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SAPTHAGIRI COLLEGE OF ENGINEERING

Bengaluru - 57

YELLOW BOOK

ASSIGNMENT

Name: Rohith K.C USN: 1SG17ME070

Subject: Dynamics of machinery Subject Code: 17ME52

Branch: Mechanical Sem & Section: V th sem 'B' sec

Assignment No.	Date	1	2	3	4	5	6	7	8	Total
1	10/9/19	Assignment								10
2	10/11/19	Mark Test								10
3	19/11/19									10
4		Quiz								07
5		Mini project								
		10				10				

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14/5, Chikkasandra, Hesaraghatta Main Road
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Rohith KC
Signature of Student

Faculty

HOD

UNIT TEST

1.) Find the natural frequency of spring mass system taking the mass of spring into account.

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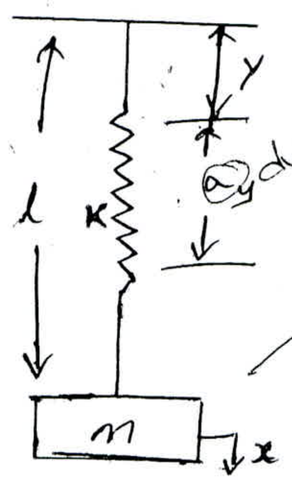

$x \to$ Displacement of ma

$l \to$ Total length of spring wire.

$m \to$ mass of spring wi per unit length.

velocity of spring wire at distance

$$\dot{x} = (y/l)$$

Kinetic ~~total~~ energy of spring element

$$dy = \frac{1}{2}(m\,dy)\left(\dot{x}\,y/l\right)^2$$

$$= \int_0^l \frac{1}{2} m \dot{x}^2 \frac{y^2}{l^2} \cdot dy = \frac{1}{2} m \frac{\dot{x}^2}{l^2} \int_0^l y^2\,dy$$

$$= \frac{1}{2} m\dot{x}^2 + \frac{1}{6} m_s \dot{x}^2 + \frac{1}{2} Kx^2 = \text{constant}$$

potential energy of the system $= \frac{1}{2} Kx^2$

total energy of system $= \frac{1}{2} m\dot{x}^2 + \frac{1}{6} m_s \dot{x}^2 + \frac{1}{2} \ldots$ $= c$

Determining above eqn

$$\frac{1}{2} m 2\dot{x} \cdot \ddot{x} + \frac{1}{6} m_s 2\dot{x}\ddot{x} + \frac{1}{2} K 2x \cdot \dot{x} = 0$$

$$m\ddot{x} + \frac{1}{3} m_s \ddot{x} + Kx = 0$$

$$\ddot{x} + \left[\frac{K}{m + \frac{1}{3} m_s}\right] x = 0 \quad \text{Natural frequency} = f_n = \frac{1}{2\pi}\omega_n = \frac{1}{2\pi}\sqrt{\frac{K}{(m + \ldots}}$$

4.) A spring mass damper system has $m = 3kg$, $K = 100 N/m$, $c = 3 N\text{-}s/m$

⇒ $m = 3kg$

$K = 100 N/m$

$c = 3 N\text{-}s/m$

i Damping factor

$$\xi = \frac{c}{c_c}$$

$$c_c = 2m\omega_n$$

ii Natural frequency $\omega_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{100}{3}}$

$$\boxed{\omega_n = 5.77 \text{ rad/sec}}$$

$$c_c = 2 \times 3 \times 5.77$$

$$\boxed{c_c = 34.688}$$

$$\xi = \frac{3}{34.688}$$

$$\boxed{\xi_1 = 0.0866}$$

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iii ~~Natural frequency of damped vibration~~

logarithmic decrement

$$\delta = \frac{2\pi\xi_1}{\sqrt{1-\xi_1^2}}$$

$$= \frac{2 \times \pi \times 0.0866}{\sqrt{1 - 0.0866}}$$

$$\boxed{\delta = 0.5461}$$

iv The ratio of two succesive amplitude

$$\delta = \ln\left(\frac{x_n}{x_{n+1}}\right)$$

$$0.5461 = \ln\left(\frac{x_n}{x_{n+1}}\right)$$

$$\frac{x_n}{x_{n+1}} = e^{0.5461}$$

$$\boxed{\frac{x_n}{x_{n+1}} = 1.7765}$$

v

$$\delta_d = \frac{1}{2\pi} \times \omega_d$$

$$= \frac{1}{2 \times \pi} \times 5.77$$

$$\boxed{\delta_d = 0.9094}$$

v) Number of cycles after which the orginal amplitude is below 20%:

$$\delta = \frac{1}{n} \ln\left(\frac{X_0}{X_n}\right)$$

$$0.546 = \frac{1}{n} \ln\left(\frac{X_0}{2X_0}\right)$$

$$0.546 = \frac{1}{n} \times 0.6988$$

$$\boxed{n = 2.31}$$

$$\boxed{n \approx 3}$$

3) A mass of 100kg has been mounted on spring support having a spring stiffness of 19600N/m & a damping co-efficient of 100 N-sec/m. The mass is acted upon by a harmonic force of 39N at the undamped natural frequency of setup, Determine.

i) Amplitude of vibration of mass.

