# WAVE MOTION

Challenging **MCQ** questions by The Physics Cafe

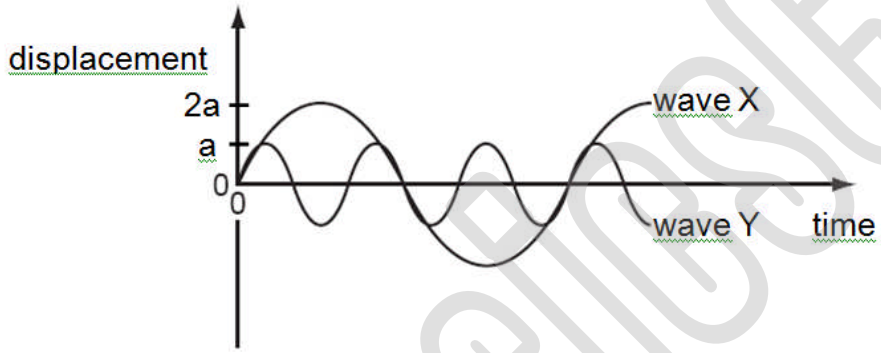

**Compiled and selected by The Physics Cafe**

1 A progressive wave in a stretched string has a speed of 2 m $s^{-1}$ and a frequency of 100 Hz. What is the phase difference between two points 25 mm apart?

**A** zero **B** $\frac{\pi}{4}$ **C** $\frac{\pi}{2}$ **D** $\pi$

2 The intensity of a progressive wave, besides being dependent on the amplitude of the wave, is also proportional to the square of the frequency.

The diagram shows two waves X and Y.

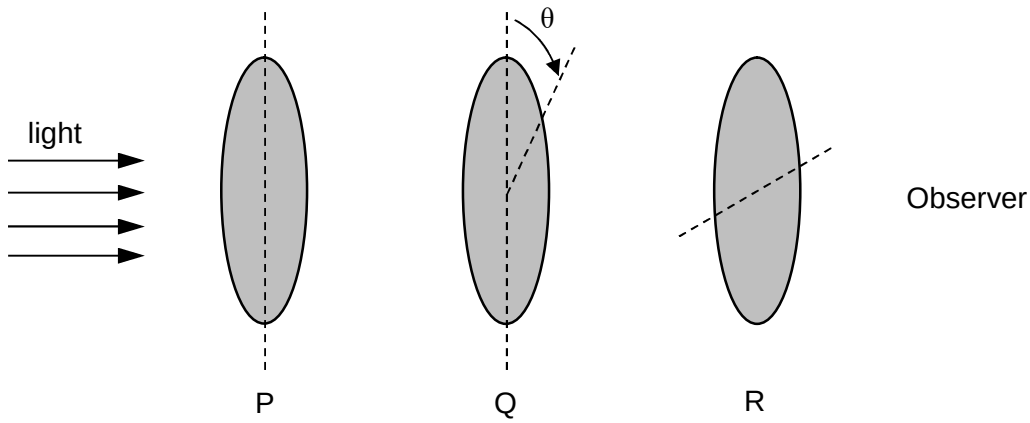



The intensity of wave X is $I_0$.

What is the intensity of wave Y?

**A** 0.028 $I_0$ **B** 0.11 $I_0$ **C** 0.44 $I_0$ **D** 2.25 $I_0$

3 Polaroids P, Q and R are aligned such that the axes of polarisation of P and Q are aligned to each other and the axis of polarisation R is perpendicular to that of P and Q as shown.




Polaroid Q is then rotated about its centre through an angle θ until its axis of polarisation is aligned with that of R.

Which of the following describes the change in light intensity seen by the observer?

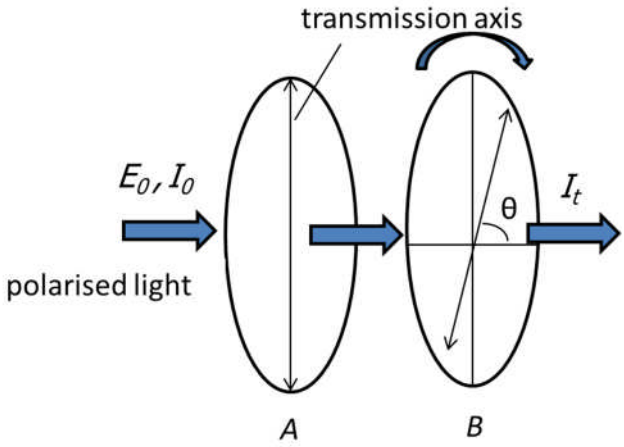
**A** Light intensity remains zero all the time.

