Level 01

Q 1.

$$Y = A \sin \omega t$$

$$V = A\omega \cos \omega t$$

$$V = \frac{A\omega}{2} \Rightarrow \cos \omega t = \frac{1}{2} \Rightarrow \sin \omega t = \frac{\sqrt{3}}{2}$$

$$Y = A \frac{\sqrt{3}}{2}$$

Q 2.

Ans.

$$f = \frac{\omega}{2\pi} = \frac{3000}{2\pi}$$

Q 3.

Ans.

$$x = A \sin \omega t$$

at $t = 0$ $\quad x = 0$

$$\frac{A}{2} = A \sin \omega T_1 \qquad \sin \omega T_1 = \frac{1}{2}$$

$$\omega T_1 = \frac{\pi}{6}$$

$$\omega T_1 = \frac{\pi}{6} \quad -(1)$$

from $\frac{A}{2}$ to A $\Rightarrow$ total time $T_1 + T_2$

$$\omega (T_1 + T_2) = \frac{\pi}{2}$$

$$\omega T_2 = \frac{\pi}{2} - \frac{\pi}{6} = \frac{\pi}{3} \quad -(2)$$

① / ② = $\frac{T_1}{T_2} = \frac{1}{2}$

Q 4.

Ans. $y = a \sin(2\pi n t + \alpha)$

phase $\rightarrow (2\pi n t + \alpha)$

Q 5.

Ans. $y = A \sin \omega t$

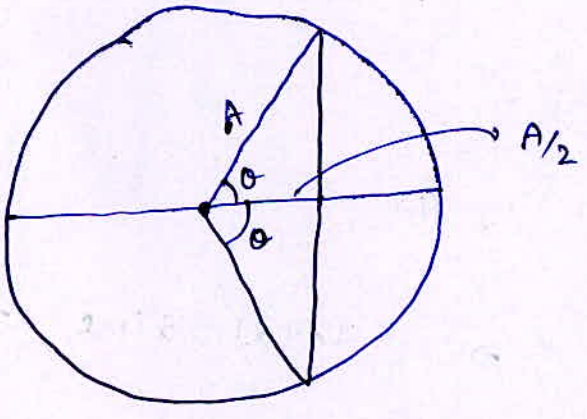
$\frac{A}{\sqrt{2}} = A \sin \omega t$

$\omega t = \frac{\pi}{4}$

$\frac{2\pi}{T} \times t = \frac{\pi}{4}$

$t = T/8$

Q 6.



$\cos\theta = \frac{A/2}{A}$

$\cos\theta = \frac{1}{2}$

$\theta = 60^\circ$

phase difference $\Rightarrow 2\theta = 120^\circ$

Q 7.

Ans.

$$y = A \sin \omega t$$

$$V = A\omega \cos \omega t$$

$$V = A\omega \sqrt{1 - \left(\frac{y}{A}\right)^2}$$

$$= \omega \sqrt{A^2 - y^2}$$

Q 8.

Ans.

$$V_{max} = A\omega = A \frac{2\pi}{T}$$

$$\frac{15 \times 10^{-2} \times 628 \times 10^{-3}}{2\pi} = A$$

$$A = 1.5 \text{ cm}$$

Q 9.

Ans.

$$x(t) = A \cos(\omega t + \theta)$$

$$1 \times 10^{-2} = A \cos(\pi \times 0 + \theta)$$

$$10^{-2} = A \cos\theta \quad -①$$

$$V = A\omega \sin(\omega t + \theta)$$

$$0 \times 10^{-2} = A \sin(\theta) \quad -②$$

$$①/② \quad \tan\theta = 1 \Rightarrow \theta = \frac{\pi}{4}$$

$$A = 10^{-2} \times \sqrt{2} = \sqrt{2} \text{ cm}$$

Q 10.

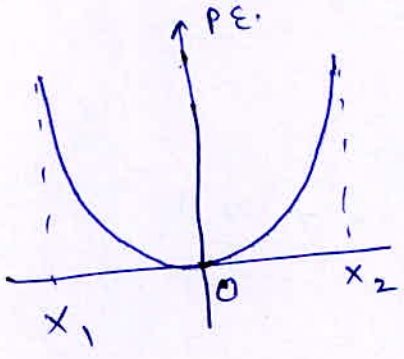
Ans. $V_{max} = A\omega = 50 \times 10^{-3} \times \frac{2\pi}{2} = 0.15\ m/s$

Q 11.

Ans. T. E. is constant in S.H.M.

Q 12.

Ans.



$P.E. = \frac{1}{2} k x^2$

So

Q 13.

Ans. $T.E. = \frac{1}{2} k A^2$

$P.E. = \frac{1}{2} k \left(\frac{A}{2}\right)^2 = \frac{T.E.}{4} = \frac{E}{4}$

Q. 14.

Ans. (I, III)

Q. $T.E. = \frac{1}{2} k A^2$

Q 15.

Ans.

$$T.E. = \frac{1}{2} KA^2$$

$$P.E. = \frac{1}{2} K\left(\frac{A}{2}\right)^2 = \frac{T.E.}{4}$$

$$K.E. = T.E. - \frac{T.E}{4}$$

$$= \frac{3}{4} T.E.$$

Q 16.

Ans.

$$\frac{P.E.}{T.E.} = \frac{\frac{1}{2} K\left(\frac{A}{2}\right)^2}{\frac{1}{2} KA^2} = \frac{1}{4}$$

Q 17.

Ans.

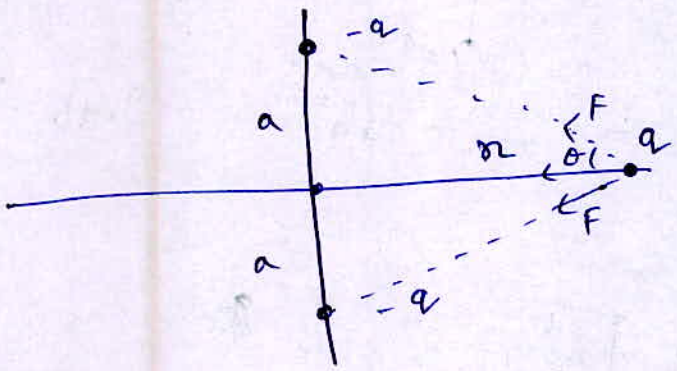
$$a = -\omega^2 y$$

$$-2 = -\omega^2 \times 0.02$$

$$\omega^2 = 100 \Rightarrow \omega = 10 \text{ rad/s}$$

Q 18.

Ans.



$$F_{net} = 2F\cos\theta$$

$$= -2 \times \frac{Kq^2}{\sqrt{x^2+a^2}} \times \frac{x}{\sqrt{x^2+a^2}}$$

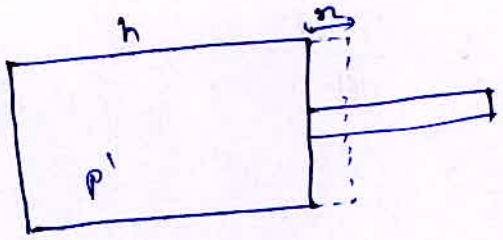
$$= -2Kq^2 \frac{x}{x^2+a^2}$$

$$F \propto \frac{x}{x^2+a^2}$$

Oscillatory motion but no S.H.M.

Q 19.

Ans.



$$F_{net} = (P - P')A$$

$$PAh = P'A(h+x)$$

$$P' = \frac{Ph}{(h+x)}$$

$$= P\left(1 - \frac{x}{h}\right)$$

$$F_{net} = \left[P - P\left(1 - \frac{x}{h}\right)\right]A$$

$$= PA\left[\frac{x}{h}\right]$$

$$= \frac{PA}{h}x$$

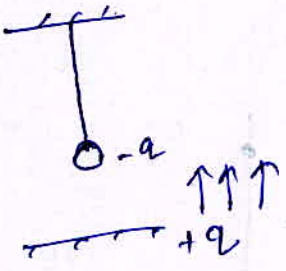
$$K = \frac{PA}{h}$$

$$T = 2\pi\sqrt{\frac{mh}{PA}}$$

Q 20.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$



$g' \equiv g_{eff}$.

$g_{eff} > g$

$$T' = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$T' < T$$

Q 21.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$ $\quad T' = T = 2\,sec.$

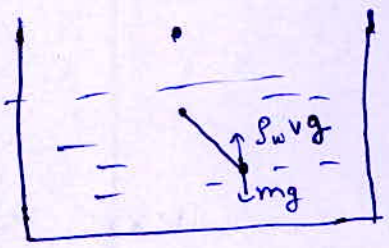
Ans.

time period of seconds pendulam is 2sec.

Q 22.

Ans. $t = 2\pi\sqrt{\frac{l}{g_{eff}}}$

$t_0 = 2\pi\sqrt{\frac{l}{g}}$



$$g_{eff} = \frac{\rho_b V g - \rho_w V g}{\rho_b V} = \frac{\frac{1}{3}}{4/3} g = \frac{g}{4}$$

$$t = 2\pi\sqrt{\frac{l}{g/4}} = 2t_0$$

Q 23.

Ans. $T_1 = 2\pi\sqrt{\frac{5}{g}}$ $\quad T_2 = 2\pi\sqrt{\frac{20}{g}}$

$T_2 = 2T_1$

after 2 Oscillation.

Q 24.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$ $\quad$ l decreases $\Rightarrow$ T decreases

[$I_1\omega_1 = I_2\omega_2 \Rightarrow$ I decreases $\rightarrow$ ω increases]

$\rightarrow$ T decreases ']

Q 25.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

$T' = 2T_0 \Rightarrow l' = 4l$

Q 26.

Ans.

$K_{eq.} = \frac{K_1 K_2}{K_1 + K_2} = \frac{K^2}{2K} = \frac{K}{2}$

$f = \frac{1}{2\pi}\sqrt{\frac{K}{2M}}$

Q 27.

Ans. $\frac{1}{K_{eq}} = \frac{1}{K} + \frac{1}{2K} + \frac{1}{4K}$

$= \frac{\frac{1}{K}(\quad)}{1 - \frac{1}{2}}$

$= \frac{2}{K}$

$K_{eq} = K/2$

Q 28.

Ans. $K \propto \frac{1}{l}$

$Kl = \text{const.}$

$K_2 l/2 = Kl$

$K_2 = 2K$

Q 29.

Ans.

$$t_1 = 2\pi\sqrt{\frac{M}{K_1}}$$

$$t_2 = 2\pi\sqrt{\frac{M}{K_2}}$$

$$T = 2\pi\sqrt{\frac{M(K_1+K_2)}{K_1K_2}}$$

$$T^2 = 2\pi M\left(\frac{1}{K_1}+\frac{1}{K_2}\right) = t_1^2 + t_2^2$$

Q 30.

