizing filter. The angle between the plane of polarization of the incident light and the transmission plane of the polarizer is θ. Which graph shows how the intensity I of the light transmitted through the polarizer varies with θ?

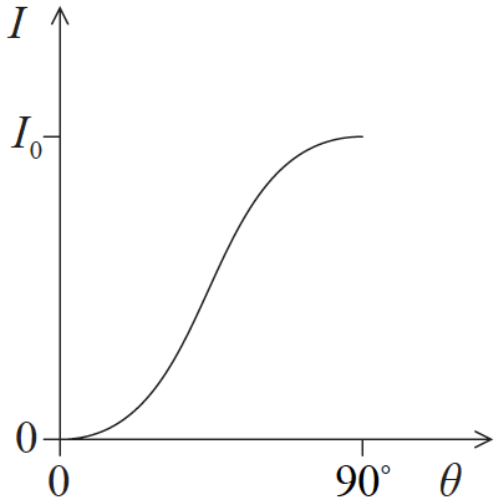
A.



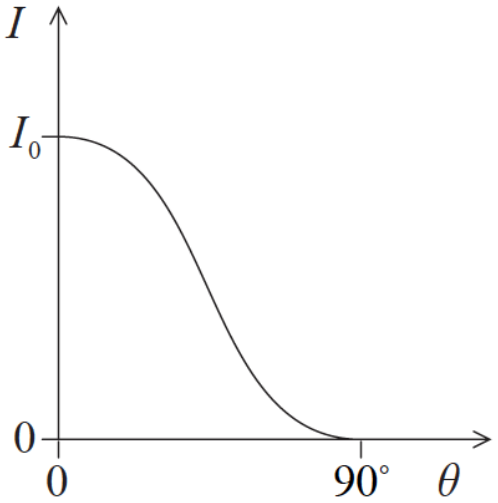
B.



C.



D.



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

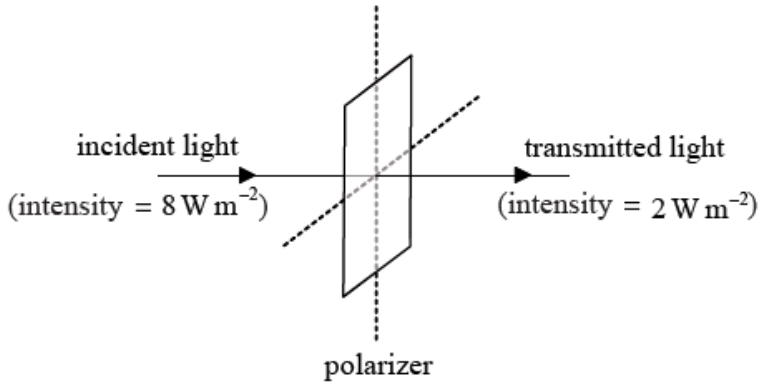
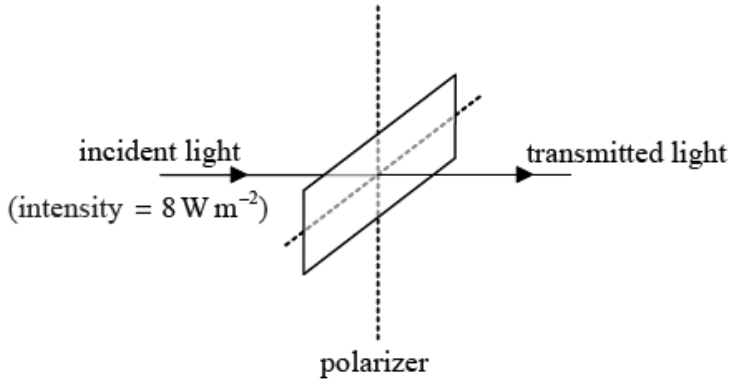


