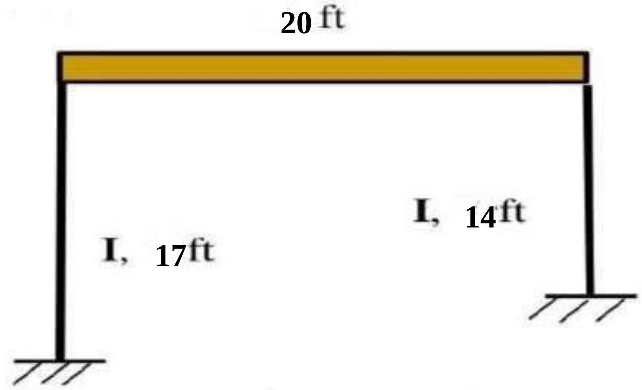
Q.NO.(01) (6)

(a) Determine the lateral stiffness of the frame if a lateral load is applied at the beam level. Assume

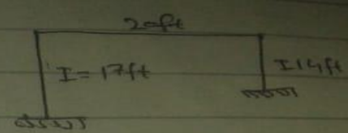
1. The flexural stiffness of beam is too high as compared to that of connected columns.
2. Axial deformations in beam is negligible.



Question #01

(a)

Given data



Take

$E = 28,000$ ksi

$I = 1400 \, in^4$

Required data

lateral stiffness $K = ?$

Solution:

$h_1 = 17 \times 12$ in

$h_2 = 14 \times 12$ in

Now $K_{eq} = K_1 + K_2$

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

$$\Rightarrow 12 \times EI \left(\frac{1}{h_1^3} + \frac{1}{h_2^3}\right)$$

$$\Rightarrow 12 \times (28000 \, K/in^2) \times (1400 \, in^4) \times \left[\frac{1}{(17 \times 12 \, in)^3} + \frac{1}{(14 \times 12 \, in)^3}\right]$$

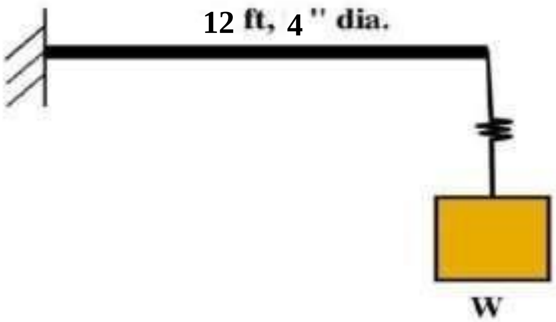
$$= 470400000 \times \left[\frac{1}{8489664} + \frac{1}{4741632}\right]$$

