

Waves — CBSE Pattern Test 1

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

Test 1 — 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)

- In a transverse wave, the particles of the medium vibrate
 - perpendicular to the direction of propagation
 - parallel to the direction of propagation
 - along the direction of the wave speed
 - in circles
- Sound waves are
 - longitudinal mechanical waves
 - transverse mechanical waves
 - electromagnetic waves
 - transverse and electromagnetic
- A wave transfers
 - energy and momentum without transporting matter
 - matter from one point to another
 - only energy, never momentum
 - both matter and energy
- The distance between two successive crests of a wave is called the
 - wavelength
 - frequency
 - amplitude
 - period
- If the frequency of a wave is doubled while its speed stays constant, the wavelength
 - becomes half
 - is doubled
 - remains the same
 - becomes one-fourth
- Sound travels fastest in
 - solids
 - liquids
 - gases
 - vacuum
- The Laplace correction factor γ for air is approximately
 - 1.4

(B) 1.0

(C) 2.0

(D) 0.7

8. In a standing wave, the distance between two consecutive nodes is

(A) $\lambda/2$

(B) λ

(C) $\lambda/4$

(D) 2λ

9. Define beats.

10. State the Doppler effect for sound.

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

11. A wave travels with a speed of 330 m/s and has a frequency of 660 Hz. Find its wavelength.

12. A string of length 2 m and mass 50 g is under a tension of 200 N. Find the speed of a transverse wave on it.

13. Two tuning forks of frequencies 256 Hz and 260 Hz are sounded together. Find the beat frequency.

14. A wave travels the length of a 20 m string in 5 s. If consecutive crests are 0.4 m apart, find the frequency and period of the wave.

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

15. Derive the expression for the velocity of a transverse wave on a stretched string.

16. Write and explain the equation of a plane progressive wave and derive the relation among particle velocity, wave velocity and slope.

17. Derive the conditions for a stationary wave on a string fixed at both ends and find the frequencies of the first three harmonics.

18. A fork of unknown frequency produces 5 beats per second with a 256 Hz fork. When the unknown fork is slightly loaded with wax, the beats drop to 3 beats per second. Find the unknown frequency and justify your answer.

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

19. Describe the formation of stationary waves on a stretched string and derive the expressions for the allowed frequencies. Hence find the fundamental frequency and its overtones for a string of length L with tension T and linear density μ .

20. State and derive the Doppler effect for sound — obtain the observed frequency when a source moves towards a stationary observer and when the observer moves towards a stationary source.

Answer Key (Marking Scheme)

Q1 — (A) perpendicular. Q2 — (A) longitudinal mechanical. Q3 — (A) energy and momentum without transporting matter. Q4 — (A) wavelength.

Q5 — (A) becomes half ($v = f\lambda$, v constant). Q6 — (A) solids. Q7 — (A) 1.4. Q8 — (A) $\lambda/2$.

Q9 — Beats are the periodic rise and fall in the loudness of sound produced when two waves of nearly equal frequencies superpose.

Q10 — A change in the observed frequency of sound (or any wave) due to the relative motion of the source and the observer.

Q11 — $\lambda = v/f = 330/660 = 0.5 \text{ m}$.

Q12 — $\mu = 0.05/2 = 0.025 \text{ kg/m}$; $v = \sqrt{T/\mu} = \sqrt{(200/0.025)} = \sqrt{8000} \approx 89.4 \text{ m/s}$.

Q13 — Beat frequency = $|260 - 256| = 4 \text{ Hz}$.

Q14 — $v = 20/5 = 4 \text{ m/s}$; $\lambda = 0.4 \text{ m}$ $f = v/\lambda = 10 \text{ Hz}$; $T = 1/f = 0.1 \text{ s}$.

Q15 — Consider a small element of the string; the restoring force is $T \cdot (\partial^2 y / \partial x^2) dx$ and the wave equation gives $v = \sqrt{T/\mu}$, where μ is the mass per unit length.

Q16 — $y = A \sin(\omega t - kx)$, with $\omega = 2\pi f$, $k = 2\pi/\lambda$; particle velocity $v_p = \partial y / \partial t = A\omega \cos(\omega t - kx)$ and slope = $\partial y / \partial x = -kA \cos(\omega t - kx)$ $v_p = -v \times (\text{slope})$.

Q17 — Fixed ends $y(0) = y(L) = 0$ $kL = n\pi$, $n = 1, 2, 3 \dots$; $f_1 = v/2L$, $f_2 = v/L$, $f_3 = 3v/2L$ ($f_n = nv/2L$).

Q18 — $f = 256 \pm 5 = 251 \text{ Hz}$ or 261 Hz ; loading lowers the frequency and beats fall to 3 (frequency moves toward 256), so the unknown fork is 261 Hz .

Q19 — Standing waves form when reflected waves superpose; allowed modes $kL = n\pi$ give $f_n = nv/2L = (n/2L)\sqrt{T/\mu}$; $n = 1$ is the fundamental, $n = 2, 3, \dots$ its overtones.

Q20 — Source moving toward stationary observer: $f' = f_v/(v - v_s)$. Observer moving toward stationary source: $f' = f(v + v_o)/v$.