

Superposition and Wave Motion Questions

– OCR A Level Physics

Praneel Physics

1. Define the principle of superposition. (P)

Working and Answer:

When two or more waves meet, the resultant displacement is the vector sum of the displacements of the individual waves.

2. What is constructive interference? (P)

Working and Answer:

When two waves meet in phase and their displacements add to produce a wave of greater amplitude.

3. What is destructive interference? (P)

Working and Answer:

When two waves meet out of phase and their displacements cancel each other out, producing reduced or zero amplitude.

4. State two conditions necessary for observable interference. (P)

Working and Answer:

1. The waves must be coherent (same frequency and constant phase difference).
2. They must have similar amplitudes.

5. What does it mean for waves to be coherent? (P)

Working and Answer:

Waves that have the same frequency and a constant phase difference.

6. Describe how interference patterns can be produced using sound waves. (PP)

Working and Answer:

Two loudspeakers connected to the same signal generator emit sound waves. At certain points, the waves constructively or destructively interfere, forming an interference pattern.

7. Explain the difference between transverse and longitudinal waves. (PP)

Working and Answer:

Transverse waves oscillate perpendicular to the direction of wave propagation, while longitudinal waves oscillate parallel to the direction of wave propagation.

8. What happens when two waves of slightly different frequencies interfere? **(PP)**

Working and Answer:

They produce a beat pattern where the amplitude oscillates at the beat frequency:

$$f_{\text{beat}} = |f_1 - f_2|$$

9. Explain the term phase difference. **(PP)**

Working and Answer:

The angular difference between points on two waves of the same frequency, measured in degrees or radians.

10. State the speed–frequency–wavelength relationship. (PP)

Working and Answer:

$$v = f\lambda$$

11. In a Young's double-slit experiment, describe how an interference pattern is formed. (PPP)

Working and Answer:

Light passes through two narrow slits from a coherent source. The waves diffract and overlap, forming bright and dark fringes due to constructive and destructive interference.

12. Two coherent sources produce an interference pattern with spacing between fringes of 3 mm. If the wavelength is 600 nm and the distance to the screen is 2 m, calculate the slit separation. (PPP)

Working and Answer:

$$x = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{x} = \frac{600 \times 10^{-9} \times 2}{3 \times 10^{-3}} = 0.4 \text{ mm}$$

13. What is the phase difference between two points one wavelength apart? (PPP)

Working and Answer:

360° or 2π radians.

14. A wave travels at 340 m/s and has a frequency of 1700 Hz. Calculate its wavelength. (PPP)

Working and Answer:

$$\lambda = \frac{v}{f} = \frac{340}{1700} = 0.2 \text{ m}$$

15. Describe the displacement of a point on a wave at a phase of 90° . (PPP)

Working and Answer:

It is at maximum displacement (peak or trough), depending on wave direction.

16. Describe how to demonstrate two-source interference using a ripple tank. (PPPP)

Working and Answer:

Use two dipper sources at a fixed frequency. The overlapping circular waves form regions of constructive and destructive interference, observed on the tank base.

17. Explain why a laser is used in Young's experiment. (PPPP)

Working and Answer:

Because it provides monochromatic and coherent light, ensuring clear and stable interference fringes.

18. Two waves interfere destructively. Their amplitudes are 3 cm and 2 cm. What is the resultant amplitude? **(PPPP)**

Working and Answer:

$$A = |3 - 2| = 1 \text{ cm}$$

19. How can the wavelength of microwaves be measured using interference? **(PPPP)**

Working and Answer:

Use a microwave source and a metal plate to reflect the wave. Move a detector to find positions of maxima and minima. Distance between two consecutive minima is half a wavelength.

20. A double-slit interference pattern is produced with light of wavelength 550 nm. The fringe spacing is 0.25 cm and the screen is 1.5 m away. Calculate the slit separation. (PPPPP)

Working and Answer:

$$x = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{x} = \frac{550 \times 10^{-9} \times 1.5}{2.5 \times 10^{-3}} = 3.3 \times 10^{-4} \text{ m} = 0.33 \text{ mm}$$

21. Describe the conditions needed for a stable standing wave to be formed in an air column. (PPPPP)

Working and Answer:

Reflected waves must interfere with incoming waves of the same frequency and amplitude. Boundary conditions determine node and antinode positions depending on whether the ends are open or closed.

22. Explain how phase difference affects the resulting wave in superposition. (PPPPP)

Working and Answer:

If waves are in phase, amplitudes add (constructive). If out of phase by 180° , amplitudes subtract (destructive). Intermediate phase causes partial interference.