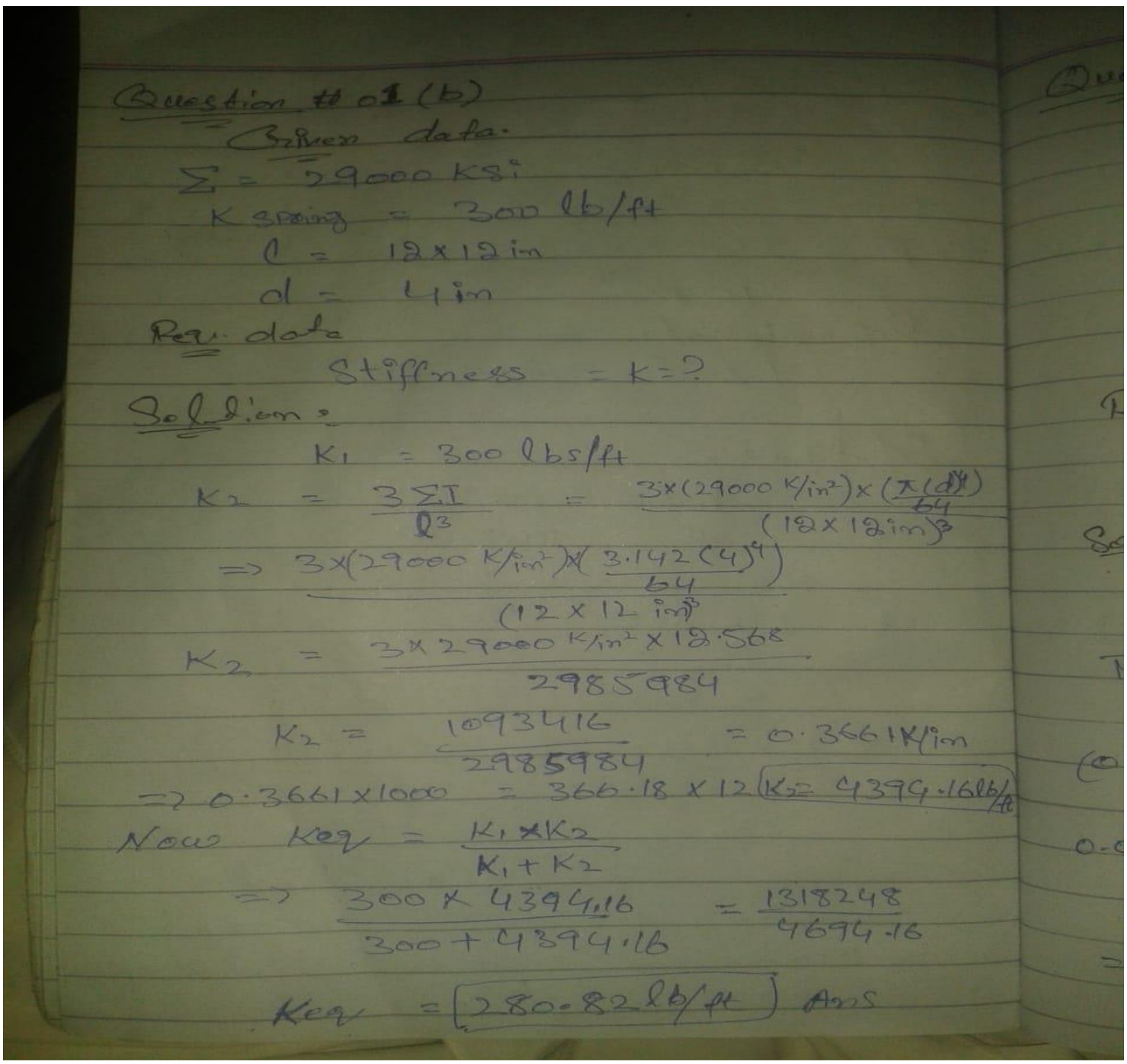
$$= 470400000 \times (1.1779 \times 10^{-7} + 2.1089 \times 10^{-7})$$

$$= 470400000 \times 3.2868 \times 10^{-7} = 154.61 \, K/in$$

$\boxed{1855.33 \, K/ft}$ Ans

(b) Determine the stiffness of cantilever beam by assuming that the self weight of the beam is negligible. Take E = 29,000 ksi and K_{spring} = 300 lb/ft





Question # 01 (b)

Given data.

$\Sigma = 29000$ ksi

$K_{spring} = 300$ lb/ft

$l = 12 \times 12$ in

$d = 4$ in

Req. data

Stiffness = $k = ?$

Solution:

$K_1 = 300$ lbs/ft

$$K_2 = \frac{3\Sigma I}{l^3} = \frac{3 \times (29000\ K/in^2) \times \left(\frac{\pi (d)^4}{64}\right)}{(12 \times 12\ in)^3}$$

$$\Rightarrow \frac{3 \times (29000\ K/in^2) \times \left(\frac{3.142 (4)^4}{64}\right)}{(12 \times 12\ in)^3}$$

$$K_2 = \frac{3 \times 29000\ K/in^2 \times 12.568}{2985984}$$

$$K_2 = \frac{1093416}{2985984} = 0.3661\ K/in$$

$\Rightarrow 0.3661 \times 1000 = 366.18 \times 12$ $\boxed{K_2 = 4394.16\ lb/ft}$

Now $K_{eq} = \dfrac{K_1 \times K_2}{K_1 + K_2}$

$$\Rightarrow \frac{300 \times 4394.16}{300 + 4394.16} = \frac{1318248}{4694.16}$$

$K_{eq} = \boxed{280.82\ lb/ft}$ Ans

Q.NO.(02)

A rotating machine with a 500 kg mass operating at a constant speed produces harmonic force in vertical direction. The harmonic force is expressed as p(t)= 5000 Sin 150t, where p(t) is in N. If the damping ratio of isolators at the foundation of machine is 7.0%, determine the stiffness of isolators so that the Transmissibility at the operating speed does not exceed 0.15. Also determine the amplitude of force transmitted to the foundation

