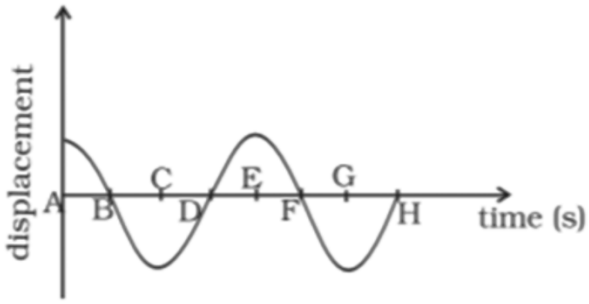
Exemplar Solutions for Class 11 Physics Chapter 13 – Oscillations

Very Short Answers

19. Displacement versus time curve for a particle executing SHM is shown. Identify the points where:



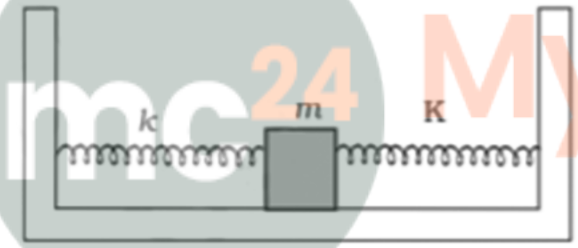
(i) velocity of the oscillator is zero

(ii) speed of the oscillator is maximum

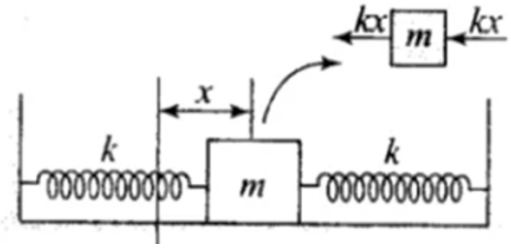
Answer: (i) Velocity is zero at extreme positions: points A, C, E, and G

(ii) Speed is maximum at mean positions: points B, D, F, and H

20. Two identical springs of spring constant K are attached to a block of mass m. When displaced by distance x towards right, find the restoring force.



Answer: For the system shown:



- Left spring force: $F_1 = -kx$
- Right spring force: $F_2 = -kx$
- Total restoring force: $F = F_1 + F_2 = -2kx$

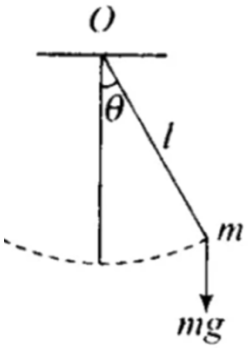
21. What are the two basic characteristics of simple harmonic motion?

Answer:

1. Acceleration is directly proportional to displacement: $a \propto -x$

2. Direction of acceleration is always towards the mean position (opposite to displacement direction)

22. When will the motion of a simple pendulum be simple harmonic?



Answer: Simple pendulum executes SHM when the angular displacement θ is small (θ < 10°). For small angles: sin θ ≈ θ Restoring force: F = -mg sin θ ≈ -mgθ = -mg(x/l) This gives F ∝ -x, which is the condition for SHM.

23. What is the ratio of maximum acceleration to maximum velocity of a simple harmonic oscillator?

Answer: For SHM: $x = A \sin(\omega t + \phi)$

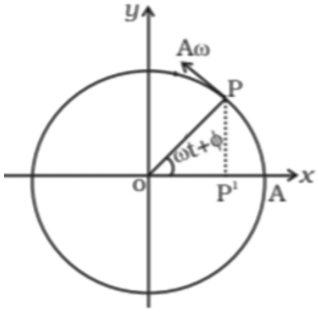
- Maximum velocity: $v_{max} = A\omega$
- Maximum acceleration: $a_{max} = A\omega^2$
- Ratio: $a_{max}/v_{max} = \omega$ (angular frequency)

24. What is the ratio between distance travelled by the oscillator in one time period and amplitude?

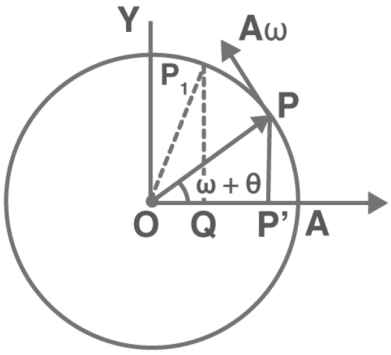
Answer: In one complete oscillation, the particle travels:

- Mean → Extreme → Mean → Other Extreme → Mean
- Total distance = 4A
- Ratio = 4A/A = 4:1

25. What will be the sign of velocity of point P' (projection of velocity of reference particle P moving anticlockwise)?



Answer:



From the figure, when P moves from its current position towards P_1, the projection P' moves towards the negative x-axis. Therefore, the sign of velocity of P' is **negative**.

