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SECTION A

Subject Earth Quake & Dynamic

Subb-to : ENGR + YASEEN MAHMOOD

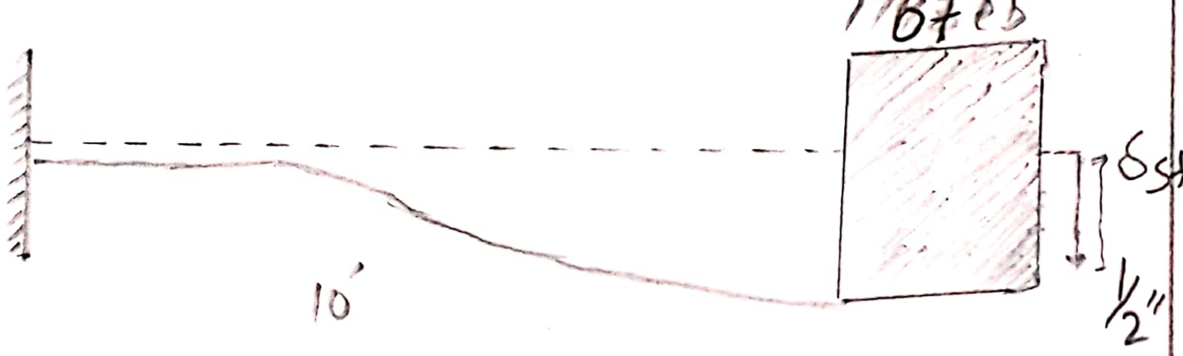
Q NO 01

GIVEN DATA

$E = 29000$ ksi

$I = 150$ in²

$\delta_1 = 7767$



Q NO # 01

Solution :-

The general E.O.M for SDOF System is

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

In our case system is Unclamped $(c = 0)$ Undergoing free vibration $(P(t) = 0)$

Hence general EOM became

$$ku + m\ddot{u} = 0 \quad --- (1)$$

$$k = 3EI/L^3$$

put value.

$$k = \frac{3 \times 29000 \times 150}{(10 \times 12)^3}$$

$$k = 7.55\, k/in$$

In order to eliminate the chances of mistake during Calculation. It is more appropriate to use fundamental Units like lb, ft sec or kg, m, sec

$$K = 7.55\ k/in = 90625\ lb/ft$$

$$m = \frac{7767\ lb/sec^2}{32.2\ ft}$$

$$m = 241.2$$

$$\omega_n = \sqrt{K/m} = \sqrt{\frac{90625}{241.2}}$$

$$\omega_n = 19.95\ rad/sec$$

$$T_n = 2\pi/\omega_n = \frac{2\pi}{19.95} = 0.3149\ sec$$

Subsitituting the corrosponding values in eq (1)

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

$90625u + 241.2\ddot{u} = 0$

Where "k" in lb/ft and "m" is in lb sec/ft^2

General Solution to the EOM for Undamped free vibration is

$$u(t) = u(0)\cos(w_n t) + \frac{u(0)}{w_n \sin(w_n t)}$$

$$u(0) = \frac{1}{2}'' , \frac{1}{2 \times 12} = \frac{1}{24 ft} \text{ and } u(0) = 0$$