Question # 02

Given data

Mass $= m = 500$ kg

Harmonic force $= P(t) = 5000 \times \sin \times 150 \times t$ N

Amplitude, $P_o = 5000$ N

Force Frequency, $\omega = 150$ rad/sec

Damping ratio $\xi = 7.0\% = 0.07$

Transmissibility, $TR = 0.15$

Required data

Force transmitted Amplitude $(f_T)_o = ?$

Stiffness, $K = ?$

Solution:

$$TR = \frac{(f_T)_o}{P_o} = \sqrt{\frac{1+(2\xi r\omega)^2}{(1-r\omega^2)^2+(2\times\xi r\omega)^2}} \quad (1)$$

$$TR = \sqrt{\frac{1+(2\xi r\omega)^2}{(1-r\omega^2)^2+(2\times\xi\times r\omega)^2}}$$

$$(0.15)^2 = \left(\sqrt{\frac{1+(2\times 0.07\times r\omega)^2}{(1-r\omega^2)^2+(2\times 0.07\times r\omega)^2}}\right)^2$$

$$0.0225 = \frac{1+(0.14\times r\omega)^3}{(1-r\omega^2)^2+(0.14\times r\omega)^2}$$

$$= 0.0225 = \frac{1+(0.0196\times r\omega^2)}{(1-r\omega^2)^2+(0.0196\times r\omega^2)}$$

Put $r\omega^2 = x$

$$0.0225 = \frac{1 + 0.0196x}{(1-x)^2 + (0.0196x)}$$

$$0.0225 = \frac{1 + 0.0196x}{1 + x^2 - 2x + 0.0196x}$$

$$0.0225 = \frac{1 + 0.0196x}{x^2 - 1.9804x + 1}$$

By cross multiplication

$$x^2 - 1.9804x + 1 = \frac{1 + 0.0196x}{0.0225}$$

$$x^2 - 1.9804x + 1 = \frac{1}{0.0225} + \frac{0.0196x}{0.0225}$$

$$x^2 - 1.9804x + 1 = 44.44 + 0.8711x$$

Simply the equation.

$$x^2 - 1.9804x - 0.8711x + 1 - 44.44 = 0$$

$$x^2 - 2.8515x - 43.44$$

By quadratic formula

we again value of x

$$x = 8.169$$

$$\Rightarrow r\omega^2 = 8.169 \Rightarrow \sqrt{r\omega^2} = \sqrt{8.169}$$

$$\Rightarrow r\omega = 2.8581$$

$$\Rightarrow r\omega = \frac{\omega}{\omega_n} \Rightarrow 2.8581 = \frac{150}{\sqrt{\frac{K}{m}}}$$

$$\sqrt{\frac{K}{m}} = \frac{150}{2.8581} \Rightarrow \left(\sqrt{\frac{K}{m}}\right)^2 = (52.48)^2$$

$$\frac{K}{500} = 2754.40$$

$$K = 2754.40 \times 500$$

$$K = 1377202.12 \text{ N/m}$$

Put all value in eq ①

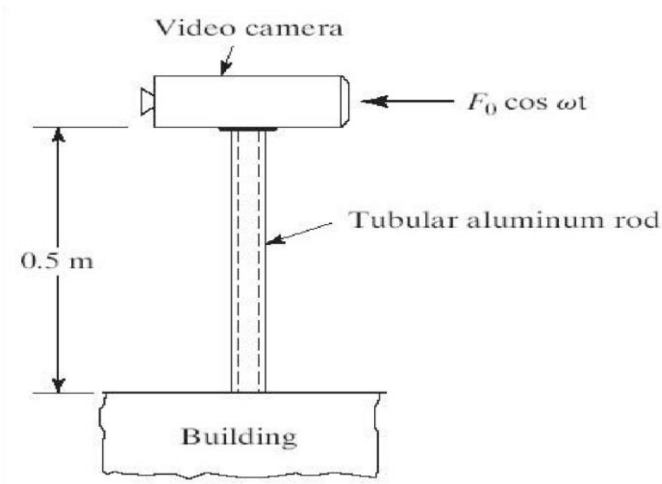
$$TR = \frac{(ft)_o}{P_o} = 0.15 = \frac{(ft)_o}{P_o}$$

$$(fT)_o = 0.15 \times 5000$$

$$\boxed{(fT)_o = 750}$$

Q.NO.(03) (12)

A video camera, of mass 3.0 kg, is mounted on the top of a bank building for surveillance. The video camera is fixed at one end of a tubular aluminium rod whose other end is fixed to the building as shown in Fig. The wind-induced force acting on the video camera, is found to be harmonic with p(t) = 25 sin 75t N. Determine the cross-sectional dimensions of the aluminium tube if the maximum amplitude of vibration of the video camera is to be limited to 0.005 m. E Aluminium =70GPa.



