Exemplar Solutions for Class 11 Physics Chapter 13 – Oscillations

Multiple Choice Questions I

1. The displacement of a particle is represented by the equation y = 3 cos(π/4 - 2ωt). The motion of the particle is:

Options:

(a) simple harmonic with period 2π/ω

(b) simple harmonic with period π/ω

(c) periodic but not simple harmonic

(d) non-periodic

Answer: (b) simple harmonic with period π/ω

Explanation: The given equation can be rewritten as: y = 3 cos(2ωt - π/4) = 3 cos(2ω(t - π/8ω))

Comparing with the standard SHM equation y = A cos(ωt + ϕ), we get:

- Angular frequency = 2ω
- Time period T = 2π/(2ω) = π/ω

2. The displacement of a particle is represented by the equation y = $\sin^3\omega t$. The motion is:

Options:

(a) non-periodic

(b) periodic but not simple harmonic

(c) simple harmonic with period 2π/ω

(d) simple harmonic with period π/ω

Answer: (b) periodic but not simple harmonic

Explanation: Using the identity: $\sin^3\theta = (3\sin\theta - \sin3\theta)/4$ $y = \sin^3\omega t = (3\sin\omega t - \sin3\omega t)/4$

This is a combination of two sinusoidal functions with different frequencies (ω and 3ω). The motion is periodic with period 2π/ω but not simple harmonic since it's not of the form A sin(ωt + ϕ).

3. The relation between acceleration and displacement of four particles are given below:

Options:

(a) $a_x = +2x$

(b) $a_x = +2x^2$

(c) $a_x = -2x^2$

(d) $a_x = -2x$

Which one of the particles is executing simple harmonic motion?

Answer: (d) $a_x = -2x$

Explanation: For simple harmonic motion, acceleration must be directly proportional to displacement and opposite in direction: $a = -\omega^2 x$

Only option (d) satisfies this condition with $\omega^2 = 2$.

4. Motion of an oscillating liquid column in a U-tube is:

Options:

(a) periodic but not simple harmonic

(b) non-periodic

(c) simple harmonic and time period is independent of the density of the liquid

(d) simple harmonic and time period is directly proportional to the density of the liquid

Answer: (c) simple harmonic and time period is independent of the density of the liquid

Explanation: For a U-tube oscillation, the restoring force is $F = -\rho g A x$ (where A is cross-sectional area, ρ is density) Mass of liquid column = $\rho A l$ (where l is total length) Therefore: $a = F/m = -gx/l$ This gives $\omega^2 = g/l$, so $T = 2\pi\sqrt{(l/g)}$

The time period is independent of density ρ.

5. A particle is acted simultaneously by mutually perpendicular simple harmonic motions x = a cos ωt and y = a sin ωt. The trajectory of motion of the particle will be:

Options:

(a) an ellipse

(b) a parabola

(c) a circle

(d) a straight line

Answer: (c) a circle

Explanation: Given: $x = a \cos \omega t$ and $y = a \sin \omega t$ Therefore: $x^2 + y^2 = a^2(\cos^2\omega t + \sin^2\omega t) = a^2$

This is the equation of a circle with radius a centered at origin.

6. The displacement of a particle varies with time according to the relation y = a sin ωt + b cos ωt:

Options:

(a) the motion is oscillatory but not SHM

(b) the motion is SHM with amplitude a + b

(c) the motion is SHM with amplitude $a^2 + b^2$

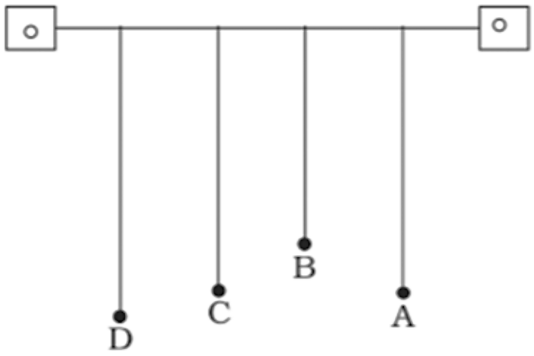
(d) the motion is SHM with amplitude $\sqrt{(a^2 + b^2)}$

Answer: (d) the motion is SHM with amplitude $\sqrt{(a^2 + b^2)}$

Explanation: $y = a \sin \omega t + b \cos \omega t$ can be written as: $y = \sqrt{(a^2 + b^2)} \sin(\omega t + \phi)$ where $\tan \phi = b/a$

This is simple harmonic motion with amplitude $A = \sqrt{(a^2 + b^2)}$.

