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ID:- 7379

Subject:- Earthquake & dynamics

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Final Term

Q1:-

Data:-

$\Delta = \frac{1}{2}''$

$T_n = ?$

$E = 29{,}000\ ksi$

$I = 150\ in^4$

$P_{st} = ?$

ID = 7379

Sol:-

$EOM = ku + c\dot{u} + m\ddot{u} = P(t)$

As the system is undamped ($c = 0$) undergoing free vibration $P(t) = 0$

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

$$k = \frac{3EI}{L^3}$$

$$k = \frac{3(29{,}000)(156)}{(10 \times 12)^3} = [illegible]$$

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$k = 7.55$ k/in

$k = 7.55 = 90625$ lb/ft

$$m = \frac{7379}{32.2} = 229.16 \text{ slug}$$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{90625}{229.16}} = \sqrt{395}$$

$$\omega_n = 19.87 \text{ rad/sec}$$

$$T_n = \frac{2\pi}{\omega_n} = \frac{2(3.14)}{19.87} = 0.316 \text{ sec}$$

EOM:

$$90625\,u + 229.16\,\ddot{u} = 0$$

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

$$U(0) = \frac{1}{24} \text{ ft}$$

$$U(t) = \left(\frac{1}{24}\right) \times \cos(19.87t)$$

$$f_s(t) = k \cdot U(t) = \frac{(90625)(\cos(19.87))}{24}$$

$f_s(t) = 3776 \cos(19.87)$

Amplitude of dynamic displacement, U_0 for undamped free vibration.

$$U_0 = \sqrt{\left(U_0(0)\right)^2 + \left(\frac{\dot{U}(0)}{\omega_n}\right)^2}$$

