A LEVEL PHYSICS

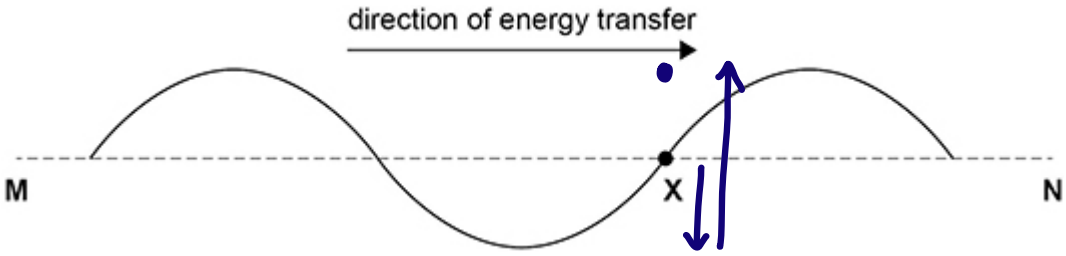
WORKED SOLUTIONS

3.1. Progressive and Stationary Waves MCQ

Worked Solutions by Lewis Matheson from
ALevelPhysicsOnline.com in collaboration
with **PhysicsAndMathsTutor**.com

1. A progressive wave travels along a rope in the direction **M** to **N**.

X marks a point on the rope.



The wave has a frequency of 5.0 Hz, a wavelength of 1.0 m and an amplitude of 0.20 m.

Where will **X** be after 0.15 s?

$T = \frac{1}{f} = \frac{1}{5.0} = 0.20\text{s}$

$0.15\text{s} = \frac{3}{4}T$

A below **MN** by 0.20 m ○

B above **MN** by 0.20 m ●

C ~~nearer~~ **N** by 0.15 m ○

D ~~nearer~~ **N** by 0.75 m ○

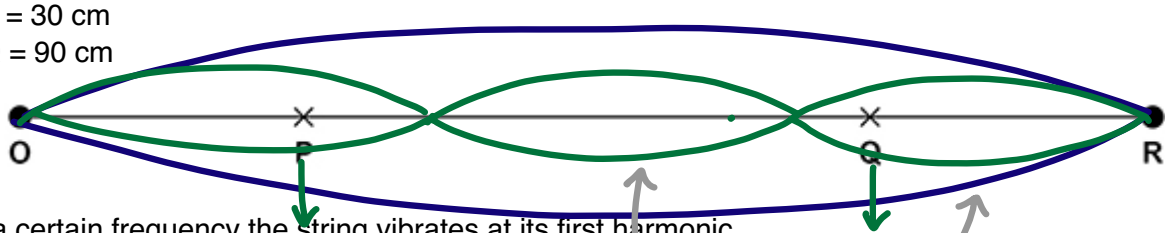
After t=0, X will initially move down

(Total 1 mark)

2. The diagram shows a string stretched between two fixed points **O** and **R** which are 120 cm apart.

P and **Q** are points on the string.

OP = 30 cm
OQ = 90 cm



At a certain frequency the string vibrates at its first harmonic.

In blue

P and **Q** oscillate in phase.

The frequency is gradually increased.

In green

What is the next harmonic at which **P** and **Q** will oscillate in phase?