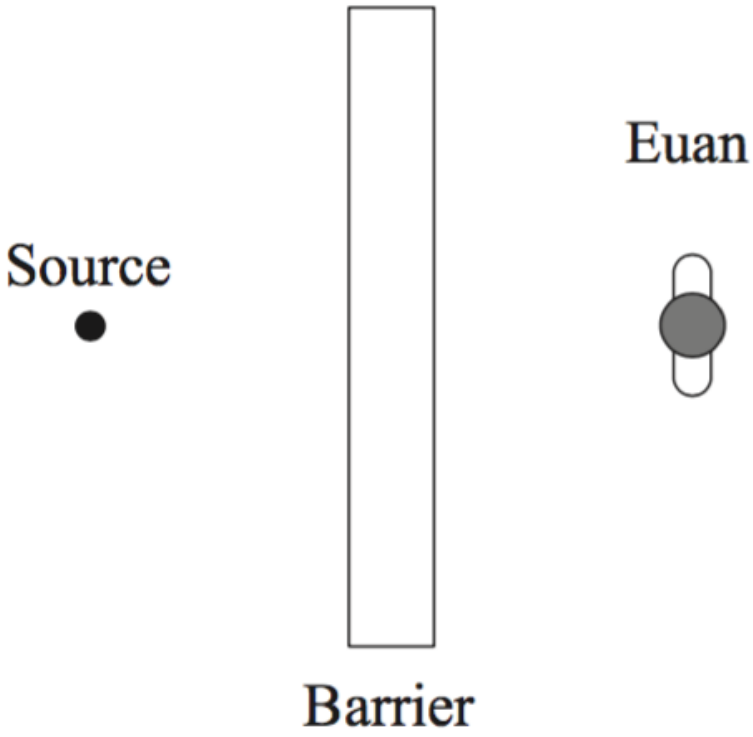
Diagram 2



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}

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



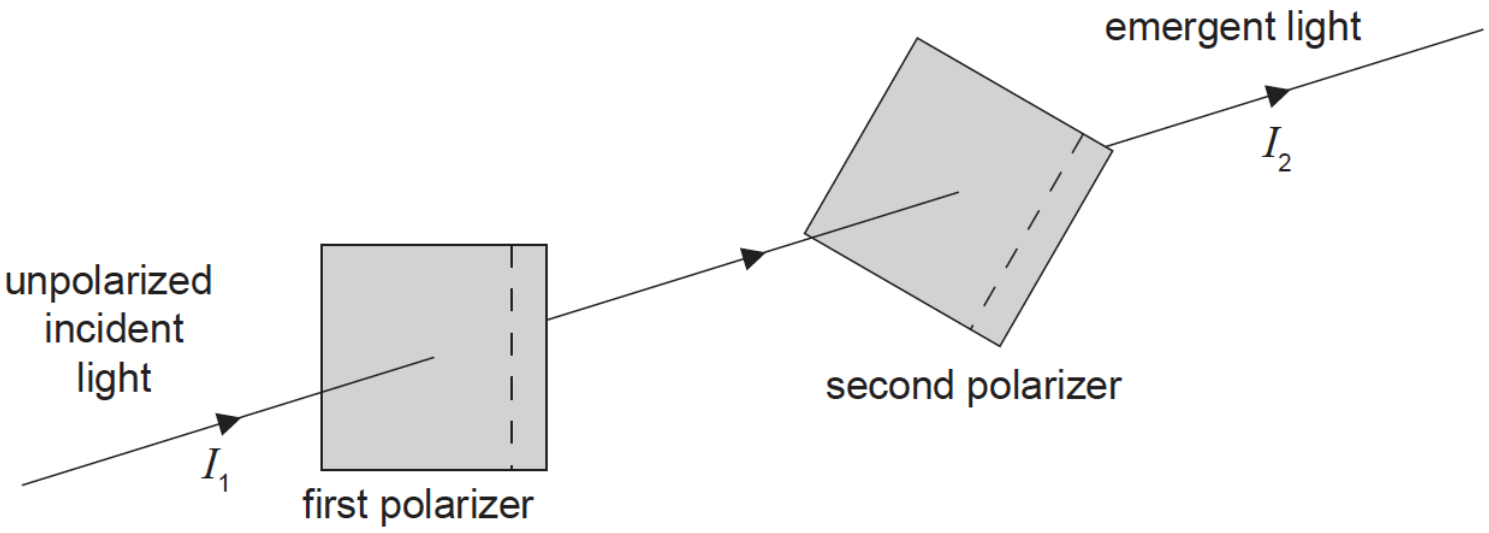
From where Euan is standing he can hear the sound. Which of the following best explains this observation?

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

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

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

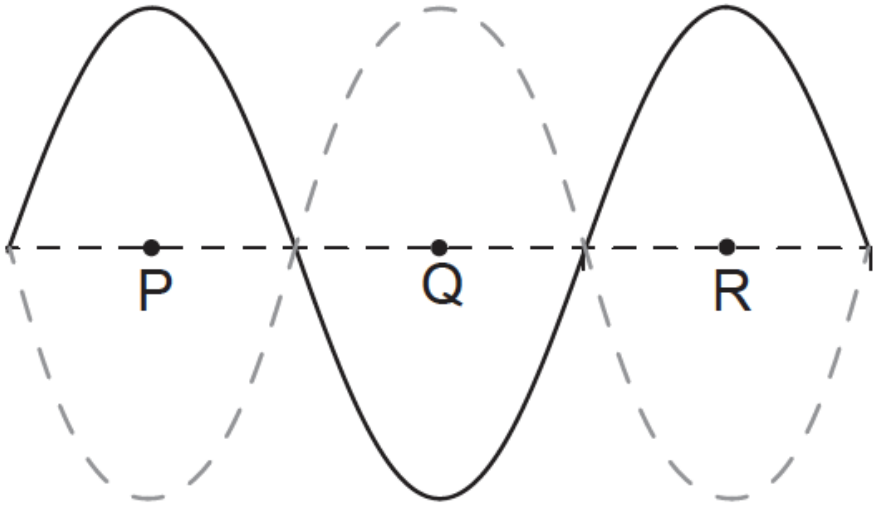
Two polarizers have polarizing axes that make an angle of 30° to each other. Unpolarized light of intensity I_1 is incident on the first polarizer so that light of intensity I_2 emerges from the second polarizer, as shown below.