$$U_0 = \sqrt{\left(\frac{1}{24}\right)^2 + 0}$$

$$U_0 = \frac{1}{24} \text{ ft}$$

Amplitude of f_{s0}

$$k U_0 = 90625 \times \frac{1}{24} = 3776 \text{ lb}$$

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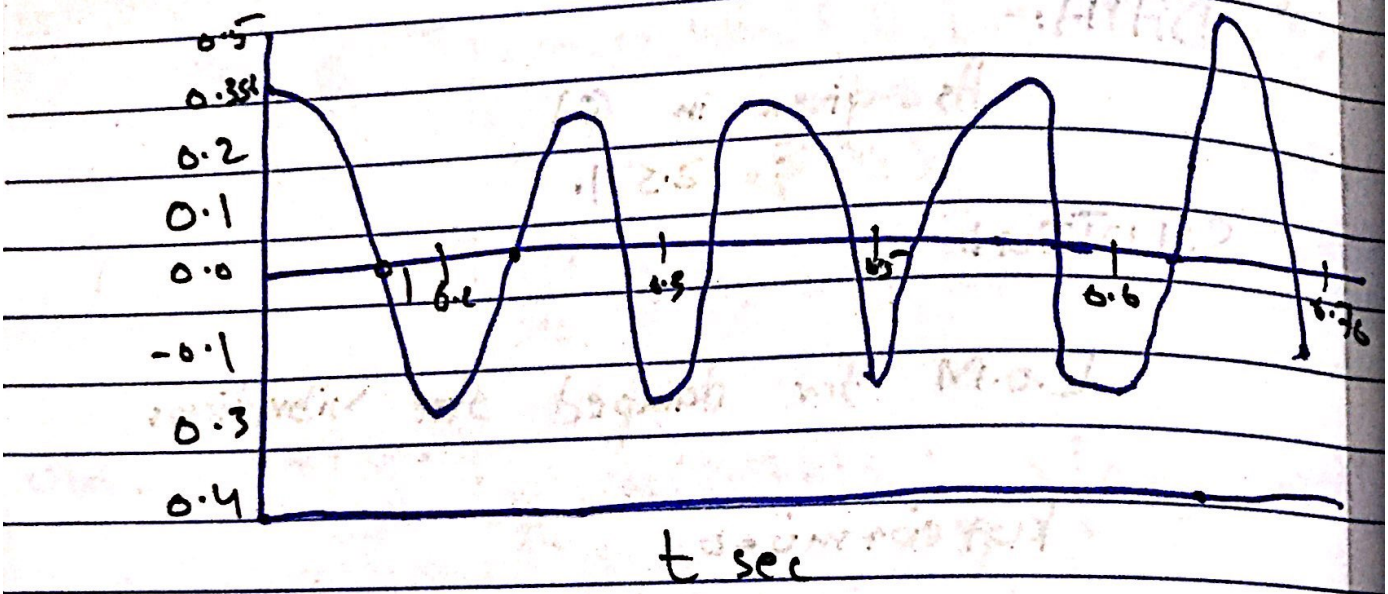
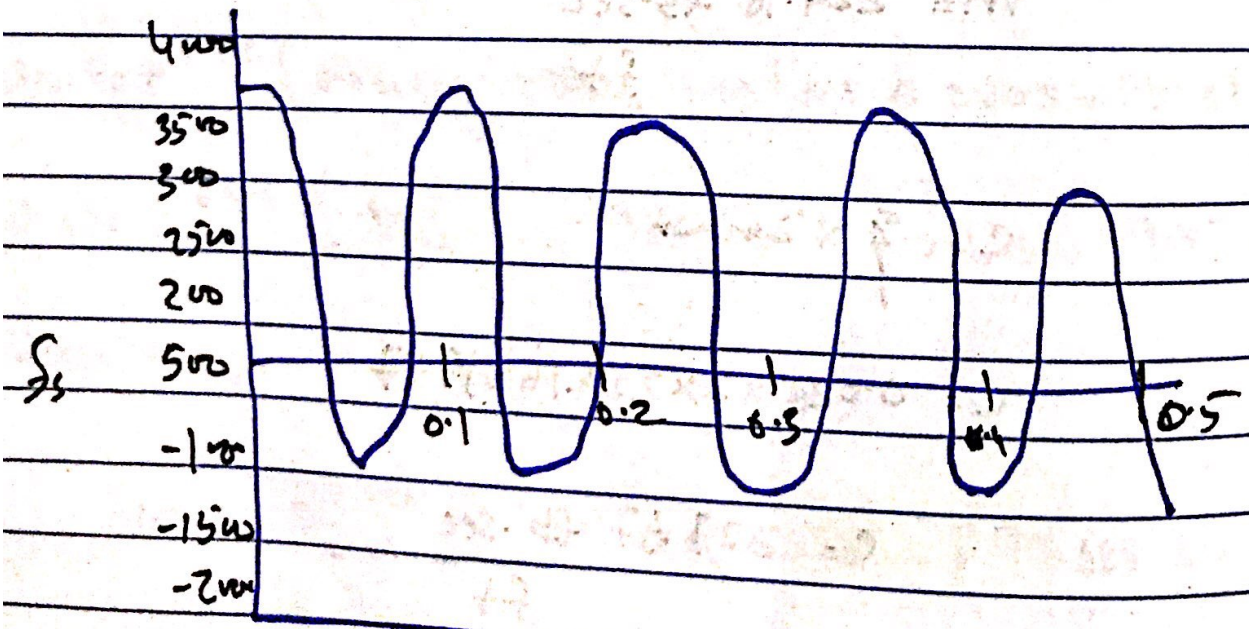
UNDAMPED FREE VIBRATION





Q2:-

for the ------ with time.

DATA:-

As given in Q1

$\xi = 2.5\%$

SOLUTION:-

E.O.M for damped free vibrations

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

$$k = 90625 \frac{lb}{ft}$$

$$m = 229.16 \frac{lb\text{-}sec^2}{ft}$$

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

$$c = 0.025 \times 2 \times 229.16 \times 19.87$$

$$c = 227.67 \frac{lb.sec}{ft}$$

As we know

$$90625u + 227.67\dot{u} + 229.16\ddot{u} = 0$$

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Solution of E.O.M for damped free vibration

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

$$\omega_D = 19.87 \frac{rad}{sec}$$

$$v(t) = e^{-(0.025)(19.87)t}\left[\frac{1}{24}\cos(19.87t) + \frac{1}{19.87} \times \left[0 + \frac{1}{24}(0.025)^{\times} 19.87^{\times}\sin(19.87t)\right]\right.$$

$$v(t) = e^{-0.496}\left[0.041\cos(19.87t)\right] + 0.05\left[0 + (0.041 \times 0.025 \times 19.87 \times \sin(19.87)\right]$$

