NAME# M. Saqib

I.D# 11381

TECH# B.Tec. Civil

Instructor:- Sir Ihsan ul Mulk

paper:- Earth Quake Engineering

Page #1

Answer #1

Vibration:

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The word comes from latin vibrationem (shaking, brandishing) The oscillations may be periodic, such as the motion of pendulum or random, such as the movement of a tire on a gravel road.

→ vibration can be desirable for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica a mobile phone, or the cone of a loudspeaker.

→ In many cases, however, vibration is undesirable wasting energy and creating unwanted sound for example. Such vibration the vibrational motions of engines electric motors or any mechanical in operation are typically unwanted such vibrations could be caused by imbalances in the rotating parts uneven friction or the meshing of gear teeth careful designs usually minimize unwanted vibrations.

RANDOM vibration:

Random vibration is motion which is non-deterministic meaning the future behavior cannot be precisely precisely predicted. The randomness is a characteristic of the excitation or input not the mode shapes or natural frequencies. Some common examples include an automobile riding on a rough road. wave height on the water or the load induced on an airplane wing during flight. Structural response to random vibration is usually treated using statistical or probabilistic approaches mathematically, random vibration is characterized as an ergodic and stationary process.

Free vibration:

Free vibration occurs when a mechanical system is set in motion with an initial input and allowed to vibrate freely. examples of this types of vibration are pulling a child back on a swing and letting it go, or hitting a tuning fork and letting it go ~~or~~ hitting a tuning ring. The mechanical system vibrates at one or more of its natural frequencies and damps down to motionlessness.

Forced vibration:

Forced vibration is when a time-varying disturbance (load, displacement or velocity) is applied to a mechanical system. The disturbance can be a periodic and steady-state input a transient input or a random input. The periodic input can be a harmonic or a non-harmonic disturbance. Examples of these types of vibration include a washing machine shaking due to an imbalance transportation vibration

caused by an engine or uneven road, or the vibration of a building during an earthquake.
For linear system the frequency of the steady state vibration response resulting from the application of a periodic harmonic input is equal to the frequency of the applied force or motion with the response magnitude being dependent on the actual mechanical system.

Harmonic Force:

A harmonic force is one whose variation with time which is defined by any one of the following equation

$$P(t) = P_o \sin(\omega t) \; P_o \cos(\omega t)$$

where

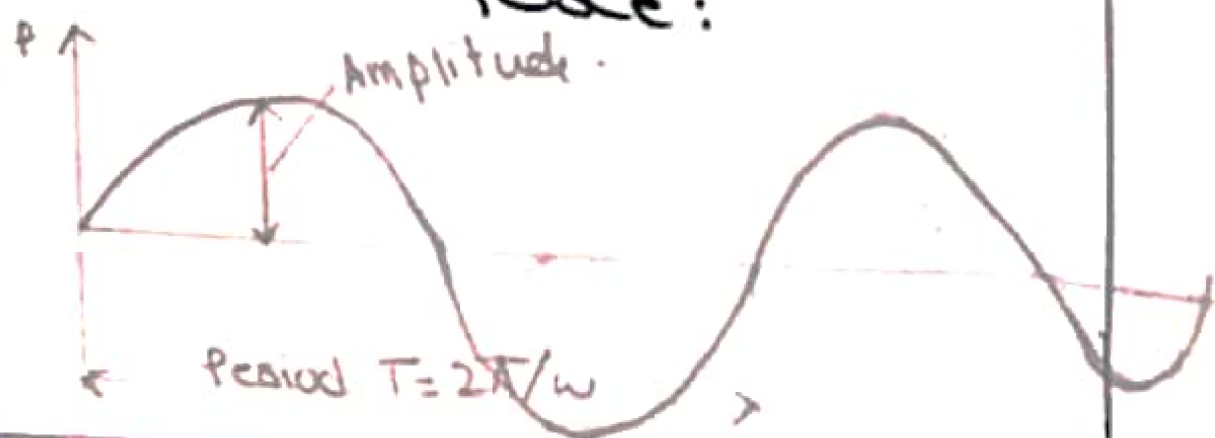
P_o is the amplitude or maximum value of force

ω is its frequency also called as exciting frequency or forcing frequency

$T = 2\pi/\omega$ is exciting period or forcing period

The equation used in this module are strictly applicable to $P_o \sin(\omega t)$

Harmonic force:



~~Determi~~ HARMONIC FORCE:

A common source of such a sinsoidal force is unbalance in a rotating machines (such as turbines, electric motor and electric generators as well as fans, or rotating shafts).