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. $\frac{8}{3}$

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.

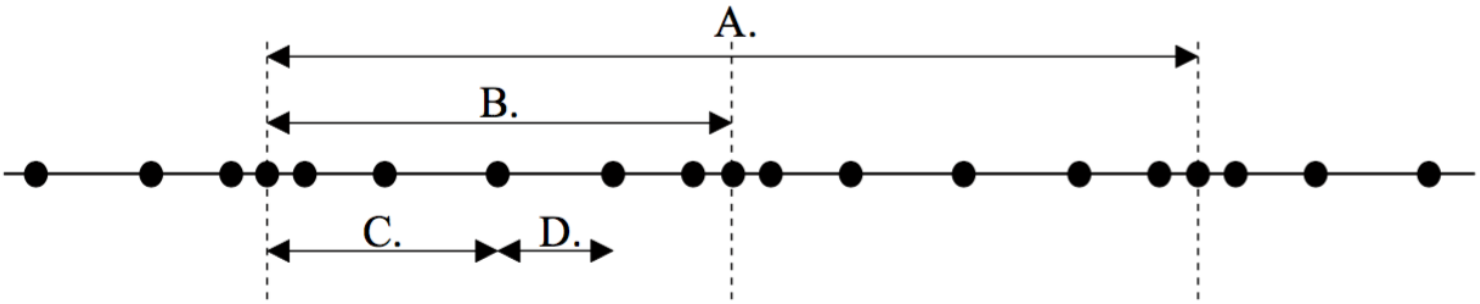


Which of the following gives two points on the string that are in phase and two points on the string that are one wavelength apart?

	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

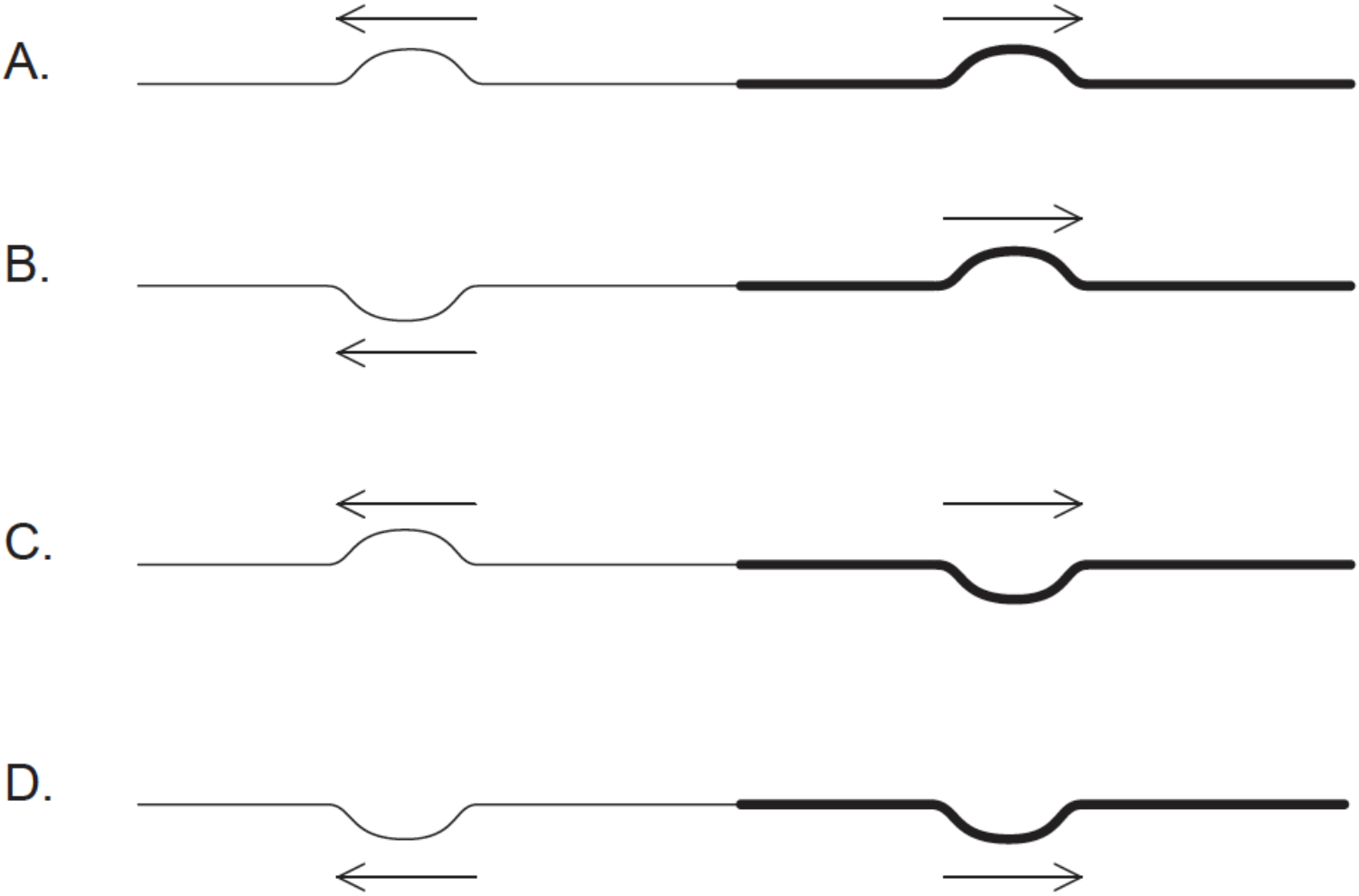
Gas particles are equally spaced along a straight line. A sound wave passes through the gas. The positions of the gas particles at one instant are shown below.

