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P# 4:

Given data:

$f = 60\ Hz.$

$T = ?$

As we know that

$T = \frac{1}{f}$ — (1)

Putting the of "f" in eq (1)

$T = \frac{1}{60}$

$T = 0.016\ sec.$

P# 5:

Given data:

$f = 150$ beats/min

$f = 150$ beats/60 sec ($\because$ 1min = 60 sec)

$f = \frac{150}{60}$ beats/sec

$f = \frac{150}{60}$ beats/sec.

$f = 2.5$ beats/sec.

$T = ?$

As we know that

$$T = \frac{1}{f} \quad -① $$

Putting the values in eq ①.

$$T = \frac{1}{2.5}$$

$T = 0.4$ sec.

P#6

Given data:

$T = 2.50 \times 10^{-3}$ sec

$f = ?$

As we know that

$$f = \frac{1}{T} \quad -① $$

Putting the value of "T" in eq ①.

$$f = \frac{1}{2.50 \times 10^{-3}}$$

$f = 400\,Hz$.

P# 7

Given data:

$T = 8 \times 10^{-5}$ sec

$f = ?$

As we know that

$f = \frac{1}{T}$ — ①

Putting the value of "T" in eq ①.

$f = \frac{1}{8 \times 10^{-5}}$

$f = 12500$ Hz.

P #8

Given data:

$m = 85$ kg.

$k = 1.50 \times 10^{6}$ N/m

$A = 0.2$cm

$= 0.002$ m

$V_{max} = ?$

$E_{max} = ?$

As we know that

$V_{max} = \sqrt{\frac{k}{m}}\, A$ — ①

Putting the values in eq ①

$$V_{max} = \sqrt{\frac{1.5\times10^6}{85}}(0.002)$$

$$V_{max} = 0.26\ m/sec.$$

Now to find E_{max}, we know that.

$$E_{max} \text{ in spring} = P.E = \frac{1}{2} kA \quad \text{—} ②$$

Putting the values in eq ②

$$E_{max} = \frac{1}{2}(1.5\times10^6)(0.002).$$

$$E_{max} = 1500\ J.$$

P#13

For minimum Time period, the distance between point of suspention and CG (centre of Gravity) of meterstick is equal to the radius of gyration, ~~that~~ so we will drill the hole at the end of meterstick in such a way that distance of hole from the CG is equal to the radius of gyration. In this way Time Period will be minimum.

P#1

Given data:

$m = 50g$
$= 0.05\ kg$

$a_{max} = 15\ m/s^2$

$V_{max} = 3.5\ m/s$

Angular frequency = ω = ?

k = ?

A = ?

As we know that

$$V_{max} = \omega A \quad — (1)$$

$$a_{max} = \omega^2 A \quad — (2)$$

$$V = \omega A$$

$$\omega = \frac{V}{A} \quad — (3)$$

Putting eq (3) in (2)

$$a_{max} = \frac{V^2}{A^{\cancel{2}}} \times \cancel{A}$$

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

$$A = \frac{V^2}{a} \quad — (4)$$

Putting the values in eq (4)

$$A = \frac{(3.5)^2}{15}$$

$$A = 0.81\ m$$

Now find ω.

$$\omega = \frac{V}{A}$$

Putting the values in eq (3)

$$\omega = \frac{V}{A}$$

$$\omega = \frac{3.5}{0.816}$$

$$\omega = 4.28$$

For finding k we know that

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

$$\omega^2 = \frac{k}{m}.$$

$$k = \omega^2 m. \text{ --- } (5)$$

Putting the values in eq (5)

$$k = (4.28)^2(0.05)$$

$$k = 0.91$$

P# 11

Given data

$m = 1.50 \, kg$

$k = 500 \, N/m$

$V_{max} = 70 \, cm/s.$

$= 0.7 \, m/s$

$A = ?$

$E_{mech} = ?$

As we know that

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

$$A = \frac{V}{\omega}$$

$$A = V\sqrt{\frac{m}{k}} \quad -(1)$$

Putting the values in eq (1)

$$A = 0.7\sqrt{\frac{1.5}{500}}$$

$$A = 0.038\,m.$$

Now to find E_{mech}, we know that

$$E = \frac{1}{2}kA^2 \quad -(2)$$

Putting the values in eq (2)