7. Four pendulums A, B, C, and D are suspended from the same elastic support. A and C are of the same length, while B is smaller than A and D is larger than A. If A is given a transverse displacement:



Options:

(a) D will vibrate with maximum amplitude

(b) C will vibrate with maximum amplitude

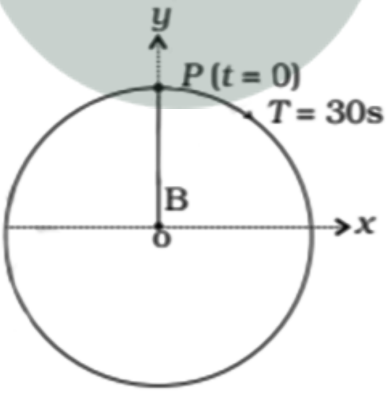
(c) B will vibrate with maximum amplitude

(d) all the four will oscillate with equal amplitude

Answer: (b) C will vibrate with maximum amplitude

Explanation: This is a case of forced oscillations. When pendulums are coupled through an elastic support, resonance occurs when the natural frequency matches the driving frequency. Since A and C have the same length, they have the same natural frequency. When A oscillates, it drives C at its natural frequency, causing resonance and maximum amplitude in C.

8. Figure shows the circular motion of a particle with radius B, period T = 30s, and initial position as shown. The simple harmonic motion of the x-projection is:



Options:

(a) $x(t) = B \sin(2\pi t/30)$

(b) $x(t) = B \cos(\pi t/15)$

(c) $x(t) = B \sin(\pi t/15 + \pi/2)$

(d) $x(t) = B \cos(\pi t/15 + \pi/2)$

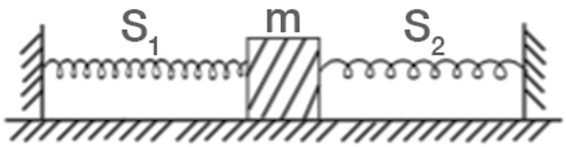
Answer: (a) $x(t) = B \sin(2\pi t/30)$

Explanation: From the figure, at t = 0, the particle is at the topmost position. Angular frequency $\omega = 2\pi/T = 2\pi/30 = \pi/15$ At t = 0, x = 0, and the particle is moving in the positive x-direction. Therefore: $x(t) = B \sin(2\pi t/30)$

9. The equation of motion of a particle is $x = a\cos(\alpha t)^2$. The motion is:
Options: (a) periodic but not oscillatory
(b) periodic and oscillatory
(c) oscillatory but not periodic
(d) neither periodic nor oscillatory
Answer: (c) oscillatory but not periodic
Explanation: $x = a\cos(\alpha t)^2$ The function oscillates between +a and -a, so it's oscillatory. However, since the argument is $(\alpha t)^2$, the function doesn't repeat at regular intervals, making it non-periodic.

10. A particle executing SHM has a maximum speed of 30 cm/s and a maximum acceleration of 60 cm/s². The period of oscillation is:
Options: (a) π s
(b) π/2 s
(c) 2π s
(d) π/t s
Answer: (a) π s
Explanation: For SHM: $x = A\sin(\omega t + \phi)$ Maximum velocity: $v_{max} = A\omega = 30$ cm/s Maximum acceleration: $a_{max} = A\omega^2 = 60$ cm/s²
Dividing: $a_{max}/v_{max} = \omega = 60/30 = 2$ rad/s Therefore: $T = 2\pi/\omega = 2\pi/2 = \pi$ s

11. When a mass m is connected individually to two springs S_1 and S_2, the oscillation frequencies are v_1 and v_2. If the same mass is attached to both springs in series, the oscillation frequency would be:



Options: (a) $v_1 + v_2$
(b) $\sqrt{(v_1^2 + v_2^2)}$
(c) $(1/v_1 + 1/v_2)^{-1}$
(d) $\sqrt{(v_1^2 - v_2^2)}$
Answer: (b) $\sqrt{(v_1^2 + v_2^2)}$
Explanation: For individual springs: $v_1 = (1/2\pi)\sqrt{(k_1/m)}$ and $v_2 = (1/2\pi)\sqrt{(k_2/m)}$ Therefore: $k_1 = 4\pi^2 v_1^2 m$ and $k_2 = 4\pi^2 v_2^2 m$
For springs in series: $1/k_{eff} = 1/k_1 + 1/k_2$ After calculation: $v_{eff} = \sqrt{(v_1^2 + v_2^2)}$

Multiple Choice Questions II

12. The rotation of earth about its axis is:

Options:

(a) periodic motion

(b) simple harmonic motion

(c) periodic but not simple harmonic motion

(d) non-periodic motion

Answer: (a) periodic motion and (c) periodic but not simple harmonic motion

Explanation: Earth's rotation is periodic (repeats every 24 hours) but not simple harmonic since it involves circular motion, not oscillation about an equilibrium position.