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

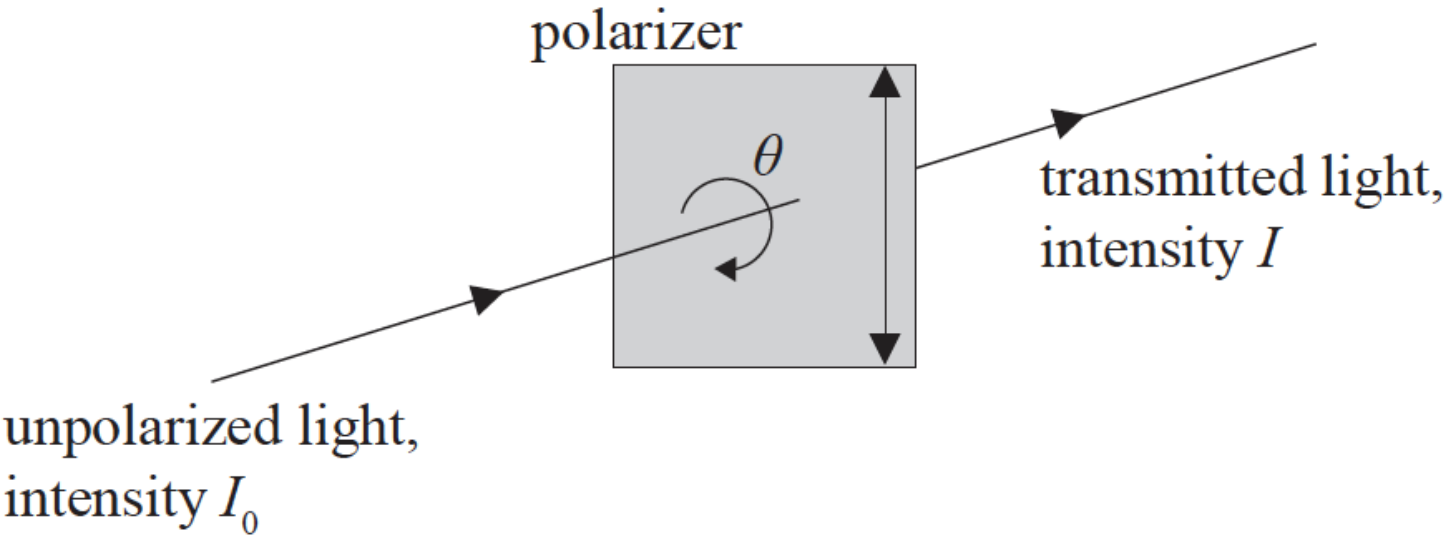


A wave pulse is sent along a light string which is attached to a heavy rope as shown. The diagrams are not to scale.

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

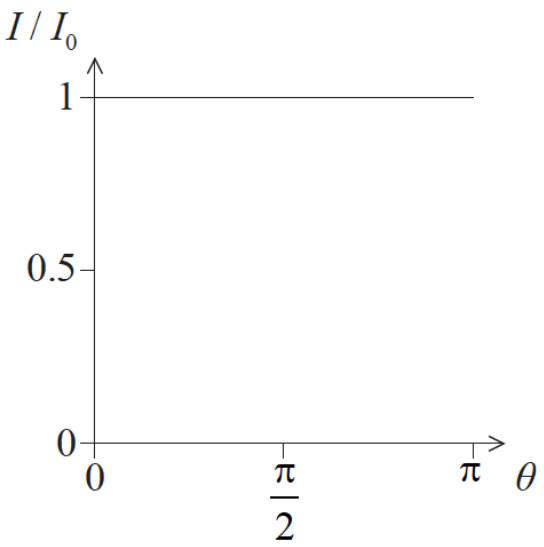


Unpolarized light of intensity I_0 is incident on a polarizer that has a vertical transmission axis.