A second ⬭

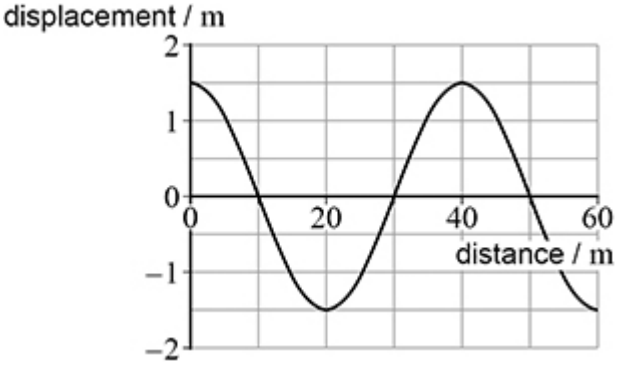
B third ●

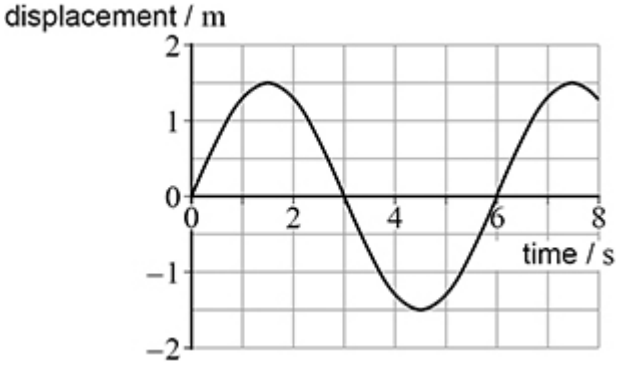
C fourth ⬭

D fifth ⬭

(Total 1 mark)

3. The diagrams show the displacement–distance graph for a wave and the displacement–time graph for a point in the wave.





Which is correct for this wave?

A The amplitude is 3.0 m. ⬭

B The wavelength is 6 m. ⬭

C The speed is 8.3 m s^{-1}. ⬭

D The frequency is 0.17 Hz. ●

$A = 1.5m$

$\lambda = 40m$

$v = f\lambda = \frac{1}{60} \times 40 = 6.67 ms^{-1}$

$f = \frac{1}{6} = 0.167\ Hz$

(Total 1 mark)

4. The diagram shows a stationary wave on a string at one instant in time.

P, **Q** and **R** are three points on the string.

P + Q in phase

$A_P = A_Q \neq A_R$

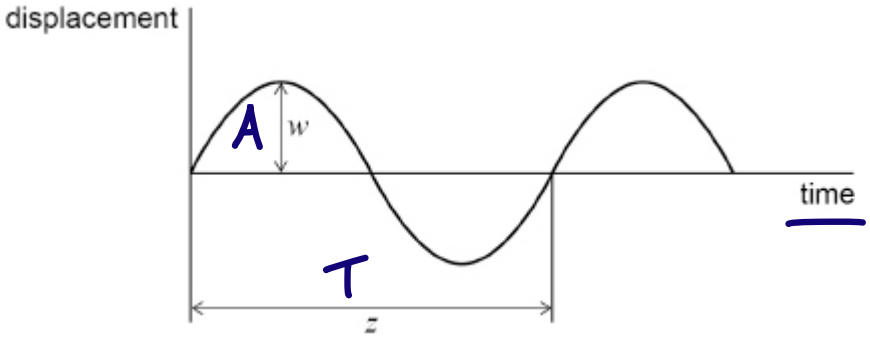
Which row is correct?

A	**P** is in antiphase with **R**	**P** has the same amplitude as **Q**	●
B	**P** is out of phase with **R**	**P** has the same amplitude as **R**	○
C	**P** is in phase with **Q**	**P** has the same amplitude as **R**	○
D	**P** is out of phase with **Q**	**P** has a smaller amplitude than **R**	○

(Total 1 mark)

5. A wave travels along a water surface.

The variation with time of the displacement of a water particle at the surface is shown.



What properties of the wave are represented by w and z?

	w	z	
A	phase	frequency	○
B	amplitude	wavelength	○
C	wavelength	phase	○
D	amplitude	period	●

(Total 1 mark)

6. Two points on a progressive wave are out of phase by 0.41 rad.

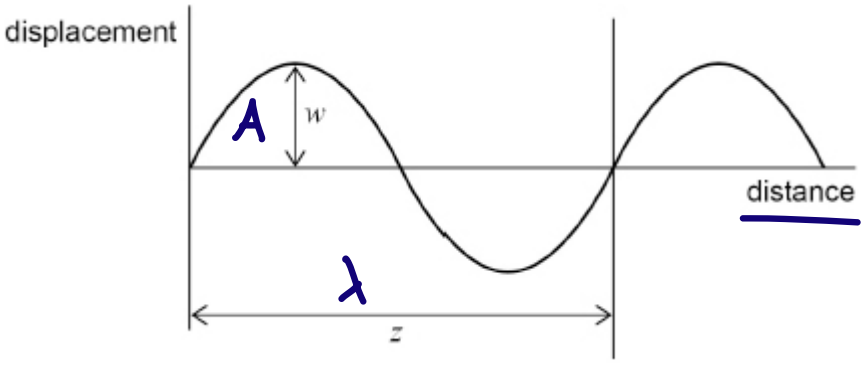
What is this phase difference?