$$E = \frac{1}{2}(500)(0.038)^2$$

$$E = \frac{1}{2}(500)(0.076)$$

$$E = 0.361\,J.$$

P # 12

$m = 3\,kg$

$A = 8\,cm$

$= 0.08\,m$

$a = 3.5\,m/s^2$

$E_{mech} = ?$

As we know that

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

$$a = \frac{k}{m} \cdot A. \qquad \left(\because \omega = \sqrt{\frac{k}{m}}\right)$$

$$\frac{am}{A} = k \quad — ①$$

Putting the values in eq ①

$$k = \frac{(3.5)(3)}{0.08}$$

$$k = 131.25 \text{ N/m}$$

Now to find E_{mech}, we know that

$$E_{mech} = \frac{1}{2} k A^2 \quad — ②$$

E = Putting the values in eq ②

$$E = \frac{1}{2}(131.25)(0.08)^2$$

$$E = 0.42 \text{ J}.$$

P # 14

Given data:

$m = 450g$

$= 0.45 \text{ kg}$

$f = 1.2 \text{ Hz}$

$E = 0.51 \text{ J}$

$A = ?$

As we know that

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

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

$$(2\pi f)^2 = \frac{k}{m}$$

$$4\pi^2 f^2 m = k \quad -(1)$$

Putting the values in eq (1)

$$k = 4(\pi)^2(1.2)^2(0.45)$$

$$k = 25.58 \text{ N/m}$$

Now to find the A, we know that

$$E = \frac{1}{2}kA^2$$

$$\frac{2E}{k} = A^2$$

$$A = \sqrt{\frac{2E}{k}} \quad -(2)$$

Putting the values in eq (2)

$$A = \sqrt{\frac{2(0.51)}{25.58}}$$

$A = 0.199\ m.$

P # 9

Given data:

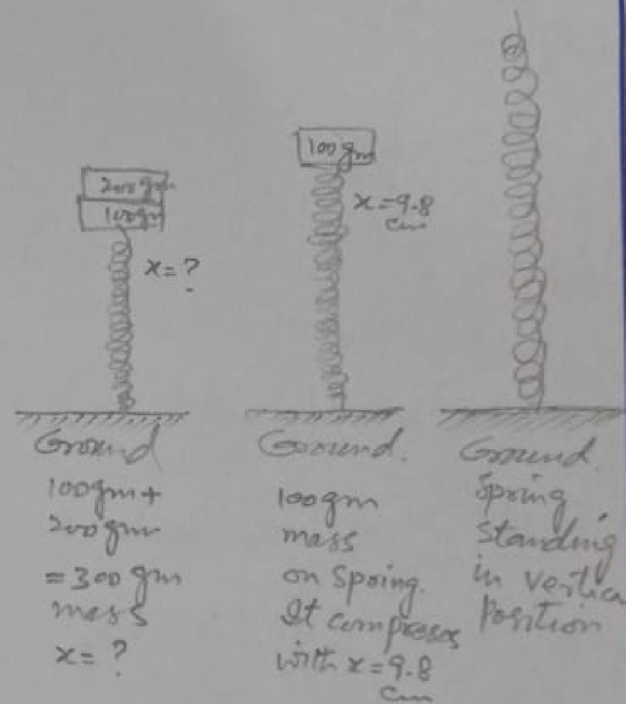
$m = 100\ gm$
$= 0.1\ kg.$

$x = 9.8\ cm$

$x = 0.098\ m$

$x = ?$ when $m = 300\ g$
$= 0.3\ kg$

$k = ?$



As we know that

$F = -kx$

$k = \frac{F}{x}$ — ①

In eq ①, F is force which spring compresses, so

$F = W = mg$

$F = 0.1 \times 9.8$

$F = 0.98\ N$

Putting the values in eq ①

$k = \frac{0.98}{0.098}$

$k = 10\ N/m$

Now to find x with $m = 0.3\,kg$, so we know

$$F = -kx.$$

But $F = W = mg$

$$F = 0.3 \times 9.8$$

$$F = 2.94\,N$$

So,

$$x = \frac{F}{k} \quad -②$$

Putting the values in eq ②

$$x = \frac{2.94}{10}$$

$$x = 0.294\,m.$$

P# 10

Given data:

$$x = 49\,cm$$
$$= 0.49\,m$$

$$T = ?$$

Total distance between top to bottom $= x = 49\,cm = 0.49\,m.$

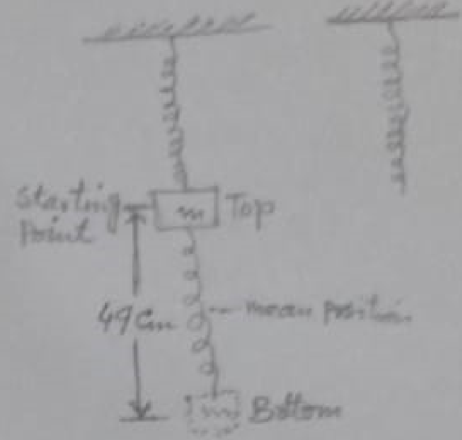
So,

$$A = \frac{\text{Total distance}}{2}$$

$$A = \frac{0.49}{2}$$

$$A = 0.245\,m.$$

Now to find T, we know that.



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

$$T = 2\pi\sqrt{\frac{m}{k}} \quad \left(\because \omega = \sqrt{\frac{k}{m}}\right) \text{ — (1)}$$

To find $\frac{m}{k}$, we know that

$$F = -kx.$$

But $F = W = mg$, so.

$$mg = -kx.$$

$$\frac{m}{k} = \frac{x}{g} \text{ — (2)}$$

Putting eq (2) in (1)

$$T = 2\pi\sqrt{\frac{x}{g}} \text{ — (3)}$$

Putting the values in eq (3)

$$T = 2\pi\sqrt{\frac{0.245}{9.8}}$$

$$T = 0.99 \approx 1 \text{ sec.}$$

P # 2

Given data:

$m = 2$ kg

$F = 20$N

$A = 0.2\ m$

$k = ?$

$f = ?$

$V_{max} = ?$

$a_{max} = ?$

$E_T = ?$

As we know that

$$f = \frac{1}{T}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{m}{k}} \quad -① \qquad \left(\because T = 2\pi\sqrt{\frac{k}{m}}\right)$$

Putting the values in eq ①

$$f = \frac{1}{2\pi}\sqrt{\frac{2}{k}} \quad -②$$

To find the value of k, we know that

$$F = -kx.$$

$$k = \frac{F}{x}$$

So

$$k = \frac{20}{0.2}$$

$$k = 100\ N/m$$

Putting the value of k in eq ②, we get.

$$f = \frac{1}{2\pi}\sqrt{\frac{2}{100}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{50}}$$

$$f = 0.02\ Hz.$$

Now find V_{max}, we know that

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

$$V = \sqrt{\frac{K}{m}}\, A \quad \text{— (3)} \qquad \left(\because \omega = \sqrt{\frac{k}{m}}\right)$$

$$V = \sqrt{\frac{100}{2}} \times (0.2)$$

$$V = 1.414\ m/s.$$

And the maximum speed will occur at the mean position.

Now to find a_{max}, we know that

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

$$a = \frac{k}{m} A \quad \text{— (4)} \qquad \left(\because \omega = \sqrt{\frac{k}{m}}\right)$$

Putting the values in eq (4).

$$a = \frac{100}{2}(0.2)$$

$$a = 10\ m/s^2.$$

And the maximum acceleration will occur at extreme position.

Now we find Total Energy (E_T), as we know that

Total Energy = P.E + K.E.

At mean position, P.E = 0 and K.E is maximum while at extreme position, P.E is maximum and K.E = 0. Therefore when object is pulled to $x = 0.2\,m$ then this $x = x_o = 0.2\,m$ which is maximum displacement. Thus at $x = x_o = 0.2\,m$ all the energy of the object is P.E and K.E will be zero at $x_o = 0.2\,m$.

Therefore Total Energy = P.E = $\frac{1}{2} k x_o^2$ — ⑤

Putting the values in eq ⑤, we get

$$E_T = \frac{1}{2}(100)(0.2)^2$$

$$E_T = 2\,J$$

Hence the total energy of the oscillating system is 2 Joules.

Now we will find "a" and "v" when its position is equal to one-third the maximum. i.e.