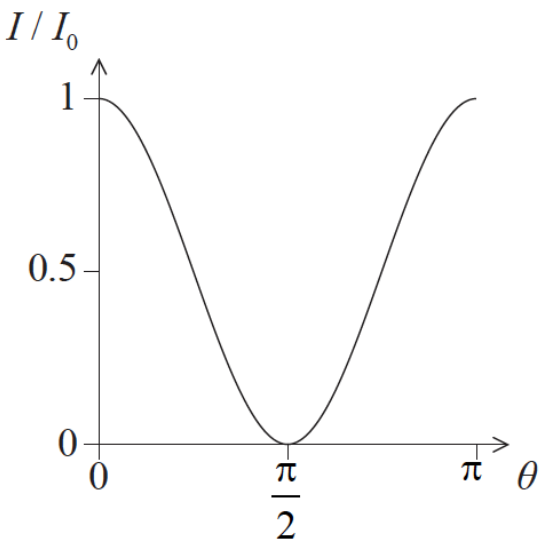


The polarizer is rotated by an angle θ about the direction of the incident light. The intensity of the transmitted light is I. Which graph correctly shows the variation with the angle θ of the ratio $\frac{I}{I_0}$?

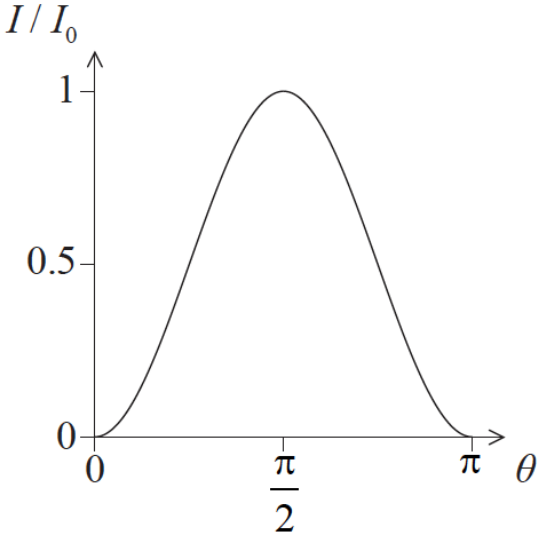
A.



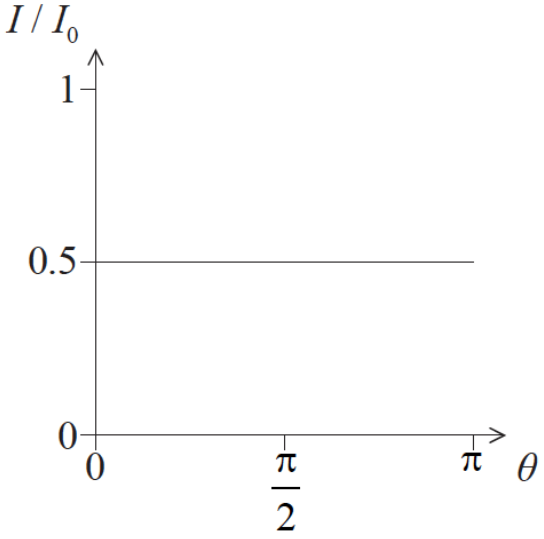
B.



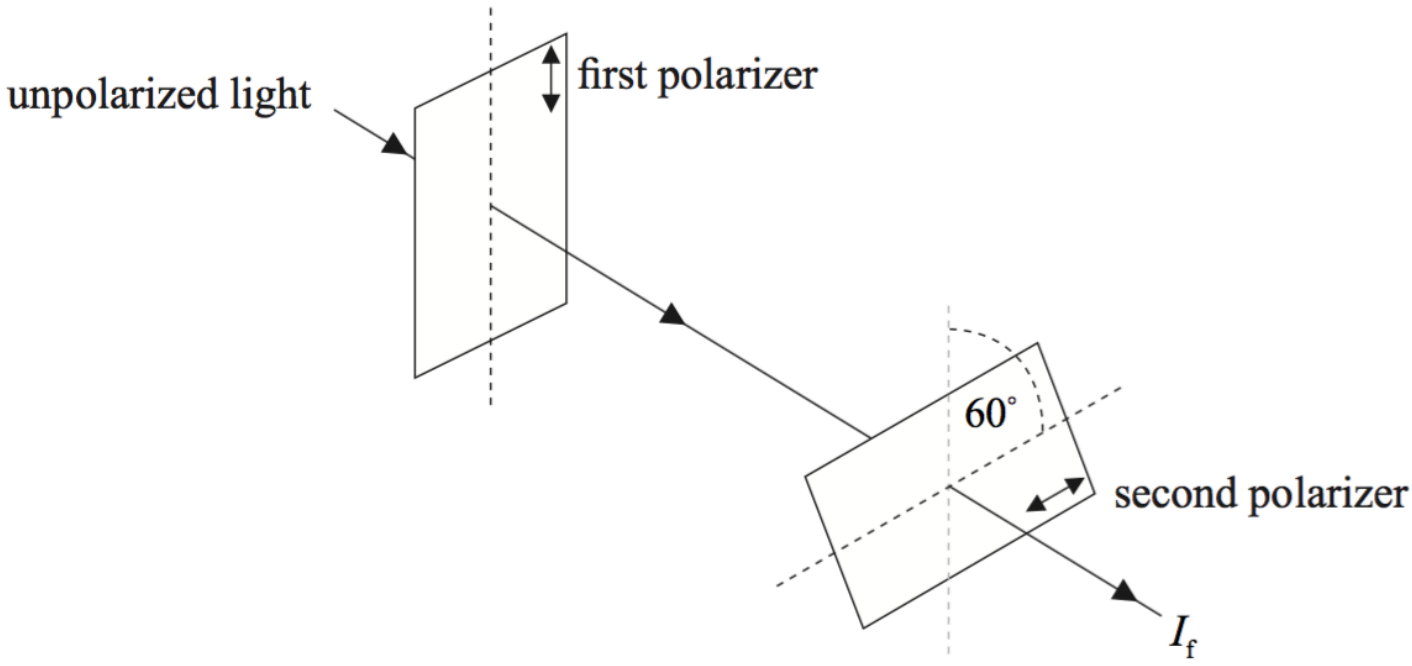
C.



