R.K.

GROUP OF COLLEGE

Behind Kalwar Police Station, Kalwar, Jaipur (Raj.)

ASSIGNMENT

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B.A. / B.Sc. / B.Com.

ASSIGNMENT WORK / MIDTERM TEST

Session 20 .... - 20 ....

Semester ....

Name of Student Manisha Choudhary Father's Name Mr. Sohan lal Choudhary

Roll No. .... Enrollment No. ....

Year .... Semester ....

Question - 1 Prove that in Galilean Transformation
(A) Displacement for distance between two points remains constant.
(B) At what speed should a clock be moved so that it appears to be 1 minute slow in a day.

Question 2.
(A) What do you understand by angular mome-ntum? Prove that the rate of change of angular momentum is equal the torque.
(B) Three identical masses are given they are located at the points (a,0,0), (0,a,2a), and (0,2a,a) objective.

Question 3 (A) Derive the differential equation of motion for a particle moving under the influence of a central force and prove that the linear momentum and angular momentum of particle remains constant. Also prove that the total energy of the particle is conserved.
(B) A stallite is orbiting close to the Earth's surface (very close) Calculate its time period if the radius of the Earth is 6400 km and $g = 9.8\ m/s^2$

Question 4 (A) Establish and solve for a driven harmonic oscillator. Discuss the resonance conditions include various differential eq^n.
(B) The amplitude on the minor axis of an induced cell is 0.1mm. when the value of the amplitude becomes 5mm at $\omega = 99\omega_0$, find the Characteristic coefficient

Question (1) (A)

Answer (A)

Displacement or distance between two points remains constant.

→ Let the position vector of any two points P and Q in a stationary reference frame be respectively.

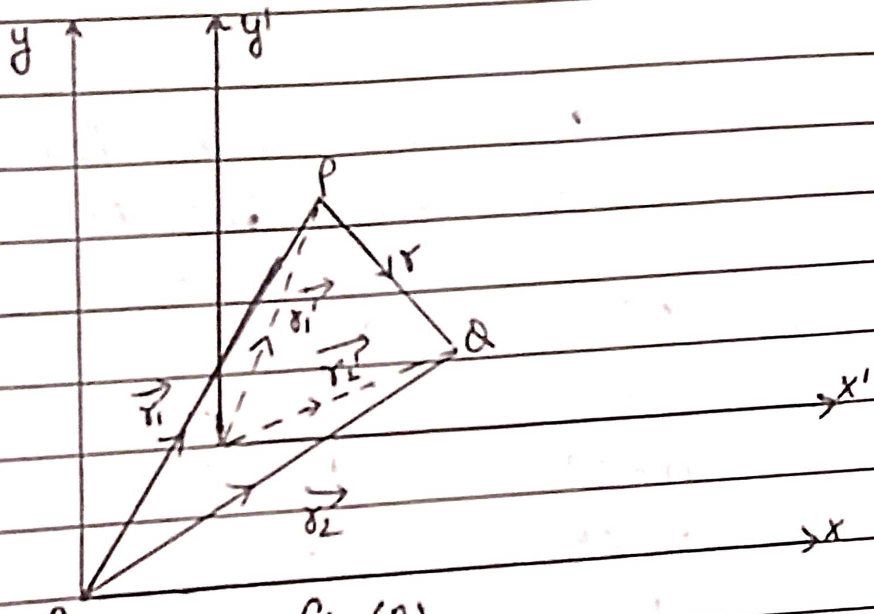


fig (A)

The vector displacement between point P and Q in the stationary reference frame is :

$$\vec{PQ} = \vec{r_1'} - \vec{r_1}$$

$$\vec{d} = \vec{r_2'} - \vec{r_1'} \quad \text{—} (2)$$

From the Galilean transformation of the position vector

$$\vec{r_1'} = \vec{r_1} + \cancel{\vec{vt}}\ \vec{V}t$$

or

$$\vec{r_2'} = \vec{r_2} + \vec{V}t \quad \text{—} (3)$$

From equation (2) and (3).

$$\vec{d'} = (\vec{r_2} + \vec{V}t) - (\vec{r_1} + \vec{V}t)$$

$$\vec{d'} = \vec{r_2} - \vec{r_1}$$

Therefore from equation (1)

DATE ....

$$\boxed{\vec{d} = \vec{d'}}$$

Therefore, it follows that in Galilean transformation the vector distance between two points remains constant.

