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Section : "B"

Subject : Earth Quicke Engineering

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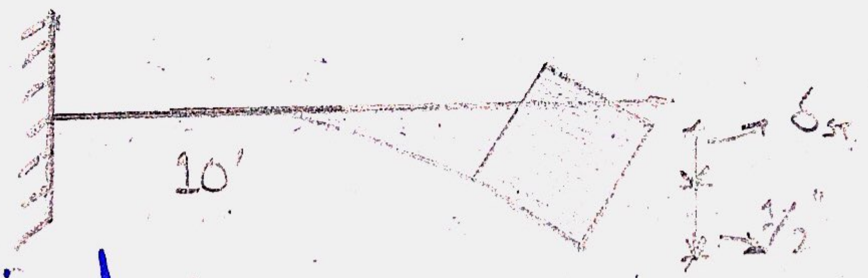
ANSWER TO QUESTION # 01

Given data :

$E = 29,000 ksi$

$I = 150 in^4$

δ_{ST} = Deflection due to 7747 lb static load beam is pulled 1/2" downward.



Required :

- Natural time period of system.
- Develop & solved the equation of motion.
- Draw graph to show the variation of equalent static forces with time.

Solution :

General equation of motion for SDOF System is ;

$$K_u + C_u + m_u = P(t)$$

Since System is undamped ($C=0$) under going for vibration $P(t)=0$

Hence general EOM Becomes

$$k_u + m_u = 0 \rightarrow (A)$$

$$k = \frac{3EI}{L^3} \Rightarrow \frac{3(29000\ \frac{k}{in^2})(150 in^4)}{(10 \times 12 in)^3}$$

$$\boxed{k = 7.55\ k/in}$$

In Order to ~~similart~~ Eliminate chances of mistake during Calculation. It is more approp-riate to use fundamental units like lb, ft, sec or kg, m, sec.

$$k = 7.55\ k/in$$

$$\boxed{k = 90625\ lb/ft}$$

$$m = \frac{w}{g} = \frac{7747}{32.2} \Rightarrow \boxed{240.59 \text{ slugs}}$$

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$$W_n = \sqrt{\frac{k}{m}} \Rightarrow \sqrt{\frac{90625}{240.59}}$$

$$\boxed{W_n = 19.41 \ rad/sec}$$

$$T_n = \frac{2\pi}{W_n} \Rightarrow \frac{2\pi}{19.41} \Rightarrow \boxed{0.324 \ sec}$$

Put the value of m & k in eq (A)

$$ku + m\ddot{u} = 0$$

$$90625 + 240.59 = 0$$

where "k" is in lb/ft and "m" is In lb sec/ft^2 = slugs

General Solution of EOM for undamped for vibration is

$$U(t) = U_{(0)} \cos(W_n t) + \frac{\dot{U}(0)}{W_n} \sin(W_n t)$$

$U_n(0) = 1/2'' = 1/24$ ft and $\dot{U}(0) = 0$

$$U_{(t)} = \frac{1}{24} \times \cos(19.39t) + 0$$

$$= \frac{1}{24} \times \cos(19.41t)$$

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Equation static force at anytime "t" is $f_s(t) = k \cdot u(t)$

$$\Rightarrow \frac{90625 \times \cos(19.41t)}{24}$$

$$\Rightarrow 3776 \times \cos(19.41t)$$

Amplitude of dynamics displacement for undamped for vibration is

$$u_0 = \sqrt{\left[(u(0))^2 + \left(\frac{v(0)}{\omega_r}\right)^2\right]}$$

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

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

$$\boxed{= 1/24 \text{ ft}}$$

Amplitude of Equilent static forces.