$m = 100kg$
$K = 19600\,N/m$

$$\frac{X}{X_0} = \frac{1}{\sqrt{(1-r^2)^2 + (2\xi r)^2}}$$

$$X_0 = \frac{F_0}{K} = \frac{39}{19600}$$

$$\boxed{X_0 = 1.9867 \times 10^{-3}\,m}$$

$$\omega_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{19600}{100}}$$

$$\boxed{\omega_n = 14 \text{ rad/sec}}$$

$$C_c = 2m\omega_n$$

$$= 2 \times 100 \times 14$$

$$\boxed{C_c = 2800}$$

$$\varepsilon = \frac{c}{C_c} = \frac{100}{2800}$$

$$\boxed{\varepsilon = 0.0357}$$

where $r = 1$

$$x_0 = \frac{1.9867 \times 10^{-3}}{\sqrt{(2 \times 0.035 \times 1)^2}}$$

$$\boxed{X_0 = 0.0259}$$

ii

$$\tan\phi = \frac{2\varepsilon r}{1 - r^2}$$

$$\phi = \tan^{-1}\left(\frac{2 \times 0.0357 \times 1}{1 - 1^2}\right)$$

$$\phi = \tan^{-1}(\infty)$$

$$\boxed{\phi = 90^\circ}$$

$$FTR = \frac{\sqrt{1+(2\xi\gamma)^2}}{\sqrt{(1-\gamma)^2+(2\xi\gamma)^2}}$$

$$= \frac{\sqrt{1+(2\times0.035\times1)^2}}{\sqrt{(1-\gamma^2)^2+(2\times0.035\times1)^2}}$$

$$\boxed{FTR = 14.32N}$$

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ASSIGNMENT

Name : RAKESH-G-K USN : 1SG17ME067

Subject : DYNAMICS OF MACHINERY -1 Subject Code : 17ME52

Branch : MECHANICAL Sem & Section : V th 'B'

Assignment No.	Date	1	2	3	4	5	6	7	8	Total
1	10/9/19		Assignment							10
2	10/10/19		Unit Test							10
3	19/11/19									10
4			Quiz							09
5			Mini project							
Max. Marks		10	Marks Obtained			10				

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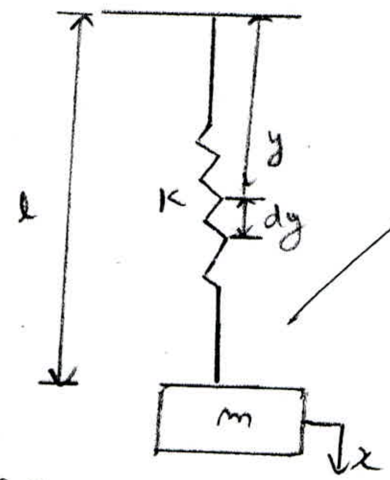
UNIT - TEST

UNDAMPED FREE VIBRATION

1) Find the natural frequency of spring mass system taking the mass of spring into account



Let us consider 'K' = stiffness of spring, let 'l' be the length of spring, 'm' be the mass, Let 'x' be the displacement of spring, Let 'dy' be the Element elongation, and distance 'y' from the fixed position. Let 'ρ' be the mass per unit area, 'ẋ' be the velocity of spring

V = Velocity of spring is given by $\frac{\dot{x} y}{l}$

Kinetic Energy is given by $= \frac{1}{2} m V^2$ where $m = \rho dy$

KE of element $= \frac{1}{2} \rho dy \times \left(\frac{\dot{x} y}{l}\right)^2$

Total KE $= \int_0^l \frac{1}{2} \rho dy \times \left(\frac{\dot{x} y}{l}\right)^2$

$= \int_0^l \frac{1}{2} \rho dy \frac{\dot{x}^2 y^2}{l^2}$

$= \frac{1}{2} \rho \frac{\dot{x}^2}{l^2} \int_0^l y^2 \cdot dy$

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$$= \frac{1}{2} \frac{\rho \dot{x}^2}{l^2} \left[\frac{y^3}{3}\right]_0^l dy.$$

$$= \frac{1}{6} \frac{\rho \dot{x}^2}{l^2} \times l^3$$

$$= \frac{1}{6} \rho \dot{x}^2 \times l.$$

Velocity of spring $= \frac{1}{6} m_s \dot{x}^2$

KE of mass $= \frac{1}{2} m \dot{x}^2$

K.E of spring $= \frac{1}{2} k x^2.$

Total Energy $\Rightarrow \frac{1}{6} m_s \dot{x}^2 + \frac{1}{2} m \dot{x}^2 + \frac{1}{2} k x^2 = \text{Constant}.$

Differentiating

$$\Rightarrow \frac{1}{6} m_s \times 2 \dot{x} \ddot{x} + \frac{1}{2} m \, 2 \dot{x} \ddot{x} + \frac{1}{2} k \, 2 x \dot{x} = 0$$

$$\Rightarrow \frac{1}{3} m_s \ddot{x} + m \ddot{x} + k x = 0.$$

$$\ddot{x} \left(\frac{1}{3} m_s + m\right) + k x = 0.$$

$$\ddot{x} + \frac{k}{\left(\frac{1}{3} m_s + m\right)} x = 0.$$

$$\ddot{x} + \omega_n^2 x = 0.$$

$$\boxed{\omega_n = \sqrt{\frac{k}{\left(\frac{m_s}{3} + m\right)}}} \qquad \boxed{f_n = \frac{1}{2\pi} \sqrt{\frac{k}{\left(\frac{m_s}{3} + m\right)}}}$$

DAMPED FREE VIBRATION.

