STEM SMART Phase One, 2022

Physics Week 12 – Standing Waves

https://isaacphysics.org/gameboards#smart_p_1_12

Travelling vs. Standing

A Level - Practice (P2)

Which of the following correctly compares the characteristics of travelling and stationary plane waves?

	Travelling wave	***Stationary wave***
A	no medium required	requires a material medium
B	separation between two adjacent points of corresponding phase is one wavelength	separation between a node and the adjacent antinode is half a wavelength
C	amplitude of vibration varies with position	the amplitude of vibration is the same at all points
D	energy at any point is always kinetic	energy at any point changes between kinetic to potential and back again
E	energy is transported at a speed given by the frequency multiplied by the wavelength	no net transport of energy

- ○ A
- ○ B
- ○ C
- ○ D
- ○ E

Adapted with permission from UCLES, A Level Physics, June 1984, Paper 2, Question 12

Essential Pre-Uni Physics D5.1

A Level - Practice (P2)

Consider a particle that is at a particular antinode of a standing wave, which we'll call point A. Fill in the table below to state how the motion of certain other particles will compare to this one. [For amplitude, state whether it will be smaller/larger/the same; for phase, state the phase difference in degrees.]

Position of Particle	Amplitude	Difference in Phase
At the next antinode along from point A	(a)	(b)

Part A Amplitude

a) Amplitude compared to point A?

- Same
- Zero
- Twice as large

Part B Phase

b) Phase relative to point A?

- $180\,^{\circ}$
- $90\,^{\circ}$
- $360\,^{\circ}$

Essential Pre-Uni Physics D5.3

A Level - Practice (P2)

Consider a particle that is at a particular antinode of a standing wave, which we'll call point A. Fill in the table below to state how the motion of certain other particles will compare to this one. [For amplitude, state whether it will be smaller/larger/the same; for phase, state the phase difference in degrees.]

Position of Particle	Amplitude	Difference in Phase
Beyond the next node along from point A, but before the next antinode to point A	(a)	(b)

Part A Amplitude

a) Amplitude compared to point A?

- Larger
- Smaller
- The same

Part B Phase

b) Phase relative to point A?

Essential Pre-Uni Physics D5.4

A Level - Practice (P2)

What is the difference between the 'amplitude' and the 'displacement' of a particle at an antinode?

- The amplitude is the maximum magnitude of displacement of a particle from its equilibrium position.
- The amplitude is the distance from the equilibrium position.
- The amplitude is the distance between successive peaks or troughs in the wave.

Essential Pre-Uni Physics D5.5

A Level - Practice (P2)

You must give a unit in all of your numeric answers in order to obtain the mark.

Part A Distance from nodes to antinodes

Two waves of amplitude $4.0\,\mathrm{cm}$ and frequency $14\,\mathrm{Hz}$ are moving in opposite directions at $5.6\,\mathrm{m\,s^{-1}}$ along a stretched string. If a standing wave were formed, how far apart would you expect the antinodes to be from the nodes on either side of them?

Part B Minimum length of the string

If the string had two fixed ends, what is the minimum length it must be in order for a standing wave to be possible?

Part C A string of length $0.70\,\mathrm{m}$

If the string had two fixed ends and was $0.70\,\mathrm{m}$ long, why would no standing wave be formed?

- Both ends cannot be nodes as the internodal distance is $0.20\,\mathrm{m}$, so no standing wave can form.
- If the string was $0.70\,\mathrm{m}$ long then both ends would be antinodes, which is not possible if both ends are fixed.
- The wavelength of the standing wave is greater than $0.70\,\mathrm{m}$.

Essential Pre-Uni Physics D5.6

A Level - Challenge (C2)

You must give a unit in all of your numeric answers in order to obtain the mark. The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

Part A Lowest frequency

A wind instrument is $60\,\mathrm{cm}$ long, and can be modelled as a tube with one closed end and one open end. What is the lowest frequency that can be played on this instrument?

Part B Second-lowest frequency

If a note of the second-lowest possible frequency were played on the instrument, state the positions of the nodes (measured as distances from the closed end of the tube).

- One at the closed end, another $40\,\mathrm{cm}$ from the closed end.
- One $20\,\mathrm{cm}$ from the closed end, another $40\,\mathrm{cm}$ from the closed end.
- One at the closed end, another $20\,\mathrm{cm}$ from the closed end and another $40\,\mathrm{cm}$ from the closed end.

Part C Third-lowest frequency

State the positions of the nodes if a note of the third-lowest possible frequency were played.

- One at closed end, another $20\,\mathrm{cm}$ from the closed end and the last $40\,\mathrm{cm}$ from the closed end.
- One at $30\,\mathrm{cm}$ from the closed end.
- One at closed end, another $24\,\mathrm{cm}$ from the closed end and the last $48\,\mathrm{cm}$ from the closed end.

Essential Pre-Uni Physics D5.7

A Level - Practice (P2)

Two microwave emitters are placed facing each other about a metre apart and coherently emit microwaves of the same frequency. A detector moved back and forth between them detects regions of maximum intensity spaced $4.0\,\mathrm{cm}$ apart. Calculate the frequency of the microwaves.

Essential Pre-Uni Physics D5.8

A Level - Challenge (C2)

You must give a unit in all of your numeric answers in order to obtain the mark. The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

Part A Water in a tube

A musical note of several frequencies is sounded at the mouth of a $1.0\,\mathrm{m}$ long vertical tube that has some water in the bottom. Give the depth of water in the tube if the fundamental frequency heard is $125\,\mathrm{Hz}$.

Part B Matching amplitudes

When the lowest frequency above the fundamental is played, at what height will the particles' displacement be out of phase and have the same amplitude as that of the particles $8.0\,\mathrm{cm}$ above the surface of the water? Give your answer as a distance above the surface of the water.

Speed Camera

A Level - Challenge (C3)

This problem involves the Doppler effect, which is not covered in some Physics A Levels. For more information please check with your teacher.

A car is travelling past a speed camera on a motorway. The camera uses a radio signal of wavelength $3.2\,\mathrm{cm}$ which is then reflected back to the camera from the rear of the car as it travels past. The camera is at the same height as the rear of the car and is close enough to the car's path that the velocity of the car can be considered to be along the path of the radio signal.

From the point of view of the car, the signal incident on the reflective surface will be Doppler shifted. This signal is now reflected back to the speed camera from a moving source. This signal, when it is received back by the camera, is therefore twice Doppler shifted.

The superposition of the transmitted and reflected signals gives beats with a frequency of $2200\,\mathrm{Hz}$.

Given that the speed limit is $100\,\mathrm{km\,h^{-1}}$, how much faster than the speed limit is the car travelling? Give your answer in $\mathrm{km\,h^{-1}}$

Adapted with permission from UCLES, A Level Physics, June 1964, Paper 3, Question 5