$$k_{u_0} = 90625 \times 1/24$$

$$\boxed{k_{u_0} = 3776 \text{ lb}}$$

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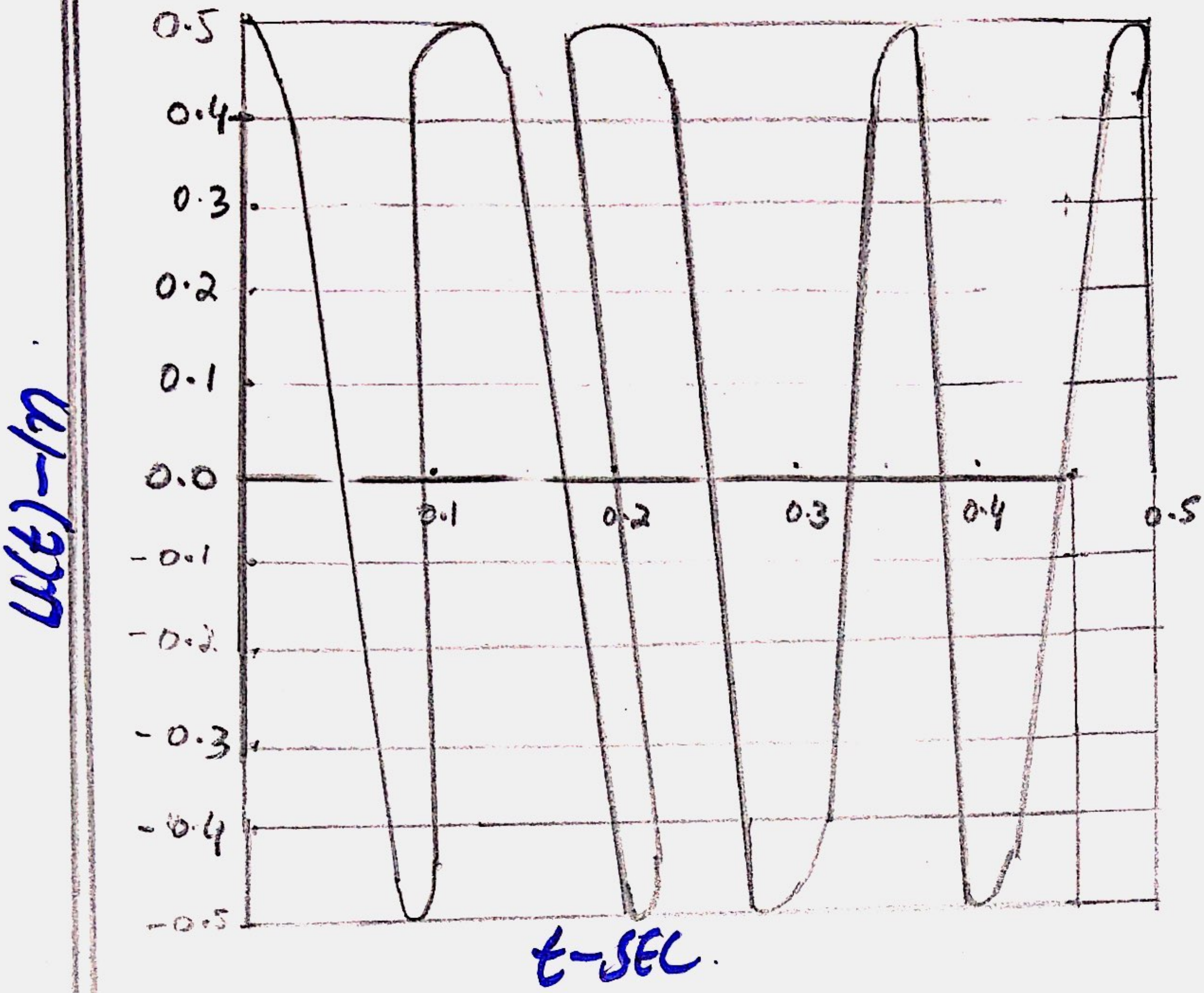
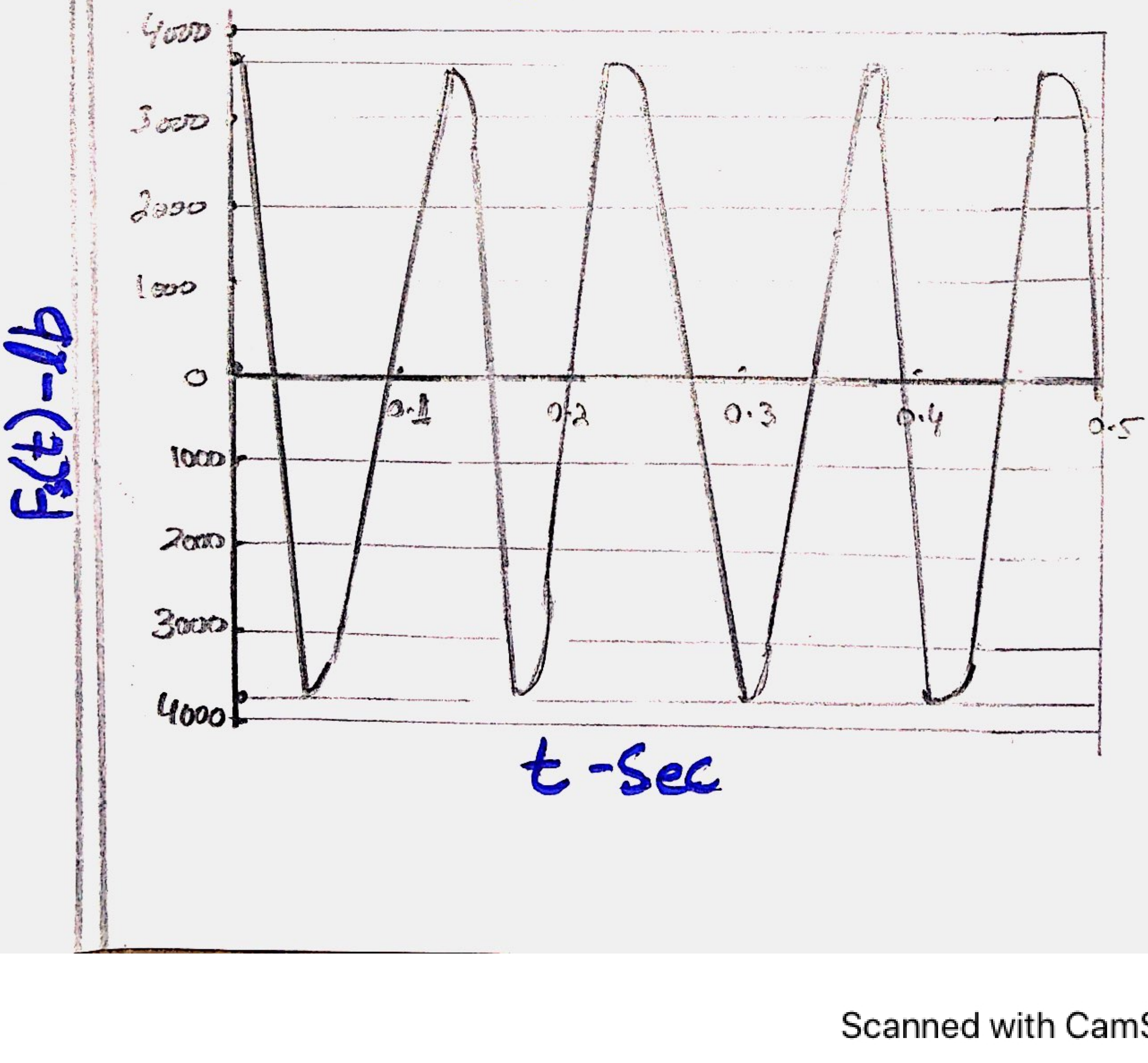

