# A Level AQA Physics
## 4 Progressive and stationary waves – answers

OXFORD Revise

| Question | Answers | Extra information | Mark | AO | Spec reference |
|---|---|---|---|---|---|
| **01.1** | 2.8 cm | | 1 | 2 | 3.3.1.1 |
| **01.2** | $\lambda = 2.8$ cm $c = 8.4$ cm s$^{-1}$<br>$c = f\lambda$<br>$f = \frac{c}{\lambda} = \frac{8.4}{2.8} = 3$ Hz | Allow e.c.f. for $\lambda$ answer from **01.1** | 1 | 2 | 3.3.1.1 |
| **01.3** | $\frac{\pi}{2}$ rad or 90° | 1 mark for phase difference,<br>1 mark for units | 1<br>1 | 2<br>1 | 3.3.1.1 |
| **01.4** | Displacement will be negative (downwards) to max in $\frac{T}{4}$ s<br>Decreases through to zero displacement at $\frac{T}{2}$ s | | 1<br>1 | 2 | 3.3.1.1 |
| **02.1** | Double-ended arrow/line from between two points in phase | | 1 | 1 | 3.3.1.1 |
| **02.2** | Maximum displacement<br>From the equilibrium position (from rest position/mean position) | | 1 | 1 | 3.3.1.1 |
| **02.3** | Longitudinal wave<br>Spring oscillates in a direction parallel to/in energy transfer<br>OR because of compressions and rarefactions | Rarefaction must be spelt correctly for second mark | 1<br>1 | 2 | 3.3.1.2 |
| **02.4** | Stationary wave formed<br>By superposition (or interference) (of two progressive waves)<br>Stationary points are nodes<br>Destructive interference where the spring is stationary | Max of 3 marks awarded | max 3 | 2 | 3.3.1.3 |
| **03.1** | With unpolarised light, the vibrations are in many planes<br>In plane polarised light, the oscillations are in one plane only | ignore 'direction' | 1<br>1 | 1 | 3.3.1.2 |
| **03.2** | Reflected light is polarised<br>So intensity of light reflected on water will be reduced by polarising filter | | 1<br>1 | 2 | 3.3.1.2 |

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| **03.3** | Rotate the polarising filter through 180°/360°<br>Variation in intensity between max and min (or light and dark)<br>One maxima and min in 180° OR two maxima (or two minima) in 360° rotation | | 1<br>1<br>1 | 3 | 3.3.1.2 |
| **03.4** | Sound waves are longitudinal waves<br>Since oscillations are parallel to/same direction as wave travel, they cannot be polarised | | 1<br>1 | 2 | 3.3.1.2 |
| **03.5** | Sketch:<br>• showing ray of light reflected away from the normal as it leaves the water<br>• straight line drawn showing where ray appears to come from person's perspective<br>Explanation that change of speed at boundary causes refraction | Max 2 marks for two rays drawn and 1 mark for explanation | 1<br>1<br>1 | 2 | 3.3.2.3 |
| **04.1** | Reflection from metal plate<br>Two waves of the same frequency/wavelength<br>travelling in opposite directions (or forward/reflected waves)<br>Maxima where waves are in phase or interfere constructively<br>Minima where waves are out of phase/antiphase or interfere destructively<br>Nodes and antinodes or stationary waves identified | Any three awarded | max 3 | 2 | 3.3.1.3 |
| **04.2** | Distance between minima is $\frac{\lambda}{2}$<br>$4 \times \frac{\lambda}{2} = 54\text{ mm}$<br>$\lambda = 27\text{ mm}$ | | 1<br>1 | 2 | 3.3.1.3<br>3.3.1.1 |
| **04.3** | $c = f\lambda$ and $c = 3.0\times10^8\text{ m s}^{-1}$<br>$f = \frac{c}{\lambda} = \frac{3.0\times10^8}{27\times10^{-3}} = 1.1\times10^{10}\text{ Hz}$<br>11 GHz | Allow e.c.f. from **04.2** | 1<br>1 | 2 | 3.3.1.3<br>3.3.1.1<br>3.1.1 |
| **04.4** | **P** labelled close to the plate in direct line with transmitter | | 1 | 1 | 3.3.1.3 |

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| **04.5** | The distance travelled by the transmitted wave and the reflected wave is similar at point **P**<br>The amplitude of both waves will be similar<br>Max destructive interference | Max of two points | max 2 | 2 | 3.3.1.3 |
| **04.6** | The microwave transmitter produces plane polarised waves and so the detector must be in the correct plane | | 1 | 3 | 3.3.1.2 |
| **05.1** | Stationary waves set up in the microwave<br>Microwaves are reflected in the oven<br>Two waves of the same frequency/wavelength travelling in opposite directions (or forward/reflected waves)<br>Melted marshmallows are where waves are in phase or interfere constructively<br>The melted marshmallows are at an antinode | Any three from | max 3 | 2 | 3.3.1.3 |
| **05.2** | $c = f\lambda$ and $c = 3.0 \times 10^8\ \text{m s}^{-1}$<br>$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{2450 \times 10^6} = 0.122\ \text{m}$<br>Distance between minima is $\frac{\lambda}{2}$<br>$= 0.061\ \text{m}$ | | 1<br>1<br>1 | 2 | 3.3.1.1<br>3.3.1.3<br>3.1.1 |
| **05.3** | $c = f\lambda = 2450 \times 10^6 \times 0.142\ \text{m} = 3.48 \times 10^8\ \text{m s}^{-1}$<br>$\%\ \text{error} = \frac{\text{difference}}{\text{actual}} \times 100\,\%$<br>$\%\ \text{error} = \frac{4.8 \times 10^7}{3.0 \times 10^8} \times 100\,\% = 16\,\%$ | Allow e.c.f. from value of $c$ | 1<br>1<br>1 | 2 | 3.3.1.3<br>3.1.2 |
| **05.4** | They would have to remove/disable the turntable so that marshmallows were stationary | | 1 | 3 | |

