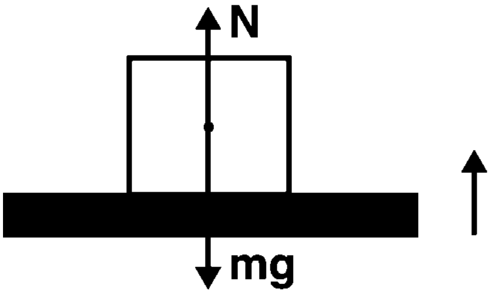
## Exemplar Solutions for Class 11 Physics Chapter 13 – Oscillations

### Long Answers

**35. Person (50 kg) on oscillating platform (f = 2 Hz, A = 5 cm). Find weight variation.**

**Answer:** (a) **Yes, there will be weight variation.**




Given: $m = 50$ kg, $f = 2$ Hz, $A = 5$ cm $= 0.05$ m $\omega = 2\pi f = 4\pi$ rad/s

Platform displacement: $y = A \sin \omega t$ Acceleration: $a = -A\omega^2 \sin \omega t$

Apparent weight: $N = mg + ma = mg - mA\omega^2 \sin \omega t$

(b) **Maximum and minimum readings:**

- Maximum weight (when a is upward): $N_{max} = mg + mA\omega^2$
- Minimum weight (when a is downward): $N_{min} = mg - mA\omega^2$

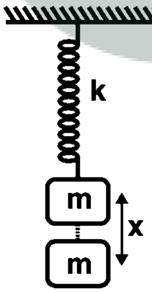
Calculating: $mA\omega^2 = 50 \times 0.05 \times (4\pi)^2 = 50 \times 0.05 \times 16\pi^2 \approx 395$ N

- Maximum weight: 490 + 395 = 885 N
- Minimum weight: 490 - 395 = 95 N

Maximum occurs at lowest point, minimum at highest point.

**36. Mass attached to vertical spring. When released, lowest point is 4 cm below initial position.**

**Answer:**




When mass is released, it falls under gravity until spring force balances weight.

Let equilibrium position be distance d below initial position. At equilibrium: $mg = kd$

When released from initial position, total energy is gravitational PE. At lowest point (4 cm below): all energy becomes elastic PE of spring.

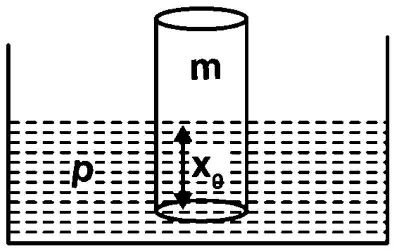
Using energy conservation: $mg(4) = \frac{1}{2}k(4)^2 + mg(d)$

Since $d = mg/k$ for equilibrium: $mg(4) = \frac{1}{2}k(4)^2 + mg(mg/k) = 8k + m^2g^2/k$

Solving: $d = 2$ cm

(a) **Amplitude of oscillation:** $A = 4 - 2 = 2$ cm
(b) **Frequency:** $\omega = \sqrt{(k/m)} = \sqrt{(g/d)} = \sqrt{(g/0.02)} \approx 22.1$ rad/s
$f = \omega/2\pi \approx 3.52$ Hz

**37. Cylindrical log floating in water executes SHM when pressed and released.**
**Answer:**

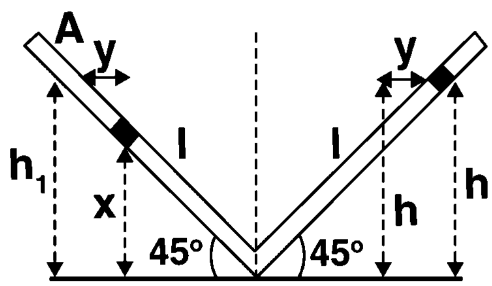



Let the log be pressed down by distance x from equilibrium.
At equilibrium: Weight = Buoyant force $mg = \rho_0 g V_0$ (where $V_0$ is submerged volume)
When displaced by x:

- Additional buoyant force = $\rho_0 g A x$ (where A is cross-sectional area)
- Net restoring force: $F = -\rho_0 g A x$
- Acceleration: $a = F/m = -\rho_0 g A x/m$

This gives: $\omega^2 = \rho_0 g A/m$
Since mass of log: $m = \rho_1 A l$ (where $\rho_1$ is wood density, l is height)
$\omega^2 = \rho_0 g A/(\rho_1 A l) = \rho_0 g/(\rho_1 l)$
For floating condition and using equilibrium: $\omega^2 = g/h_0$ (where $h_0$ is submerged depth)
Time period: $\mathbf{T = 2\pi\sqrt{(m/A\rho_0 g)}}$