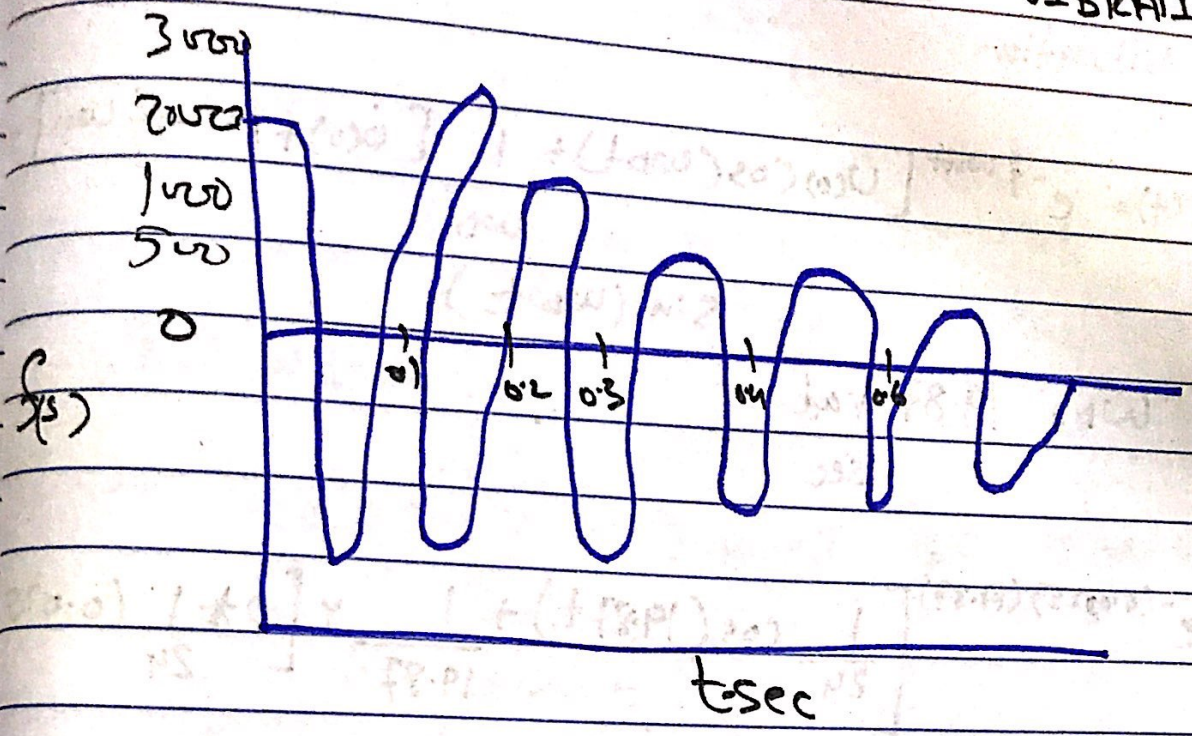
$$v(t) = e^{-0.496}\left[0.041\cos(19.87t) + 0.05\left[0 + 0.020\sin(19.87t)\right.\right.$$