Ans.

$$T = 2\pi\sqrt{\frac{M}{K}}$$

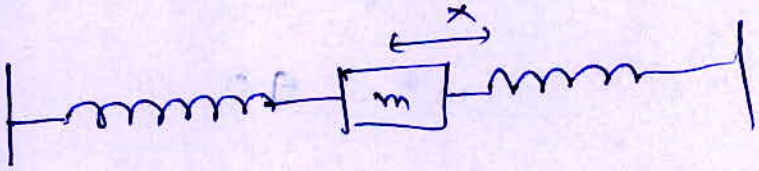
$$\frac{5T}{3} = 2\pi\sqrt{\frac{M+m}{K}}$$

$$\frac{5}{3} = \sqrt{\left(1+\frac{m}{M}\right)}$$

$$\frac{m}{M} = \frac{25}{9} - 1 = \frac{16}{9}$$

Q 31.

Ans.



$$F_{net} = 2kx + kx = 3kx$$

$$f = 2\pi\sqrt{\frac{3K}{m}}$$

Q 32.

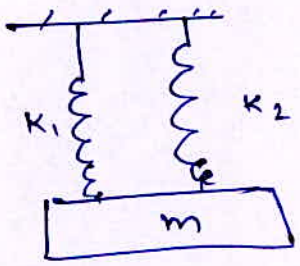
Ans. $Kl = \text{const.}$

$$Kl = K' \frac{3l}{4}$$

$$K' = \frac{4}{3} K$$

Q 33.

Ans.



$$t_1 = 2\pi \sqrt{\frac{m}{K_1}}$$

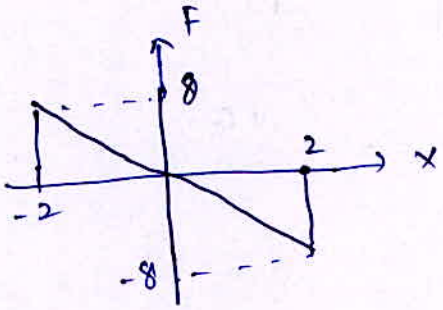
$$t_2 = 2\pi \sqrt{\frac{m}{K_2}}$$

$$T = 2\pi \sqrt{\frac{m}{K_1 + K_2}}$$

$$\frac{1}{T^2} = \frac{1}{t_1^2} + \frac{1}{t_2^2}$$

Q 34.

Ans.



$A = 2\ m.$

$m = 0.01\ kg$

$F_{max} = mA\omega^2$

$8 = 0.01 \times 2\ \omega^2$

$\omega^2 = 20$

$$T = \frac{2\pi}{20} = \frac{\pi}{10} = 0.3\ \text{sec.}$$

Q 35.

$$\varepsilon_1 = \frac{1}{2} K_1 A_1^2 = \frac{1}{2} K_2 A_2^2$$

$$= \frac{F_1^2}{2K_1} = \frac{F_2^2}{2K_2}$$

$$F_1/F_2 = \sqrt{K_1/K_2}$$

Q 36.

Ans.

$$x = \frac{mg}{K_{eq}}$$

$$K_{eq} = \frac{K_1 K_2}{K_1 + K_2}$$

$$x = \frac{mg(K_1 + K_2)}{K_1 K_2}$$

Q

Ans.

$$y = A \sin \omega t$$

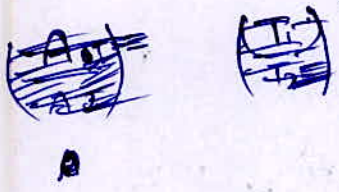
$$v = A\omega \cos \omega t$$

$$a = -A\omega^2 \sin \omega t$$

$$F = ma = -mA\omega^2 \sin \omega t \Rightarrow \text{option D}$$

Q 37.

Ans.



after one half time $\frac{A}{2}$

after n half time $= \left(\frac{A}{2}\right)\left(\frac{1}{2}\right)^n$

$$n = 3$$

$$A' = \frac{A}{8}$$

Q 38.

Ans.

$$A\omega = 1$$

$$A\omega^2 = 1.57$$

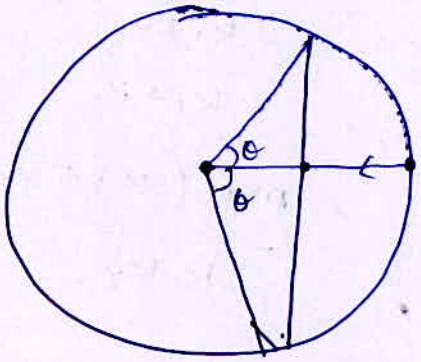
$$T = \frac{2\pi}{\omega} = \frac{2\pi}{1.57}$$

$$= 4 \text{ sec}.$$

Level - 02

Q 1.

Ans.



$x = A\cos\omega t$

$\frac{A}{2} = A\cos\omega t$

$\omega t = \frac{\pi}{3}$

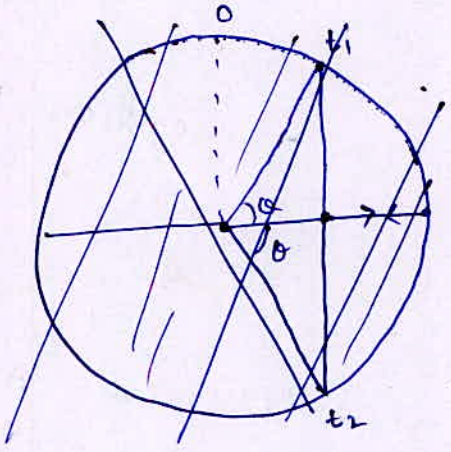
$t = \frac{\pi}{3\omega} = \frac{\pi}{3 \times \pi} \times 2$

$t = 2/3$ sec.

Q 2.

Ans.

$x = A\sin(\omega t)$



$\theta = \frac{\pi}{6}$

$\frac{\pi}{6} = \omega t_1$

$\frac{5\pi}{6} = \omega t_2$

$\omega(t_2 - t_1) = 2\frac{\pi}{3}$

$t_2 - t_1 = \frac{2\pi}{3\times\pi} \times 1.2$

$= 0.4$ sec

Q3.

Ans. $y = 3\sin\omega t + 4\cos\omega t$

$$y = 5\left(\frac{3}{5}\sin\omega t + \frac{4}{5}\cos\omega t\right)$$

$$y = 5\sin(\omega t + 53^\circ)$$

$$A = 5$$

Q4.

Ans. $y = 4\cos^2(t/2)\sin(1000t)$

$$= 2\left(\frac{1+\cos t}{2}\right)\sin(1000t)$$

$$= 2\sin(1000t) + 2\cos t\sin(1000t)$$

$$= 2\sin(1000t) + \sin(1000t + t) + \sin(1000t - t)$$

$$y = y_1 + y_2 + y_3$$

Q5.

Ans. $y = 10\sin 20\pi t$

$$f = \frac{20\pi}{2\pi} = 10\ Hz$$

Q6.

Ans. $y_1 = A\sin\omega t \qquad y_2 = \frac{A}{2}\sin\omega t + \frac{A}{2}\cos\omega t$

$$= \sqrt{2}A\left(\sin\left(\omega t + \frac{\pi}{4}\right)\right)$$

Ans. $\sqrt{2}$

Q. 7.

Ans. $y = a \sin\left(\frac{2\pi}{T} t + \alpha\right)$

Q 8.

Ans. $V_{max} = A\omega = 2 \times 10^{-3} \times \frac{2\pi}{0.1}$

$= \frac{\pi}{25}$ m/s

Q 9.

Ans. $V = \omega \sqrt{A^2 - x^2}$

$V^2 = \omega^2 A^2 - \omega^2 x^2$

$5^2 = 10^2 - \omega^2 x^2$

$\omega^2 x^2 = 75$

$\frac{100}{16_4} x^2 = 75 \frac{3}{4}$

$x = \sqrt{12} = 2\sqrt{3}$ cm.

$A\omega = 10$

$\omega = 10/4$

Q 10.

Ans. $V = \omega \sqrt{A^2 - x^2}$

$10 = \omega \sqrt{A^2 - 4^2}$

$8 = \omega \sqrt{A^2 - 5^2}$

$100 - 64 = \omega^2 (25 - 16)$

$\omega^2 = \frac{36}{9} = 4 \Rightarrow T = \pi$ sec.

Q 11.

Ans. from Graph. $T/2 = 0.02$

$$f = \frac{1}{T} = \frac{1}{0.04} = 25 \text{ Hz}$$

Q 12.

Ans.

$$P.E. = \frac{1}{2} K \left(\frac{A}{2}\right)^2 = 2.5$$

$$T.E. = \frac{1}{2} K A^2 = 2.5 \times 4 = 10 \text{ J}$$

Q 13.

Ans.

$$T.E. = \frac{1}{2} K a^2$$

Q 14.

Ans.

$$P.E. = \frac{f^2}{2K}$$

$$\frac{P.E_1}{P.E_2} = \frac{K_2}{K_1} = 2:1$$

Q 15.

Ans.

$$\frac{1}{2} K x^2 = E_1$$

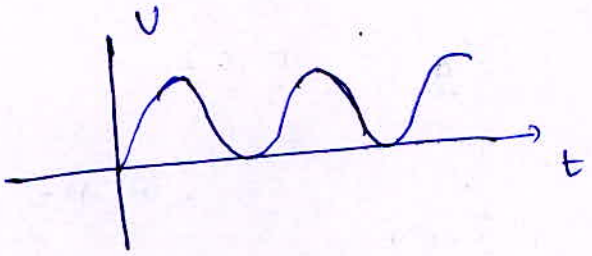
$$\frac{1}{2} K y^2 = E_2$$

$$\frac{1}{2} K (x+y)^2 = E$$

$$\sqrt{E} = \sqrt{E_1} + \sqrt{E_2}$$

Q 16.

Ans.



$U = \frac{1}{2} K x^2$

Q 17.

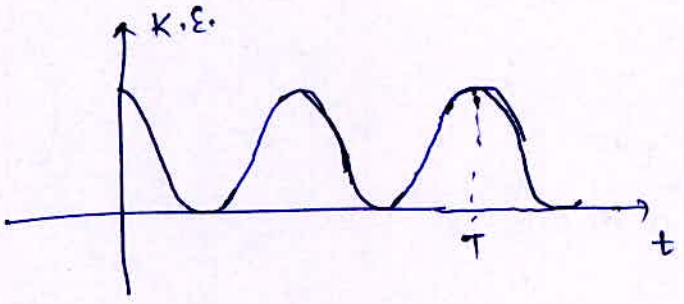
Ans. $T.E. = \frac{1}{2} K A^2 = P.E. + K.E.$

$P.E. = \frac{1}{2} K x^2 = \frac{1}{2} \left(\frac{1}{2} K A^2 \right)$

$x = \frac{A}{\sqrt{2}} = \frac{4}{\sqrt{2}} = 2\sqrt{2}$ cm.

