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Section B

Submitted to Eng- Yaseen

Subject Intro to Structural Dynamics & earthquick engi

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Q#1

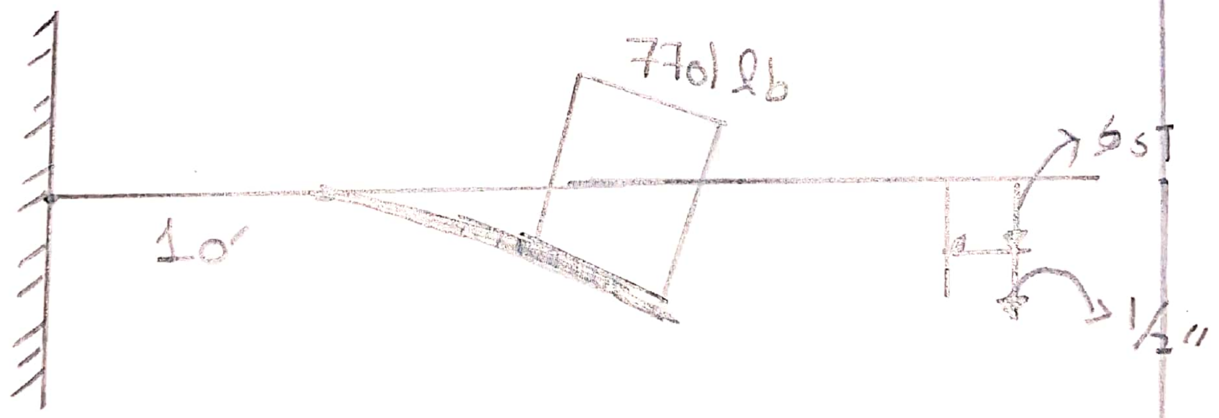
Given Data:

$E = 29,000 ksi$

$I = 150 \ in^4$

$\delta_T =$ deflection due to 7701 lb

Static load beam is pulled ½" down words.



Required Data:

→ Natural time period of system.

→ Develop and solve the equation of motion.

→ Draw graph to show

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the variation of equivalent static force with time.

Solution:-

General equation of motion for SDOF System is,

$$Ku + C\dot{u} + m\ddot{u} = p(t)$$

Since System is undamped (c=0)

Under going for vibration p(t) = 0

Hence general EOM become

$$Ku + m\ddot{u} = 0 \longrightarrow (A)$$

$$K = \frac{3EI}{L^3} = \frac{3 \times 29000\ K/m^2 \times 150}{(10 \times 12\ in)^3}$$

$$\boxed{K = 7.55\ K/m.}$$

→ In order to estimate chances of mistake during calculation, it is more appropriate to use fundamental unit like lb, ft, sec or Kg, in, sec.

K = 7.55 K/in

K = 90.625 lb/ft.

K =

③

$\omega = m/g = \frac{7701}{32.2} = \boxed{239.16 \text{ slugs}}$

$W_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{90625}{239.16}}$

$\boxed{= 19.46 \text{ rad/sec}}$

$T_n = \frac{2\pi}{\omega_n} = \frac{2(3.14)}{19.46}$

$\boxed{= 0.322 \text{ sec}}$

put the value of m and K in equation 1.

$\Rightarrow 90625u + 239.16\ddot{u} = 0.$

where K is in lb/ft and m is lb

$lb\,sec/ft^2 = \text{slugs}.$

general solution to EOM for undamped free vibrations is.