→ Unbalance cloth in a rotating drum of a washing machine is also an harmonic force.

→ when the wheels of a car are not balanced harmonic forces are developed in the rotating wheels if the rotational speed of the wheel is close to the natural frequency of the car's suspension system in vertical direction amplitude of vertical displacement in the car's suspension system increases and violent shaking occur in car due to match of frequency of the force (due to vertical component of harmonic force

Acting at unbalanced mass center with natural frequency of car's suspension system in vertical direction w_n.

PARTICULAR SOLUTION of UNDamped Harmonic vibrations:

It can be derived that the Particular solution of undamped vibration is as follows.

$$\rightarrow U_P(t) = \frac{P_0}{K}\left[\frac{1}{1-r_w^2}\right]\sin(\omega t) \quad \text{where } \omega \neq \omega_0$$

ω/ω_0 is termed as frequency ratio

For the sack of simplicity we will use r_w in our lectures to represent ω/ω_n

$$U_P(t) = \frac{P_0}{K}\,\frac{1}{1-\left[\omega/\omega_n\right]^2}\sin(\omega t)$$

$U_P(t)$ is the displacement where $\omega \neq \omega_n$ corresponding to the particular solution (i-e due to forced vibration).

Response of undamed systems subjected to harmonic forces:

The equation of motion for harmonic vibration of undamped system is

$$m\ddot{u} + ku = P_o \sin(\omega t)$$

The solution to the equation is made up of two parts. The first part is the solution which correspond to forced vibration and is known as ~~the~~ particular solution ~~The~~ ~~corr~~ steady state vibration for its present because of the applied force no matter what the initial conditions. The second part is the solution to the free vibration which does not require any forcing function this part is known as the complimentry solution the corresponding vibration is known as transient vibration which depends on the initial conditions.

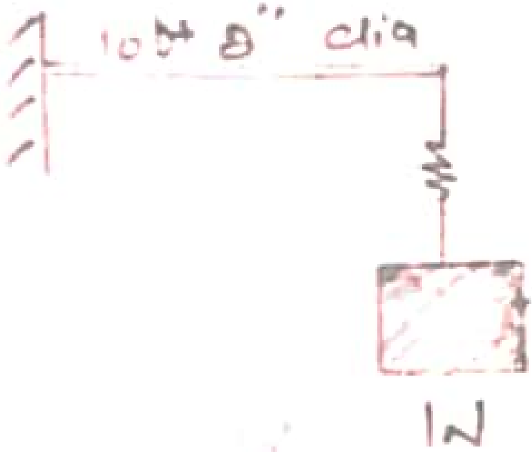
page # 09

Q5 ① Determine the stiffness of Cantilever beam by assuming that the self weight of beam is negligible.

★ Given Data:-

Take $E = 29{,}000$ ksi.

$k_{spring} = 200\ lb/ft$



Solution:-

$k_1 = 200\ lb/ft$

$$k_2 = \frac{3EI}{l^3} = \frac{3 \times (29000\ k/in^2) \times \left(\frac{\pi}{64} \times (2\right.}{(10 \times 12\ in)^3}$$