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

According to given condition when its postion is equal to $\frac{1}{3}$ the maximum so

$$x = \frac{A}{3} \quad —⑥$$

Putting the values in eq 6, we get.

$$x = \frac{0.2}{3.}$$

$$x = 0.06\ m.$$

Now to find "a", we know that

$$a = -kx \quad — 7$$

Putting the values in eq 7

$$a = -(100)(0.06)$$

$$a = -6.6\ m/s^2.$$

where the negative sign show the direction.

Now to find "v", we know that

$$V = V_{max}\sqrt{1 - \frac{x^2}{A^2}} \quad — 8$$

Putting the values in eq 8, we get.

$$V = 1.414\sqrt{1 - \frac{(0.06)^2}{(0.2)^2}}$$

$$v = (1.414)(0.95)$$

$$V = 1.34\ m/s.$$

Now the expression of position, velocity and acceleration as function of time is given below:

$$x(t) = A\cos(\omega t + \phi).$$

Expression for position.

$$v(t) = \frac{d}{dt}(x) = -\omega A \sin(\omega t + \phi).$$

Expression for velocity.

$$a(t) = \frac{d^2}{dt^2}(v) = -\omega^2 A \cos(\omega t + \phi).$$

Expression for acceleration.

P# 3

We know that

$$F = -kx \quad -①$$

But we also know that

$$F = ma \quad -②$$

Comparing eq ① & ②, we get.

$$ma = -kx$$

But

$$a = \frac{d^2x}{dt^2}, \text{ so}$$

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

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

~~whe~~ but

$\omega^2 = \frac{k}{m}$, so.

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

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

Solution of the above differential equation is

$x(t) = A\cos(\omega t + \phi)$.

Now we will find V_{max} and a_{max}, so.

$V_{max} = ?$

we know that

$V_{max} = \omega A$.

$V = 2\pi f A$ — ① $\quad (\because \omega = 2\pi f)$

Putting the values in eq ①.

$V = 2\pi(1.5)(0.02)$.

$V = 0.18$ m/s.

And for $a = ?$

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

$a = (2\pi f)^2 A$ — ②

Putting the values in eq ②.

$a = 4\pi^2(1.5)^2(0.02)$

$a = 1.77\ m/s^2$

Now to find total distance, we know that

$x(t) = A\cos(\omega t + \phi)$ — ①

Now $t = 0$, $\phi = 0$:

$x(0) = A\cos(0+0).$

$x(0) = A$ — ①

Now in question $A = 0.02m$, so.

$x(0) = 0.02m.$

Now $t = 1$

$x(1) = A\cos(\omega + \phi)$ — ②

~~Putting eq 2~~ Subtracting eq ② from ①.

$x(1) - x(0) = A\cos(\omega+\phi) - A.$

Distance travelled $= A(\cos(\omega+\phi)-1).$
between $t=0$ to $t=1$

P#15: Given data:

$L = 2m.$

$m_g = 0.8\,kg$

$m_d = 1.2\,kg.$

$d = ?$ at $t = 2.50$ sec.

As we know that

$T = 2\pi\sqrt{\dfrac{I}{mgd}}$ — ①

Now we will find I, so.

$$I = \frac{1}{3} m_r l^2$$

$$I = \frac{1}{3}(0.8)(2)^2$$

$$I = 1.066$$

~~Now putting the values in eq ①~~

$$T = 2\pi \sqrt{I/mgd}$$

on arranging, we get.

$$d = \frac{4\pi^2 I}{mgT^2} \quad \text{— ②}$$

Putting the values in eq ②.

$$d = \frac{4\pi^2(1.066)}{(1.2)(9.8)(2.5)^2}$$

$$d = 0.57 \text{ m.}$$

Now to find d ~~at t =~~ for perfect time $t = 3.5$ sec

As we know that

$$T = 2\pi \sqrt{I/mgd} \Rightarrow d = \frac{4\pi^2 I}{mgT^2}$$

Putting the values $I = 1.066$, $m = 1.2$, $g = 9.8$ & $t = 3.5$. so.

$$d = \frac{4\pi^2(1.066)}{(1.2)(9.8)(3.5)^2}$$

$$d = 0.29 \text{ m.}$$

Towards upward.