

Waves — CBSE Pattern Test 2

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 2 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · Waves · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.

(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.

(3) For MCQ questions choose the single correct option; for VSA answers write a single line.

(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- Which of the following requires a material medium to travel?
 - Sound
 - Light
 - Radio waves
 - X-rays
- The relation connecting wave speed v , frequency f and wavelength λ is
 - $v = f\lambda$
 - $v = \lambda/f$
 - $f = v\lambda$
 - $\lambda = fv$
- A sound wave of frequency 340 Hz travels with a speed of 680 m/s. Its wavelength is
 - 2 m
 - 0.5 m
 - 1 m
 - 4 m
- The frequency of a mechanical wave is determined by the
 - source that generates it
 - medium through which it travels
 - amplitude of the wave
 - wavelength of the wave
- Newton's formula for the speed of sound in air gave a value that was
 - too low compared to the experimental value
 - too high compared to the experimental value
 - exactly equal to the experimental value
 - independent of temperature
- At a fixed temperature, the speed of sound in a gas is
 - independent of the pressure of the gas
 - directly proportional to the pressure
 - inversely proportional to the pressure
 - proportional to the square of the pressure
- The equation $y = A \sin(kx + \omega t)$ represents a wave travelling
 - in the negative x direction

- (B) in the positive x direction
 - (C) along the y direction
 - (D) as a standing wave
8. A phase difference of 2π rad corresponds to a path difference of
- (A) one wavelength
 - (B) half a wavelength
 - (C) a quarter wavelength
 - (D) two wavelengths
9. What are nodes and antinodes in a stationary wave?
10. Why does a closed organ pipe produce only odd harmonics?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. Two tuning forks of frequencies 256 Hz and 260 Hz are sounded together. Find the beat frequency.
12. An observer moves towards a stationary source of sound of frequency 400 Hz at a speed of 10 m/s. Find the apparent frequency heard. (Speed of sound = 330 m/s.)
13. A string of length 1 m has a fundamental frequency of 110 Hz. Find its wavelength and the speed of waves on the string.
14. A closed organ pipe produces a fundamental of 220 Hz. Find its length and the frequency of the next higher harmonic (speed of sound = 330 m/s).

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. A progressive wave is described by $y = 0.05 \sin \pi(200t - 2x)$ m. Find its (a) frequency, (b) wavelength and (c) speed of propagation.
16. The speed of sound in air at 0°C is 331 m/s. Estimate its speed at 20°C .
17. Derive the relation between phase difference and path difference of two waves, and use it to find the path difference corresponding to a phase difference of π .
18. A source of sound of frequency 500 Hz moves towards a stationary observer at 20 m/s while the observer walks towards the source at 5 m/s. Find the apparent frequency heard. (Speed of sound = 340 m/s.)

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Two waves $y_1 = A \sin(kx - \omega t)$ and $y_2 = A \sin(kx + \omega t)$ superpose on a string. Obtain the resultant standing wave and identify the positions of nodes and antinodes.
20. State Newton's formula for the speed of sound in a gas, obtain its value for air, and explain the correction introduced by Laplace.

Answer Key (Marking Scheme)

- Q1 — (A) Sound. Q2 — (A) $v = f\lambda$. Q3 — (A) 2 m. Q4 — (A) the source that generates it.
- Q5 — (A) too low (Newton's isothermal value ≈ 280 m/s vs the experimental ≈ 332 m/s). Q6 — (A) independent of the pressure. Q7 — (A) negative x direction. Q8 — (A) one wavelength.
- Q9 — Nodes are the points of zero displacement (and zero amplitude) in a stationary wave; antinodes are the points of maximum amplitude between the nodes.

Q10 — A closed pipe has a node at the closed end and an antinode at the open end, so $L = (2n - 1)\lambda/4$; only odd multiples of the fundamental (1st, 3rd, 5th, ...) fit.

Q11 — Beat frequency = $|260 - 256| = 4$ Hz.

Q12 — $f' = f(v + v_o)/v = 400 \times (330 + 10)/330 \approx 412$ Hz.

Q13 — $\lambda_1 = 2L = 2$ m; $v = f_1\lambda_1 = 110 \times 2 = 220$ m/s.

Q14 — $L = v/4f_1 = 330/880 = 0.375$ m; next higher = 3rd harmonic = $3 \times 220 = 660$ Hz.

Q15 — $y = 0.05 \sin(200\pi t - 2\pi x)$: (a) $f = 200\pi/2\pi = 100$ Hz; (b) $k = 2\pi/\lambda = 2\pi/k = 1$ m; (c) $v = f\lambda = 100$ m/s.

Q16 — $v = 331\sqrt{(293/273)} \approx 343$ m/s ($\approx 331 + 0.6 \times 20$).

Q17 — A path difference Δx changes the phase by $\Delta\phi = (2\pi/\lambda)\Delta x$; for $\Delta\phi = \pi$, $\Delta x = \lambda/2$.

Q18 — $f' = f(v + v_o)/(v - v_s) = 500 \times (340 + 5)/(340 - 20) = 500 \times 345/320 \approx 539$ Hz.

Q19 — $y = 2A \sin kx \cos \omega t$; nodes where $\sin kx = 0 \Rightarrow x = n\lambda/2$; antinodes where $\sin kx = \pm 1 \Rightarrow x = (2n+1)\lambda/4$.

Q20 — Newton: $v = \sqrt{P/\rho}$ (isothermal compression; ≈ 280 m/s for air — too low). Laplace: compression is adiabatic, bulk modulus $B = \gamma P \Rightarrow v = \sqrt{\gamma P/\rho} \approx 332$ m/s for air ($\gamma = 1.4$) — matching experiment.