A	23°	●
B	47°	○
C	74°	○
D	148°	○

$\frac{0.41}{2\pi} \times 360 = 23.49$

(Total 1 mark)

7. A wave travels across the surface of water.
The diagram shows how the displacement of water particles at the surface varies with distance.

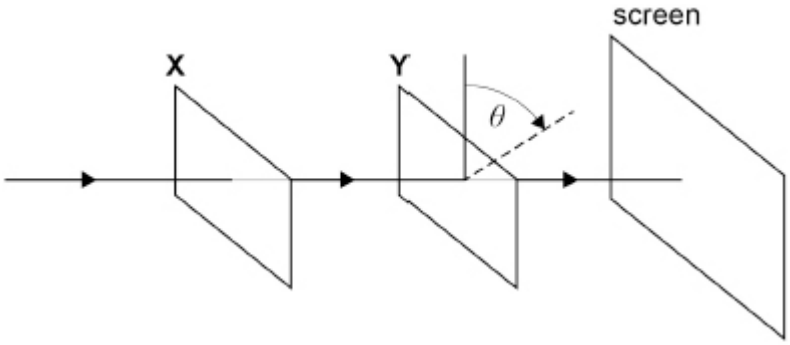


Which row correctly describes both w and z?

	w	z	
A	amplitude	wavelength	●
B	half-amplitude	period	○
C	half-amplitude	wavelength	○
D	amplitude	period	○

(Total 1 mark)

8. Unpolarised light travels through two polarising filters **X** and **Y** and is then incident on a screen. When **X** and **Y** are arranged as shown, there is a maximum intensity on the screen.
X is held stationary but **Y** is rotated in a plane at right angles to the beam so that θ increases.



What are the next three values of θ, in rad, for which the beam hits the screen with maximum intensity?

A $\frac{\pi}{2}, \frac{2\pi}{2}, \frac{3\pi}{2}$ ○

B $\frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}$ ○

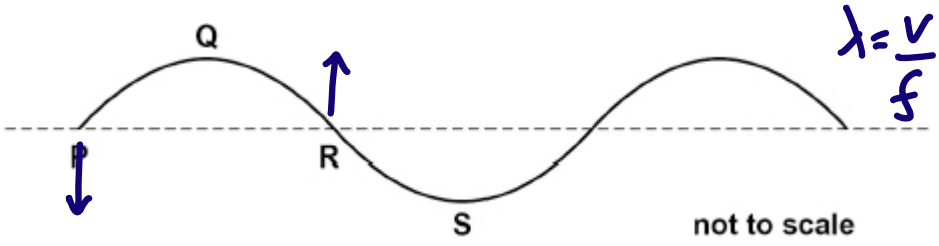
C π, 2π, 3π ●

D 2π, 4π, 6π ○

Max at 0, then every π rad (half rotation)

(Total 1 mark)

9. The diagram shows the cross-section of a progressive transverse wave travelling at 24 cm s^{-1} on water. The amplitude of the wave is 2.0 cm and the frequency is 4.0 Hz.



$\lambda = \frac{v}{f} = \frac{24}{4.0} = 6.0\,m$

Which statement is correct?

A The phase difference between particles at **P** and **S** is $\frac{\pi}{2}$ rad. (or $\frac{3\pi}{2}$ rad) ●

B The distance between **P** and **R** is 6.0 cm. 3.0 m ○

C The particle velocity at **Q** is a maximum. Minimum ○

D Particles at **P** and **R** are in phase. Anti-phase ○

(Total

10. Stationary waves are set up on a rope of length 1.0 m fixed at both ends.

Which statement is **not** correct?

A The first harmonic has a wavelength of 2.0 m. ✓ $\lambda = 2L$ ○

B The midpoint of the rope is always stationary for even-numbered harmonics. ✓ ○

C A harmonic of wavelength 0.4 m can be set up on the rope. ✓ ○

D There are five nodes on the rope for the fifth harmonic. ✗ ●

(Total 1 mark)

11. A sonar transmitter on a ship produces pulses of sound waves.
Each pulse of sound waves contains 12 complete oscillations.
The frequency of these waves is 8.0 kHz and the speed of sound in seawater is 1.5×10^3 m s^{-1}.