0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
0.1
0.2
0.3
0.4
0.5
u(t)-m
t-SEC


4000
3000
2000
1000
0
1000
2000
3000
4000
0.1
0.2
0.3
0.4
0.5
Fs(t)-lb
t-Sec

ANSWER TO QUESTION #02

Given data :

(damping ratio) of Reinforced Concrete with condsideration cracking $= 3\text{-}5\%$

$= 3\%$

Data of Beam from Q:1

Required :

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

Draw graph to show that variation of displacement with time and the ~~vati~~ variation of Equilent static force with time.

Solution :

EOM for damped force vibration is

$$ku + c\dot{u} + m\ddot{u} = 0 \longrightarrow (A)$$

As from Question # 1

$$K = 90625 \ lb/ft$$

$m = 240.59 \ lb\,sec^2/ft$

$\omega_n = 19.41 \ rad/sec$

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

$c = 3\% \times 2(240.59)(19.41)$

$c = 0.03 \times 2(240.59)(19.41)$

$\boxed{c = 280.20 \ lb\,sec/ft}$

Put the value in Eq (A)

$90625 + 280.20 + 240.59 = 0$

Solution to the EOM for Damped free vibration is

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

$\omega_D = 19.41 \ rad/sec$

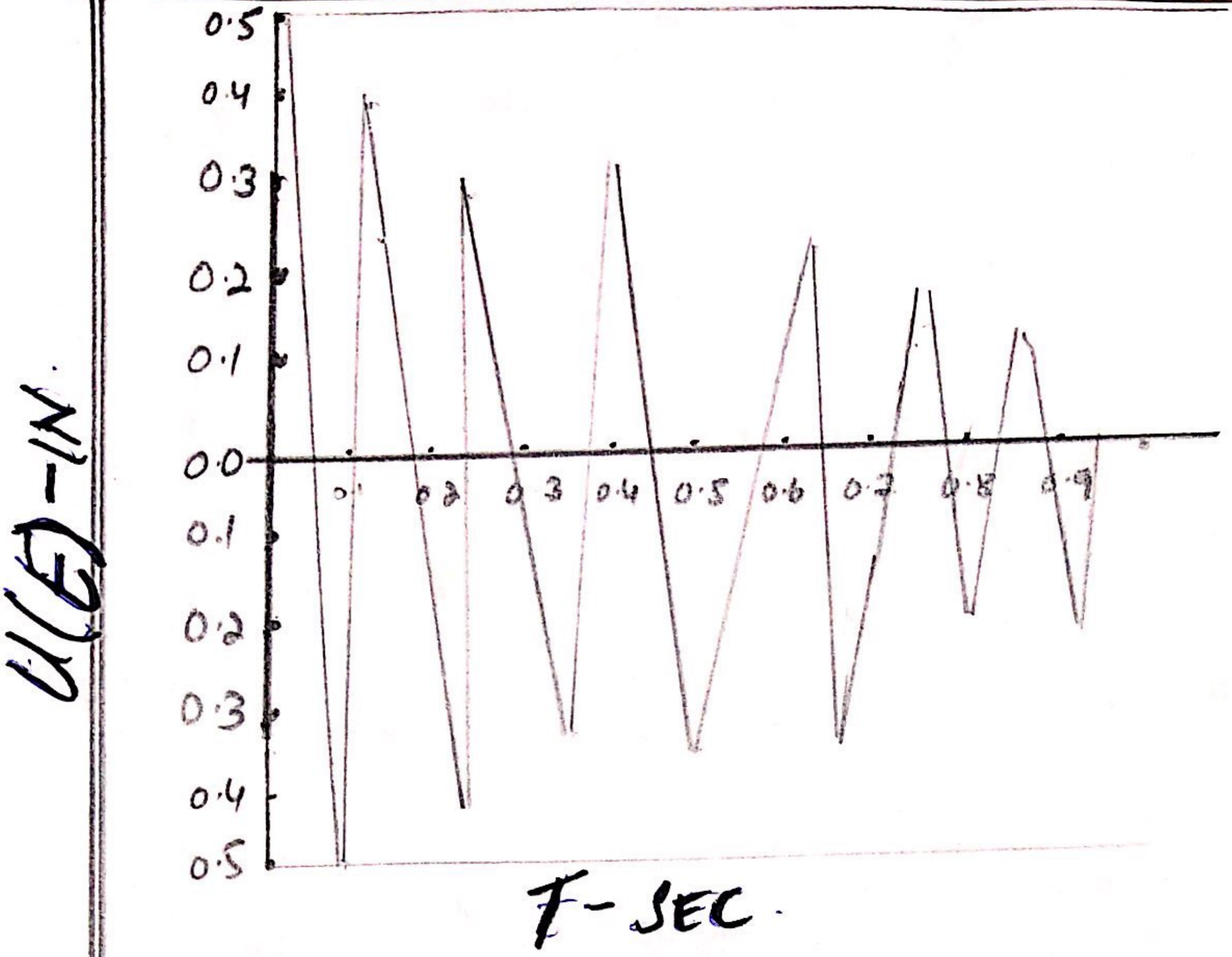
$u(t) = e^{-0.582t}\left[0.041 \times \cos(19.41t) + 0.00125 \times \sin(19.41t)\right)$