Q 18.

Ans.



$f_{K.E} = 2f$

Q 19.

Ans. $K.E.\ max. = \frac{1}{2} m A^2 \omega^2$

$= \frac{1}{2} \times 1 \times 6^2 \times 10^{-4} \times 10^4$

$= 18$ J

Q 20.

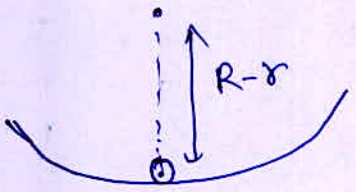
Ans. $\frac{1}{2} m A^2 \omega^2 = 16$

$\frac{1}{2} \times 5.12 \times \left(\frac{1}{4}\right)^2 \times \omega^2 = 16$

$\omega^2 = \sqrt{\frac{16 \times 16 \times 2}{5.12 \times 10^{-2}}} = 10 \Rightarrow T = \frac{\pi}{5}$ sec.

Q 21.

Ans.



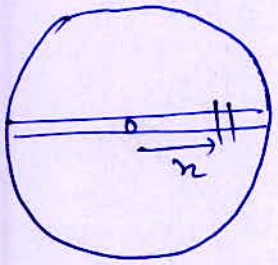
$$T = 2\pi\sqrt{\frac{\theta}{\alpha}}$$

$$\tau = I\alpha \Rightarrow mg(R-r)\theta = m(R-r)^2\alpha$$

$$T = 2\pi\sqrt{\frac{R-r}{g}}$$

Q 22.

Ans.



$$F = -\frac{GMm}{R^3}r$$

$$a = -\frac{G\cdot M}{R^3}r$$

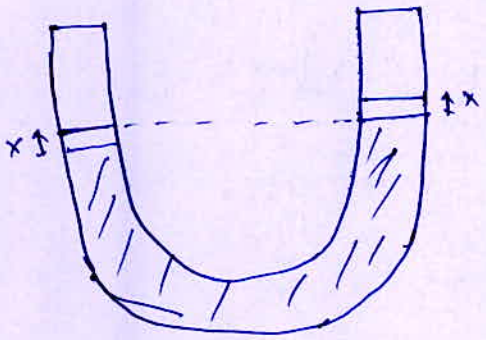
$$T = 2\pi\sqrt{\frac{r}{a}}$$

$$= 2\pi\sqrt{\frac{R^3}{GM}} = 84.6 \text{ min}$$

$$\frac{T}{2} = 42.3 \text{ min.}$$

Q 23.

Ans.



$$\Delta P = 2(\rho g x)A$$

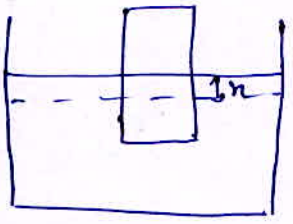
$$ma = 2\rho g x A$$

$$T = 2\pi\sqrt{\frac{x}{a}}$$

$$= 2\pi\sqrt{\frac{m}{2\rho g A}}$$

Q. 24.

Ans. $F_{extra} = \rho_{water}\, b c x g$



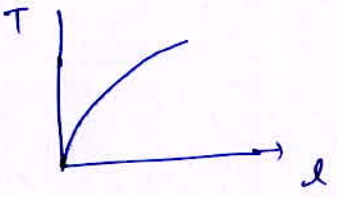
$ma = \rho_{water}\, b c g x$

$$T = 2\pi\sqrt{\frac{x}{a}} = 2\pi\sqrt{\frac{\rho_{wood}\, a b c}{\rho_{water}\, b c g}}$$

$$T = 2\pi\sqrt{\frac{d a}{g}}$$

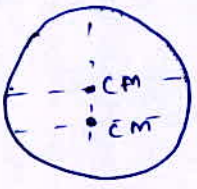
Q25.

Ans. $$T = 2\pi\sqrt{\frac{l}{g}}$$



Q 26.

Ans.



CM first decreases then increases

l increases then decreases

$T \propto \sqrt{l}$ → first increases then decreases

Q 27.

Ans. $$T = 2\pi\sqrt{\frac{l}{g_{eff.}}}$$ at surface $g_{eff.} = g$

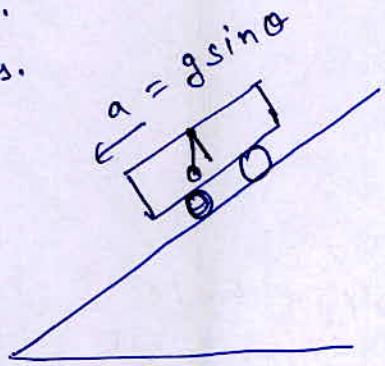
$$g = \frac{GM}{R^2}$$

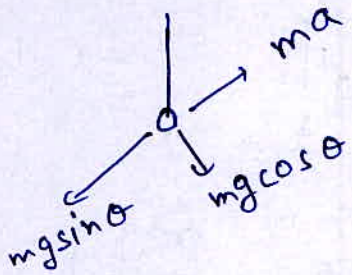
in mine $g_{eff.} < g$

$T_{mine} > T_{surface}$.

Q 28.

Ans.





$$T = 2\pi\sqrt{\frac{l}{g_{eff}}} = 2\pi\sqrt{\frac{l}{g\cos\theta}}$$

Q 29.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$ $\quad l_2 = 4l$

$T_2 = 2T$ $\quad \frac{T_2 - T_1}{T} \times 100\% = 100\%$

Q 30.

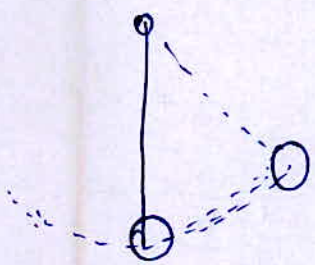
Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

$$100 \times \frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta l}{l} \times 100\right)$$

$$\Delta T = \frac{\frac{1}{2} \times 2 \times 86400}{100} = 864 \text{ sec.}$$

Q 31.

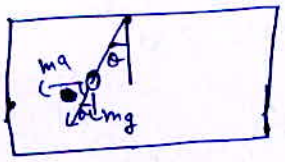
Ans.



$v = 0$ at extreme

Q. 32.

Ans.



$\rightarrow$ 49 cm/s²

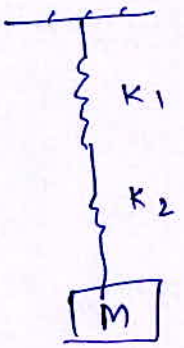
$$\tan\theta = \frac{mg}{ma} = \frac{g}{g} = \frac{9.8\ m/s^2}{49 \times 10^{-2}\ m/s^2}$$

$$\tan\theta = \frac{5}{100} = \frac{1}{20}$$

$$\theta = \tan^{-1}\frac{1}{20}$$

Q 33.

Ans.



$$f = \frac{1}{2\pi}\sqrt{\frac{K_{eq}}{M}}$$

$$K_{eq} = \frac{K_1 K_2}{K_1 + K_2}$$

Q 34.

Ans.

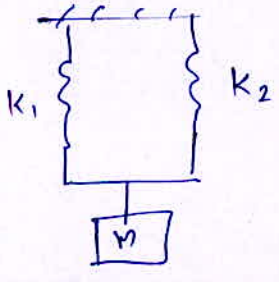
$$mg = K\ 0.2$$

$$K = 5mg$$

$$T = 2\pi\sqrt{\frac{m}{5mg}} = 2\pi\sqrt{\frac{1}{50}}$$

Q. 35.

Ans.



$$K_{eq} = K_1 + K_2$$

$$T = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$$

Q 36.

Ans.

$$2 = 2\pi \sqrt{\frac{m}{K}}$$

$$3 = 2\pi \sqrt{\frac{m+2}{K}}$$

$$\frac{3}{2} = \sqrt{\frac{m+2}{m}}$$

$$9/4 = 1 + 2/m$$

$$m = 8/5 = 1.6 \text{ kg.}$$

Q 37.

Ans.

$$Kx = mg$$

$$K = mg/x$$

$$T = 2\pi \sqrt{\frac{m+m}{K}} = 2\pi \sqrt{\frac{(m+m)x}{mg}}$$

Q 38.

Ans.

$$W_A = \frac{1}{2} K_A x^2$$

$$W_B = \frac{1}{2} K_B x_B^2$$

$$\frac{W_A}{W_B} = \frac{K_A}{K_B} > 1$$

Q 39.

Ans.

$$T_1 = 2\pi \sqrt{m/K} \qquad T_2 = 2\pi \sqrt{\frac{m}{K/2}}$$

$$T_3 = 2\pi \sqrt{\frac{m}{2K}}$$

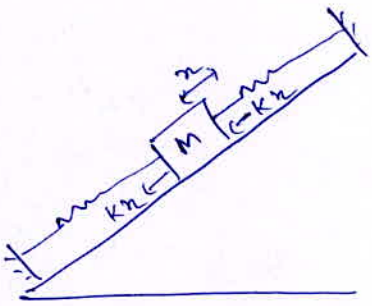
$$T_1 : T_2 : T_3 = 1 : \sqrt{2} : \frac{1}{\sqrt{2}}$$

Q 40.

Ans.

$$F = -2Kx$$

$$T = 2\pi \sqrt{\frac{M}{2K}}$$



Q 41.

Ans.

$$W = Kx \qquad K = \frac{W}{x}$$

$$Kl = K_2 \, l/2 \Rightarrow K_2 = 2K$$

$$K_{eq} = 2K_2 = 4K$$

$$K_{eq}\, x' = W$$

$$4\frac{W}{x}\, x' = W$$

$$x' = x/4$$

Q 42.

Ans.

$$K_{eq} = K_1 + K_2$$

$$f = 2\pi \sqrt{\frac{K_1 + K_2}{m}}$$

Q 43.

Ans.

$$T = 2\pi \sqrt{\frac{m}{K}}$$

$$\frac{5T}{4} = 2\pi \sqrt{\frac{M+m}{K}}$$

$$5/4 = \sqrt{\frac{M+m}{M}} \Rightarrow 1 + \frac{m}{M} = \frac{25}{16}$$

$$m/M = 9/16$$

Q 44.

Ans.

$$f = 2\pi \sqrt{\frac{K}{m}}$$

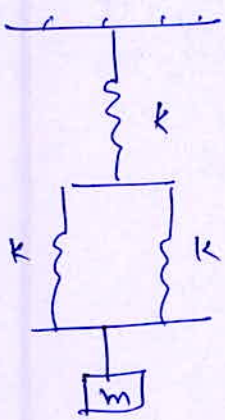
$$f \propto 1/\sqrt{m}$$

$$\frac{f}{0.5} = \frac{\sqrt{m}}{\sqrt{m}/2} = 2$$

$$f = 1\ Hz$$

Q 45.