**B** Light intensity was maximum initially and decreases to zero.

**C** Light intensity decreases to zero and then increases back to maximum.

**D** Light intensity increases to maximum and then decreases back to zero.

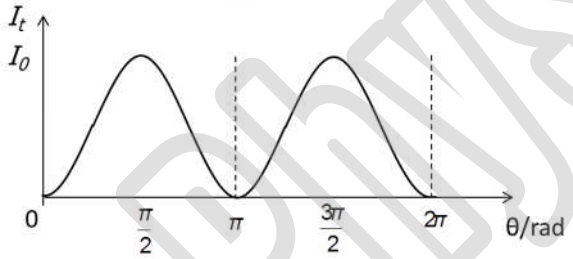
4 The figure below shows two ideal polarisers *A* and *B* where their transmission axes are initially parallel to each other.



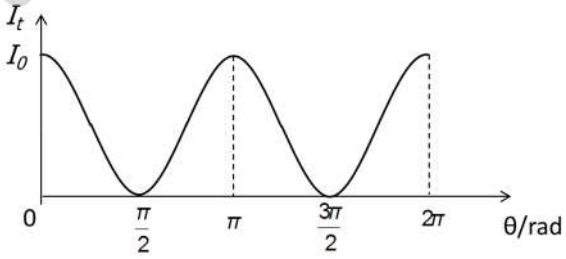

Polarised light of amplitude $E_0$ and intensity $I_0$ is incident on *A* with its electric field vector parallel to the transmission axis. Polariser *B* is then rotated so that its transmission axis makes an angle θ, as shown in the figure above.

Which of the following graphs shows how the intensity of the transmitted light $I_t$ varies with the angle θ?

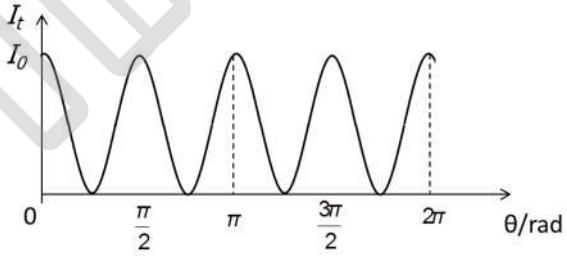
**A**



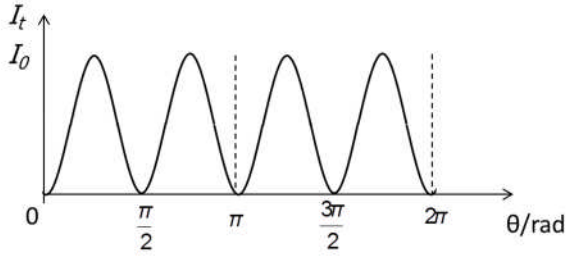

**B**



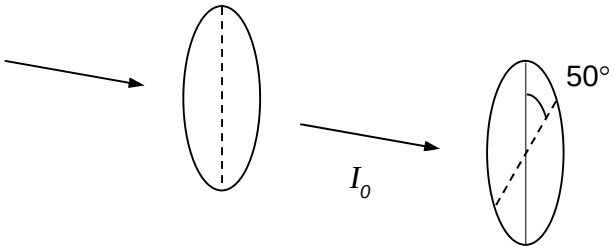

**C**




**D**



5 Unpolarized light is incident on a polarizer as shown below. The intensity of the light emerging from the first polarizer is $I_0$. The first polarizer is vertically polarized while the polarizing axis of the second polarizer is 50° from the vertical.




What is the intensity of light emerging from the second polarizer?

**A** 0.413 $I_0$ **B** 0.642 $I_0$ **C** 0.826 $I_0$ **D** $I_0$

6 A progressive wave is one which

**A** has vibrations that are perpendicular to the direction of wave travel.

**B** has vibrations that are parallel to the direction of wave travel.

**C** transfers energy in the direction of wave travel.

**D** transfers energy and particles in the direction of wave travel.

7 A sound wave of frequency 50 Hz is travelling through air at a speed of 314 m $s^{-1}$. What is the phase difference between two points of the sound wave separated by 1.0 m in the direction of travel?

**A** 0.5 rad **B** 1.0 rad **C** 2.0 rad **D** $\pi$ rad

8 Which of the following gives four regions of the electromagnetic spectrum in order of increasing frequency?

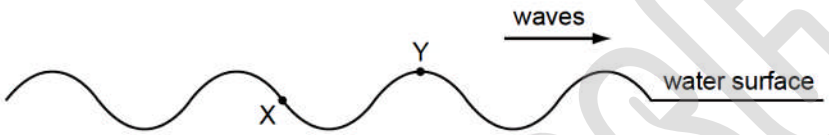
**A** Radio waves, microwaves, □-rays, x-rays.

