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Paper earthquake & dynamic

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final Term

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Q 1

Ans

Given data

=> Length of beam = L = 10'

=> Beam pulled in downward direction = 1/2"

=> E = 29000 Ksi

=> I = 150 in^4

=> f_{st} = 7337 Lb

-> ignore self wt & damping effect

Required :-

i) Natural time Period

ii) develp and solve equation of motion for vibration of free end =?

iii) develp equation showing varition the equivalent static force with time =?

iv) amplitude of equivalant static force =?

v) Graph

Solution :-

The general E.O.M for Sdof system is

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

undamed system (C=0) undergoing free vibration P(t) = 0

So general E.O.M become

$$Ku + m\ddot{u} = 0 \longrightarrow (1)$$

$$K = 3EI$$

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

$$K = 7.55 \ K/\omega$$

in order to eliminate elvces of mistake during calculation. if is more apporporte to use fundamental unit like lb, ft or kg, m, sec

$$K = 7.55 \ K/\omega = 90625 \ lb/ft$$

$$m = \frac{7337 \ lb \ sec^2}{32.2 \ ft} = 227.8 \ slug$$

$$w_u = \sqrt{K/m} = \sqrt{\frac{96025}{227.8}}$$

$$w_u = 20.5$$

$$T_n = 2\pi / \omega_u = 2\pi / 20 = 0.306$$

Putting value in eq (i)