Question (1) (B)

Answer

Time measured in S reference system $(\tau) = 24 \times 60 = 1440$ min

S' Time measured in S' reference system $(\tau_0) = 24 \times 60 - 1 = 1439$ min

We know that :

$$\Rightarrow \tau = \frac{\tau_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\Rightarrow \frac{\tau}{\tau_0} = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\Rightarrow \frac{\tau_0}{\tau} = \sqrt{1 - \frac{v^2}{c^2}}$$

$$\Rightarrow \left(\frac{1439}{1440}\right)^2 = \sqrt{1 - \frac{v^2}{c^2}}.$$

$$\Rightarrow \left(\frac{1439}{1440}\right)^2 = 1 - \frac{v^2}{c^2}$$

$$\Rightarrow (0.99)^2 = 1 - \frac{v^2}{c^2}$$

$$\boxed{v = 0.35 \times 10^8 \, m/s}$$

Teacher's Signature ....

Question 2(A)

Answer

The prodect of property of any rotating object given by moment of interia times angular velocity is called Angular momentum.

$$\boxed{\vec{J} = \vec{r} \times \vec{P}}$$

S.I unit ⇒ $kg\text{-}m^2/sec$

Torque (τ)

The moment of force is called Torque

$$\boxed{\vec{\tau} = \vec{r} \times \vec{F}}$$

S.I unit = N-M.

We known that

$$\vec{J} = \vec{r} \times \vec{P}$$

Differentiating with respect to time,

$$\frac{d(\vec{J})}{dt} = \vec{P}\left(\frac{d\vec{r}}{dt}\right) + \vec{r}\left(\frac{d\vec{P}}{dt}\right)$$

$$\vec{P} \times \vec{v} + m\vec{r}\left(\frac{d\vec{v}}{dt}\right)$$

$$m\vec{v} \times \vec{v} + \vec{r} \times m\vec{a}$$

$$\therefore \vec{v} \times \vec{v} = 0$$

Therefore →

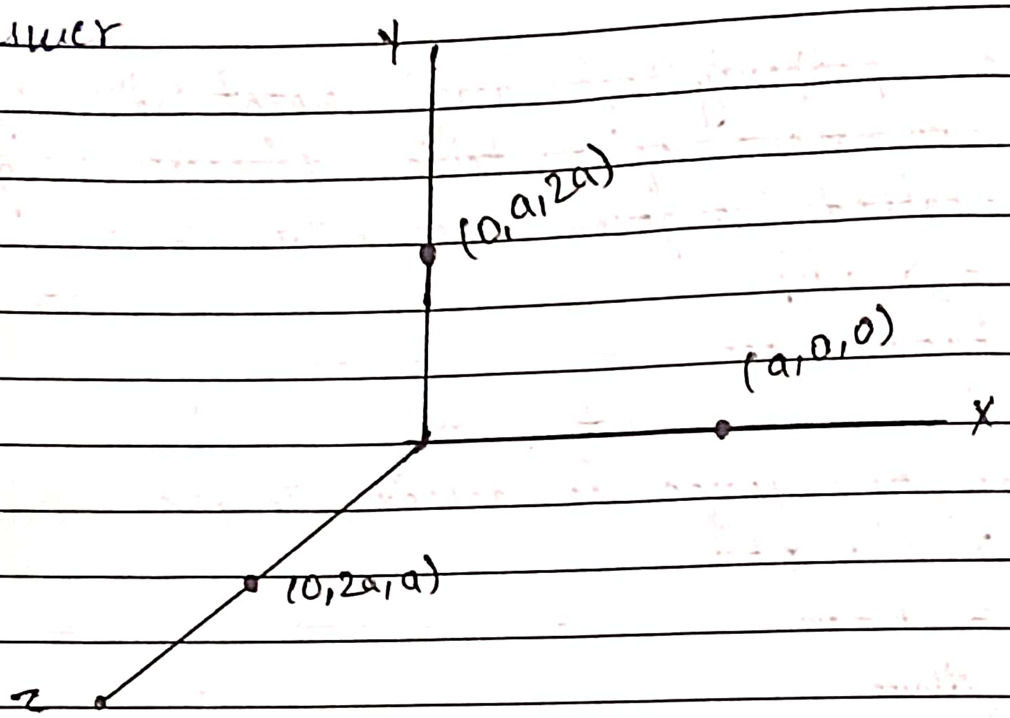
$$\frac{d\vec{J}}{dt} = 0 + \vec{r} \times \vec{F}$$

$$\boxed{\frac{d\vec{J}}{dt} = \vec{\tau}}$$

Hence, the rate of change of angular moment-um is equal to Torque.