equivalent Static force at any time "t" is

$$f_s(t) = k.u(t) = \frac{90625 \times \cos(19.95t)}{24}$$

$$f_s(t) = 3776 \cos(19.95t)$$

P.T.O

Amplitude of dynamic displacement u_o for Undamped free vibration is

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

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

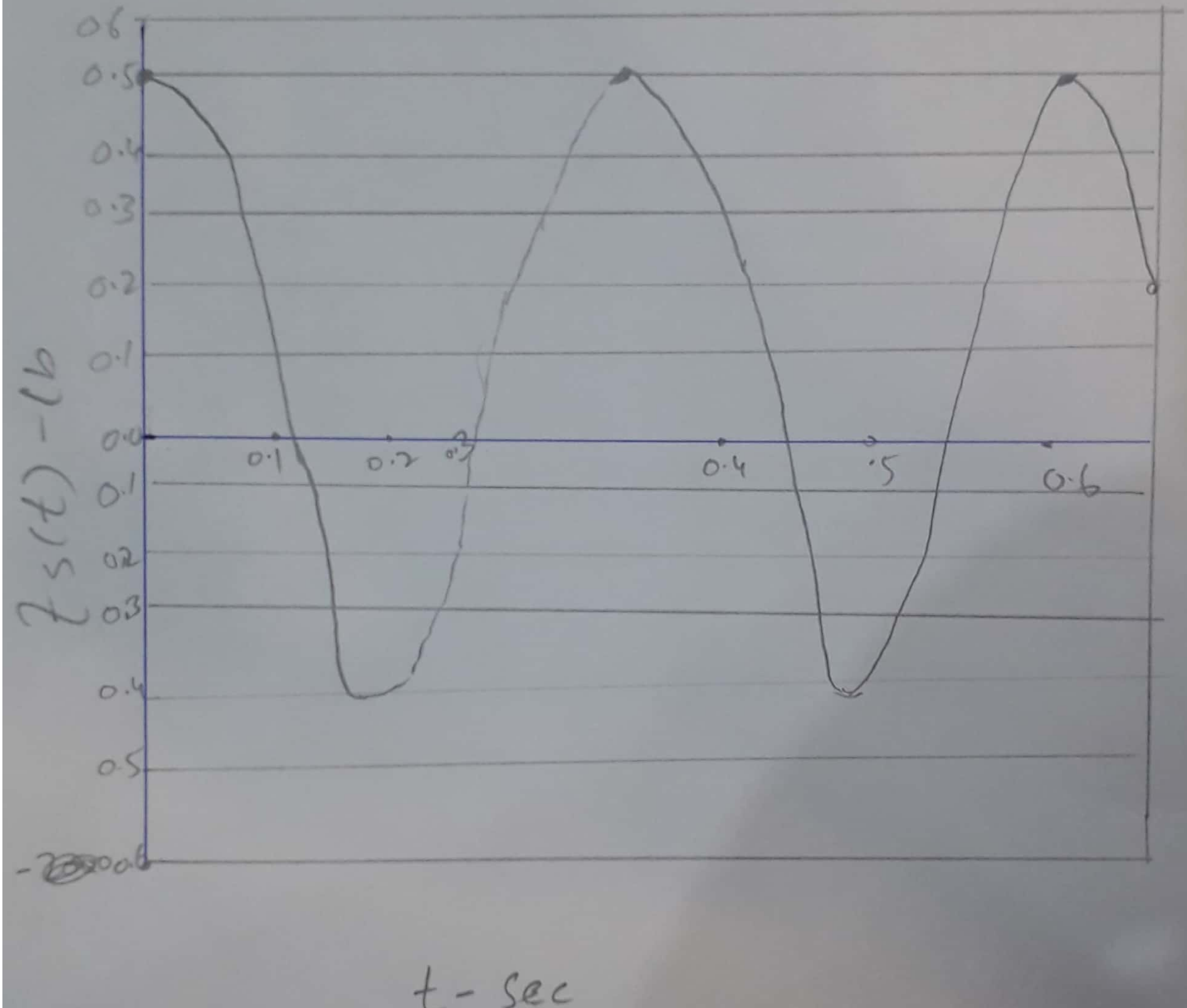
$$u_o = 1/24 \text{ ft}$$

Amplitute of equivalent Static force

f_{so}

$$k u_o = 90625 \times 1/24 = 3776 \text{ lb}$$

Undamped free vibration



Variation of displacement with time

Q NO # 02

ζ (Damping ratio) of Reinforced Concrete with Considerable Cracking

$= 3-5\%$

$= 3\%$

Using Data of beam given in Question 1

Required

- Develope & Solve the equation Showing variation in Equivalent Static Force with Time
- Draw graph to Show the variation of displacement with time & the variation of equivalent Static force with time.

Sol :

E.O.M for damped free vibration is

$ku + c\dot{u} + m\ddot{u} = 0$ — ①

for Question 1

$k = 90625\ lb/ft$

$m = 241.2$

$\omega_n = 19.95$ rad/sec

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

put value.