$$90625 + 227.8\,\ddot{u} = 0$$

where K is lb/ft & m is in lb sec/ft²

General solution to E.O.M for undamped free vibration is

$$u(t) = u(0)\cos(\omega_u t) + \dot{u}(0)/\omega_u \sin(\omega_u t)$$

$u(0) = 1/2'' = 1/24$ ft & $\dot{u}(0) = 0$

$$u(t) = (1/24) \times \cos(20.5) + 0$$

$$u(t) = (1/24) \times \cos 20.5t$$

Equivalent static force at any time 't' is

$$f_s(t) = K\,u(t) = \frac{90625 \times \cos(20.5t)}{24}$$

$$f_s(t) =$$

$$f_s(t) = 3776 \cos(20t)$$

Amplitude of dynamic displacment u_o for undamped free vibration is

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

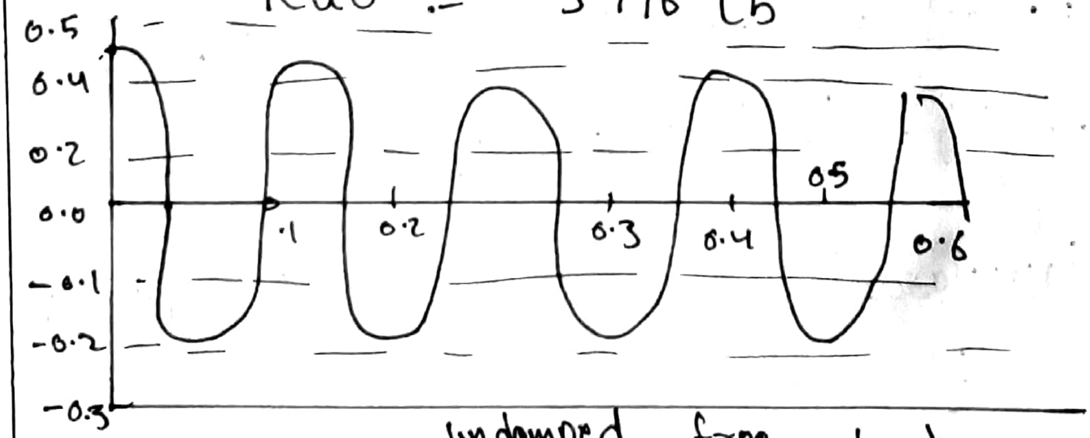
$$= \sqrt{\left((1/24)^2 + 0 \right)}$$

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

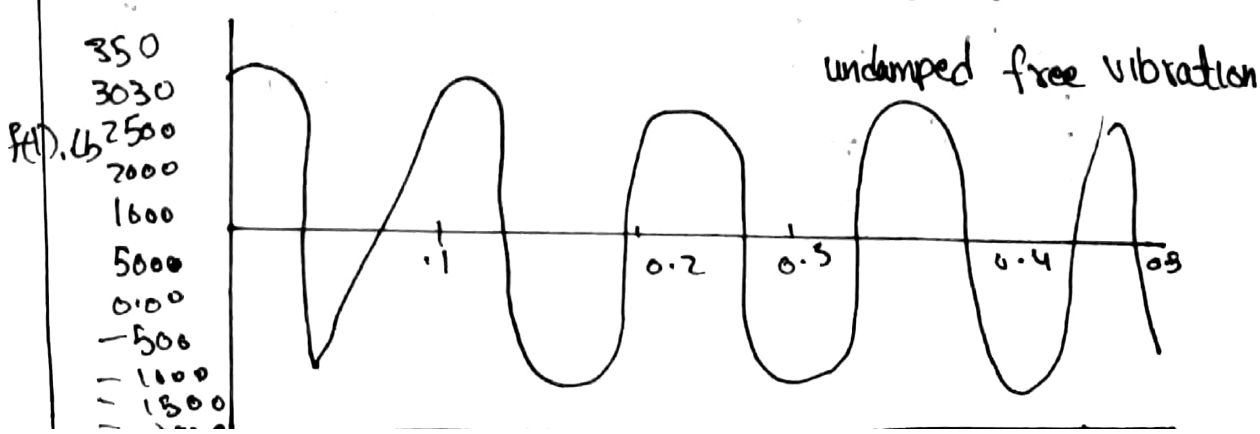
Amplitude of equivalent static force f_{so}

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

$$Ku_o = 3776 \text{ lb}$$



undamped free vibration



Q2 Ans

Given data

as given in qustion stadment we will use given data from Qustion 1

Required

i) develp and solve the eqution of motion for vibraton resulting at free end

ii) devolP eq showing variation in eauivalent static force with time

iii) Draw graph to show variation of displacment with time & variation of eauavlent force with time

Solution:-

Damping ratio for Rcc

Mm = 0.80%, Average = 1.3%

we will consider 1.3 %

E.o.m for damped free vibration

$ku + c\dot{u} + m\ddot{u} = 0$ — A

from Question 1

$K = 90{,}625 \ lb/ft$

$m = 227.8 \ lb\,sec^2/ft$

$C = \xi \times 2m\,\omega_n$

$= 2 \times 227.8 \times 20 \times 0.013$

$C = 118.45 \ lb/ft$

Now Put value of K, M, & C equation (A)