$u_t = u(0)\cos(\omega_n t) + \frac{u'(0)}{\omega_n}\sin(\omega_n t)$

$u_n(0) = 1/2'' = 1/24 \text{ ft}$ and $u''(0) = 0$

$u_t = \frac{1}{24} \times \cos(19.46) + 0$

$= \frac{1}{24} \times \cos(19.46t) +$

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equilent static force at any time "t" is

$$f_s(t) = K \cdot U(t)$$

$$= \frac{90625 \times \cos(19.46t)}{24}$$

$$= 3776 \cos(19.46t)$$

amplitude of dynamics displacement u_0 for undamped free vibration is

$$u_0 = \sqrt{\left[(x(0))^2 + \left(\frac{\dot{x}(0)}{\omega_n}\right)^2\right]}$$

$$= \sqrt{\left[\left(\frac{1}{24}\right)^2 + 0\right]}$$

$$= \sqrt{\left(\frac{1}{24}\right)^2}$$

$$= \frac{1}{24} \text{ ft}$$

Amplitude of equilent static force

F_{s0}

$$Ku_0 = 90625 \times \frac{1}{24}$$

$$Ku_0 = 3776 \text{ lb.}$$

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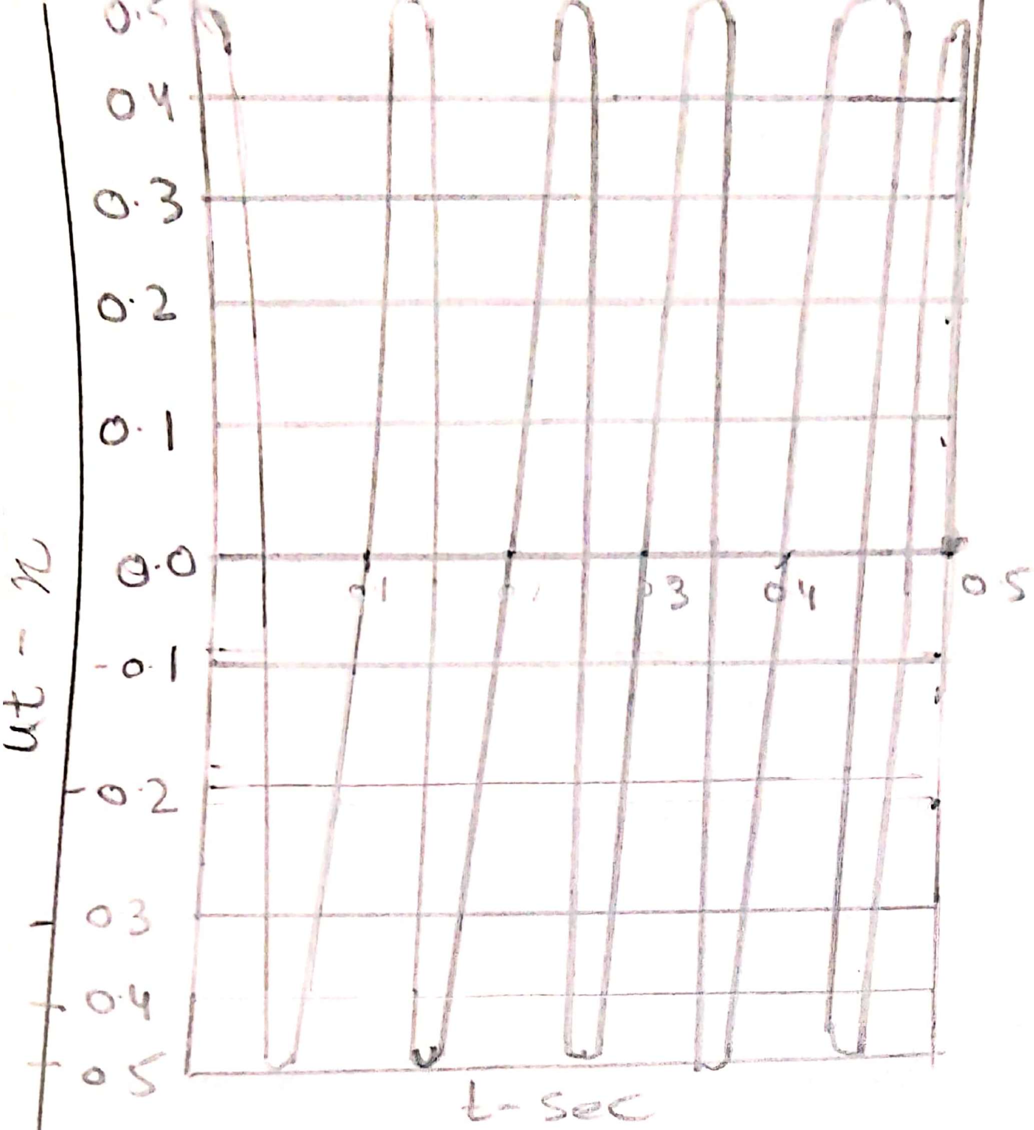