13. Motion of a ball bearing inside a smooth curved bowl, when released from a point slightly above the lower point is:

Options:

(a) simple harmonic motion

(b) non-periodic motion

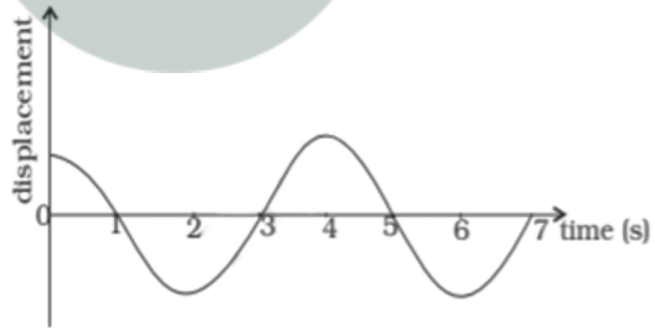
(c) periodic motion

(d) periodic but not SHM

Answer: (a) simple harmonic motion and (c) periodic motion

Explanation: For small displacements, the restoring force is proportional to displacement, making it SHM. The motion is also periodic.

14. Displacement versus time curve for a particle executing SHM is shown. Choose the correct statements:



Options:

(a) phase of the oscillator is same at t = 0 s and t = 2 s

(b) phase of the oscillator is same at t = 2 s and t = 6 s

(c) phase of the oscillator is same at t = 1 s and t = 7 s

(d) phase of the oscillator is same at t = 1 s and t = 5 s

Answer: (b) and (d)

Explanation: From the graph, the time period T = 4 s. Points separated by one complete period have the same phase.

- t = 2 s and t = 6 s are separated by 4 s (one period)
- t = 1 s and t = 5 s are separated by 4 s (one period)

15. Which of the following statements is/are true for a simple harmonic oscillator?

Options:

(a) force acting is directly proportional to displacement from the mean position and opposite to it

(b) motion is periodic

(c) acceleration of the oscillator is constant

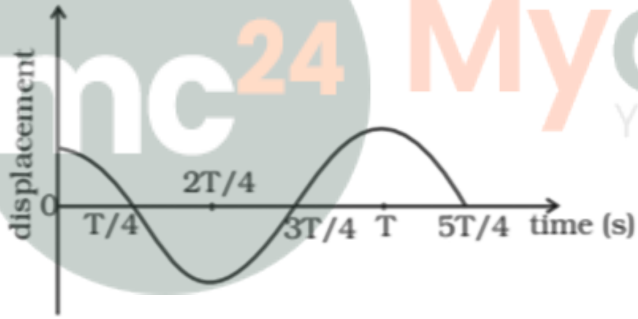
(d) the velocity is periodic

Answer: (a), (b), and (d)

Explanation:

- (a) True: F = -kx (Hooke's law)
- (b) True: SHM repeats after time period T
- (c) False: Acceleration varies as $a = -\omega^2 x$
- (d) True: Velocity repeats after time period T

16. The displacement time graph of a particle executing SHM is shown. Which statements are true?



Options: (a) the force is zero at t = 3T/4

(b) the acceleration is maximum at t = 4T/4

(c) the velocity is maximum at t = T/4

(d) the PE is equal to KE at t = T/2

Answer: (a), (b), and (c)

Explanation:

- (a) True: At t = 3T/4, displacement is zero, so force is zero
- (b) True: At t = T, displacement is maximum, so acceleration is maximum
- (c) True: At t = T/4, particle passes through mean position with maximum velocity

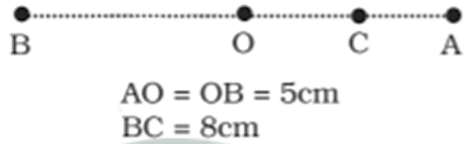
17. A body is performing SHM. Then its:

Options:

(a) average total energy per cycle is equal to its maximum kinetic energy
(b) average kinetic energy per cycle is equal to half of its maximum kinetic energy
(c) mean velocity over a complete cycle is equal to $2/\pi$ times of its maximum velocity
(d) root mean square velocity is $1/\sqrt{2}$ times of its maximum velocity
Answer: (a), (b), and (d)
Explanation:

- (a) True: Total energy = $\frac{1}{2}kA^2$ = maximum KE
- (b) True: Average KE = ½ × maximum KE
- (c) False: Mean velocity over complete cycle is zero
- (d) True: $v_{rms} = v_{max}/\sqrt{2}$

18. A particle is in linear simple harmonic motion between points A and B, 10 cm apart. Taking direction from A to B as positive, choose correct statements:



Options: (a) the sign of velocity, acceleration, and force when 3 cm from A going towards B are positive
(b) the sign of velocity at C going towards O is negative
(c) the sign of velocity, acceleration, and force when 4 cm from B going towards A are negative
(d) the sign of acceleration and force at point B is negative
Answer: (a), (c), and (d)
Explanation: Mean position O is at 5 cm from A. Analyzing each case based on direction of motion and position relative to mean position.