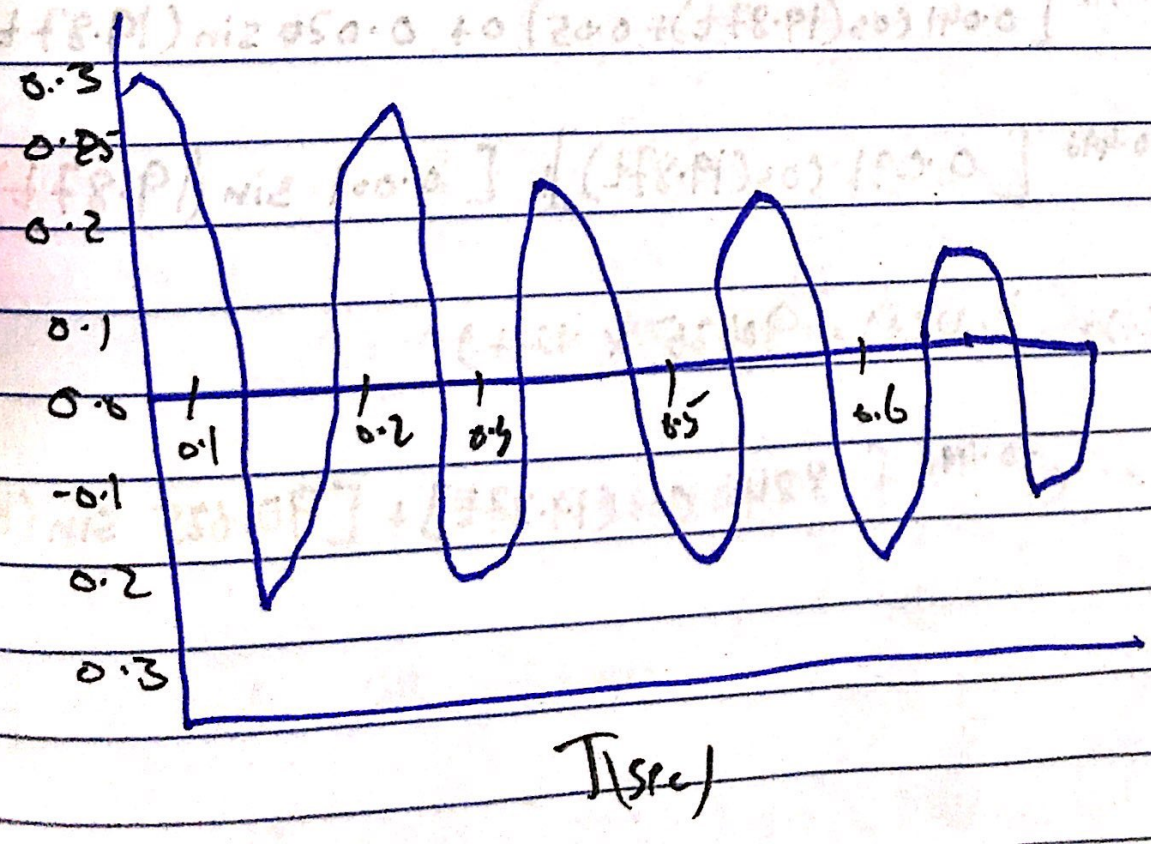
$$v(t) = e^{-0.496}\left[0.091\cos(19.87t)\right] + \left[0.001\sin(19.87t)\right]$$

$$v(t) = f_s(t) = k \cdot v(t) = 90625 \times v(t)$$

$$f_{s(t)} = e^{-0.496}\left[8246\cos(19.87t\right] + \left[90.625\sin(19.87t)\right]$$

DAMPED FREE VIBRATION





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Q3:-

A free ----- 0.5"

DATA:-

F= 60^k

D: 7.379"

7: cycles

T= 3.57 sec

Amplitude: 2.286 cm = 0.9"

Sol:-

U_j = 7.379"

j = 7

j=7, $U_{j+1} = U_8$ = 0.9"

a) Damping:-

$$j = \frac{1}{2\pi\xi} \ln\left[\frac{U_1}{U_{j+1}}\right]$$

$$7 = \frac{1}{2(3.14)\xi} \ln\left[\frac{7.379}{0.9}\right]$$

$$\xi = \frac{1}{(21(3.14)\xi)} (2.10)$$

$\frac{\xi(7)(12)(3.14)}{12/16}$

$\xi = 0.04 = 4.77\%$

$\xi = 4.77\%$

b T_n

7 cycles = 3.57 sec

$T_n = \frac{3.57}{7} = 0.51 \text{ sec}$

Now

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

$\omega_n = \omega_D \times \sqrt{1-\xi^2}$

$T_n = (0.51)(\sqrt{1-(0.04)^2}$

$T_n = 0.50 \text{ sec}$

(c) $k = ?$

$k = \frac{6.0 \times \cos(60^\circ)}{7.379} = 4.06 \frac{k}{in}$

Signature

$$k = 48720 \frac{lb}{ft}$$

d) weight of the tank, w=?

$$w = \frac{k \times g}{\omega_n}$$

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

$$\omega_n = \frac{2(3.14)}{0.51}$$

$$w = \frac{kg \times T_n^2}{4\pi^2}$$

$$w = \frac{(48720)(32.2)(0.51)}{4(3.14)^2}$$

$$w = 20286 \text{ lb}$$

$$w = 20.28 \text{ k}$$

e) c=?

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

Signature

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

$$c = \frac{(0.04)(4)(\pi)\left(\frac{2027\text{lb}}{32.2}\right)}{0.51}$$

$$c = 62.94 \frac{\text{lb.sec}}{\text{ft}}$$

No of cycles:-

$$j = \frac{1}{2\pi\xi} \ln\left[\frac{7.379}{0.5}\right]$$

$$j = \frac{1}{2\pi(0.04)} \ln\left[14.758\right]$$

$$j = \frac{2.69}{2(3.14)(0.04)}$$

$$j = 10.70 \approx 11$$