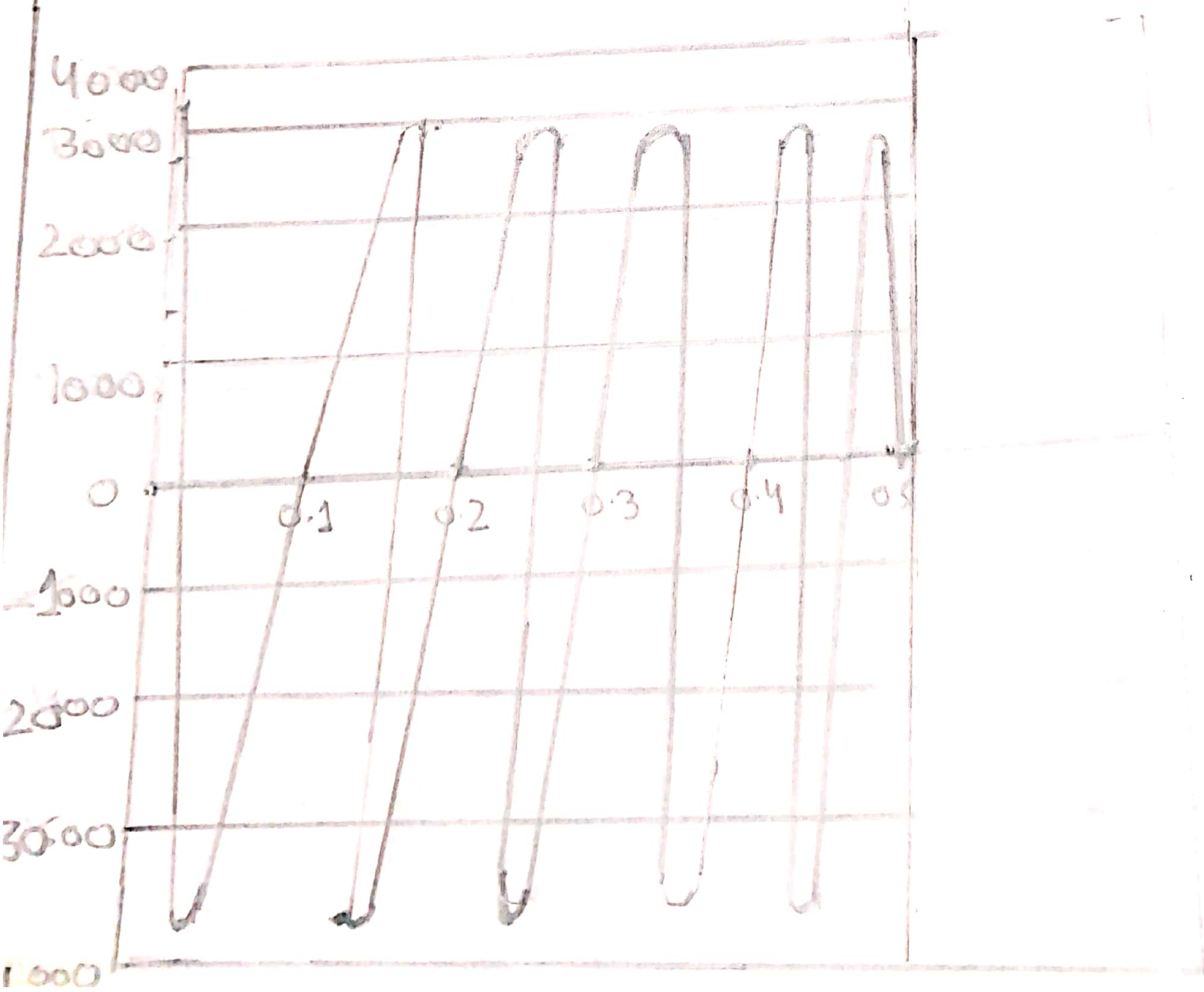

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Q#2

Given Data:.