Ans.



$$K_{eq} = \frac{2K \cdot K}{3K}$$

$$= \frac{2}{3}K$$

$$T = 2\pi \sqrt{\frac{3m}{2K}}$$

Q 46.

Ans.

$$a_{max} = A\omega^2$$

$$= 0.01 \times 4\pi^2 \times (60)^2$$

$$= 36 \times 4\pi^2$$

$$= 144\pi^2$$

Q 47.

Ans.

$$a = -\omega^2 x$$

at $-x_{max}$ a will be positive max.

Ans. 1

Q 48.

Ans. $x = 10 \text{ cm} \cos\left(10t + \frac{\pi}{2}\right)$

$a_{max} = \omega^2 A = 10^2 \times 10 \times 10^{-2} = 10 \text{ m/s}^2$

Q 49.

Ans. Air Friction

Q 50.

Ans. $F_{max} = mA\omega^2$

$= 10 \times 10^{-3} \times \frac{1}{2} \times \left(\frac{2\pi}{\pi/5}\right)^2$

$= \frac{1}{2} \text{ N}$

Q 51.

Ans. $a = \omega^2 x$

$12 \times 10^{-2} = 3 \times 10^{-2} \times \omega^2$

$\omega = 2$

$T = \frac{2\pi}{2} = \pi \text{ sec.}$

Q 52.

Ans.

$N = mg - ma_{max} > 0$

$\Rightarrow a_{max} < g$

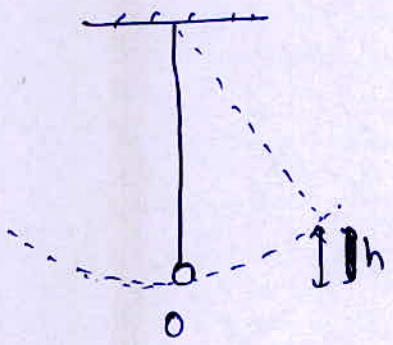
$\omega^2 A < g$

$4\pi^2 f^2 A < g$

$f = \sqrt{\frac{g}{4\pi^2 A}} = \sqrt{\frac{10}{4 \times \pi^2 \times 10^{-2}}} = 5 \text{ Hz}$

Q53.

Ans.



$$mgh = \frac{1}{2} I\omega^2$$

$$mgh = \frac{1}{2} m l^2 \omega^2$$

$$2gh = l^2\omega^2$$

$$T = mg + \frac{m l^2 \omega^2}{l}$$

$$T = 2 \text{ sec.} = \frac{2\pi}{\omega} \Rightarrow \omega = \pi$$

$$T = mg + m\frac{2gh}{l}$$

$$l = \frac{\sqrt{2gh}}{\pi}$$

$$T = m\left(g + \pi\sqrt{2gh}\right)$$

Q54.

Ans.

$$T = 2\pi\sqrt{\frac{m}{K_{eq.}}}$$

$$K_{wire} \Rightarrow \frac{F}{A} = Y\frac{\Delta l}{l}$$

$$F = \left(\frac{YA}{l}\right)\Delta l$$

$$K_{eq} = \frac{\frac{YA}{L} \times K}{\frac{YA}{L} + K} = \frac{YAK}{YA + KL}$$

$$T = 2\pi\sqrt{\frac{(YA + KL)m}{YAK}}$$

Q 55.

Ans. $a_m = a_0 / a\omega^2 - b\omega + c$

$$a\omega^2 - b\omega + c > 0$$

$$D < 0$$

$$b^2 - 4ac < 0$$

$$b^2 < 4ac$$

Assertion & Reason Question.

Q 1.

Ans. all oscillary motions have time period.

Q 2.

Ans. $v \neq$ constant

Q 3.

Ans. $a \propto -x$ not $a \propto x$

Q 4.

Ans. (A)

Q 5.

Ans. $v = \omega\sqrt{A^2 - x^2}$ not a parabola

Q 6.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$ g is less on moon

Q 7.

Ans. only when frequency of external periodic force equals frequency of vibration of body. Only then amp. will increase.

Q 8.

Ans. $T.E = \frac{1}{2} KA^2$ constant.

Q 9.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l}$$

Q 10.

Ans. $T = 2\pi\sqrt{\frac{l}{g_{eff}}}$.

$$\frac{T_1}{T_2} = \sqrt{\frac{g_2}{g_1}} = \sqrt{\frac{3}{2}}$$

$$T_2 = \sqrt{\frac{2}{3}} \times T_1 \qquad T_1 = 2\,sec.$$

$$f_2 = \frac{1}{2\sqrt{\frac{2}{3}}} = \frac{\sqrt{3}}{2\sqrt{2}} = 0.612$$

Q 12.

Ans. [redacted]

$$\frac{1}{2}KA^2 = P.E + K.E.$$

$$P.E. = \frac{1}{2}Kx^2 = \frac{1}{2} \times \frac{1}{2}KA^2 \Rightarrow x = \frac{A}{\sqrt{2}}$$

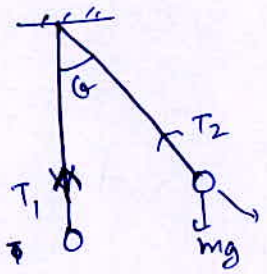
Q 13.

Ans. $T.E. = \frac{1}{2}KA^2$

$$T.E. \propto A^2$$

Q 14.

Ans.



$$T_1 = mg + \frac{mv^2}{l}$$

$$T_2 = mg\cos\theta$$

Q 15.

Ans. $Kl = \text{Constant}$

$K_2 \, l/n = Kl$

$K_2 = nK$

Q 16.

Ans. $T = 2\pi\sqrt{\frac{M}{K}}$ $\qquad K_{hard} > K_{soft}$.

Q 17.

Ans. at extreme position $v = 0$, a is max $= -\omega^2 A$

$a = -\omega^2 x$

Q 20

Ans. $|V| = \omega\sqrt{A^2 - x^2}$

Q 21.

Ans. Amplitude decreases due to loss in energy

$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \equiv \text{constant}$

Q 22.

Ans. V is max. at mean position and $a = 0$

$V = A\omega \cos\omega t$

$a = -A\omega^2 \sin\omega t$ $\Big\}$ $\quad \phi = \pi/2$

Q 23.

Ans. $F = -kx$ where x is displacement from mean position.

Question asked in 2012

Q 1.

Ans. $y = 3 \sin \frac{\pi}{2} (50t - x)$

$V_{p\ max} = 3 \times 50 \times \pi/2$

$V_{wave} = 50$

$\frac{V_{p\ max}}{V_{wave}} = 3\pi/2$

Q 2.

Ans. $\frac{1}{2} k x^2 = \frac{1}{2} \times 3 \times 4^2 + \frac{1}{2} \times \frac{mR^2}{2} \times \frac{4^2}{R^2}$

$200 \times \frac{1}{2} x^2 = \frac{1}{2} \times \frac{9}{2} \times 4^2$

$x = \sqrt{\frac{36}{100}} = 0.6\ m.$

Q 3.

Ans. $A = 4\ cm.$

$\omega = 16/4 = 4$

$v = \omega \sqrt{A^2 - x^2}$

$(8\sqrt{3})^2 = \omega^2 (A^2 - x^2)$

$8^2 \times 3 = 4^2 \times (4^2 - x^2)$

$3 \times 4 = 4^2 - x^2$

$x = 2\ cm.$

Q 4.

Ans. $k l = \text{const.}$

$K_2 = 2K$

$T = 2\pi \sqrt{\frac{m}{K_2}} = \frac{T}{\sqrt{2}}$

Q 5.

Ans. $P.E = \frac{1}{2} K x^2 = \frac{1}{2} K (2y)^2 = \frac{1}{2} K y^2 \times 4$

$\frac{1}{2} k y^2 = E$

$P.E. = 4E$

Q 6.

Ans. $x_1 = A \sin(\omega t + \pi/6)$

$x_2 = A \cos(\omega t) = A \sin(\omega t + \pi/2)$

$\Delta\phi = \pi/2 - \pi/6 = \pi/3$

Q 7.

Ans. $T = 2\pi \sqrt{\frac{l}{g}} \Rightarrow \frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta l}{l} \phi - \frac{\Delta g}{g}\right) = 0$

$\frac{0.3}{100} = \frac{.981 - g}{981} \Rightarrow g = 978 \text{ cm/s}^2$

Q 8.

Ans. $K.E. = T.E. - P.E.$

$= \frac{1}{2} K A^2 - \frac{1}{2} K \frac{A^2}{2}$

$= \frac{1}{2} \frac{K A^2}{2}$

$K.E' = P.E.$

Previous Year Questions

Displacement of SHM & Phase

1) $y = A \sin(\omega t + \phi_1) + B \cos(\omega t + \phi_2)$

only (I) & (II) satisfies.

Ans (C)

---

2) Ans (C)

In motion of planet around sun,

→ planet is undergoing

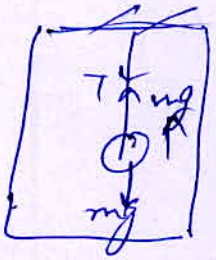
i) circular motion } simultaneously.
ii) Rotational motion }

---

3) $\frac{1}{f} = T = 2\pi\sqrt{\frac{\ell}{(g-g)}}$

$f \propto \sqrt{(g-g)}$ →

$f = 0$



↓ a = g

(Ans (d))

4)

Ans (a)

phase constant

---

5)

$$y = A \sin\left(\frac{2\pi}{T}\right) t.$$

$$\frac{A}{2} = A \sin\left(\frac{2\pi}{T}\right) t.$$

$$\frac{1}{2} = \sin\left[\left(\frac{2\pi}{T}\right) t\right].$$

$$\frac{\pi}{6} = \frac{2\pi}{T} \times t \qquad (T=6)$$

$$\boxed{t = 1/2 \text{ sec}}$$

Ans (b)

---

6)

$$\frac{A_1}{A_2} = \frac{5\sqrt{3+1}}{5} = \frac{2}{1}$$

Ans (b)

---

7)

$$F = -\frac{dU}{dx}$$

$$\rightarrow \frac{2U}{F} + x = 0$$

$$\boxed{\text{Ans (b)}}$$

9) $a = \psi \sin(\omega t + \theta)$

$a = -k(x+0)$

Ans (b)

---

10) At resonance,

$f = f_0$

Ans (d)

---

11) $\sin^2(\cdot)$

↳ periodic

but need not harmonic

Ans (b)

---

12)

$x = A \sin \omega t$

$A/2 = A \sin \omega t$

$\omega t = \pi/6$

$t = \frac{\pi}{6\omega} = \frac{\pi}{6 \times 2\pi} T = T/12$

13)

$v = A\omega \sin \omega t$

$a = A\omega^2 \cos \omega t$

$\Delta\phi = \pi/2$

Q 14.

Ans. $y = A\sin\omega t - B\cos\omega t$

$$y = \sqrt{A^2+B^2}\ \sin(\omega t - \phi)$$

Amp. $\sqrt{A^2+B^2}$

Q 15.