$0.0396\ k/in^2 = 474.7\ lb/ft$

$$K_{eq} = \frac{K_1 K_2}{K_1 + K_2} = \frac{200 \times 474.7}{200 + 474.7}$$

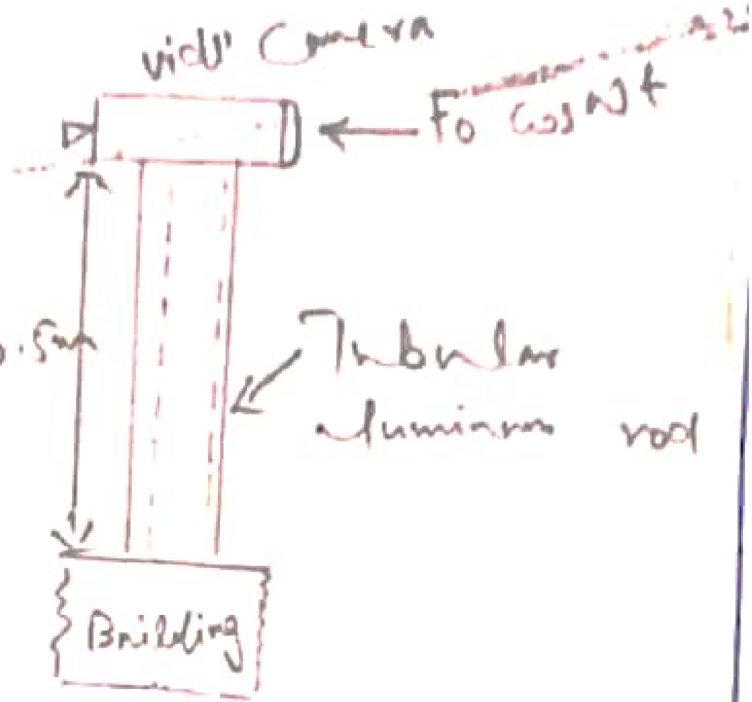
$$K_{eq} = 140.7 \ lb/ft$$

Q(4) A vedio Camera of mass 2.0kg is mounted on the Top of a Dam building for Survivalence. The vedio Camera is fixed at one end of the tubular alluminium rod whose other end is fixed to the building as shown in fig.

The wind induced force acting on the vedio Camra is found to be harmonic with $P(t) = 85 \sin 75t$ N!

① Determing The Cross-sectional dimensional of the alluminum tub of the maximum amplitude of vibration of the vedio camera is to be a limited to 0.005m.

$E_{Aluminium} = 71$ GPa.



Given Data :-

Mass, $m = 2\,kg$

Harmonic force, $p(t) = 25 \sin 75t$ N

Amplitude, $P_0 = 25$ N

Force frequency, $\omega = 75$ rad/sec

$U_0 = 0.005$ in

Modulus of Elasticity,

$E_{Al} = 71$ GPa $= 71 \times 10^9$ Pa

length, $L = 0.5$ m

Required :- Diameter $d = ?$

E Aluminium $= 71$ GPa.

Solution :-

For undamped structure

$$R_d = \frac{u_0}{(u_{st})_0} = \frac{1}{(1-r_w^2)} \quad \text{---} (1)$$

$$(u_{st})_0 = \frac{P_0}{k} \Rightarrow (u_{st}) = \frac{25}{k}$$

$$w_n = \sqrt{\frac{k}{m}} \Rightarrow w_n = \sqrt{\frac{k}{2}} \rightarrow \text{Natural frequency}$$

Frequency Ratio, $r_w = \frac{w}{w_n} = \frac{75}{\sqrt{\frac{k}{M}}}$

$= 75 \times \sqrt{2}$

Put ~~rw~~ the value of $(u_{st})_0$ and "r_w") in eq (1)

$$\frac{0.005}{\frac{25}{k}} = \frac{1}{\left(1-\left(\frac{75\times\sqrt{2}}{\sqrt{k}}\right)^2\right)}$$

$$0.005 \times \left(1-\left(\frac{11250}{k}\right)\right) = \frac{25}{k}$$

$$0.005 = \frac{56.25}{k} + \frac{25}{k}$$

$$0.005 = \frac{81.25}{k}$$

$$K = \frac{81.25}{0.005}$$

$$K = 16250 \ N/m$$

Now, $K = \dfrac{3EI}{L^3}$ $\rightarrow$ 

$$I = 9.54 \times 10^{-9} \ m^4$$

so $I = \dfrac{\pi}{64} \times d^4$

$$d = \left(\frac{I \times 64}{\pi}\right)^{\frac{1}{4}}$$

$$d = \left(\frac{(9.54 \times 10^{-9}) \times (64)}{3.14}\right)$$

$$d = 0.021 \ m$$

$$d = 0.021 \times 1000$$

$$\boxed{d = 21 \ mm}$$

D2 Sm

Solution :-

$$k_{eq} = k_1 + k_2$$

$$K = \frac{12EI}{h_1^3} + \frac{12EI}{h_2^3}$$

$$= 12EI\left[\frac{1}{h_1^3} + \frac{1}{h_2^3}\right]$$

$$= 12 \times (27000\,k/in^2) \times (1200\,in^4)\left[\frac{1}{(15 \times 12\,in)^3} + \frac{1}{(10 \times 12\,in)^3}\right]$$

$$K = 388800000\,[7.498($$

$$k = 291.545\,k/\cancel{ft}\,in$$

$$k = 3498.48\,k/ft$$