ξ (damping ratio) of rienforced Concrete with consideration cracking
$= 3 - 5\%$
$= 3\%$

Data of beam from Question#1

Required:.

→ Develop and solve the equation showing variation in equilient static force with time.

→ Draw graph to show the variation of displacement with time and the variation of equilient static force with time.

Solution:.

EOM for dumped free vibration is

$$Ku + Cu + mu'' = 0 \longrightarrow (A)$$

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As from ~~equation~~ question 1

$K = 90625$ lb/ft , $M = 239.16$ lb sec²/ft

$\omega_n = 19.46$ rad/sec

$C = \zeta \times 2 m \omega_n$

$C = 3\% \; 2(239.16)(19.46)$

$= 0.03 \times 2(239.16)(19.46)$

$= 279.24$ lb.sec/ft

put the value in equation (A)

$= 90625 + 239.16 + ~~240~~ 34\ 279.24 = 0$

Solution to the ~~load~~ Eom for damped free vibration is

$u(t) = e^{-\zeta\omega_n t}\left[u(0)\cos(\omega_D t) + \frac{1}{\omega_D}\left[\dot{x}(0) + x(0)\zeta\omega_n\right]\sin(\omega_D t)\right]$

$\omega_D = 19.46$

$u t = e^{-0.583 t}\left[0.041 \times \cos(19.46) + 0.00125 \times \sin(19.46t)\right]$

$F_s(t) = K \cdot u(t) = 90625 \times u(t).$

$F_s(t) = e^{-0.583t}\left[(90625 \times 0.041)\cos(19.46) + 90625 \times 0.00125 \sin 19.46)\right]$