D.



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?

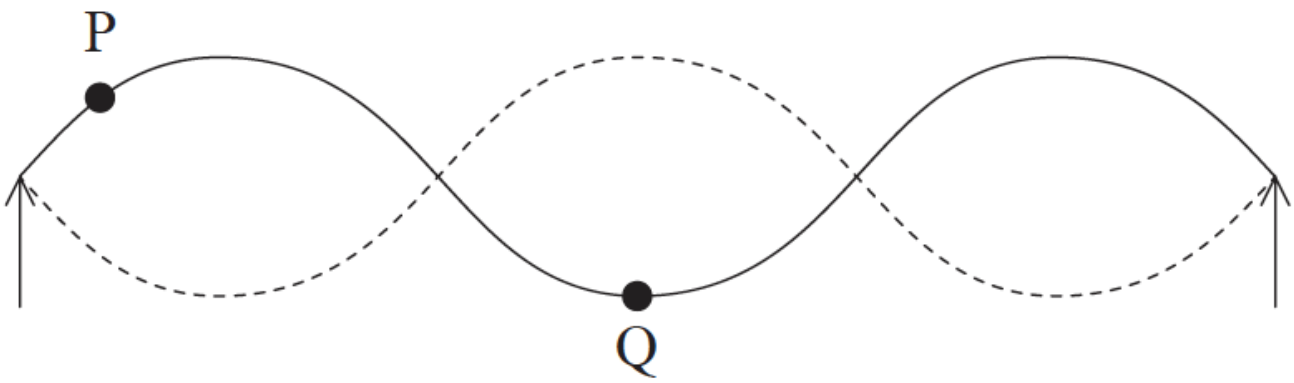
A. $\frac{I_f}{8}$

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

C. $4I_f$

D. $8I_f$

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

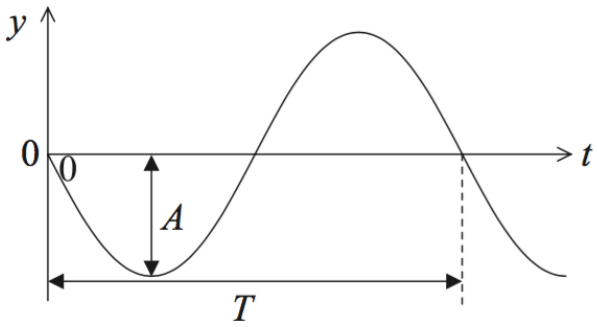


Which of the following compares the period of vibration of P and Q and the average speed of P and Q?

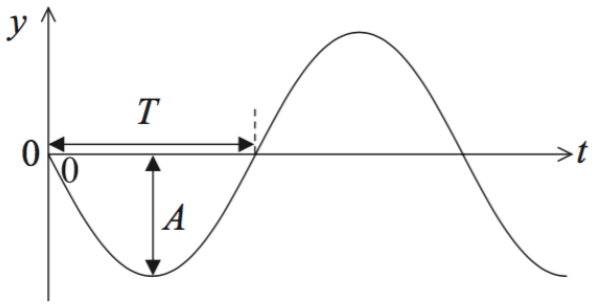
	Period of vibration of P and Q	Average speed of P and Q
A.	same	same
B.	same	different
C.	different	same
D.	different	different

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?

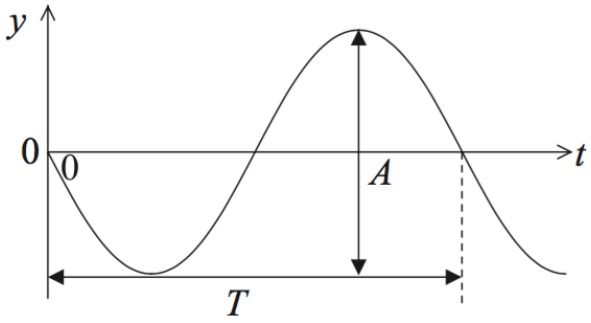
A.



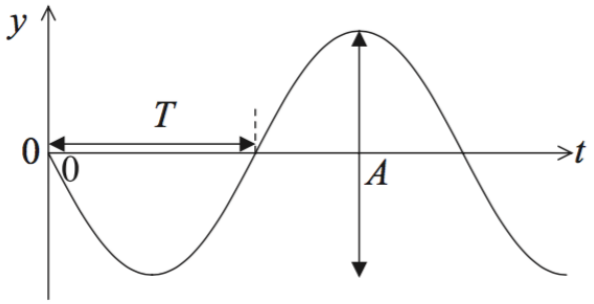
B.