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| **05.5** | In a progressive wave, all particles vibrate at same frequency<br>AND in a stationary wave, all particles except those at nodes vibrate at same frequency<br>In a progressive wave, all particles have same amplitude<br>AND in stationary waves, particles vary in amplitude from zero at nodes to max at antinodes<br>In progressive waves, the phase difference between particles = $\frac{2\pi d}{\lambda}$, where $d$ is the distance apart<br>AND in stationary waves, phase difference = $n\pi$, where $n$ is the number of nodes between the particles | Each statement must compare stationary and progressive waves<br><br>2 marks maximum for each property compared<br><br>Two properties compared for maximum marks | max 4 | 2 | 3.3.1 |
| **06.1** | Waves travel to the boundaries and are reflected<br>Two waves travelling in opposite directions interfere/superpose<br>Antinodes or maxima where waves are in phase or interfere constructively<br>OR<br>Nodes/minima where waves are out of phase/antiphase or interfere destructively<br>Nodes form at fixed ends | NOT bounces off | max 3 | 1 | 3.3.1.3 |
| **06.2** | $\lambda = 0.62 \times 2 = 1.24\,\text{m}$<br>$c = f\lambda = 82.41 \times 1.24 = 102\,\text{m s}^{-1}$ | | 1<br>1 | 2 | 3.3.1.1 |
| **06.3** | $f = \frac{c}{\lambda} = \frac{102}{0.62}\ 165\,\text{Hz}$ | Allow e.c.f. from **06.2** | 1 | 2 | 3.3.1.1 |
| **06.4** | Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$<br>$f^2 \propto \frac{1}{\mu}$<br>$f^2\mu = \text{constant} = 82.41^2 \times 6.44\times10^{-3}$<br>New $\mu = \frac{82.41^2 \times 6.44\times10^{-3}}{196^2}\ 1.14\times10^{-3}\,\text{kg m}^{-1}$ | Alternatively, they could work out $T$ from initial info and calculate | 1<br><br><br>1 | 3 | 3.3.1.3 |
| **07.1** | 3rd/third harmonic | | 1 | 1 | 3.3.1.3 |

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| **07.2** | **P** antinode AND constructive interference/in phase<br>**Q** node AND destructive interference/out of phase | Need name and description for each mark | 1<br>1 | 1 | 3.3.1.3 |
| **07.3** | **P** has positive amplitude and **Q** negative<br>**P** and **Q** are $\pi$ rad or 180° out of phase | | 1<br>1 | 1 | 3.3.1.3<br>3.3.1.1 |
| **07.4** | $\lambda = \frac{2}{3}L = 0.80\text{ m}$<br>$c = f\lambda$<br>$f = \frac{c}{\lambda} = \frac{13.6}{0.80} = 17\text{ Hz}$ | | 1<br><br>1 | 2 | 3.3.1.1<br>3.3.1.3 |
| **07.5** | 6th harmonic sketched – expect to see 6 antinodes and 7 nodes | | 1 | 2 | 3.3.1.3 |
| **08.1** | 80 (ms)<br>$f = \frac{1}{T} = 12.5\text{ Hz}$<br>$f^2 = 156\text{ Hz}$ | Answer in table row should be completed | 1<br><br>1 | 2 | 3.3.1.1 |
| **08.2** | $T = mg$<br>$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{mg}{\mu}}$<br>$f^2 = \frac{1}{4l^2} \times \frac{mg}{\mu}$<br>Since $l$, $g$, and $\mu$ are constant<br>$f^2 \propto m$ | | 1<br>1<br>1 | 2 | 3.3.1.3 |
| **08.3** | Mark for plotting point $\pm\frac{1}{2}$ square on graph<br>Mark for drawing line of best fit<br>Large triangle drawn or evidence shown<br>$1.2 \pm 0.1\ (\text{g Hz}^{-2})$ | | 1<br>1<br>1<br>1 | 2 | MS 3.2, 3.3, 3.4 |

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| **08.4** | Gradient = $\frac{g}{4l^2\mu}$<br>$\mu = \frac{9.81}{4 \times 1^2 \times 1.2}$<br>2.0 g m$^{-1}$ | e.c.f. | 1<br>1 | 2 | 3.3.1.3 |
| **08.5** | % uncertainty in length = $\frac{0.001}{1.000} \times 100\% = 0.1\%$<br>OR % uncertainty in mass = $\frac{0.1}{1.7} \times 100\% = 5.9\%$<br>total % error = 6.0 %<br>absolute error = 0.06 × 1.7 = ± 0.1 g m$^{-1}$ | 1 mark for calculating either % uncertainty | 1<br>1<br>1 | 2 | 3.1.2 |
| **08.6** | % difference = $\frac{\text{difference}}{\text{actual}} \times 100\%$<br>% difference = $\frac{0.3}{1.7} \times 100\% = 18\%$ | Possible e.c.f. from their value for **08.4** | 1 | 2 | 3.1.2 |

**Skills box answers**

| Question | Answer |
|---|---|
| **1** | Wear goggles in case the wire snaps. Place a box containing padding material below the masses in case they fall. |
| **2** | Set up the apparatus as shown in the diagram. Record values of $f$ for different values of $l$. Change the length in the string by moving the vibrator closer to the pulley. $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$, therefore plot a graph of $l$ against $\sqrt{T}$, will produce a straight line through the origin, confirming the relationship between $l$ and $T$. |
| **3** | The gradient of the graph = $\frac{1}{(4l^2\mu)}$, so $\mu = (4l^2 \text{ gradient})^{-1}$ |