$F_s(t) = e^{-0.583t}(3715.62 \cdot \cos(19.46t) + 113.28$

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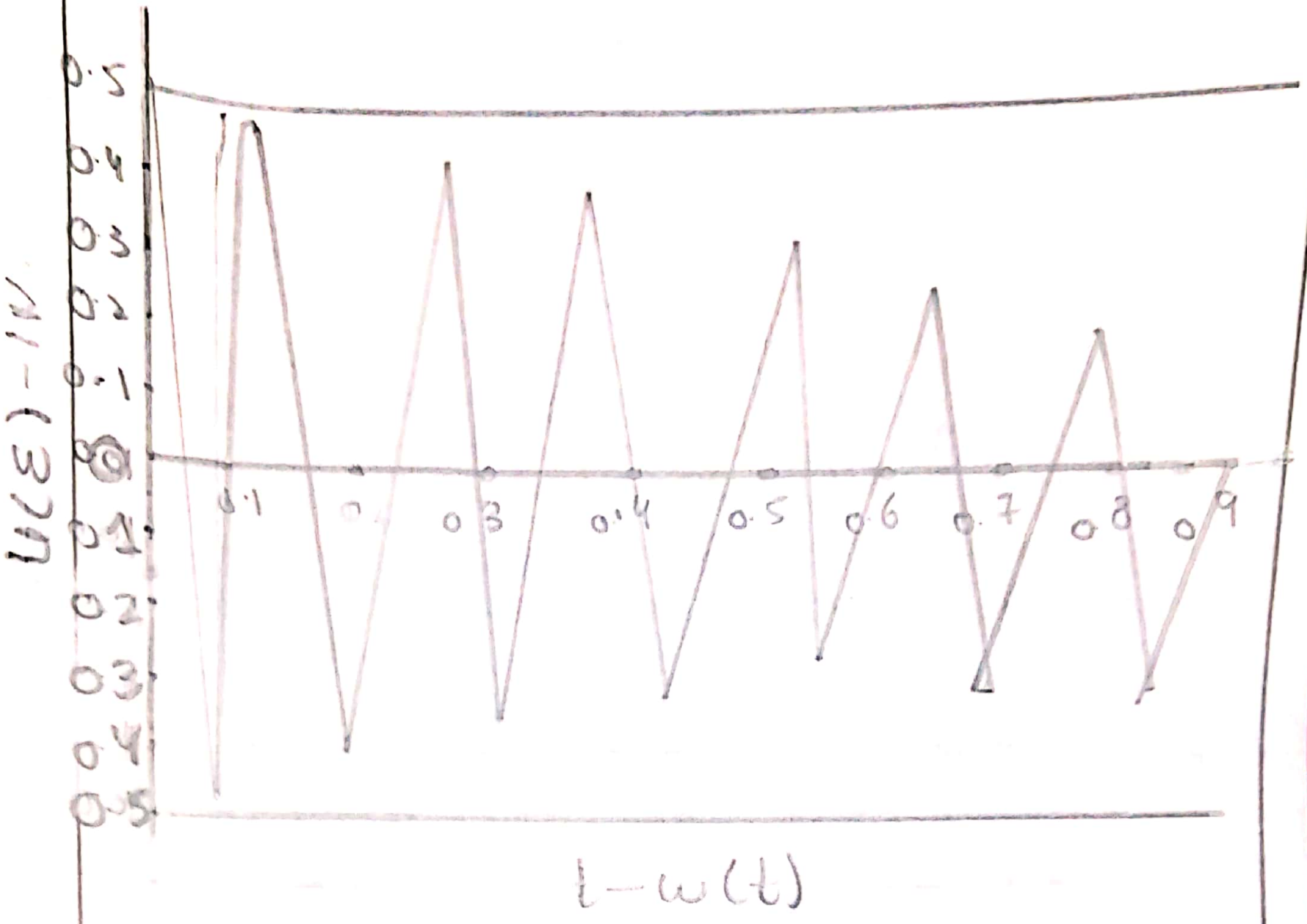