C.

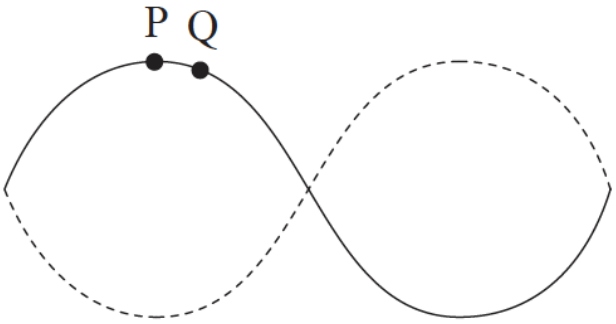


D.

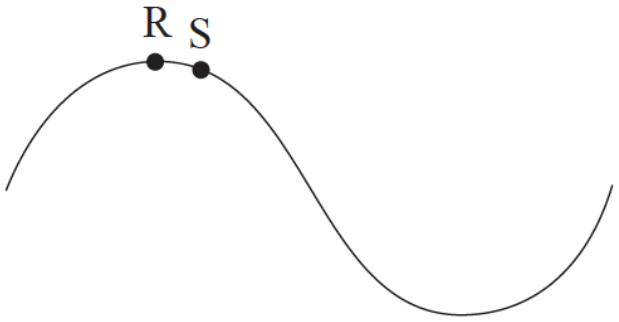


P and Q are two points on a standing wave. R and S are two points on a progressive (travelling) wave.

