



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ where needed. Neglect air resistance unless stated.

A. Very short answers - 1 mark each

1. Define periodic motion and give an example that is not oscillatory.
2. State the defining acceleration-displacement relation for SHM.
3. Define amplitude, phase and angular frequency.
4. At which positions are SHM speed and acceleration maximum?
5. What is the phase difference between displacement and velocity in SHM?
6. Does doubling amplitude change the period of ideal SHM?
7. Why must the angular amplitude be small for a simple pendulum to execute SHM?
8. What happens to a pendulum's period when its length is quadrupled?

B. Short answers / practice - 2 marks each

9. Show that $a = -\omega^2 x$ implies a restoring force towards equilibrium.
10. A particle executes $x = 0.05 \cos(4\pi t)$ m. Find amplitude, frequency, period and initial phase.
11. For $A = 0.10 \text{ m}$ and $\omega = 5 \text{ rad/s}$, find maximum speed and acceleration.
12. A 0.5 kg block is attached to a spring of constant 200 N/m . Find its oscillation period.
13. What fraction of total SHM energy is kinetic at $x = A/2$?
14. Explain why a pendulum clock runs slow when taken to a place with smaller g .
15. Sketch displacement, velocity and acceleration versus time for $x = A \cos \omega t$.
16. A spring's extension under a 2 kg load is 5 cm . Find its spring constant.

C. Application / reasoning - 3 marks each

17. Derive $v = \pm \omega \sqrt{(A^2 - x^2)}$ for SHM and interpret both signs.
18. A particle has $A = 8 \text{ cm}$ and period 2 s . Find its speed and acceleration magnitude at $x = 4 \text{ cm}$.
19. A 0.2 kg oscillator has $\omega = 10 \text{ rad/s}$ and $A = 0.05 \text{ m}$. Find total energy and kinetic energy at $x = 0.03 \text{ m}$.

20. A spring-mass system has period 0.4 s . What mass must be added to its 0.5 kg block to double the period?

21. An oscillator starts at equilibrium moving in the positive direction. Write its displacement equation and find the first time it reaches $x = A/2$.

22. Compare the periods of the same pendulum on Earth and on a planet where g is one-fourth of Earth's value.

23. A pendulum of length 1 m is in a lift accelerating upward at 2 m/s^2 . Find its small-oscillation period. What occurs in free fall?

24. Two springs of constants k_1 and k_2 support a mass in parallel. Obtain the effective spring constant and period of vertical oscillation.

25. Explain why the equilibrium extension of a vertical spring does not affect its oscillation period. State the idealisations.

D. Extended practice - 5 marks each

26. Derive displacement, velocity and acceleration equations for SHM using the projection of uniform circular motion. Show their phase relations.
27. Derive the period of a horizontal spring-mass oscillator. Obtain kinetic, potential and total energies as functions of displacement.
28. Derive the small-amplitude period of a simple pendulum. State the assumptions and explain dependence on length, mass and g .
29. Derive kinetic and potential energies in SHM as functions of time. Sketch their variation over one period and identify their oscillation frequency.
30. A 0.5 kg block on a smooth table is attached to a 50 N/m spring, displaced 0.10 m and released. Obtain $x(t)$, $v(t)$, $a(t)$, total energy and the first time it reaches equilibrium.

ANSWER KEY - Numerical / closed questions

5) $\pi/2$. 6) No. 8) It doubles. 10) 0.05 m ; 2 Hz ; 0.5 s ; 0 . 11) 0.50 m/s ; 2.5 m/s^2 . 12) $\pi/10 \approx 0.314 \text{ s}$. 13) $3/4$. 16) 400 N/m . 18) $0.04\pi\sqrt{3} \approx 0.218 \text{ m/s}$; $0.04\pi^2 \approx 0.395 \text{ m/s}^2$. 19) 0.025 J ; 0.016 J . 20) 1.5 kg . 21) $x = A \sin \omega t$; first time $T/12$. 22) Planet period is twice Earth period. 23) $2\pi/\sqrt{12} \approx 1.814 \text{ s}$; no gravitational restoring force in free fall. 24) $k_{\text{eff}} = k_1 + k_2$; $T = 2\pi\sqrt{[m/(k_1 + k_2)]}$. 30) $x = 0.1 \cos 10t$; $v = -\sin 10t$; $a = -10 \cos 10t$ (SI); $E = 0.25 \text{ J}$; first equilibrium $\pi/20 \text{ s}$.