Stationary Waves Questions – OCR A Level Physics

Praneel Physics

1. What is a stationary wave? **(P)**

Working and Answer:

A wave formed by the superposition of two progressive waves with the same frequency and amplitude travelling in opposite directions.

2. Define the terms node and antinode. **(P)**

Working and Answer:

Node: A point on a stationary wave where the displacement is always zero.
Antinode: A point where the displacement is at maximum.

3. State the condition required for a stationary wave to form. **(P)**

Working and Answer:

Two waves of equal frequency and amplitude must travel in opposite directions and interfere.

4. What is the distance between two adjacent nodes? **(P)**

Working and Answer:

$$\text{Distance between nodes} = \frac{\lambda}{2}$$

5. What is the fundamental frequency of a string of length L? **(P)**

Working and Answer:

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

6. Describe how a stationary wave can form on a stretched string. **(PP)**

Working and Answer:

When a wave reflects at the fixed ends of the string and meets an incoming wave, they interfere constructively and destructively to form a stationary wave.

7. Explain why no energy is transferred in a stationary wave. **(PP)**

Working and Answer:

Because the two waves are equal and opposite, their energy transfers cancel out, so there is no net energy transfer.

8. In a stationary wave, what is the phase relationship between points on opposite sides of a node? **(PP)**

Working and Answer:

They are out of phase by $180°$ or π radians.

9. What is meant by the first harmonic? **(PP)**

Working and Answer:

It is the lowest frequency at which a stationary wave can form — with one antinode and two nodes (one at each end).

10. Draw and label the first and second harmonics on a string fixed at both ends. **(PP)**

Working and Answer:

(Diagram to be sketched showing:)
First harmonic: one loop.
Second harmonic: two loops.

11. A string of length 1.5 m is fixed at both ends and vibrates at its fundamental frequency. The wave speed is 300 m/s. Calculate the frequency. **(PPP)**

Working and Answer:

$$f = \frac{v}{2L} = \frac{300}{2 \times 1.5} = 100\,\text{Hz}$$

12. Explain how resonance relates to the formation of stationary waves. **(PPP)**

Working and Answer:

Stationary waves form when the driving frequency matches the natural frequency of the medium, producing resonance and large amplitude oscillations.

13. A stationary wave has 3 nodes and 2 antinodes. What harmonic is this? **(PPP)**

Working and Answer:

This is the second harmonic.

14. What is the wavelength of the third harmonic in a string of length L? **(PPP)**

Working and Answer:

$$\lambda = \frac{2L}{3}$$

15. Explain how you would use a microwave generator to produce stationary waves. **(PPP)**

Working and Answer:

Direct microwaves at a metal reflecting plate. Measure the pattern of maxima and minima using a probe to detect points of constructive and destructive interference.

16. A string under tension produces a stationary wave of frequency 200 Hz. If its length is 0.5 m and mass per unit length is 2.5×10^{-3} kg/m, calculate the tension. **(PPPP)**

Working and Answer:

$$v = 2Lf = 2 \times 0.5 \times 200 = 200\,\text{m/s}$$

$$T = \mu v^2 = (2.5 \times 10^{-3}) \times (200)^2 = 100\,\text{N}$$

17. Describe how stationary sound waves can be demonstrated in a tube. **(PPPP)**

Working and Answer:

Use a signal generator and loudspeaker at one end of a closed or open tube. Adjust frequency or tube length to observe resonance at nodes and antinodes using a microphone.

18. In a closed pipe, explain why only odd harmonics are present. **(PPPP)**

Working and Answer:

A closed end is a node and an open end is an antinode. This boundary condition only allows odd multiples of the fundamental frequency.

19. A tube closed at one end is 0.85 m long. Calculate the frequency of its first harmonic. Speed of sound = 340 m/s. **(PPPP)**

Working and Answer:

$$\lambda = 4L = 4 \times 0.85 = 3.4\,\text{m}$$

$$f = \frac{v}{\lambda} = \frac{340}{3.4} = 100\,\text{Hz}$$

20. A stretched string has length 0.75 m and supports the third harmonic at 600 Hz. Find the wave speed. **(PPPPP)**

Working and Answer:

$$\lambda = \frac{2L}{3} = \frac{2 \times 0.75}{3} = 0.5\,\text{m}$$

$$v = f\lambda = 600 \times 0.5 = 300\,\text{m/s}$$

21. Describe an experiment to measure the speed of sound in air using stationary waves. **(PPPPP)**

Working and Answer:

Set up a resonance tube partially submerged in water. Use a tuning fork of known frequency and adjust the air column length until loudest sound (resonance) is heard. Use the shortest resonant length to estimate $\lambda/4$, then calculate speed:

$$v = f\lambda$$