Question 2 (B)

Answer



We have given

$$m_1 = m_2 = m_3 = m$$

Moment of inertia is calculated using the formula.

$$I_{xx} = \Sigma M_i \left(y_i^2 + z_i^2\right]$$

$$= \left[m_1 (0+0) + m_2 (a^2 + 4a^2) + m_3 (4a^2 + a^2)\right]$$

$$= 0 + 5ma^2 + 5ma^2$$

$$\boxed{I_{xx} = 10ma^2}$$

$$I_{yy} = \Sigma M_i \left[x_i^2 + z_i^2\right]$$

$$= \left[m_1 (a^2 + 0) + m_2 [0 + 4a^2] + m_3 [0 + a^2]\right]$$

$$= ma^2 + 4ma^2 + ma^2$$

$$\boxed{I_{yy} = 6ma^2}$$

$$I_{zz} = \sum M_i (x_i^2 + y_i^2)$$
$$= (m_1(a^2+0) + m_2(0+a^2) + m_3(0+4a^2)]$$
$$= ma^2 + ma^2 + 4ma^2$$
$$\boxed{I_{zz} = 6ma^2}$$

$$I_{xy} = -\sum m_i (x_i y_i)$$
$$= [m_1(a \times 0) + m_2(0 \times a) + m_2[0 \times 2a)]$$
$$= 0$$
$$\boxed{I_{xy} = I_{yx} = 0}$$

$$I_{yz} = -\sum m_i [y_i z_i]$$
$$= [m_1[0 \times 0] + m_2[a \times 2a) + m_3(a \times 2a)]$$
$$= 0 + 2ma^2 + 2ma^2$$
$$I_{yz} = 4ma^2$$

$$\boxed{I_{yz} = I_{zy} = -4ma^2}$$

$$I_{zx} = I_{xz} = -\sum m_i (x_i z_i)$$
$$= -[m_1(a \times 0) + m_2(0 \times 2a)\ m_3[0 \times a)]$$
$$= 0$$

$$\boxed{I_{zx} = I_{xz} = 0}$$

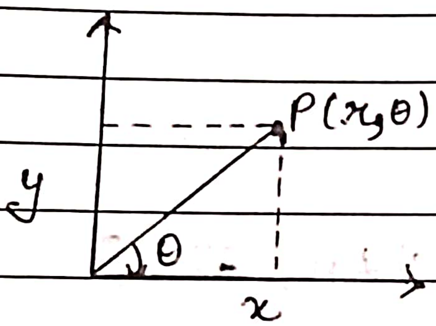
Question - 3 (A)

Answer,

Let a particle (m) be moving in a polar coordinate system, whose r and θ coordinate syst are x and y respectively as follows :-

$$x = r\cos\theta \quad -(1)$$

$$y = r\sin\theta \quad -(2)$$



Differentiating equation (1) with respect to r ~~t~~, we get →

$$\frac{dx}{dt} = \frac{d(r\cos\theta)}{dt}$$

$$\frac{dx}{dt} = \frac{dr}{dt}\cos\theta + r\frac{d(\cos\theta)}{dt}$$

$$\frac{dx}{dt} = \cos\theta\frac{dr}{dt} - r\sin\theta\left(\frac{d\theta}{dt}\right) \quad -(3)$$