$\Rightarrow 90625u + 118.45\dot{u} + 227.8\ddot{u} = 0$

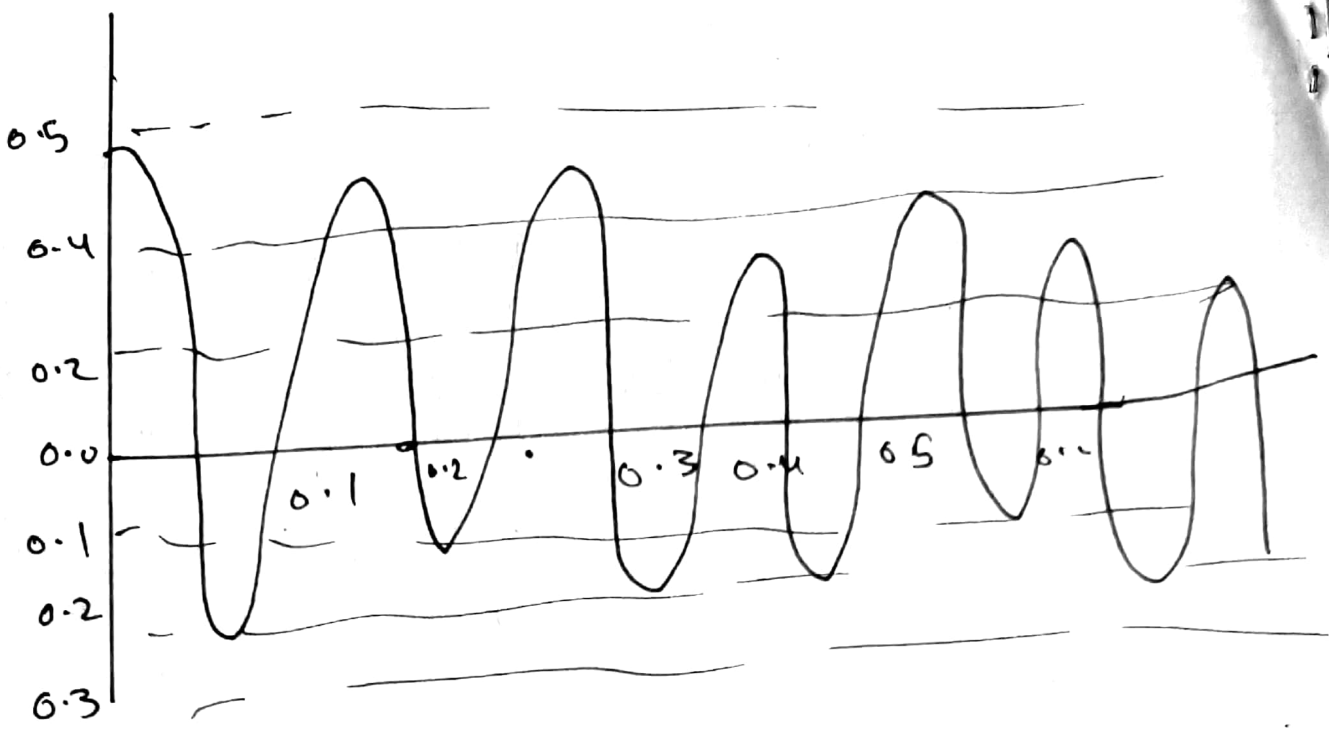
solection to the E.O.M for damped free vibration

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

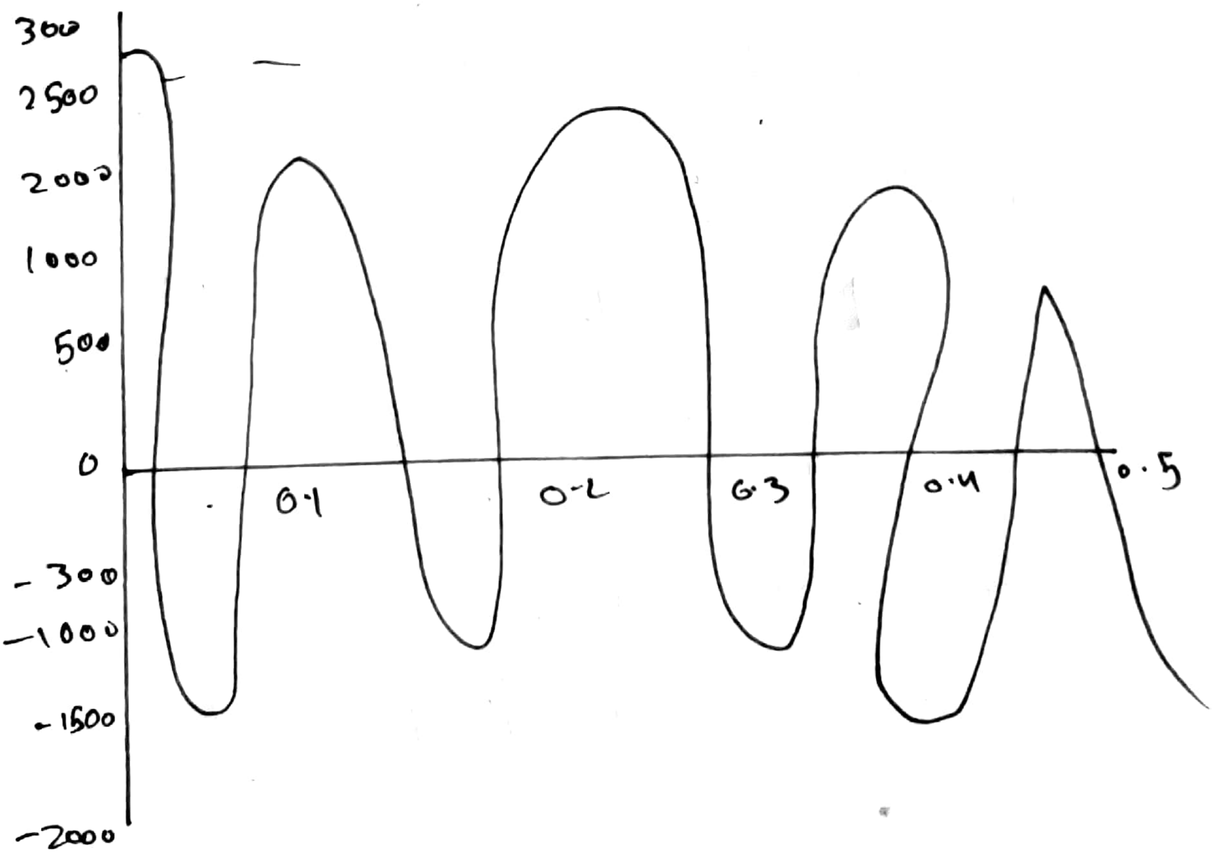
$u(t) = e^{-0.26t}\left[0.041 \times \cos(20t) + 0.0005416\sin(20t)\right]$