**B** Radio waves, microwaves, x-rays, □-rays.

**C** Microwaves, radio waves, □-rays, x-rays.

**D** Microwaves, radio waves, x-rays, □-rays.

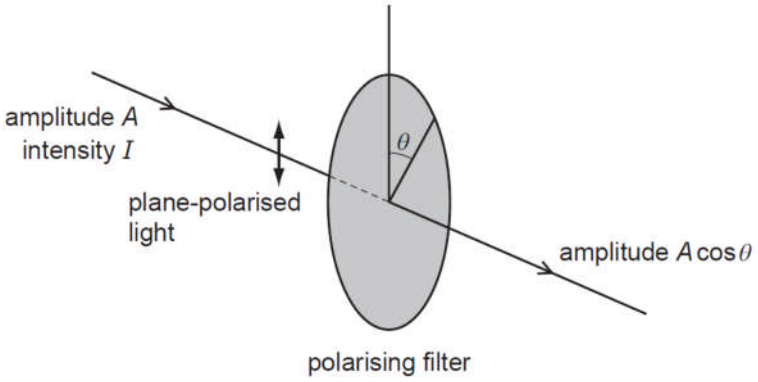
9 X and Y are two points on the surface of water in a ripple tank. A source of waves of constant frequency begins to generate waves which then travel past X and Y, causing them to oscillate.




What is the phase difference between X and Y?

**A** 45° **B** 135° **C** 180° **D** 270°

10 When plane-polarised light of amplitude *A* is passed through a polarising filter as shown, the amplitude of the light emerging is *A* cos $\theta$.




The intensity of the incident beam is *I*.

What is the intensity of the emerging light when $\theta$ is 60°.

**A** 0.25 *I* **B** 0.50 *I* **C** 0.75 *I* **D** 0.87 *I*

11 In microwave ovens, water molecules in food are set into resonance when microwaves of fixed frequency are incident upon them. This causes the molecules to receive energy and hence warm up the food.

In order to warm up the food faster, one can

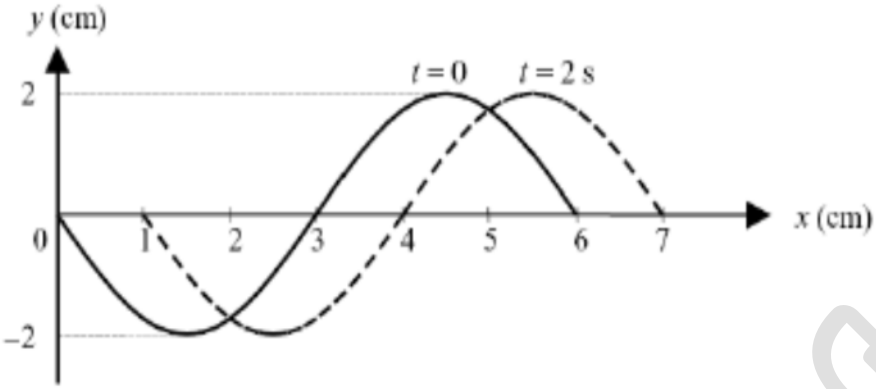
**A** increase the frequency of the incident microwave while keeping its amplitude fixed.

**B** increase the frequency and amplitude of the incident microwave.

**C** increase the amplitude of the incident microwave while keeping its frequency fixed.

**D** keep both frequency and amplitude of the incident microwave the same as before but increase the frequency of the water molecules.

12 The figure below shows the positions of a travelling wave at time intervals $t = 0$ and $t = 2$ s.




Calculate the speed of the wave.

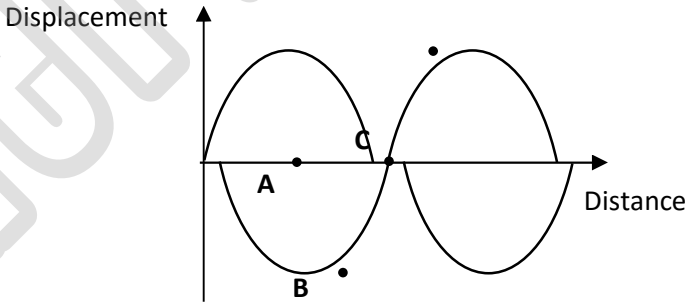
**A** 0.5 cm $s^{-1}$

**B** 2.0 cm $s^{-1}$

**C** 0.5 m $s^{-1}$

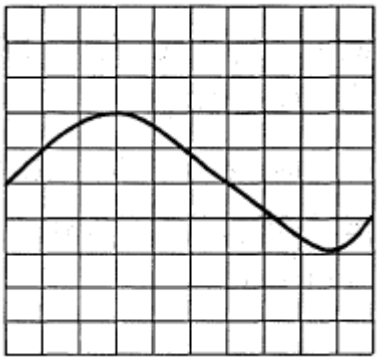
**D** 2.0 m $s^{-1}$

13 A sound wave travelling towards the right through air causes the air molecules to be displaced from their original positions. The graph below shows the variation with distance of the displacement of air molecules at a particular instant of time.