Differentiating equation (3)

$$\frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d}{dt}\left[\cos\frac{dr}{dt} - r\sin\theta\frac{d\theta}{dt}\right]$$

$$\frac{d^2x}{dt^2} = \frac{d}{dt}\left[\cos\theta \frac{dr}{dt}\right] - \frac{d}{dt}\left[r\sin\theta \frac{d\theta}{dt}\right]$$

$$= \cos\theta \frac{d^2r}{dt^2} + \frac{dr}{dt}(-\sin\theta)\frac{d\theta}{dt} - \frac{d}{dt}(r\sin\theta)\frac{d\theta}{dt} - r\sin\theta\frac{d^2\theta}{dt^2}$$

$$\frac{d^2x}{dt^2} = \cos\theta\frac{d^2r}{dt^2} - \sin\theta\frac{dr}{dt}\cdot\frac{d\theta}{dt} - \frac{d\theta}{dt}\left[\frac{dr}{dt}\sin\theta + r\cos\theta\frac{d\theta}{dt}\right] - r\sin\theta\frac{d^2\theta}{dt^2}$$

$$\frac{d^2x}{dt^2} = -2\sin\theta\frac{dr}{dt}\frac{d\theta}{dt} - r\sin\theta\frac{d^2\theta}{dt^2} + \cos\theta\frac{d^2r}{dt^2} - r\cos\theta\frac{d\theta}{dt}$$

$$\left\{\frac{d^2x}{dt^2} = -\sin\theta\left[2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right) + r\left(\frac{d^2\theta}{dt^2}\right)\right] + \cos\theta\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right]\right\} - (4)$$

Differentiating equation (2) w.r.t. t(dt) →

$$\frac{dy}{dt} = \frac{d}{dt}(r\sin\theta)$$

$$\frac{dy}{dt} = \frac{dr}{dt}\sin\theta + r\cos\theta\frac{d\theta}{dt}$$

$$\frac{dy}{dt} = r\cos\theta\frac{d\theta}{dt} + \sin\theta\frac{dr}{dt}$$

Again differentiating

$$\frac{d^2y}{dt^2} = \frac{d}{dt}\left[r\cos\theta\frac{d\theta}{dt} + \sin\theta\frac{dr}{dt}\right]$$

$$\frac{d}{dt}\left(r\cos\theta\frac{d\theta}{dt}\right) + \frac{d}{dt}\sin\theta\left(\frac{dr}{dt}\right)$$

$$\frac{d^2y}{dt^2} = r\cos\theta\frac{d^2\theta}{dt^2} + \frac{d\theta}{dt}\cdot\frac{d}{dt}(r\cos\theta) + \frac{dr}{dt}\cos\theta\frac{d\theta}{dt} + \sin\theta\frac{d^2r}{dt^2}$$

$$\frac{d^2y}{dt^2} = r\cos\theta\frac{d^2\theta}{dt^2} + \frac{d\theta}{dt}\left[\cos\theta\frac{dr}{dt} - r\sin\theta\left(\frac{d\theta}{dt}\right)\right] + \cos\theta\frac{dr}{dt}\cdot\frac{d\theta}{dt} + \sin\theta\frac{d^2r}{dt^2}$$

$$\frac{d^2y}{dt^2} = r\cos\theta\frac{d^2\theta}{dt^2} + 2\cos\theta\frac{dr}{dt}\cdot\frac{d\theta}{dt} - r\sin\theta\left(\frac{d\theta}{dt}\right)^2 + \sin\theta\frac{d^2r}{dt^2}$$

$$\left\{\frac{d^2y}{dt^2} = \cos\theta\left[r\frac{d^2\theta}{dt^2} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right] + \sin\theta\left[\frac{d^2r}{dt^2} + r\left(\frac{d\theta}{dt}\right)^2\right]\right\} \quad -(5)$$

$$\vec{a} = a_1\hat{i} + a_2\hat{j}$$

$$\vec{a} = \left(\frac{d^2x}{dt^2}\hat{i} + \frac{d^2y}{dt^2}\hat{j}\right)$$

Differentiating equation (4) and (5)

$$\vec{a} = -\sin\theta\left[2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right) + r\left(\frac{d^2\theta}{dt^2}\right)\right]\hat{j} + \cos\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right]\hat{i} +$$

$$= +\cos\theta\left[r\frac{d^2\theta}{dt^2} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right]\hat{j} + \sin\theta\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right]\hat{j}$$

$$\vec{a} = \left[2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right) + r\left(\frac{d^2\theta}{dt^2}\right)\right]\left[-\sin\theta\hat{i} + \cos\theta\hat{j}\right] +$$

$$\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right](\cos\theta\hat{i} + \sin\theta\hat{j})$$