26. Show that for a particle executing SHM, velocity and displacement have a phase difference of π/2.

Answer: For SHM: $x = A \cos \omega t$ Velocity: $v = dx/dt = -A\omega \sin \omega t = A\omega \cos(\omega t + \pi/2)$

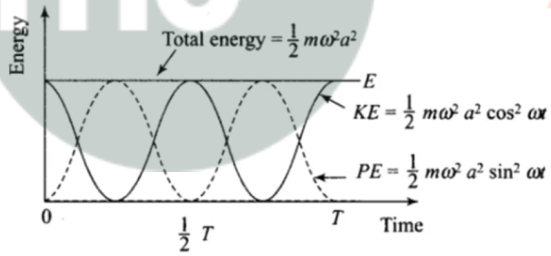
Phase of displacement: $\phi_1 = \omega t$

Phase of velocity: $\phi_2 = \omega t + \pi/2$

Phase difference: $\phi_2 - \phi_1 = \pi/2$

27. Draw a graph showing variation of PE, KE, and total energy with displacement.

Answer: For SHM:



- PE = ½kx² (parabolic, minimum at mean position)
- KE = ½k(A² - x²) (inverted parabola, maximum at mean position)
- Total Energy = ½kA² (constant horizontal line)

28. The length of a second's pendulum on Earth is 1 m. What will be the length on the moon?

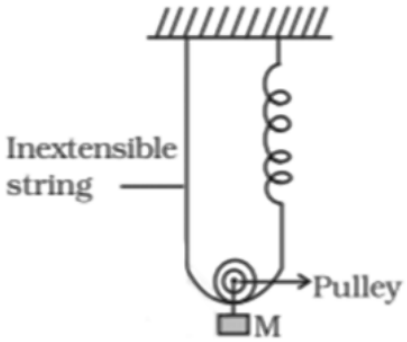
Answer: Time period: $T = 2\pi\sqrt{(l/g)}$ For same period: $l_1/g_1 = l_2/g_2$

Given: T = 2 s, $l_{earth} = 1$ m, $g_{moon} = g_{earth}/6$

$l_{moon} = l_{earth} \times (g_{moon}/g_{earth}) = 1 \times (1/6) = 1/6$ m

Short Answers

29. Find the time period of mass M for the pulley system shown.



Answer: When mass is displaced by distance y:

- Total spring extension = 2y (both springs extend by y)
- Restoring force = 2ky
- For equilibrium: $T = mg = kx_o$

Net restoring force when displaced: $F = -2ky$ Acceleration: $a = -2ky/m$
Comparing with SHM: $\omega^2 = 2k/m$ Time period: $T = 2\pi\sqrt{(m/2k)} = 2\pi\sqrt{(m/2k)}$

30. Show that motion represented by y = sin ωt - cos ωt is SHM with period 2π/ω.

Answer: $y = \sin \omega t - \cos \omega t$
Using trigonometric identity: $y = \sqrt{2}[1/\sqrt{2} \sin \omega t - 1/\sqrt{2} \cos \omega t]$
$y = \sqrt{2}[\sin \omega t \cos(\pi/4) - \cos \omega t \sin(\pi/4)]$
$y = \sqrt{2} \sin(\omega t - \pi/4)$
This is SHM with amplitude $\sqrt{2}$ and period $T = 2\pi/\omega$.

31. Find displacement where PE equals half the maximum energy.

Answer: For SHM:

- PE at displacement x: $PE = \frac{1}{2}kx^2$
- Maximum energy: $E = \frac{1}{2}kA^2$

Given: $PE = \frac{1}{2}E$ $\frac{1}{2}kx^2 = \frac{1}{2}(\frac{1}{2}kA^2)$
$x^2 = A^2/2$
$x = \pm A/\sqrt{2}$

32. A body in potential field $U(x) = U_o(1 - \cos \alpha x)$. Find time period of small oscillations.

Answer: For small oscillations: $\cos \alpha x \approx 1 - (\alpha x)^2/2$ $U(x) \approx U_o(\alpha x)^2/2$
Force: $F = -dU/dx = -U_o\alpha^2 x$ This gives: $\omega^2 = U_o\alpha^2/m$ Time period: $T = 2\pi\sqrt{(m/U_o\alpha^2)} = (2\pi/\alpha)\sqrt{(m/U_o)}$

33. Mass of 2 kg attached to spring (k = 50 N/m), pulled 5 cm and released. Write displacement equation.

Answer: Given: m = 2 kg, k = 50 N/m, A = 5 cm = 0.05 m
$\omega = \sqrt{(k/m)} = \sqrt{(50/2)} = 5$ rad/s
At t = 0, x = A and v = 0, so we use cosine function: x = 0.05 cos(5t) m or x = 5 cos(5t) cm

34. Two identical pendulums: one at 2° right, other at 1° left. Find phase difference.
Answer: Let $\theta_1 = \theta_o \sin(\omega t + \delta_1)$ and $\theta_2 = \theta_o \sin(\omega t + \delta_2)$
At given instant:

- First pendulum: $\theta_1 = 2° = \theta_o \sin(\omega t + \delta_1)$
- Second pendulum: $\theta_2 = -1° = \theta_o \sin(\omega t + \delta_2)$

From the geometry and given conditions: Phase difference: $\delta_1 - \delta_2 = 120° = 2\pi/3$ radians