4). 4) A spring mass damper system has $m = 3kg$ $k = 100\ N/m$ $C = 3\ N\text{-}s/m$. Determine.
(i) Damping factor
(ii) Natural frequency of damped vibration
(iii) Logarithmic decrement.
(iv) The ratio of two successive amplitudes.
(v) Number of cycles after which the original amplitude is 2...

$m = 3kg$
$k = 100\ N/m$
$C = 3\ N\text{-}s/m$

(i) Damping factor $= \frac{C}{C_c}$

Circular frequency of undamped vibration $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{100}{3}}$

$= 5.7735\ rad/s$

critical damping coefficient :- $2m\omega = 2 \times 3 \times 5.7735 = 34.641\ N\text{-}s/m$

ξ = Damping factor $= \frac{C}{C_c} = \frac{3}{34.641} = 0.0866$

(ii) Frequency of Damped vibration $= \omega_d = \sqrt{1-\xi^2}\ \omega_n$

$= \sqrt{1-0.0866^2} \times 5.7735 = 5.75$

Frequency $= F_d = \frac{1}{2\pi}\ \omega_d = \frac{1}{2\pi} \times 5.75 = 0.9154\ Hz$

(iii) Logarithmic decrement :- $\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}} = \frac{2 \times \pi \times 0.0866}{\sqrt{1-0.0866^2}} = 0.54$

(iv) The ratio of two successive amplitudes:

Logarithmic decrement $= \ln \frac{x_n}{x_{n+1}}$

The ratio of two successive amplitude :- $= \frac{x_n}{x_{n+1}} = e^{\delta} = e^{0.5462} = 1.7266$

(v) Number of cycles after which the original amplitude is below 20%

$$\text{Logarithmic decrement} = \delta = \frac{1}{n}\ln\left(\frac{x_0}{x_n}\right)$$

$$= 0.5462 = \frac{1}{n}\ln\left(\frac{x_0}{2x_0}\right)$$

$$n = 2.94 \simeq 3$$

Number of cycles after which the orginial amplitude is below 20% is 3.

FORCED VIBRATION:-

). A mass of 100 kg has been mounted on the spring support having a spring stiffness of 19600 N/m and a damping coefficient of 100 N-s/m. The mass is acted upon by a harmonic force of 39 N at the undamped natural frequency of the set up. determine :-

(i) Amplitude of vibration of the mass

(ii) Phase difference between the force and displacement

(iii) Force transmissibility ratio :

$m = 100\ kg$, $k = 19600\ N/m$, $C = 100\ N\text{-}s/m$, $F_0 = 39\ N$

undamped natural frequency $\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{19600}{100}} = 14\ rad/s$

$$c_c = 2m\omega_n = 2\times100\times14 = 2800\ N\text{-}s/m$$

$$\xi = \frac{c}{c_c} = \frac{100}{2800} = 0.035$$

(i) At undamped natural frequency $\omega = \omega_n$

$$X_{max} = \frac{F_0/k}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

$$X_{max} = \frac{39/19600}{\sqrt{\cancel{\left(1-\left(\frac{14}{14}\right)^2\right)^2}^{\,0} + \left(2\times 0.035\times\frac{14}{14}\right)^2}}$$

$$X_{max} = 0.0278\ m$$

(ii) Phase difference $= \omega = \omega_n \Rightarrow \tan\phi = \frac{2\xi\,\omega/\omega_n}{1-\left(\frac{\omega}{\omega_n}\right)^2}$ $(\omega=\omega_n)$.

$$\tan\phi = \frac{2\times 0.035\times 14/14}{\cancel{1-\left(\frac{14}{14}\right)^2}^{\,0}}$$

$$\tan\phi = \infty \Rightarrow \phi = \tan^{-1}(\infty)$$

$$\phi = \pi/2$$

(iii) Force transmissibility ratio :- $(\omega=\omega_n)$

$$TR = \frac{\sqrt{1+\left(2\xi\,\omega/\omega_n\right)^2}}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

$$TR = \frac{\sqrt{1+\left(2\times 0.035 \times \frac{14}{14}\right)^2}}{\sqrt{\left(1-\left(\frac{14}{14}\right)^2\right)^2+\left(2\times 0.035\times \frac{14}{14}\right)^2}}$$

$$TR = 14.04$$

Transmissibility ratio = 14.04

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