$c = (0.03) \times 2(241.2) \times (19.95)$

$c = 288.71$ lb sec/ft

Put value in eq → ①

$ku + cu + mu = 0$ — ① put value.

$= 90625u + 288.71 + 241.2 = 0$

Solution to the EOM for damped free vibration is

$$U(t) = e^{-\xi \omega_n t} \left[u(0) \cos(\omega_D t) + \frac{1}{\omega_D} \left[v(0) + u(0) \right. \right.$$

$$\& \ \xi \omega_n . \sin \omega_D t$$

$$\omega_D = 19.95 \text{ rad sec}$$

$$u(t) = e^{-0.03 \times 19.95} + \left[\frac{1}{24} \times \cos(19.95t) + \frac{1}{19.95} \right) \&$$

$$\times \left[0 + \frac{1}{24} \times 0.03 \times 19.95 \right) \&$$

$$\times \sin(19.95t)$$

$$p\,U(t) = e^{-0.598} + \left[0.041 \times \cos(19.95t) + 0.00125 \right.$$

$$\times \sin(19.95t)$$

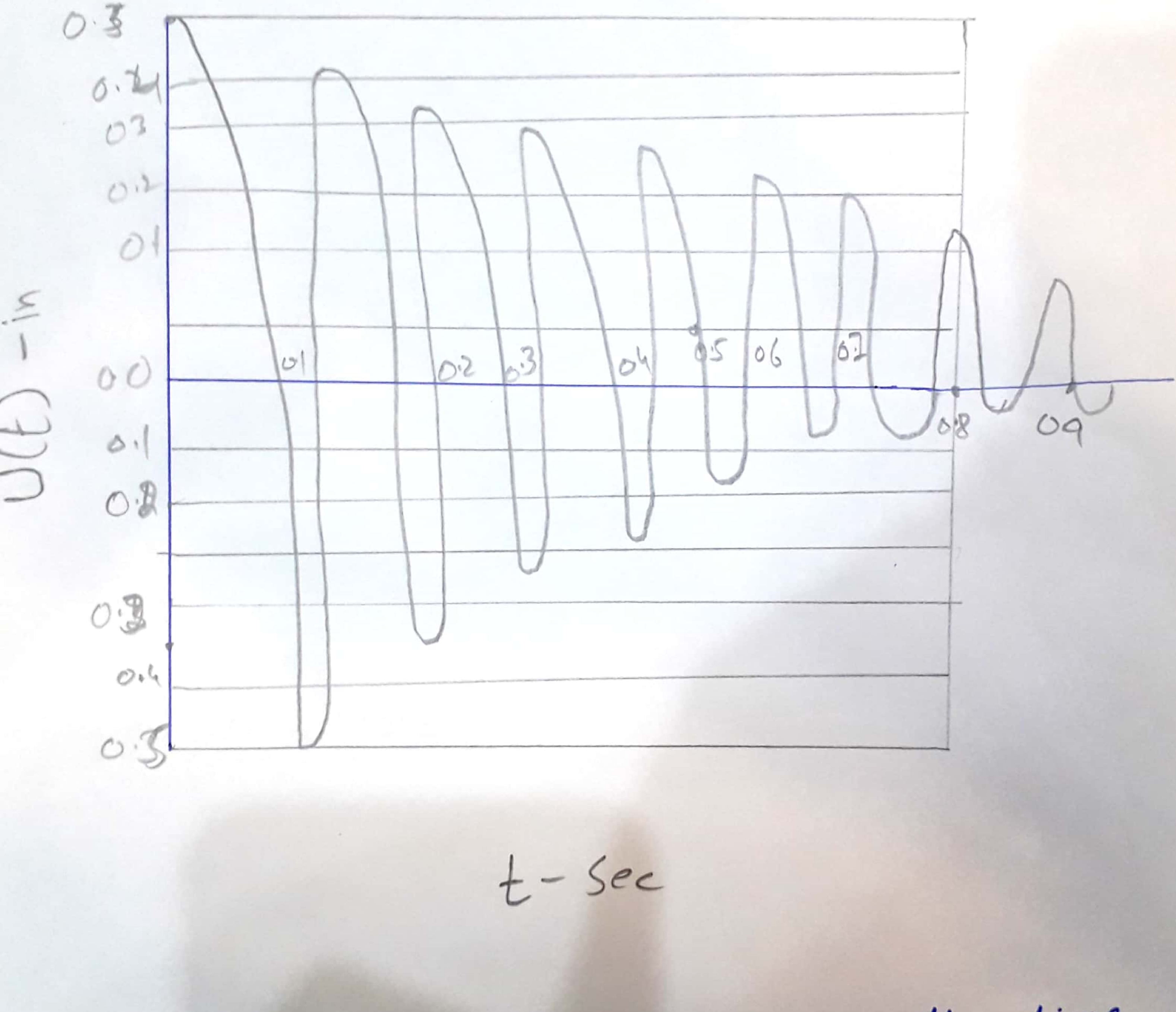
$$z_s(t) = k \cdot u(t) \Rightarrow 90625 \times u(t)$$