Question #03

Given data:

Mass = m = 3.0 kg

Harmonic force = $P(t)$ = 25 sin 75t N

Amplitude P_0 = 25N N

Force frequency = ω = 75 rad/sec

U_0 = 0.005 m

E_{Al} = 70 GPa = 70×10^9 Pa

Length = L = 0.5 m

Req data

Diameter = d

Solution

For undamped structure

$$R_d = \frac{U_o}{(U_{st})_o} = \frac{1}{(1-r_\omega)} \quad \text{—} \quad (1)$$

$$(U_{st})_o = \frac{P_o}{K} \Rightarrow (U_{st})_o = 25/K$$

$$\omega_n = \sqrt{\frac{K}{m}} \Rightarrow \omega_n = \sqrt{\frac{K}{3}} \rightarrow \text{natural frequency}$$

Frequency ratio $= r_\omega = \frac{\omega}{\omega_n} = \frac{75}{\sqrt{K/m}}$

$$\Rightarrow \frac{75 \times \sqrt{3}}{\sqrt{K}}$$

Put the value of $(U_{st})_o$ and r_ω in eq (1)

$$\frac{0.005}{\frac{25}{K}} = \frac{1}{\left(1-\left(\frac{75\sqrt{3}}{\sqrt{K}}\right)^2\right)}$$

$$\Rightarrow 0.005 \times \left(1 - \left(\frac{16875}{K}\right)\right) = \frac{25}{K}$$

$$= \cancel{0.005 \times 84.375}$$

$$0.005 \times \frac{84.375}{K} = \frac{25}{K}$$

$$= 0.005 = \frac{84.375}{K} + \frac{25}{K}$$

$$0.005 = \frac{109.375}{K}$$

$$K = \frac{109.375}{0.005}$$

$$K = 21875 \ N/m$$

Now $K = \frac{3EI}{l^3}$ → 

$$I = \frac{K \times l^3}{3E} = \frac{21875 \times (0.5)^3}{3 \times (70 \times 10^9)}$$

$$I = \frac{2734.375}{2.1 \times 10^{11}}$$

$$I = 1.302 \times 10^{-8} \, m^4$$

So

$$I = \frac{\pi}{64} d^4$$

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

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

$$d = \left(\frac{(1.302 \times 10^{-8}) \times (64)}{3.142}\right)^{1/4}$$

$$d = (2.6539 \times 10^{-7})^{1/4}$$

$$d = 0.0226 \, m$$

$$0.0226 \times 1000 = \boxed{22.69 \, m}$$

$\boxed{d = 22.69 m}$ Ans

Q.NO.(04) (8)

What is meant by Plate boundaries and explain different types of Plate boundaries along with diagrams.

Plate boundaries

• A plate boundary is the region where plates meet. The plates may either collide, move away from each other, or slip/slide past each other. Three types of Plate Boundaries:

1. Divergent Plate Boundary (or rift zone)
2. Convergent Plate Boundary (destructive plate boundary)
3. Transform Plate Boundary (or strike slip fault boundary)

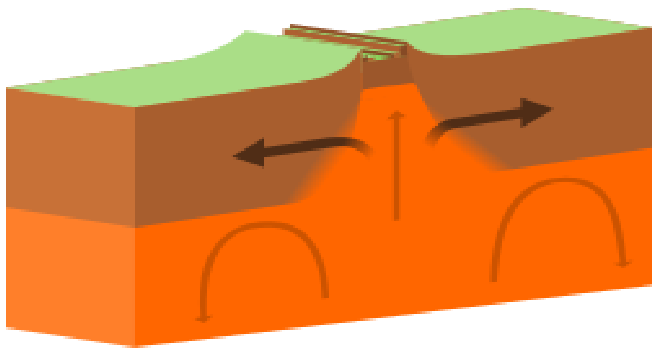
Types of plate boundaries

Three types of plate boundaries exist, characterized by the way the plates move relative to each other. They are associated with different types of surface phenomena.

The different types of plate boundaries are:

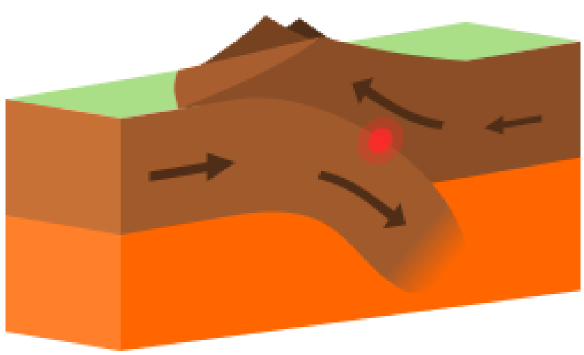
1. *Divergent boundaries* *(Constructive)* occur where two plates slide apart from each other. At zones of ocean-to-ocean rifting, divergent boundaries form by seafloor spreading, allowing for the formation of new ocean basin. As the ocean plate splits, the ridge forms at the spreading center, the ocean basin expands, and finally, the plate area increases causing many small

volcanoes and/or shallow earthquakes. At zones of continent-to-continent rifting, divergent boundaries may cause new ocean basin to form as the continent splits, spreads, the central rift collapses, and ocean fills the basin. Active zones of mid-ocean ridges (e.g., the Mid-Atlantic Ridge and East Pacific Rise), and continent-to-continent rifting (such as Africa's East African Rift and Valley and the Red Sea), are examples of divergent boundaries.