$\because$ $\hat{r} = \cos\theta\hat{i} + \sin\theta\hat{j}$

$\hat{\theta} = -\sin\theta\hat{i} + \cos\theta\hat{j}$

$$\vec{a} = \left[\left(\frac{d^2r}{dt^2}\right) - r\left(\frac{d\theta}{dt}\right)^2\right]\hat{r} + \left[2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right) + r\left(\frac{d^2\theta}{dt^2}\right)\right]\hat{\theta}$$

$$\vec{a} = a_r\vec{r} + a_\theta\hat{\theta}$$

Where

$$a_r = \frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2$$

$$a_\theta = r\left(\frac{d^2\theta}{dt^2}\right) + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)$$

$$\therefore \vec{F}(r) = F(r)\hat{r}$$

$$\vec{F}(r) = F(r)\hat{r} = m(a_r\hat{r} + a_\theta\hat{\theta})$$

L.H.S R.H.S

$$ma_r = F(r) = M\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right] = F(r) \quad — (6)$$

$$ma_\theta = 0 \Rightarrow M\left[r\left(\frac{d^2\theta}{dt^2}\right) + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right] = 0 \quad — (6)$$

The equation of motion of body under the action of central force are called equation

$$M\left[r\left(\frac{d^2\theta}{dt^2}\right) + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right] = 0$$

$$\frac{d}{dt}\left[mr^2\left(\frac{d\theta}{dt}\right)\right]$$

$$\frac{d}{dt}\left[I\omega\right] = 0$$

$$\therefore I\omega = J$$

$$\boxed{\frac{d\vec{J}}{dt} = 0} \quad — (7)$$

Total energy

We known that

$$m\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right] = f(r) \quad —(8)$$

For central force

$$F(r) = -\frac{dU}{dr} \quad —(9)$$

Therefore

$$\frac{md^2r}{dt^2} - mr\left(\frac{d\theta}{dt}\right)^2 = -\frac{du}{dr}$$

$\therefore J = I\omega$

$= mr^2\frac{d\theta}{dt}$

$\frac{d\theta}{dt} = \frac{J}{mr^2}$

$$\frac{md^2r}{dt^2} - mr \times \frac{J^2}{m^2r^4} = -\frac{dU}{dr}$$

$$\frac{md^2r}{dt^2} = -\frac{du}{dr} + \frac{J^2}{mr^3}$$

$$m\frac{d^2r}{dt^2} = -\frac{du}{dr} - \frac{d}{dr}\left[\frac{J^2}{2mr^2}\right] \quad —(10)$$

eqn (10) × by $\frac{dr}{dt}$

$$m\left(\frac{dr}{dt}\right)\frac{d^2r}{dt^2} = -\frac{dr}{dt} \times \frac{d}{dt}\left[U + \frac{J^2}{2mr^2}\right]$$

$$\frac{d}{dt}\left[\frac{1}{2}m\left(\frac{dr}{dt}\right)^2\right] = -\frac{d}{dt}\left[U + \frac{J^2}{2mr^2}\right]$$

$$\frac{d}{dt}\left[\frac{1}{2}m\left(\frac{dr}{dt}\right)^2 + U + \frac{J^2}{2mr^2}\right] = 0$$

$$\frac{dE}{dt} = 0 \quad \text{—— (11)} \qquad \text{where } E = \text{Constant}$$

Therefore from eq^n (7) & (11) is proved the total energy and angular momentum of particle are remains constant.

Question 3(B)

Answer :- We known that

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

$$R = 6400\,km \qquad g = 9.8\times\ m/s^2$$

$$T = 2\pi\sqrt{\frac{6400\times10^3}{9.8}}$$

$$T = \frac{2\pi\times80\times10^2}{\sqrt{9.8}}$$

$$T = \frac{2\pi\times80\times10^2}{7\times0.1414}$$

$$T = 1.60\times3.14\times10^2$$

$$T = 5074 \text{ Second}$$

$$\boxed{T = 84.6 \text{ min}}$$

Question-4(A) Answer

When an oscillator oscillates under the influence of damping forces, its amplitude decreases with time. But if an external periodic force is applied to it, this external force compensates for the lose due to damping and the oscillator starts oscillating with the frequency of this external force. This type of oscillation is called driven oscillation.

forces acting on the oscillator :-
(i) Restoring force $= F_R = -kx$
(ii) Damping force $= F_d = -bv$ dV
(iii) Driving force $= F_x = F_0 \sin\omega t$.