Taking the displacement towards the right as positive, at which point is the pressure maximum?

14 In an attempt to find the frequency of a wave with a CRO, the timebase was set to 5 ms per division and a trace of the waveform is as shown.



What is the frequency?

**A** 16.7 Hz **B** 33.3 Hz **C** 50.0 Hz **D** 100 Hz

15 Alice is standing 15 m away from a speaker listening to a music broadcast. Due to a technical fault, the power of the speaker is suddenly reduced by 25%.

How far away from the speaker should Alice stand now in order for the music to be as loud as before? Assume that the speaker is a point source of sound.

**A** 13m **B** 11m **C** 7.5m **D** 3.8m

# WAVE MOTION WORKED SOLUTIONS

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1 Ans: **C**

1λ=2 cm, hence 2.5 cm is 1.25 λ; 0.25 x 2π = 0.5 π

2 Ans: **D**

Amplitude of X = 2 x Amplitude of Y

Period of X = 3 x Period of Y ➔ Frequency of X = 1/3 Frequency of Y

Hence, $I_X / I_Y = (2)^2(1/3)^2$

$I_Y = 9/4\ I_X = 2.25\ I_0$

3 Ans: **D**

At the original position, the light from Q is polarized vertically. Hence no light will pass through R as the incoming light from Q is in the plane that is perpendicular to the axis of polarisation of R.

At the final position where the axes of polarisation of Q and R are aligned, the light that passes through P is polarized vertically. Hence no light will pass through Q as the incoming light from P is in the plane that is perpendicular to the axis of polarisation of Q. Therefore the intensity of light through R is zero.

When Q is rotated, the light intensity will increase until it reaches a maximum at an angle of 45°, and it reduces again as the angle is increased.

4 Ans: **A**

Option A is the answer as when θ is 0°, the transmission axes are perpendicular to one another and hence no light passes through.

When θ is 90°, the axes are parallel to one another and maximum intensity of light passes through.

In between these two angles, the intensity transmitted increases.

5 Ans: **A**

6 Ans: **C**

7 Ans: **B**

8 Ans: **B**

9 Ans: **D**

$$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$$

$$\frac{\Delta\phi}{2\pi} = \frac{3/4\,\lambda}{\lambda}$$

$$\Delta\phi = \frac{3}{2}\pi \quad \text{rad}$$

$$\Delta\phi = 270°$$

10 Ans: **A**

$I \propto A^2$

$\frac{I}{I'} = \left(\frac{A}{A'}\right)^2$

$\frac{I}{I'} = \left(\frac{A}{A\cos 60°}\right)^2$

$\frac{I}{I'} = \left(\frac{1}{0.5}\right)^2$

$I' = 0.25\, I$

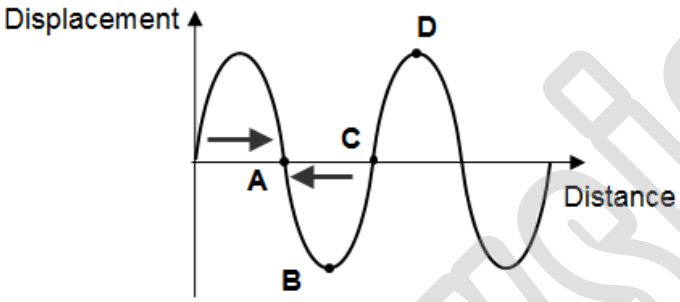
11 Ans: **C**

Energy ∝ (amplitude)$^2$, increase amplitude would increase the energy
Keeping frequency constant so that resonance with water molecules is maintained.

12 Ans: **A**

In 2 s, the wave travels 1 cm → speed = 1 cm / 2 s = 0.5 cm s$^{-1}$

13 Ans: **A**




Displacement towards Right is positive

At point A, air molecules are displaced on either side to create a Compression.

14 Ans: **A**

Period, $T$ = 60 ms = 0.060 s

Frequency, $f = 1/T$ = 16.7 Hz

15 Ans: **A**

For Alice to hear the music as loud as before, the intensity of the sound reaching her ears should remain the same.

$\frac{P}{4\pi(15)^2} = \frac{0.75P}{4\pi(x)^2}$

$x = 13$ m