Ans. $A = 25$ cm. $\quad T = 3$ s.

$$x = A\sin\omega t$$

$$-\frac{A}{2} = A\sin\omega t_1 \qquad \omega t_1 = -\pi/6$$

$$A/2 = A/2 \sin\omega t_2 \Rightarrow \omega t_2 = \pi/6$$

$$\omega(t_2 - t_1) = \frac{2\pi}{6}$$

$$t_2 - t_1 = \frac{2\pi \times 3}{6\ 2\pi} = \frac{1}{2}\ \text{sec.}$$

Q 16.

Ans. $y = a(\sin\omega t + \cos\omega t)$

$$= \sqrt{2}a\left(\sin\left(\omega t + \frac{\pi}{4}\right)\right)$$

Amp $= \sqrt{2}a \rightarrow$ SHM.

Q 17.

Ans. $x = \frac{A}{2}\sin\omega t$

$$\frac{A}{2} = A\sin\omega t \qquad \Delta\phi = \frac{5\pi}{6} - \frac{\pi}{6}$$

$$\omega t = \pi/6,\ \frac{5\pi}{6} \qquad = 2\pi/3$$

Q 18.

Ans. $y = \sin \omega t - \cos \omega t$

$y = \sqrt{2} \left(\sin \left(\omega t - \pi/4 \right) \right)$

Q 19.

Ans. $a = -\omega^2 x$

Q 20.

Ans. $x = 8 \sin \omega t + 6 \cos \omega t$

$x = 10 \left(\sin (\omega t + 37^\circ) \right)$

Q 21.

Ans. $y_1 = \sin \left(\omega t + \frac{\pi}{3} \right)$

$y_2 = \sqrt{2} \sin \left(\omega t + \pi/4 \right)$

$\Delta \phi = \pi/3 - \frac{\pi}{4} = \pi/12$

Q 22.

Ans. $x = 5\sqrt{2} \left(\sin 2\pi t + \cos 2\pi t \right)$

$= 10 \left(\sin \left(2\pi t + \pi/4 \right) \right)$

Q 23.

Ans. $\Delta \phi = \omega \left(t_2 - t_1 \right)$

$= \frac{2\pi}{12} \times 1 = \pi/6$

Q 24.

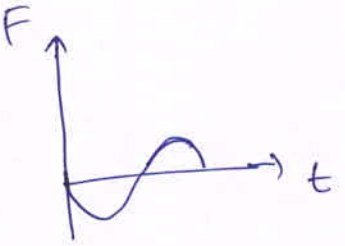
Ans. $y = 0.2 \sin(10\pi t + 1.5\pi) \cos(10\pi t + 1.5\pi)$

$y = 0.1 \sin(20\pi t + 3\pi)$

Q 25.

Ans. $a = -\omega^2 x$

$F = ma = -m\omega^2 x$



Velocity, Acceleration and Energy of SHM

Q 1.

Ans.

$$\left.\begin{aligned} v &= A\omega \sin \omega t \\ a &= A\omega^2 \cos \omega t \end{aligned}\right\} \quad \Delta\phi = \pi/2$$

Q 2.

Ans.

$$P.E. = \frac{1}{2} T.E.$$

$$= \frac{1}{2} \frac{KA^2}{2} = \frac{1}{2} K x^2$$

$$x = A/\sqrt{2}$$

Q 3.

Ans.

$$a = A\omega^2 \qquad v = A\omega \qquad A$$

$$a = \frac{v^2}{A}$$

Q 4.

Ans

$$a = A\omega^2 \underbrace{\cos \omega t}$$

↳ avg zero in a time period

Q 5.

Ans.

$$K.E. = \frac{1}{2} m v^2 = T.E. - P.E.$$

$$= \frac{1}{2} KA^2 - \frac{1}{2} K \frac{A^2}{4}$$

$$= 3/4 \times \frac{1}{2} KA^2$$

$$= 3/4\, E$$

Q6.

Ans. $A = 4\,cm.$

$$T.E. = \frac{1}{2} KA^2$$

$$P.E. = \frac{1}{2} K x^2 = \frac{1}{2} T.E.$$

$$\frac{1}{2} K x^2 = \frac{1}{2} \left(\frac{1}{2} KA^2 \right)$$

$$x = A/\sqrt{2} = \frac{4}{\sqrt{2}} = 2\sqrt{2}\ cm.$$

Q7.

Ans.

$$N = mg - m\omega^2 x = 0$$

$$x = \frac{g}{\omega^2} = \frac{10 \times 1^2}{4\pi^2} = 0.25$$

Q8.

Ans.

$$V = \omega \sqrt{A^2 - x^2}$$

$$3 = \omega \sqrt{A^2 - 4^2 \times 10^{-4}} \quad -(1)$$

$$4 = \omega \sqrt{A^2 - 3^2 \times 10^{-4}} \quad -(2)$$

$$\frac{(2)^2}{(1)^2} = \frac{16}{9} = \frac{A^2 - 3^2 \times 10^{-4}}{A^2 - 4^2 \times 10^{-4}}$$

$$7A^2 = (4^4 - 3^4) \times 10^{-4}$$

$$A = 5\ cm.$$

Q 9.

Ans. $P.E. = \frac{1}{2}kx^2 = \frac{1}{2}k\left(\frac{A}{4}\right)^2 = \underbrace{\frac{1}{2}kA^2}_{\downarrow T.E.} \times \frac{1}{16}$

$$P.E. = \frac{1}{16}\, T.E.$$

Q 10.

Ans. $a = \omega^2 x$ $\qquad v = \omega\sqrt{A^2 - x^2}$

$$\omega x = \omega\sqrt{A^2 - x^2}$$

$$\omega^2 x^2 = A^2 - x^2 \qquad 2A = 4\ cm.$$

$$x^2(\omega^2 + 1) = A^2$$

$$x^2 = \frac{(2)^2}{1 + \left(\frac{2\pi\sqrt{3}}{2\pi}\right)^2} = 1$$

$$x = 1\ cm.$$

Q 11.

Ans. $\frac{a_1\ max}{a_2\ max} = \frac{\omega_1^2 A}{\omega_2^2 A} = \left(\frac{\omega_1}{\omega_2}\right)^2 = \frac{1}{10^2}$

Q 12.

Ans. $x = a\sin\left(\omega t + \frac{\pi}{6}\right)$

$$v = \omega\sqrt{a^2 - x^2} \qquad T = \frac{2\pi}{\omega}$$

$$\frac{a\omega}{2} = \omega\sqrt{a^2 - x^2}$$

$$x = \frac{\sqrt{3}a}{2}$$

$$\boxed{\frac{t}{T} = \frac{1}{12}}$$

$$\omega t + \frac{\pi}{6} = \frac{\pi}{3} \qquad t = \frac{\pi}{6\omega}$$

Q 13.

Ans.

$$y_1 = A \sin(\omega t - k x_1)$$

$$y_2 = A \sin(\omega t - k x_2)$$

$$\Delta\phi = k(x_2 - x_1)$$

$$= \frac{\omega}{v}(15 - 10)$$

$$= \frac{2\pi}{0.05 \times 300} \times 5$$

$$= \frac{2\pi}{3}$$

Q 14.

Ans.

$$y = 3 \sin(0.2t)$$

$$K.E. = \frac{1}{2} \times m \times \omega^2 \left(A^2 - \frac{A^2}{9}\right)$$

$$= \frac{4}{9} \times 3 \times 10^{-3} \times (3 \times 0.2)^2$$

$$= 0.48 \times 10^{-3} \text{ J}$$

Q 15.

Ans.

$$v = \omega \sqrt{A^2 - x^2}$$

$$\frac{v^2}{\omega^2} = A^2 - x^2$$

$$\frac{v^2}{\omega^2} + x^2 = A^2$$

~~$\left(\frac{v}{A\omega}\right)^2 + x^2$~~

$$\frac{v^2}{A^2\omega^2} + \frac{x^2}{A^2} = 1 \quad \rightarrow \text{ellipse}$$

Q 16.

Ans. $K.E. = \frac{1}{2} m \omega^2 (A^2 - x^2) \Rightarrow$ max. at $x = 0$

$T.E. = \frac{1}{2} K A^2$

$P.E. = \frac{1}{2} K x^2$

Q 17.

Ans. at equil. position. $T.E. = \frac{1}{2} K A^2 = K.E.$

Q 18.

Ans. $K.E._{max.} = P.E._{max.} = T.E. = K_0$

Q 19.

Ans. $P.E. = \frac{1}{2} K x^2$

$= \frac{1}{2} K \left(\frac{A}{2}\right)^2$

$= \frac{1}{2} K A^2 \times \frac{1}{4}$

$= \frac{E}{4}$

$\frac{1}{2} K A^2 = E$

Q 20.

Ans. $v = \omega \sqrt{A^2 - x^2}$ v is max. at $x = 0$

$a = \omega^2 x$ is zero at $x = 0$

Q 21.

Ans. $T.E. = \frac{1}{2} K A^2$

Q 22.

Ans. $V_{max} = A\omega = 4 \times \frac{2\pi}{8} = \pi$ cm/s

Q 23.

Ans. $V_{max} = A\omega \sqrt{A^2 - x^2}$

$2 = A \frac{2\pi}{16}$

$A = \frac{16}{\pi}$

$x = A \sin(\omega t)$

$x = A \sin\left(\frac{2\pi}{16} \times 2\right)$

$= \frac{A}{\sqrt{2}}$

$V = \omega \sqrt{A^2 - x^2}$

$2 = \frac{2\pi}{16} \times \frac{A}{\sqrt{2}}$

$A = \frac{16\sqrt{2}}{\pi} = 7.2 \text{ m}$

Q 24.

Ans. $a_{max} = A\omega^2$

$= 0.01 \times (2\pi \times 60)^2$

$= 144\pi^2 \text{ m/s}^2$

Q 25.

Ans. $V = \omega \sqrt{A^2 - x^2}$

$= 8 \sqrt{(60)^2 - (22)^2}$

$= 4 \sqrt{900 - 121}$

$V = 111 \text{ mm/s}$

Q 26.

Ans. $K.E. = \frac{1}{2} m\omega^2 A^2 \underbrace{\cos^2 \omega t}$

avg. in one time period is $\frac{1}{2}$

$= \frac{1}{4} m\omega^2 A^2$

Q 27.

Ans. $V_{max} = \omega \sqrt{A^2 - x^2}$

V_{max} at $x = 0$

Q 28.

Ans. $a_{max} = A\omega^2$

$7.5 = A(3.5)^2$

$A = \frac{7.5}{(3.5)^2} = 0.61$ m.

Q 29.