Therefore ; the total force acting on the oscillator is,

$$F = F_R + F_d + F_x$$
$$F = -kx - d\,dV + F_0\sin\omega t$$

According to newton's law.

$$m\frac{d^2x}{dt^2} = -kx - dV + F_0\sin\omega t \Rightarrow m\frac{d^2x}{dt^2} + kx + dV = F_0\sin\omega t$$

$$\frac{md^2x}{dt^2} + \frac{kx}{m} + \frac{d\,dV}{mdt} = F_0\sin\omega t$$

$$\frac{d^2x}{dt^2} + \frac{d}{m}\frac{dx}{dt} + \frac{kx}{m} = \frac{F_0}{m}\sin\omega t$$

$$\therefore \frac{d}{m} = 2r, \quad \frac{k}{m} = \omega_0^2, \quad \frac{F_0}{m} = f_0$$

$$\frac{d^2x}{dt^2} + 2r\frac{dx}{dt} + \omega_0^2 x = f_0 \sin\omega t \quad \text{--- (1)}$$

The above equation in the differential equation for driven harmonic oscillations

Let the solution of eq^n (1) be $x(t) = x_0 \sin(\omega t - \phi)$ --- (2)

Therefore :

$$\left.\begin{aligned} \frac{dx}{dt} &= x_0\omega\cos(\omega t - \phi) \\ \frac{d^2x}{dt^2} &= -x_0\omega^2\sin(\omega t - \phi) \end{aligned}\right\} \text{--- (3)}$$

from eq^n (1), (2) & (3)

$$-x_0\omega^2\sin(\omega t - \phi + 2r x_0\omega\cos(\omega t - \phi) + \omega_0^2 x_0 \sin(\omega t - \phi) = f_0 \sin\omega t$$

$$-x_0(\omega^2 - \omega_0^2)\sin(\omega t - \phi) + 2r x_0 \omega\cos(\omega t - \phi) = f_0 \sin(\omega t - \phi + \phi)$$

from calculation

$$-x_0(\omega^2 - \omega_0^2) = f_0 \cos\phi \quad \text{--- (4)}$$

$$2r x_0 \omega = f_0 \sin\phi \quad \text{--- (5)}$$

from eq^n (4) + (5)

$$(-\omega^2+\omega_0^2)^2 x_0^2 + 4\gamma^2 x_0^2 \omega^2 = f_0^2(\cos^2\phi + \sin^2\phi)$$

$$x_0^2[(\omega_0^2-\omega^2)^2] + 4\gamma^2 x_0^2 \omega^2 = f_0^2$$

$$x_0^2[(\omega_0^2-\omega^2)^2 + 4\gamma^2\omega^2] = f_0^2$$

$$x_0^2 = \frac{f_0^2}{[\omega_0^2-\omega^2]^2 + 4\gamma^2\omega^2}$$

$$x_0 = \frac{f_0}{[(\omega_0^2-\omega^2)^2 + 4\gamma^2\omega^2]^{1/2}} \quad \text{---} \quad (6)$$

from eq^n (6) it is clear from the above that the amplitude of a driven oscillator does not depend on time

eq^n (4) / eq^n (5)

$$\frac{f_0 \sin\phi}{f_0 \cos\phi} = \frac{2\gamma\omega x_0}{(\omega_0^2-\omega^2)x_0}$$

$$\tan\phi = \frac{2\gamma\omega}{\omega_0^2-\omega^2}$$

from eq^n (6) and (7)

$$x = \frac{f_0}{[(\omega_0^2-\omega^2)^2 + 4\gamma^2\omega^2]^{1/2}} \sin\left[\omega t - \tan^{-1}\left(\frac{2\gamma\omega}{\omega_0^2-\omega^2}\right)\right]$$

All of the above are driven oscillators / displacement solution.

