

Oscillations — 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 · Oscillations · 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 simple harmonic motion the acceleration is
 - proportional to $-\text{displacement}$
 - proportional to displacement
 - independent of displacement
 - proportional to velocity
- The time period of a mass m attached to a spring of force constant k is
 - $2\pi\sqrt{(m/k)}$
 - $2\pi\sqrt{(k/m)}$
 - $2\pi\sqrt{(m k)}$
 - $\sqrt{(m/k)}$
- The time period of a simple pendulum of length l is
 - $2\pi\sqrt{(l/g)}$
 - $2\pi\sqrt{(g/l)}$
 - $2\pi\sqrt{(l g)}$
 - $\sqrt{(l/g)}$
- The total energy of a particle executing SHM of amplitude A with force constant k is
 - $\frac{1}{2}kA^2$
 - kA^2
 - $\frac{1}{4}kA^2$
 - $2kA^2$
- The SI unit of angular frequency is
 - rad s^{-1}
 - hertz
 - second
 - rad
- At the mean position the energy of a SHM particle is
 - entirely kinetic
 - entirely potential
 - half kinetic and half potential
 - zero
- The amplitude of a damped oscillator decreases
 - exponentially with time

- (B) linearly with time
 - (C) as the square of time
 - (D) it does not change
8. Resonance occurs when the driving frequency
- (A) equals the natural frequency
 - (B) is zero
 - (C) is twice the natural frequency
 - (D) is very much greater than the natural frequency
9. Define simple harmonic motion.
10. Define the phase of SHM.

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

11. A particle executes SHM with $x = 0.05 \sin(4\pi t)$ m. Find its amplitude and time period.
12. A mass of 0.5 kg is attached to a spring of spring constant 200 N/m. Find its period of oscillation.
13. At a displacement x the velocity of a SHM particle is half its maximum value. Find x in terms of the amplitude A .
14. At what displacement is the kinetic energy of a SHM particle equal to its potential energy?

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

15. Show that the motion of a mass attached to a spring is simple harmonic and derive the expression for its time period.
16. Explain what is meant by the time period of a simple pendulum and derive its expression for small oscillations.
17. Derive the expressions for the kinetic and potential energies of a particle executing SHM and show that the total energy is conserved.
18. Define damped oscillations and resonance, and give one example of resonance.

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

19. Starting from the restoring force relation, derive the differential equation $x'' + \omega^2 x = 0$ and show that its solution represents SHM. Hence obtain the expressions for velocity, acceleration and total energy in terms of displacement.
20. Define damped oscillations and resonance. Discuss the energy of SHM graphically and explain the difference between free, damped and forced oscillations with an example of resonance.

Answer Key (Marking Scheme)

- Q1 — (A) proportional to $-$ displacement. Q2 — (A) $2\pi\sqrt{m/k}$. Q3 — (A) $2\pi\sqrt{l/g}$. Q4 — (A) $\frac{1}{2}kA^2$.
- Q5 — (A) rad s^{-1} . Q6 — (A) entirely kinetic. Q7 — (A) exponentially with time. Q8 — (A) equals the natural frequency.
- Q9 — A to-and-fro motion about a mean position in which the acceleration is proportional to the displacement and directed towards the mean position.
- Q10 — The quantity $(\omega t + \phi)$ that specifies the state (position and direction of motion) of the oscillator.
- Q11 — $A = 0.05$ m; $T = 2\pi/4\pi = 0.5$ s.
- Q12 — $T = 2\pi\sqrt{m/k} = 2\pi\sqrt{0.5/200} \approx 0.31$ s.
- Q13 — $v = \omega\sqrt{A^2 - x^2} = \frac{1}{2}A\omega \sin \phi = (\sqrt{3}/2)A$.
- Q14 — $x = A/\sqrt{2}$.

Q15 — Restoring force $F = -kx$ $\Rightarrow a = -kx/m = -(k/m)x$, which is SHM with $T = 2\pi\sqrt{m/k}$.

Q16 — Time for one complete oscillation; for small angles, $a = -(g/l)x$ $\Rightarrow T = 2\pi\sqrt{l/g}$.

Q17 — $KE = \frac{1}{2}m\omega^2(A^2 - x^2)$, $PE = \frac{1}{2}m\omega^2x^2$; sum = $\frac{1}{2}m\omega^2A^2$, independent of x , hence conserved.

Q18 — Damped: amplitude decays due to resistive forces. Resonance: large-amplitude oscillation when driving frequency equals the natural frequency; example — pushing a swing in step with its natural frequency.

Q19 — $F = -kx$ $\Rightarrow d^2x/dt^2 = -\omega^2x$, $\omega^2 = k/m$; solution $x = A \sin(\omega t + \phi)$; $v = A\omega \cos(\omega t + \phi)$, $a = -\omega^2x$, $E = \frac{1}{2}m\omega^2A^2$.

Q20 — See the assignment answer key: free (undamped), damped (exponential decay) and forced (driven); resonance is the peak of the amplitude–frequency curve; example — Tacoma Narrows bridge.