Ans. $v = \omega \sqrt{A^2 - x^2}$

$10 = \omega \sqrt{A^2 - 3^2}$

$7 = \omega \sqrt{A^2 - 4^2}$

$\frac{100}{49} = \frac{A^2 - 9}{A^2 - 16}$

$51 A^2 = 100 \times 16 - 49 \times 9$

$A^2 = \frac{100 \times 16 - 49 \times 9}{51}$

length of path $= 2A = 2 \times \sqrt{22.72}$

$= 9.5$ cm.

Q 30.

Ans. $K.E. = \frac{1}{2} m\omega^2(A^2 - x^2)$

$P.E. = \frac{1}{2} m\omega^2 x^2$

$K.E. = \frac{1}{3} P.E.$

$\frac{1}{2} m\omega^2 (A^2 - x^2) = \frac{1}{3} \times \frac{1}{2} m\omega^2 x^2$

$A^2 - x^2 = \frac{1}{3} x^2$

$x = \frac{\sqrt{3}}{2} A$

$\frac{x}{A} \times 100 = \frac{\sqrt{3}}{2} \times 100 = 87$

Q 31.

Ans. $T.E. = \frac{1}{2} KA^2$

$= \frac{1}{2} m\omega^2 A^2$

$= \frac{1}{2} m \frac{4\pi^2}{T^2} A^2$

Q 32.

Ans. $y = 3 \sin\left(100t + \frac{\pi}{6}\right)$

$V_{max} = A\omega = 3 \times 100 = 300$

Q 33.

Ans. $a = \omega^2 x$ at $x = A$ a is max.

$a_{max} = \omega^2 A$

Q. 34.

Ans. $K.E. = P.E. = \frac{1}{2} T.E.$

$$P.E. = \frac{1}{2} K x^2 = \frac{1}{2} \times \frac{1}{2} K A^2$$

$$x = \frac{A}{\sqrt{2}}$$

Q 35.

Ans. $T.E._1 = \frac{1}{2} m \omega^2 A^2 = E$

$$T.E._2 = \frac{1}{2} m \omega^2 \left(\frac{3A}{4}\right)^2 = \frac{9E}{16}$$

Q 36.

Ans. $T.E. = \frac{1}{2} K A^2$

Q 37.

Ans. $P.E. = \frac{1}{2} K y^2$

$$= \frac{1}{2} m \omega^2 a^2 \cos^2 \omega t$$

Q 38.

Ans. $K.E. = T.E. - P.E.$

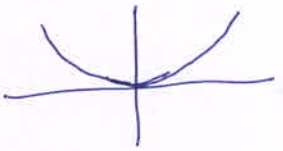
$$= \frac{1}{2} K A^2 - \frac{1}{2} K \left(\frac{A}{\sqrt{2}}\right)^2$$

$$= \frac{1}{2} K A^2 \times \frac{1}{2}$$

$$= \frac{1}{2} T.E.$$

Q. 39.

Ans. $P.E. = \frac{1}{2} K x^2$



Q. 40.

Ans. $V_{max} = A\omega$

$a_{max} = \omega^2 A$

$\omega = \frac{a_{max}}{V_{max}} = \frac{4}{2} = 2 \text{ rad/s}^{-1}$

Time Period and Frequency

Q 1.

Ans. $V(x) = A(1 - \cos px) = A \sin^2 \frac{px}{2}$

~~$F(x) = \frac{dV(x)}{dx}$~~

~~$F(x) = Ap^2 \sin px$~~

for small oscillation.

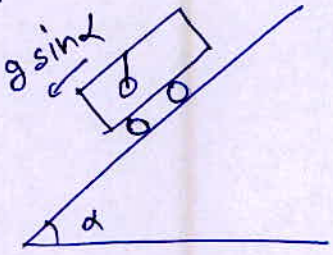
$$V(x) = \frac{1}{2} A p^2 x^2 \quad \doteq \quad \frac{1}{2} k x^2$$

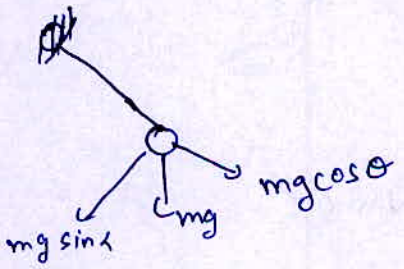
$$K = Ap^2$$

$$T = 2\pi \sqrt{\frac{m}{Ap^2}}$$

Q 2.

Ans.





$$g_{eff} = g \cos\theta$$

$$T = 2\pi \sqrt{\frac{l}{g \cos\theta}}$$

Q 3.

Ans. A becomes large.

Q 4.

Ans.

$$v = \omega \sqrt{A^2 - x^2}$$

$$10 = \omega \sqrt{A^2 - 4^2}$$

$$8 = \omega \sqrt{A^2 - 5^2}$$

$$\left(\frac{10}{\omega}\right)^2 - \left(\frac{8}{\omega}\right)^2 = 5^2 - 4^2$$

$$\frac{36}{\omega^2} = 9$$

$$\omega = 2 \text{ rad/sec.}$$

$$T = \frac{2\pi}{\omega} = \pi \text{ sec.}$$

Q 5.

Ans.

$$Kl = \text{const.}$$

$$Kl = K_2 \frac{3l}{4}$$

$$K_2 = \frac{4}{3} K$$

Q 6.

Ans.

$$V_{max} = A\omega = A \times \frac{2\pi}{T}$$

$$V = 2A \times \frac{2\pi}{T/3} = 6A \frac{2\pi}{T} = 6 V_{max}$$

$$V = 6V$$

Q 7.

Ans.

$$f = \frac{1}{2\pi} \sqrt{\frac{2K}{m}} \qquad f_2 = \frac{1}{2\pi} \sqrt{\frac{K}{m}}$$

$$f_2 = \frac{1}{\sqrt{2}} f$$

Q 8.

Ans.

$$2\frac{d^2x}{dt^2} + 32x = 0$$

$$\frac{d^2x}{dt} = -16x$$

$$a = -16x$$

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{1}{16}} = \frac{\pi}{2}$$

Q 9.

Ans.

$$f = \frac{1}{2\pi}\sqrt{\frac{8\pi^2}{1/2}} = 2\ Hz$$

Q 10.

Ans.

P. E. $= \frac{1}{2} k A^2 \sin^2 \omega t$ time period $T/2$

[where T is time period of $\sin \omega t$]

Q 11.

Ans.

$$T = 2\pi\sqrt{\frac{M}{k}}$$

$$T \propto \sqrt{m}$$

$$T_2 = 2T_1 = 2P$$

Q 12.

Ans.

$$x = -0.3 \sin\left(t + \frac{\pi}{4}\right)$$

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}$$

Q 13.

Ans. $$\frac{m\,d^2x}{dt^2} + \frac{b\,dx}{dt} + kx = 0$$

on solving

$$\omega = \left(\frac{k}{m} - \frac{b^2}{4m^2}\right)^{1/2}$$

Q 14.

Ans. $$T = 2\pi\sqrt{\frac{m}{K}} \qquad K_{hard} > K_{soft}$$

Q 15.

Ans. $$F_1 \propto \omega_1^2$$

$$F_2 \propto \omega_2^2$$

$$(F_1 + F_2) \propto \omega_1^2 + \omega_2^2 = \omega_3^2$$

$$T_3^{-2} = \left(t_1^{-2} + t_2^{-2}\right) = \frac{25}{16} + \frac{25}{9}$$

$$T_3^{-2} = \frac{25 \times 25}{16 \times 9} \Rightarrow T_3 = 12/25$$

Q 16.

Ans. $$v = \omega\sqrt{A^2 - x^2}$$

$$= \frac{2\pi}{T} \times \sqrt{A^2 - \frac{A^2}{4}}$$

$$= \frac{\pi}{T}\, a\sqrt{3}$$

Q. 17

Ans.

$$x = A \sin \omega t$$

$$\frac{A}{2} = A \sin \omega t$$

$$\omega t = \frac{\pi}{6}$$

$$t = \frac{\pi}{6} \frac{T}{2\pi} = \frac{T}{12}$$

Q 18.

Ans.

$$T = 2\pi \sqrt{\frac{m_2}{k}}$$

$$\omega = \sqrt{\frac{k}{m_2}}$$

Q 19.

Ans.

$$f = \frac{\omega}{2\pi} = \frac{2}{2\pi} = \frac{1}{\pi}$$

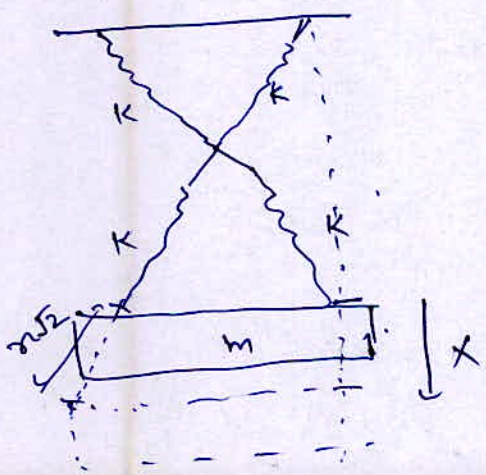
Q 20.

Ans.

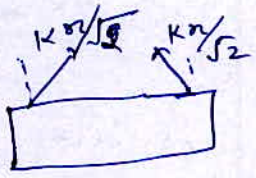
$$T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi} = 0.02$$

Q 21.

Ans.



. elongation in one spring $\frac{x}{\sqrt{2}}$



$$\text{Frestoring} = 2 \cos 45^\circ \, k \frac{x}{\sqrt{2}}$$

$$= kx$$

$$T = 2\pi \sqrt{\frac{m}{K}}$$

Q 22.

Ans.

$$t = T/4 = 1 \text{ sec.}$$

Q 23.

Ans.

$$U(x) = K x^3$$

$$F(x) = -3K x^2$$

$$A = -\frac{3K}{m} x^2$$

$$V \frac{dV}{dx} = \frac{-3K}{m} x^2$$

~~$\frac{v^2 - u^2}{2} = \frac{-3K}{m} x^3$~~

$$\frac{V^2 - V_0^2}{2} = \frac{-K}{m} x^3$$

at extreme $V = 0$

$$\left(\frac{mV_0^2}{2K}\right)^{1/3} = x_0$$

$$V^2 = V_0^2 - \frac{2K}{m} x^3$$

$$\frac{dx}{dt} = \sqrt{V_0^2 - \frac{2K}{m} x^3}$$

$$\int_0^{x_0} \frac{dx}{\sqrt{V_0^2 - \frac{2K}{m} x^3}} = \int_0^{T/4} dt$$

after integration $T \propto \frac{1}{\sqrt{a}}$

or $F = m\omega^2 x = 3Kx^2$

$\omega \propto \sqrt{x} \Rightarrow T \propto \frac{1}{\sqrt{x}}$

Q 24.