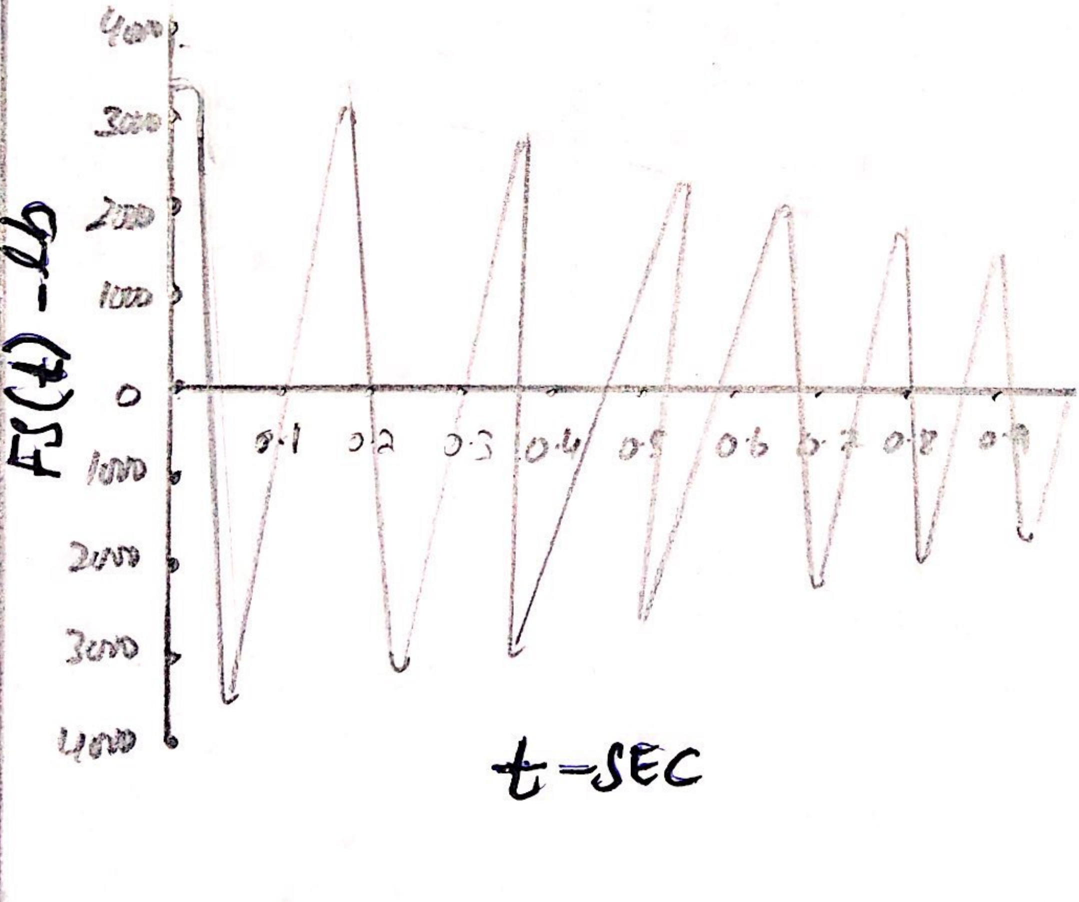
$F_{s}(t) = k \cdot u(t)$

$F_{s(t)} = 90625 \times u(t)$

$F_{s(t)} = e^{-0.582t}\left[(90625 \times 0.041) \cos(19.41t) + 90625 \times 0.00125 \sin(19.41)\right]$