What is the length of one pulse in seawater?

A 0.188 m ○

$\lambda = \frac{v}{f} = \frac{1.5 \times 10^3}{8.0 \times 10^3} = 0.1875$ m

B 2.25 m ●

C 2.25×10^3 m ○

$L = 12\lambda = 12 \times 0.1875 = 2.25$ m

D 1.44×10^5 m ○

(Total 1 mark)

12. The frequency of the first harmonic of a wire fixed at both ends is 300 Hz.
The tension in the wire is now doubled.

What is the frequency of the first harmonic after this change?

A 150 Hz ○

$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ $\quad f \propto \sqrt{T}$

B 210 Hz ○

C 420 Hz ●

$\frac{f_1}{\sqrt{T_1}} = \frac{f_2}{\sqrt{T_2}}$ $\quad f_2 = f_1\sqrt{\frac{T_2}{T_1}}$

D 600 Hz ○

(Total 1 mark)

$f_2 = \sqrt{\frac{2T}{T}} \cdot f_1 = \sqrt{2} f_1 = \sqrt{2} \times 300$

$f_2 = 424$ Hz

13. The fundamental frequency f is the lowest frequency heard when a stretched string is vibrating.

The string is now lightly touched one third of the way along its length.

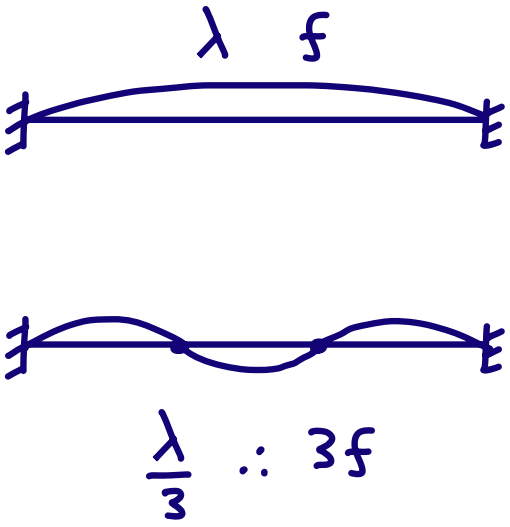
What is the lowest frequency heard?

A $\frac{f}{3}$ ○

B $\frac{2f}{3}$ ○

C f ○

D $3f$ ●



(Total 1 mark)

14. Two points on a progressive wave have a phase difference of $\frac{\pi}{6}$ rad

The speed of the wave is 340 m s^{-1}

What is the frequency of the wave when the minimum distance between the two points is 0.12 m?

A 240 Hz ●

B 470 Hz ○

C 1400 Hz ○

D 2800 Hz ○

π/6 rad → 0.12 m

2π rad → λ = 1.44 m

(Total 1 mark)

$f = \frac{v}{f} = \frac{340}{1.44} = 236\ Hz$

15. Which statement is correct about the properties of an unpolarised electromagnetic wave as it passes through a polariser?

A The wave remains unchanged. ○

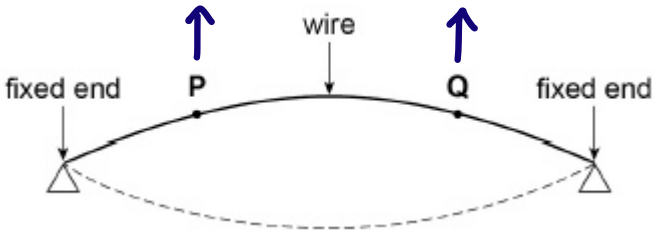
B The wave does not pass through the polariser. ○

C The wave's electric field oscillates along the direction of travel. ○

D The intensity of the wave is reduced. ●

(Total 1 mark)

16. A uniform wire, fixed at both ends, is plucked in the middle so that it vibrates at the first harmonic as shown.



What is the phase difference between the oscillations of the particles at **P** and **Q**?