$$z_s(t) = e^{-0.598} \left[(90625 \times 0.041) \cos(19.95) \right.$$

$$\left. + (90625 \times 0.00125) \sin(19.95t) \right]$$

$$= e^{-0.598} \left(3715.62 \cos(19.95) + 113.28 \sin(19.95) \right)$$

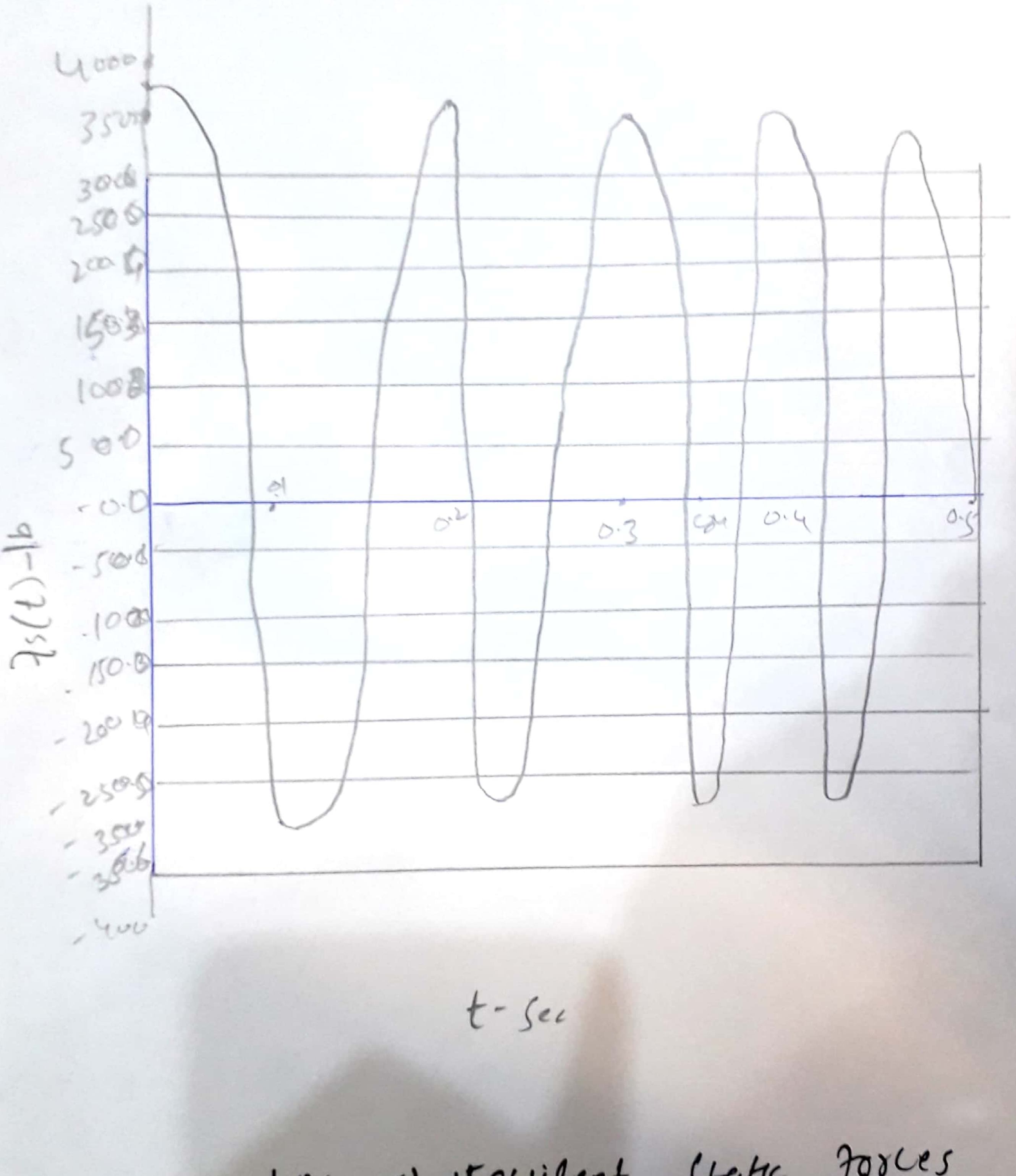
$$= 1941.89$$



Variation of displacement with time.

Scanned with CamScanner

Damped free variation



Variation of Equilent Static forces with time :-

QNO NO 3

GIVEN DATA:-

* Amplitude cable force = 60 kips
* Horizental displacement of tank = $\frac{7767}{1000}$

  $= 7.767 \text{ in}$
* Cycles = 7
* Cycle Completion Time = 3.57 sec
* Amplitude of displacement = 2.286 cm

  $= 0.9 \text{ in}$

Required DATA:-

* Damping ratio
* Natural period of undamped vibration
* Stiffness of Structures
* Weight of tank
* Damping co-efficient
* Number of cycle to reduce the displacement amplitude to = 0.5

Solution:-

As given in equation

$u_1 = 7.767$ in

After $J = 7$

$u_{J+1} = u_8 = 2.286$ cm $= 0.9$ in

a :

ζ = Damping ratio = ?

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

By putting values we get

$$7 = \frac{1}{2\pi\zeta} * \ln\left(\frac{7.767}{0.9}\right)$$

$\zeta = 0.0490 = 4.90\%$ Ans

$\zeta = 4.90\%$

$\boxed{\zeta = 4.90\%}$ Ans

(b) Natural period of undamped vibration $= T_n = ?$

As the 7 cycles of vibration are completed in 3.57 sec

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

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

Now,

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