**38. V-tube with mercury, arms at 45° to horizontal. Find if motion is SHM and time period.**
**Answer: Yes, the motion will be SHM.**



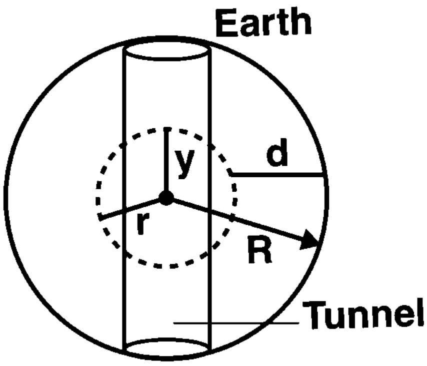

Let the mercury column be displaced by length l from equilibrium in one arm. Due to 45° inclination:

- Vertical height difference = $l \sin 45° = l/\sqrt{2}$
- Total height difference between arms = $2l/\sqrt{2} = l\sqrt{2}$

Restoring force due to pressure difference: $F = \rho g A(l\sqrt{2})$ (acting along the tube)
But this force acts along the inclined tube, so net restoring displacement is l. Mass of mercury column = $\rho A L$ (where L is total length of mercury)

Acceleration: $a = -\rho g A(l\sqrt{2})/(\rho A L) \times (1/\sqrt{2}) = -gl/L$
This gives: $\omega^2 = g/L$
**Time period: $T = 2\pi\sqrt{(L/g)}$**
where L is the total length of mercury column in the V-tube.

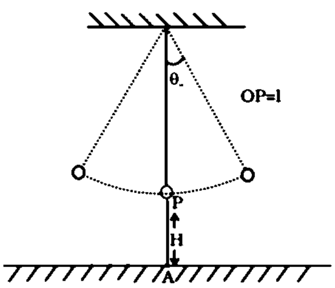
**39. Tunnel through Earth's center. Show body executes SHM.**
**Answer:** Consider a body of mass m at distance r from Earth's center.




By Gauss's law, only the mass within radius r contributes to gravitational force: $M(r) = M(R^3/r^3) \times (r/R)^3 = Mr^3/R^3$
Gravitational force: $F = GM(r)m/r^2 = GMmr/R^3$
Since this force is toward the center: $F = -GMmr/R^3$
At Earth's surface: $mg = GMm/R^2$, so $GM = gR^2$
Therefore: $F = -mgr/R$
Acceleration: $a = -gr/R$
This is SHM with $\omega^2 = g/R$
**Time period: $T = 2\pi\sqrt{(R/g)}$**
Remarkably, this is the same as a pendulum of length R!



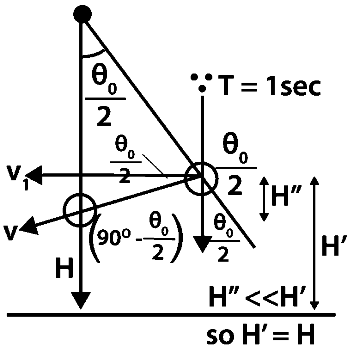
**40. Simple pendulum ($T = 1$s, length l, height H above ground, amplitude $\theta_0$). String snaps at $\theta = \theta_0/2$.**




**Answer:** Given: $T = 1$ s, so $\omega = 2\pi$ rad/s
The motion is: $\theta = \theta_0 \cos(2\pi t)$
When $\theta = \theta_0/2$: $\theta_0/2 = \theta_0 \cos(2\pi t_1)$ $\cos(2\pi t_1) = 1/2$ $2\pi t_1 = \pi/3$ **$t_1 = 1/6$ s**

Angular velocity at this instant: $d\theta/dt = -2\pi\theta_0 \sin(2\pi t)$ At $t = 1/6$: $d\theta/dt = -2\pi\theta_0 \sin(\pi/3) = -\pi\theta_0\sqrt{3}$

Horizontal velocity of bob: $v_x = l(d\theta/dt) = -\pi\theta_0\sqrt{3}\, l$ Vertical velocity: $v_y = 0$ (at this instant)




**Projectile motion after string snaps:**

- Initial horizontal velocity: $v_{xo} = \pi\theta_0\sqrt{3}\, l$
- Initial height: $H' \approx H$ (since $\theta_0$ is small)
- Time to hit ground: $t = \sqrt{2H/g}$

**Horizontal distance from A:** $d = v_{xo} \times t = \pi\theta_0\sqrt{3}\, l \times \sqrt{2H/g}$ = $\boldsymbol{\theta_0 l\sqrt{6\pi H/g}}$

**Total time to hit ground:** $t_1 + \sqrt{2H/g}$ = $\mathbf{1/6 + \sqrt{2H/g}}$ seconds