Ans.

$$Y_1 = A \sin(\omega_1 t)$$

$$Y_2 = A \sin(\omega_2 t)$$

$$\Delta\phi = (\omega_1 - \omega_2) \times 5T/4$$

$$= \left(\frac{2\pi}{T} - \frac{2\pi}{5T} \times 4\right) \times \frac{5T}{4}$$

$$= \frac{1}{5} \times \frac{2\pi}{T} \times \frac{5T}{4}$$

$$= \frac{\pi}{2}$$

Q 25.

Ans.

$$a_{max} = A\omega^2$$

$$V_{max} = A\omega$$

$$a_{max} = n\, V_{max}$$

$$\omega = n$$

$$T = \frac{2\pi}{n}$$

Q 26.

Ans.

$$a_{max} = A\omega^2 = (1.57)^2$$

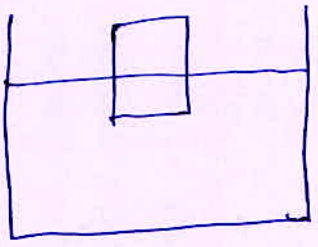
$$1. \quad \omega^2 = \left(\frac{\pi}{2}\right)^2$$

$$\omega = \pi/2$$

$$T = \frac{2\pi}{\omega} = 4 \text{ sec.}$$

Q 27.

Ans.



$F_{restoring} = \rho_{water} A x g$

$$T = 2\pi \sqrt{\frac{m_{block}}{\rho_{water} A g}}$$

$$T \propto \frac{1}{\sqrt{A}}$$

Q 28.

Ans. P.E. $\frac{1}{2} m\omega^2 \underbrace{\sin^2 \omega t}$

$\downarrow$

frequency $2f$

Simple Pendulum and Its Applications.

Q 1.

Ans. $A = 3 \text{ cm}.$

Q 2.

Ans.

$$\tau = I\alpha$$

$$mg\theta = I\alpha$$

$$\alpha = \frac{mg\theta}{I}$$

$$\frac{1}{2} I_1 \omega_1^2 = \frac{1}{2} I_2 \omega_2^2 = \frac{1}{2} K A^2$$

$$\frac{1}{2} \frac{m_1 g}{I_1} A_a^2 = \frac{1}{2} \frac{m_2 g}{I_2} A_b^2$$

$$\left(\frac{A_a}{A_b}\right)^2 = \frac{I_1}{I_2} = \frac{4ML^2}{ML^2}$$

$$\frac{A_a}{A_b} > 1$$

Q 3.

Ans. $$T = 2\pi \sqrt{\frac{l}{g}} = 2\pi \sqrt{\frac{lR^2}{GM}}$$

$$T' = 2\pi \sqrt{\frac{l}{g'}} = 2\pi \sqrt{\frac{l\,4R^2}{G\,2M}} = 2\sqrt{2}\, T$$

Q 4.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L}$$

Q 5.

Ans.

$$T_{pendulam} = 2\pi\sqrt{\frac{l}{g}}$$

$$T_p' = 2\pi\sqrt{\frac{l}{g'}} = 2\pi\sqrt{\frac{l+R^2}{GM}} = \frac{T}{\sqrt{2}}$$

$$T_p' < T$$

Q 6.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$= 2\pi\sqrt{\frac{l}{2g/3}}$$

Q 7.

Ans.

$$T' = 2\pi\sqrt{\frac{l}{g'_{eff}}} \quad \Theta = \sqrt{2}\,T$$

$$g_{eff} = g/2$$

$$\rho_b \cdot V g - \rho_w V g = \rho_b V g'_{eff}$$

$$g\left(1 - \frac{\rho_w}{\rho_b}\right) = g/2$$

$$\rho_b = 2\rho_w = 2$$

Q 8.

Ans. $T' = 2\pi \sqrt{\frac{l}{g_{eff}}}$

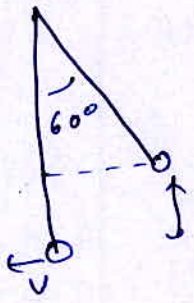
$g_{eff} = 2g$

$T' = T/\sqrt{2}$

Q 9.

Ans. $mgl(1-\cos\theta) = \frac{1}{2} m l^2 \omega^2$

$gl\left(1-\frac{1}{2}\right) = \frac{1}{2} v^2$



$v = \sqrt{gl}$

$v = \sqrt{2 \times 9.8}$ m/s

Q 10.

Ans. $T_1 = 2\pi \sqrt{\frac{100 \times 10^{-2}}{g}} = \frac{2\pi}{10\sqrt{g}} \times 10$

$T_2 = 2\pi \sqrt{\frac{121 \times 10^{-2}}{g}} = \frac{2\pi}{10\sqrt{g}} \times 11$

$T_2 - T_1 = \frac{2\pi}{10\sqrt{g}} \times 1$

$(1+n) T_1 = (n \bullet) T_2$

$\frac{n+1}{n \bullet} = \frac{11}{10}$

$n = 10$ Ans.

Q 11.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$ independent of m

Q 12.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$2 = 2\pi\sqrt{\frac{l}{g}}$$

$$l = 100 \text{ cm.}$$

Q 13.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$g_{eff} = \sqrt{a^2 + g^2}$$

Q 14.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l}$$

$$\frac{\Delta T}{0.5} = \frac{1}{2} \times \alpha \Delta t$$

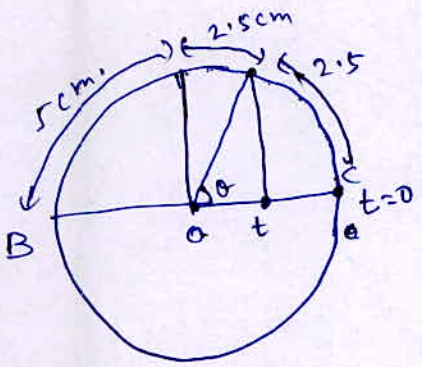
~~$\Delta T = 10 \times 9 \times 10^{-7}$~~

$$\Delta T = \frac{1}{4} \times 9 \times 10^{-7} \times 10$$

$$\Delta T = 2.25 \times 10^{-6} \text{ s}$$

Q 15.

Ans.



$$x = A\cos\omega t$$

$$\frac{A}{2} = A\cos\omega t$$

$$\omega t = \frac{\pi}{3}$$

$$t = \frac{\pi \times 12}{2\pi} = 1.5 \text{ sec.}$$

Q 16.

Ans.

$$T = 2\pi\sqrt{\frac{1}{g\left[\frac{1}{l}+\frac{1}{R}\right]}}$$

for max g $l = R$

$$T_{max} = 2\pi\sqrt{\frac{R}{2g}} = 1.5 \text{ min}$$

Q 17.

Ans.

$$100 \times \frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta l}{l} \times 100\right)$$

$$\Delta T = \frac{\frac{1}{2} \times 2 \times 86400}{100}$$

$$= 864 \text{ s.}$$

Q 18.

Ans.

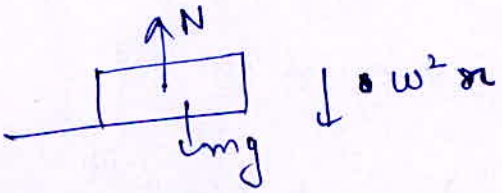
$$V_{max} = A\omega$$

$$= 50 \times 10^{-3} \times \frac{2\pi}{2}$$

$$= 0.15 \text{ m/s}$$

Q 19.

Ans.



$$N = mg - m\omega^2 r = 0$$

$$r = \frac{g}{\omega^2}$$

Q 21.

Ans.

$$Kl = \text{constant}$$

$$Kl = K_2 \, l/3$$

$$K_2 = 3K$$

$$Kl = K_3 \, 2l/3$$

$$\boxed{K_3 = \frac{3K}{2}}$$

Q 22.

Ans.

$$T = 2\pi \sqrt{\frac{l}{g_{eff}}}$$

$$\frac{T_1}{T_2} = \sqrt{\frac{\frac{l}{g}}{\frac{l}{g/4}}}$$

$$T_2 = 2T_1$$

Q 23.

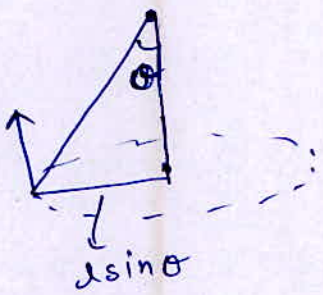
Ans. $I_1 \omega_1 = I_2 \omega_2$

I decreases ω increases

Time period decreases.

Q 24.

Ans. $T = \frac{2\pi}{\omega}$



$T\cos\theta = mg$

$T\sin\theta = \frac{mv^2}{R}$

$\tan\theta = \frac{v^2}{Rg}$

$\tan\theta = \frac{\omega^2 R}{g}$

$\omega = \sqrt{\frac{g\tan\theta}{R}}$

$R = l\sin\theta$

$T = \frac{2\pi}{\sqrt{\frac{g\tan\theta}{l\sin\theta}}} = 2\pi\sqrt{\frac{l\cos\theta}{g}}$

Q 25.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

$\frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta l}{l} - \frac{\Delta g}{g}\right) = 0$

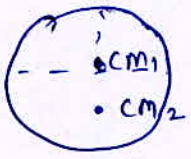
$\frac{981 - g}{981} = \frac{0.3}{100} \Rightarrow g = 978 \text{ cm/s}^2$

Q 27

Ans. $100 \times \frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta l}{l} \times 100 = 10.5\ \%$

Q 26.

Ans.



CM decreases then increases

l increases then decreases

T increases then decreases

Q 28.

Ans. $T_0 = 2\pi \sqrt{\frac{M}{K}}$

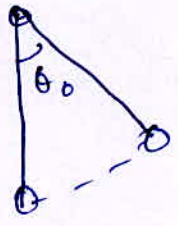
$$\frac{5}{3} T_0 = 2\pi \sqrt{\frac{M+m}{K}}$$

$$\left(\frac{5}{3}\right)^2 = \left(1 + \frac{m}{M}\right)$$

$$\frac{m}{M} = \frac{16}{9}$$

Q 29.

Ans.



$$T_{max} = mg + \frac{mv^2}{l}$$

$$mgl(1-\cos\theta) = \frac{1}{2} mv^2$$

$$\frac{mv^2}{l} = 2mg(1-\cos\theta)$$

$$T_{max} = mg + 2mg\left(1 - 1 + \frac{\theta_0^2}{2}\right) = mg(1+\theta_0^2)$$

Q. 31.

Ans. $T_p = 2\pi \sqrt{\frac{l}{\sqrt{g^2+s^2}}}$ $\qquad T_s = 2\pi \sqrt{\frac{l}{g}}$

$T_p < T_s$

Q 32

Ans. $T = 2\pi \sqrt{\frac{m}{2adg}}$

Q 33.

Ans. cm first decreases then increases $\Rightarrow$

l increases and then decreases

Q 34.