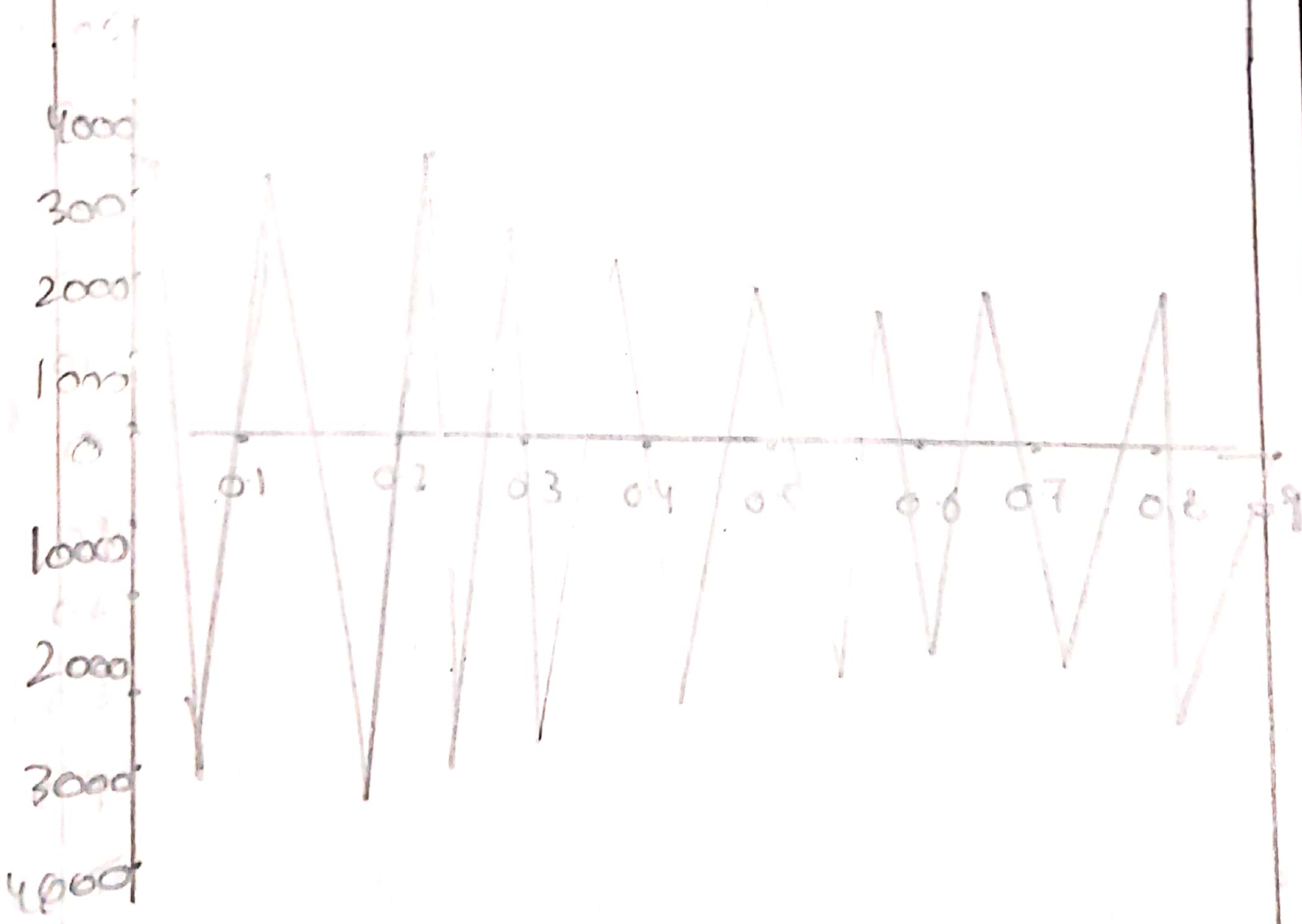

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MacBook Pro

Q No# 3

Given data:

Force = 60 Kips.

Displacement of tank = $\frac{1D}{1000}$ = $\frac{770}{1000}$

= 7.70"

Time taken to complete 7 cycles = 3.57

Amplitude of displacement = 2.286 cm

= 0.9"

Required:

1. Damping Radio.
2. Natural period of undamped vabirad
3. stif ness of structure.
4. weight of tank.
5. damping co-efficient.
6. The displacement amplitude to 0.5"

Numbre of cycle to reduced.

Solution:

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Displacement of tank = 7.70

After, 7 cycle

$J = 7, 4J+1 = u8 = 0.9''$

ⓐ Dumping ratio:

$$J = \frac{1}{2\pi\zeta} \ln\left[\frac{u_1}{u_1 + 1}\right]$$

~~$$7 = \frac{1}{2\pi\zeta} \ln\left[\frac{7.70}{7.70 + 1}\right]$$~~

$$J = \frac{1}{2\pi\zeta} \ln\left[\frac{7.70}{0.9}\right]$$

$\zeta = 0.0488$
$\zeta = 4.88\%$

ⓑ Natural period of un damping vibration. $T_n = ?$

As 7, cycle of vibration are completed in 3.57 sec

→ Time Required to complete one cycle,

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$T_D = \frac{3.57}{7} = 0.51$ sec

$T_D = 0.51$ sec.

Now,

$\omega_D = \omega_n \sqrt{(1 - \zeta^2)}$

$\frac{2\pi}{\omega_D} = \frac{2\pi}{(\omega_n(\sqrt{1-\zeta^2})}$

$T_D = \frac{T_n}{(1-\zeta)^2}$

$T_n = T_D \times \sqrt{1-\zeta^2}$

$T_n = 0.51 \times \sqrt{1 - (0.0488)^2}$

$T_n = 0.50944 \doteq 0.51$ sec

$T_n = 0.51$ sec

(c) Stiffness of structure, K=?