Standing wave



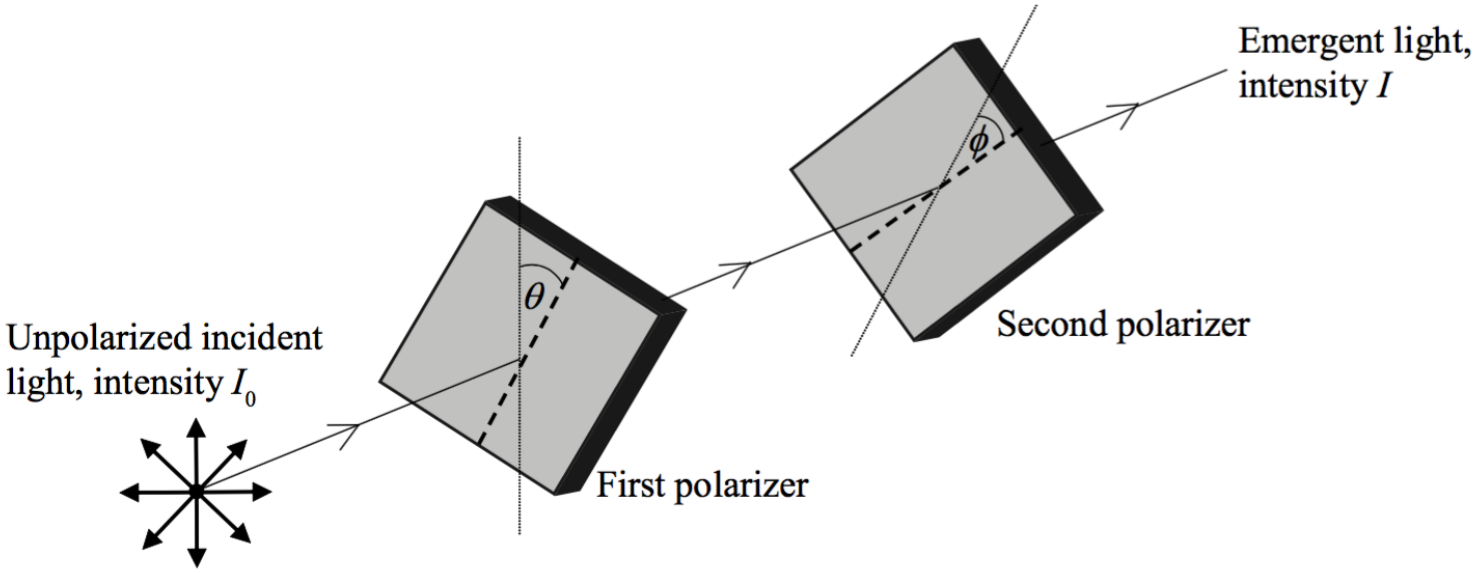
Progressive (travelling) wave



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

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



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

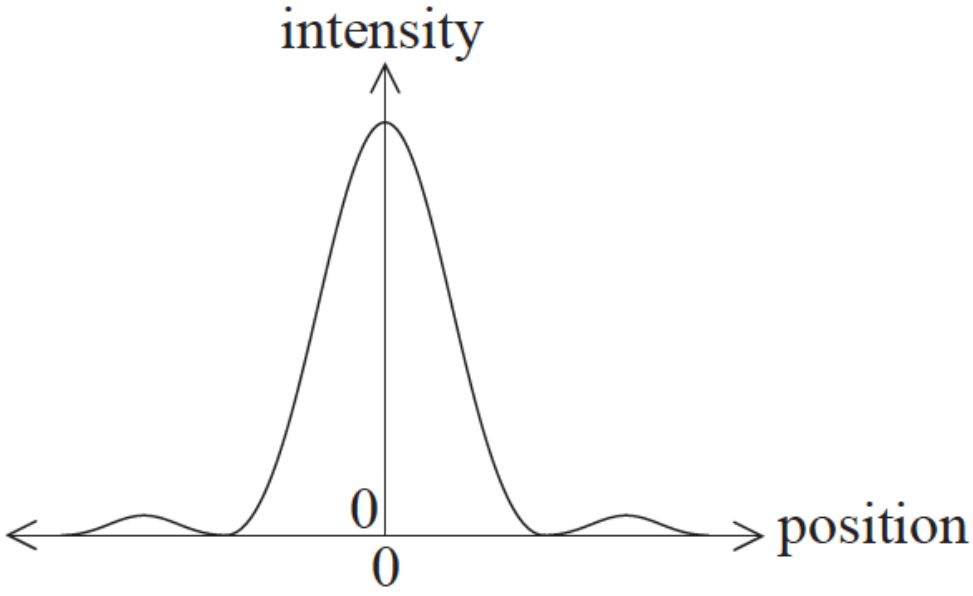
A. 0.25

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

C. $0.5 \cos^2 \phi$

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

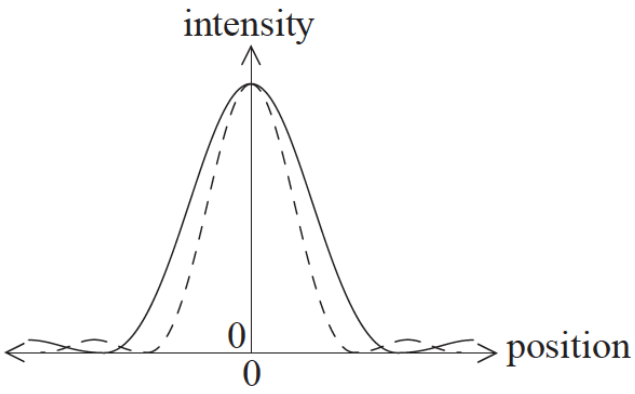
Monochromatic coherent light is incident on a narrow rectangular slit. The diffracted light is observed on a distant screen. The graph below shows how the intensity of the light varies with position on the screen.



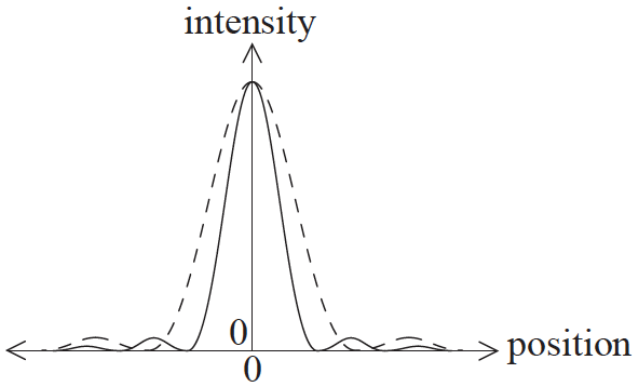
The width of the slit is reduced.

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.

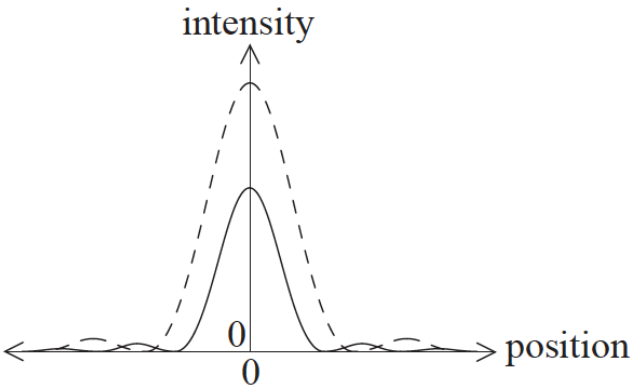
A.


intensity
0
position
0

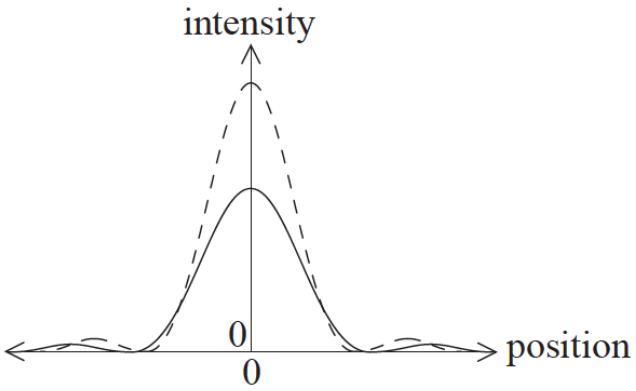
B.


intensity
0
position
0

C.


intensity
0
position
0

D.


intensity
0
position
0