$F_{s(t)} = e^{-0.582t}\left[3715.62 \cos(19.41t) + 113.28 \times \sin(19.41)\right]$


U(t)-IN
0.5
0.4
0.3
0.2
0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
t-SEC


FS(t)-lb
4000
3000
2000
1000
0
1000
2000
3000
4000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
t-SEC

ANSWER TO QUESTION # 3

Given data :

Force = 60 kips

Displacement of tank = $\frac{1D}{1000} = \frac{7747}{1000}$

$= \phi\ 7.747$

Time taken to complete 7 cycles

$= 3.57 sec$

Amplitude of displacement = 2.286 cm

$= 0.9''$

Required :

(1) Damping Ratio

(2) Natural period of Undamped vibration

(3) Stiffness of structure

(4) Weight of tank

(5) Damping co-efficient

(6) Displacement amplitude to 0.5'' Number of cycle of Reduce.

SOLLUTION :

Displacement of tank , $u_1 = 7.747$

After , 7 cycles

$J = 7$, $4J+1 = u_8 = 0.9''$

1→ Damping Ratio :

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

$$\zeta = \frac{1}{2\pi 7} \ln\left(\frac{7.747}{0.9}\right)$$

$$\zeta = 0.04889$$

$$\boxed{\zeta = 4.89\,\%}$$

2→ Natural Period Of Undamped Vibration $= T_n = ?$

As the 7 cycle of vibration are complete in 3.57 sec

→ Time Req to complete one cycle , $T_D = \frac{3.57}{7} = 0.51$ sec

$$\boxed{T_D = 0.51\ \text{sec}}$$

Now,

$$W_D = W_n \sqrt{(1-\zeta^2)}$$

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

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

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

$$T_n = 0.51 \times \sqrt{1-(0.0489)^2}$$

$$\boxed{T_n = 0.51}$$

3 → STIFFNESS OF STRUCTURE, $k = ?$

$$k = \frac{60 \times \cos 60^\circ}{7.747} \Rightarrow 3.872 \ k/m$$

$$k = 3.9 \ k/m$$

$$\boxed{k = 46920 \ lb/ft}$$

4 → Weight of tank, $w = ?$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{w/g}} \quad \because m = w/g$$

$$\omega_n = \sqrt{\frac{k \cdot g}{w}}$$ Taking Square b/s

$$\omega_n^2 = \frac{k \cdot g}{w}$$

$$\omega_n^2 = \frac{k \cdot g}{w}$$

$$W = \frac{k \times g}{W_n^2}$$

also;

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

$$W = \frac{k \cdot g}{\left(\frac{4\pi^2}{T_n^2}\right)}$$

$$W = \frac{k \times g \; T_n^2}{4\pi^2}$$

$$= \left[\frac{46920}{ft} \times \frac{32.2\,ft}{sec^2}\right] \times \left[\left(\frac{0.51\,sec}{4\pi}\right)^2\right]$$

$$\Rightarrow 9953.93\,lb$$

$$\boxed{\Rightarrow 9.95\,k}$$

5→ Damping Co-efficient, $c = ?$

$$\xi = \frac{c}{2mW_n}$$

$$c = \xi \times 2mW_n \Rightarrow \xi \times 2m \times \left(\frac{2\pi}{T_n}\right)$$

$$c = \frac{0.0489 \times \underset{4\times\pi}{\cancel{2(2\pi)}} \times \frac{9953.9}{32.2}}{0.51}$$

$$\boxed{c = 371.71\,lb\text{-}sec/ft}$$

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6 → NUMBER OF CYCLES TO REDUCE the Displacement AMPLITUDE TO 0.5", J=?

$$J = \frac{1}{2\pi \times \zeta} \ln\left(\frac{u_i}{u_{j+1}}\right)$$

$$J = \frac{1}{2\pi \times 0.04489} \ln\left(\frac{7.747}{0.5}\right)$$

$$J = 8.919$$

$$\boxed{J = 9 \text{ cycles}}$$