$K = \frac{60 \times \cos 60^\circ}{7.70} = 3.896$ K/in

$K = 3.9$ K/in

$K = 46920$ lb/ft

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(d) weight of tank, w = ?

$$\omega_n = \sqrt{K/M} = \frac{K}{w/g}$$

$$\sqrt{\frac{K \cdot g}{w}}$$

$$\omega_n = \sqrt{\frac{K \times g}{w}}$$ taking square.

$$\omega_n^2 = \frac{K \times g}{w}$$

$$w = \frac{K \times g}{\omega_n^2}$$

also

$$\omega_n = \frac{2\pi}{T_n}$$

$$w = \frac{K \times g}{\left(\frac{4\pi^2}{T_n^2}\right)}$$

$$= K \times g \frac{T_n^2}{4\pi^2}$$

$$= \left[\frac{46920}{ft} \times \frac{32.2\ ft}{sec^2}\right] \times \left[\frac{(0.5 sec)^2}{4\pi^2}\right]$$

$$= 9953.93$$ $$\boxed{= 9.95K}$$

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(e) Dumping co-effient, c=?

$\tau = \frac{c}{2 m \omega_n}$

$c = \tau \times 2 m \omega_n$.

$= \tau \times 2m \times \left(\frac{2\pi}{T_n}\right)$

$= \frac{0.0488 \times 4 \times \pi \times \frac{9953.9}{32.2}}{0.51}$

$= 371.71$ lb·sec/ft

F Numbre of cycle to reduce the displacement amplitude to 0.5", J=?

$J = \frac{1}{2\pi\tau} \ln\left(\frac{u_1}{u_{J+1}}\right)$

$J = \frac{1}{2\pi \times 0.0488} \ln\left|\frac{7.70}{0.5}\right|$

$J = 8.91$

$\simeq 9$ cycles.

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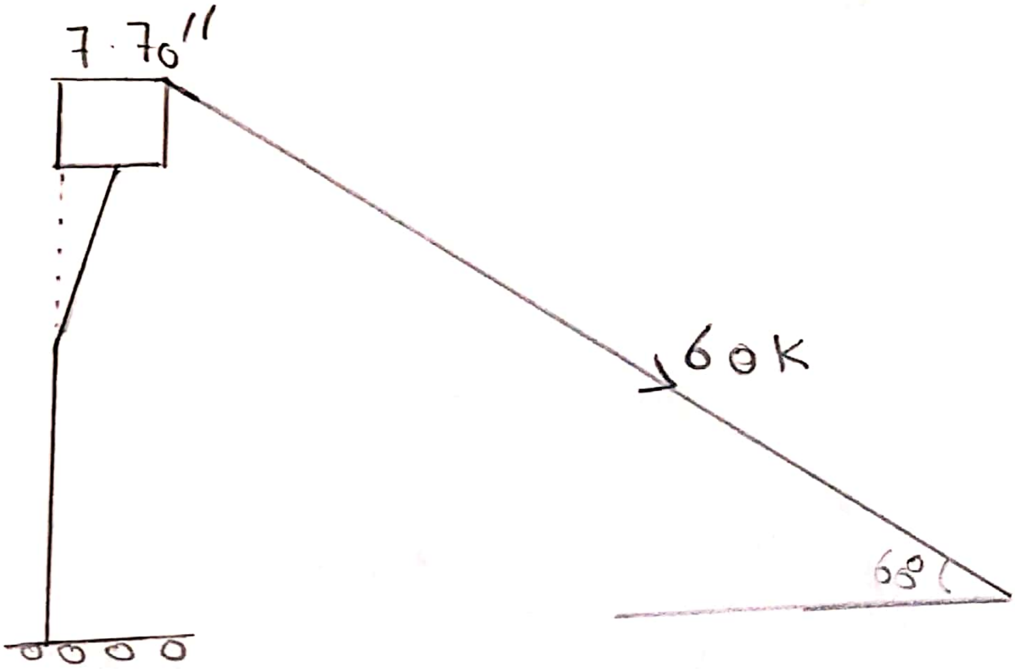

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