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

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

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

$$T_n = 0.51 \times \sqrt{1-(0.0490)^2}$$

$$T_n = 0.5094 = 0.51 \text{ sec}$$

C Stiffness Structure $K = ?$

$$K = \frac{60 \times \cos 60}{7.767} = 3.862 \text{ k/in}$$

$$K = 46344 \text{ lb/ft}$$

D weight of tank $W = ?$

$$W_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{K}{W/g}} = \sqrt{\frac{K \cdot g}{W}}$$

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

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

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

$$|x| = \frac{Kg}{\left(\frac{4\pi^2}{T_n^2}\right)}$$

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

$$W = \left[\left[\frac{46344\,lb}{ft} \times \frac{32.2\,ft}{sec^2}\right] \times \frac{(0.51\,sec)}{4\pi^2}\right]$$

$W = 9831.73\ lb = 9.83\ k$

e Damping Co-efficient, $c = ?$

It is Known that

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

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

P.T.O

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

$$C = (0.0490) \times 4 \times \pi \frac{\left(\frac{9831.73}{32.2}\right)}{0.51}$$

$$C = 368.46 \text{ lb-sec/ft}$$

Number of cycles to reduce the displacement amplitude to 0.5"

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

$$j = \frac{1}{2\pi \times 0.0490} \ln\left[\frac{7.767}{0.5}\right]$$

$$j = 8.90 \text{ or } 9 \text{ cycles}$$