Ans. $\frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta l}{l}$

$\frac{\Delta T}{T} \times 100 = 1$

$\Delta T = 0.01$

$T_2 = 1.01\ T$

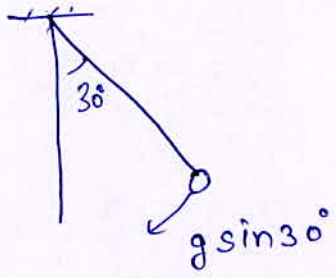
Q 35.

Ans. $F = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$

$m' = \frac{m}{4}$

Q 36.

Ans.



$$a = g \sin 30^\circ$$

$$= 5$$

Q 37.

Ans.

$$T = 2\pi \sqrt{\frac{l}{g_{eff}}}$$

$$\rho V g_{eff} = \rho V g - \frac{1}{8} \rho V g$$

$$g_{eff.} = \frac{7}{8} g$$

$$T' = 2\pi \sqrt{\frac{8l}{7g}} = \sqrt{\frac{8}{7}}\, T$$

Q 38.

Ans.

$$f = \frac{5}{\pi} = \frac{1}{2\pi} \sqrt{\frac{K}{20 \times 10^{-3}}}$$

$$100 \times 20 \times 10^{-3} = K$$

$$K = 2 \text{ N m}^{-1}$$

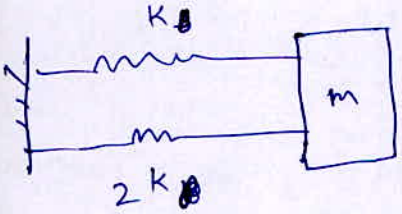
Q 39.

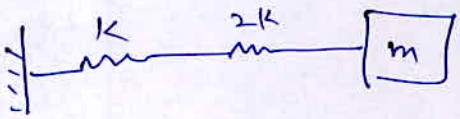
Ans. g_{eff} will decrease.

T increases.

Q40.

Ans.





$$K_S = \frac{2K}{3} \qquad \frac{K_S}{K_P} = \frac{2}{9}$$

$$K_P = 3K$$

Q41.

Ans.

$$\frac{1}{2} mv^2 = mg \times 10 \times 10^{-2}$$

$$v = \sqrt{2}$$

Q42.

Ans.

$$Kl = K_2 \frac{2l}{3}$$

$$K_2 = \frac{3}{2} K$$

Q43.

Ans.

$$2 = 2\pi \sqrt{\frac{1}{g}}$$

$$2 = 2\pi \sqrt{\frac{l}{g/2}}$$

$$2l = 1$$

$$l = 1/2$$

Q 44.

Ans. $g_{eff.}$ Decreases

$$f = \frac{1}{2\pi}\sqrt{\frac{g_{eff.}}{l}} \Rightarrow \text{Decreases}$$

Q 45.

Ans.

$$f_s = \frac{1}{2\pi}\sqrt{\frac{K}{2M}}$$

$$f_p = \frac{1}{2\pi}\sqrt{\frac{2K}{M}}$$

$$\frac{f_s}{f_p} = \frac{1}{2}$$

Q 46.

Ans.

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{2K}{M}}$$

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

$$f_2 = \frac{f_1}{\sqrt{2}}$$

Q 47.

Ans.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Q 48.

Ans.

$$F_1 = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

$$F_2 = \frac{1}{2\pi}\sqrt{\frac{2K}{M}} = \sqrt{2}\,F_1$$

Q 49.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

$l = \frac{g}{4\pi^2} T^2 \Rightarrow$ Parabola

Q 50

Ans. $Kl = K_2 \frac{3l}{4}$

$K_2 = \frac{4}{3} K$

$T_2 = 2\pi\sqrt{\frac{3m}{4K}}$ $\qquad T_1 = 2\pi\sqrt{\frac{m}{K}}$

$T_2 = \frac{\sqrt{3}}{2} T$

Q. 51.

Ans. $f_A = \frac{1}{2\pi}\sqrt{\frac{g}{l_A}}$

$f_B = \frac{1}{2\pi}\sqrt{\frac{g}{l_B}}$

$f_A = 2f_B \Rightarrow l_A = \frac{l_B}{4}$

Q 52.

Ans. at the extreme position $V = 0$

Q 53.

Ans. $g_{eff.}$ will decrease

Q 54.

Ans. $T = 2\pi \sqrt{\frac{l}{g}}$

$T_2 = 2\pi \sqrt{\frac{9l}{g}} = 3T$

Q 55.

Ans. $Kl = K_2 l/2$

$K_2 = 2K$

Q 56.

Ans. $T_1 = 2\pi \sqrt{\frac{1000 \times 10^{-2}}{g}}$

$T_2 = 2\pi \sqrt{\frac{121 \times 10^{-2}}{g}}$

$nT_2 = (n+1)\,T_1$

$\frac{T_2}{T_1} = \frac{n+1}{n} = \frac{11}{10}$

$n = 10$

Q 57.

Ans. $T = 2\pi \sqrt{\frac{l}{g_{eff}}}$

at pole $g_{eff} > g_{equator}$

$g_{equator} = g - R\omega^2$ at pole $g_{eff} = g$

Q 58.

Ans.

~~$\frac{K_1 K_2}{K_1 + K_2} + K_3$~~ $\qquad \frac{(K_1 + K_2) \times K_3}{K_1 + K_2 + K_3}$

~~$\frac{(K_1 + K_2) \cdot K_3}{}$~~

Q 59.

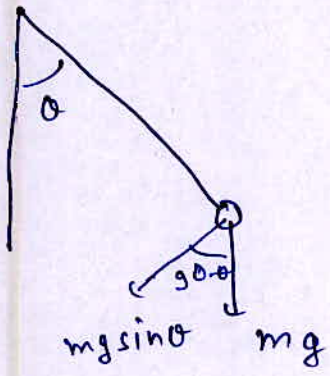
Ans.

$$T = 2\pi \sqrt{\frac{l}{g}} = 2 \text{ sec.}$$

$$T_2 = 2\pi \sqrt{\frac{l}{g/2}} = 2\sqrt{2} \text{ sec.}$$

Q 60.

Ans.



$$F_{rest.} = -mg\sin\theta$$

Q 61.

Ans.

$$\frac{F}{A} = -Y \frac{\Delta l}{l}$$

$$F = \left(\frac{YA}{l}\right) \Delta l$$

$$f = \frac{1}{2\pi} \sqrt{\frac{YA}{ml}}$$

Q 62.

Ans. $T' = 2\pi \sqrt{\frac{l}{g_{eff}}}$.

$$g_{eff} = \frac{\rho V g - \frac{\rho}{10} V g}{\rho V}$$

$$= \frac{9}{10} g$$

$$T' = 2\pi \sqrt{\frac{10l}{9g}} = \sqrt{\frac{10}{9}}\, T$$

Q 63.

Ans. $T_1 = 2\pi \sqrt{\frac{1}{g}}$

$$T_2 = 2\pi \sqrt{\frac{1.44}{g}} = 1.2\, T_1$$

$$n T_2 = (n+1) T_1$$

$$\frac{T_2}{T_1} = \frac{n+1}{n} = \frac{1.2}{1}$$

$$n = 5$$

5 oscillation for bigger pendulam

6 ——————— smaller ———————

Q 64.

Ans. $\frac{F_1}{F_2} = \frac{2\pi \sqrt{\frac{g}{l_1}}}{2\pi \sqrt{\frac{g}{l_2}}} = \frac{7}{8}$

$$\sqrt{\frac{l_2}{l_1}} = \frac{7}{8}$$

$$\frac{l_1}{l_2} = 64/49$$

Q 65.

Ans.

$$g_{eff} = 9g$$

$$T' = 2\pi\sqrt{\frac{l}{9g}} = \frac{T}{3}$$

Q 66.

Ans.

$$K_{eq} = \frac{K}{2}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{2m}}$$

Q 67.

Ans. constant amp.

Q 68

Ans.

$$2 = \sqrt{\frac{2\times 8}{g'}} \qquad g' = 4$$

$$T = 2\pi\sqrt{\frac{1}{4}} = \pi \text{ sec.}$$

Q 69.

Ans.

$$T = 2\pi\sqrt{\frac{m}{K}}$$

$$T' = 2\pi\sqrt{\frac{2m}{K}} = \sqrt{2}\,T$$

Q 70.

Ans. V_{max} at mean position

Q 71.

Ans. $40 = \omega \sqrt{A^2 - x^2}$

$$40 = \frac{2\pi}{2\pi\sqrt{\frac{m}{k}}} \sqrt{A^2 - x^2}$$

$$1600 = \frac{k}{m}(A^2 - x^2)$$

$$1600 = \frac{10}{10}((50)^2 - x^2)$$

$$x = 30 \text{ cm.}$$

Q 72.

Ans. $T = 2\pi\sqrt{\frac{l}{g}}$

Q. 73.

Ans. $\frac{1}{k_{eq}} = \frac{1}{k} + \frac{1}{2k} + \frac{1}{4k}$

$$\frac{1}{k_{eq}} = \frac{\frac{1}{k}}{1 - \frac{1}{2}}$$

$$k_{eq} = k/2$$

Q 74.

Ans. $kl = k_2 l/4 \Rightarrow k_2 = 4k$

$$T = 2\pi\sqrt{\frac{m}{4k}} = \frac{T}{2}$$

Q 75.

Ans. air friction

Q 76.

Ans. $K_{eq} = K + 2K$

$= 3K$

$T = 2\pi \sqrt{\frac{m}{3K}}$

$f = \frac{1}{2\pi} \sqrt{\frac{3K}{m}}$

Q 77.

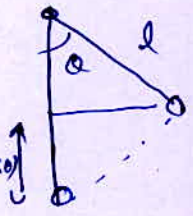
Ans. amplitude decreases due to air friction

$f = \frac{1}{2\pi} \sqrt{\frac{g}{l}} =$ constant

Q 78.

Ans. K.E. max = Δ P.E.

$= mgl(1-\cos\theta)$



Q 79.

Ans. $x = A \sin(\omega t + \delta)$ $\quad y = A \sin(\omega t + \delta + \frac{\pi}{2})$

$y = A \cos(\omega t + \delta)$

$x^2 + y^2 = A^2$

Q 80.

Ans. damped force is small

Q 81.

Ans. $x = A_1 \sin(\omega t)$ $\quad \phi = \pi/2$

$$y = A_2 \sin(\omega t + \phi) = A_2 \sin\omega t \cos\phi + A_2 \cos\omega t \sin\phi$$

$$x + y = (A_1 + A_2 \cos\phi) \sin\omega t + A_2 \sin\phi \cos\omega t$$

$$x + y = A_1 \cdot \sin\omega t + A_2 \cos\omega t$$

$$x + y = \sqrt{A_1^2 + A_2^2} \sin(\omega t + \alpha)$$