A zero ●

B $\frac{\pi}{4}$ rad ○

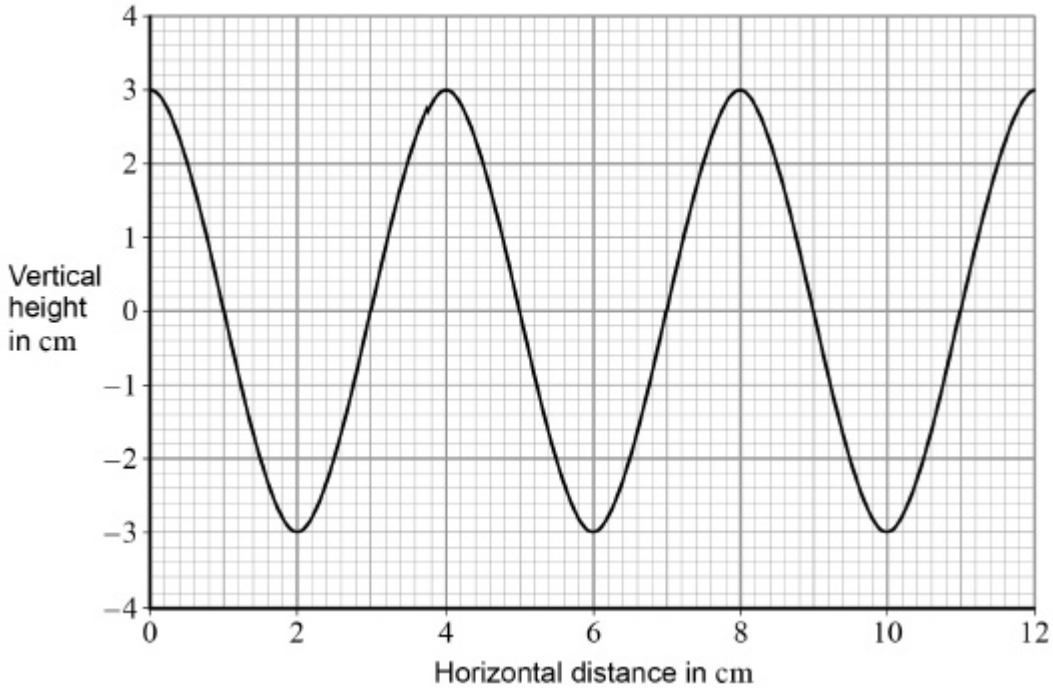
C $\frac{\pi}{2}$ rad ○

D $\frac{3\pi}{4}$ rad ○

They move in the same direction at the same time
∴ phase difference = 0

(Total 1 mark)

17. The graph shows how the vertical height of a travelling wave varies with distance along the path of the wave.



The speed of the wave is 20 cm s^{-1}.

What is the period of the wave?

A 0.1 s ⬭

B 0.2 s ⬬

C 5.0 s ⬭

D 10.0 s ⬭

$\lambda = 4.0\,cm$

$f = \frac{v}{f} = \frac{20}{4.0} = 5.0\ Hz$

$T = \frac{1}{f} = \frac{1}{5.0} = 0.20\ s$

(Total 1 mark)

18. What is the phase difference between two points 0.16 m apart on a progressive sound wave of frequency 256 Hz?

speed of sound = 330 m s^{-1}

A	$\frac{\pi}{8}$	○
B	$\frac{\pi}{6}$	○
C	$\frac{\pi}{4}$	●
D	$\frac{\pi}{3}$	○

$\lambda = \frac{v}{f} = \frac{330}{256} = 1.289\ m$

$\frac{0.16}{1.289} = 0.124$ of a wave cycle

$2\pi \times 0.124 \approx 2\pi \times \frac{1}{8} \approx \frac{\pi}{4}$

(Total 1 mark)

19. The frequency of the first harmonic of a standing wave on a wire is f. The length of the wire and tension in the wire are both doubled.

What is the frequency of the first harmonic as a result?

A	$\frac{f}{\sqrt{2}}$	●
B	f	○
C	$\sqrt{2}f$	○
D	$2f$	○

$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

$f \propto \frac{\sqrt{T}}{L}$

$f_2 = f_1 \frac{L_1}{L_2} \cdot \sqrt{\frac{T_2}{T_1}}$

(Total 1 mark)

$f_2 = f_1 \times \frac{1}{2} \times \sqrt{2} = f_1 \frac{\sqrt{2}}{2} = f_1 \cdot \frac{1}{\sqrt{2}} = \frac{f_1}{\sqrt{2}}$