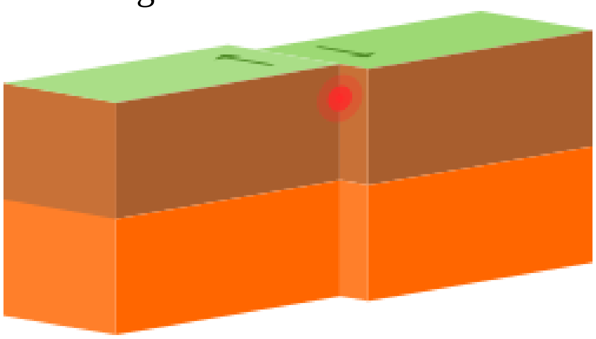
Divergent boundary

2. <u>*Convergent boundaries*</u> *(Destructive)* (or *active margins*) occur where two plates slide toward each other to form either a subduction zone (one plate moving underneath the other) or a continental collision. At zones of ocean-to-continent subduction (e.g. the Andes mountain range in South America, and the Cascade Mountains in Western United States), the dense oceanic lithosphere plunges beneath the less dense continent. Earthquakes trace the path of the downward-moving plate as it descends into asthenosphere, a trench forms, and as the subducted plate is heated it releases volatiles, mostly water from hydrous minerals, into the surrounding mantle. The addition of water lowers the melting point of the mantle material above the subducting slab, causing it to melt. The magma that results typically leads to volcanism. At zones of ocean-to-ocean subduction (e.g. Aleutian islands,



Convergent boundary

3. *<u>Transform boundaries</u> (Conservative)* occur where two lithospheric plates slide, or perhaps more accurately, grind past each other along transform faults, where plates are neither created nor destroyed. The relative motion of the two plates is either sinistral (left side toward the observer) or dextral (right side toward the observer). Transform faults occur across a spreading center. Strong earthquakes can occur along a fault. The San Andreas Fault in California is an example of a transform boundary exhibiting dextral motion.



Transform boundary

Q.NO. (05) (6)

What is meant by degree of freedom and differentiate between continuous and discrete systems.

DEGREE OF FREEDOM

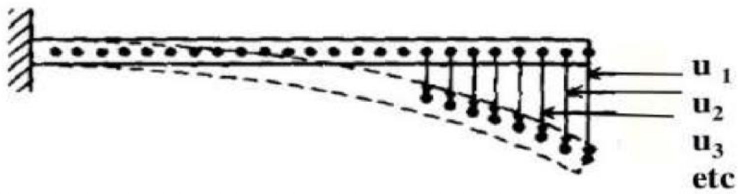
Degrees of freedom (DOF) of a system is defined as the number of independent variables required to completely determine the positions of all parts of a system at any instant of time.

It is defined as minimum number of parameters used to define a system.

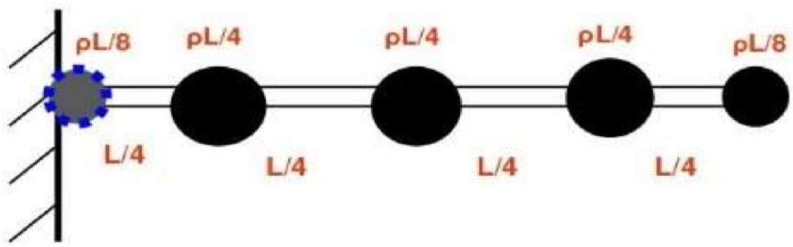
CONTINOUS VS DISCRETE SYSTEMS

Some systems, especially those involving continuous elastic members, have an infinite number of DOF. As an example of this is a cantilever beam with self-weight only (see next slide). This beam has infinites mass points and need infinites number of displacements to draw its deflected shape and thus has an infinite DOF. Systems with infinite DOF are called **Continuous or Distributed systems.**

Systems with a finite number of degree of freedom are called **Discrete or Lumped mass parameter systems**.



Continuous or distributed system



Corresponding lumped mass system of the above given cantilever beam with DOF= 4

ρ = Mass per unit length