(i) $\omega << \omega_0$ (Low - Speed)

Meaning Equation

$$\tan\phi = \frac{2r\omega}{\omega_0^2 - \omega^2} \simeq 0$$

$$\tan\phi = 0$$

$$\boxed{\phi = 0}$$

Meaning : Dimension

$$x = \frac{f_0}{[(\omega_0^2 - \omega^2)^2 + 4r^2\omega^2]^{1/2}}$$

$$= \frac{f_0}{[(\omega_0^2)^2]^{1/2}} \Rightarrow \frac{f_0}{\omega_0^2} = \frac{mf_0}{m\omega_0^2}$$

$$\boxed{x = \frac{F_0}{k}} \qquad \therefore m\omega_0^2 = k$$

(ii) $\omega \cong \omega_0$

Art

$$\tan\phi = \frac{2r\omega}{\omega_0^2 - \omega^2}$$

$$\tan\phi = \frac{2r\omega_0}{\omega_0^2 - \omega_0^2}$$

$$\tan\phi = \infty$$

$$\boxed{\phi = 90^\circ}$$ (critical motion)

Dimension

$$x = \frac{f_0}{[(\omega_0^2 - \omega^2)^2 + 4r^2\omega^2]^{1/2}}$$

$$\Rightarrow \quad x = \frac{f_0}{[[(\omega_0^2 - \omega^2]^2 + 4r^2\omega^2]^{1/2}}$$

$$x = \frac{f_0}{2r\omega_0}$$

$$x = \frac{mf_0}{2rm\omega_0}$$

mean :-

$$2rm = d$$

$$\boxed{x = \frac{\cancel{m}F_0}{d\omega_0}}$$

(iii) $\omega >> \omega_0$ (Overloaded)

$$\tan\phi = \frac{2r\omega}{(\omega_0^2 - \omega^2)}$$

$\therefore \omega >> \omega_0$ so $\omega_0 = 0$

$$\tan\phi = \frac{2r\omega}{\omega^2\left(\frac{\omega_0^2}{\omega^2} - 1\right)}$$

$$\tan\phi = \frac{2r\omega}{-\omega^2}$$

$$\tan\phi = \frac{-2r}{\omega}$$

$$\tan\phi \simeq -0$$

$$\boxed{\phi = \pi}$$

i) $$x = \frac{f_0}{[(\omega_0^2-\omega^2)^2 + 4r^2\omega^2]^{1/2}}$$

$$x = \frac{f_0}{[(-\omega)^2 + 4r^2\omega^2]^{1/2}}$$

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$$\boxed{x = \frac{f_0}{\omega^2}}$$

Resonance :-

$$x = \frac{f_0}{[(\omega_0^2-\omega^2)^2 + 4r^2\omega^2]^{1/2}}$$

for maximum value the denominator should be minium

$$[(\omega_0^2 - \omega^2)^2 + 4r^2\omega^2]^{1/2} = m(k)$$

$$\frac{d}{d\omega}[(\omega_0^2-\omega^2)^2 + 4r^2\omega^2] = 0$$

$$2(\omega_0^2 - \omega^2)(-2\omega) + 4r^2(2\omega) = 0$$

$$\boxed{\omega = \sqrt{\omega_0^2 - 2r^2}}$$

Question 4 (B)

Answer

$x = 5 \times 10^{-3}$ m

$\omega = 0.99\omega_0$

$\theta = ?$

$$x = \frac{f_0}{\omega_0^2} = 0.1 \times 10^{-3}\ m$$

then

$$x = \frac{f_0}{[[\omega_0^2 - \omega^2]^2 + 4r^2\omega^2]^{1/2}}$$

$$5 \times 10^{-3} = \frac{f_0}{([\omega_0^2 - \omega^2)^2 + 4r^2\omega^2]^{1/2}}$$

$$5 \times 10^{-3} = \frac{f_0}{[(\omega_0^2 - (0.99\omega_0)^2))^2 + 4r^2(0.99\omega_0)^2]^{1/2}}$$

$$5 \times 10^{-3} = \frac{f_0}{\omega_0^2((1-(0.99)^2)^2 + 4r^2 \frac{(0.99)^2}{\omega_0^2}}$$

$$5 \times 10^{-3} = \frac{0.1 \times 10^{-3}}{\sqrt{1 + (0.98)^2 - 2 \times 0.9801 + \frac{(0.99)^2}{\theta^2}}}$$

$$\frac{(0.99)^2}{\theta^2} = 4 \times 10^{-6}$$

$$\theta = \frac{990}{2}$$

$$\boxed{\theta = 495}$$

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