$f_s(t) = Ku(t) = 90625 \times u(t)$

$f_s(t) = e^{-26t}\left[3715\cos(20t) + 49.08\sin(20t)\right]$



Damp free vibration



Q3

Given data

force = F = 60 kips

displacment = $7337/1000$ = 7.337"

no of cycle 7 are complete in 3.57sec

Amplitude = 2.286 cm = 0.9"

ignore vertical vibration

Required:-

i Damping ratio
ii) Natural period of undamped vibration
iii) stiffness of structure
iv) weight of tank
v) Damping cofficent
vi) No of cycle to reduce displacment 0.5"

Solution

$u_1 = 7.337''$

After $J = 7$, $u_{i+1} = u_8 = 0.9''$

ζ = Damping ratio = ?

$j = \frac{1}{2\pi 3} \ln (7.37/0.9)$

$7 = \frac{1}{2\pi 3} \ln (7.37/0.9)$

$\zeta = \frac{2.13}{2\pi 7}$

$\zeta = 0.0488 = 4.88\%$

T_n = ?

7 cycle of vibration are

Completed in 3.57 sec

Now Time required for 1 cycle

$= T_0 = 3.57/7$

$T_0 = 0.51$ sec

Now

$\omega_0 = \omega_n \sqrt{(1-\zeta^2)}$

$2\pi / \omega_n = 2\pi / \omega_n \sqrt{1-\zeta^2}$

$T_0 = \dfrac{T_n}{\sqrt{1-\zeta^2}}$

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

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

$= 0.5093 = 0.51$ sec

$k = ?$

$= \dfrac{60 \times \cos 60°}{2} = 15 \, 1b/in$

$k = 18000$ lb/ft

weigh of tank = $W = ?$

$\omega_n = k/m = \sqrt{k / \omega/g} = \sqrt{\dfrac{k \times g}{\omega}}$

$\omega^2 n = \dfrac{k \times g}{\omega}$

$W = \dfrac{k \times g}{\omega^2 a}$

also $w_n = 2\pi / T_n$

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

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

$$W = 18000 \times 32.2 \times \frac{(0.51)^2}{4\pi^2}$$

$W = 3818.64\ lb = 3.81K$

Now

$C = ?$ It is know that $S = \frac{C}{2 m w_n}$

$C = S \times 2 m w_n$

$C = S \times 2m\ (2\pi / T_n) = 0.0488 \times 2 \times \left(\frac{3818.6}{32.2}\right)\left(\frac{2\pi}{0.51}\right)$

$C = 142.59\ lb\,sec/ft$

No we find nos of cycle to reduce displacment amplitude from 7.75 to 0.5" $J = ?$

$$J = \frac{1}{2\pi \times 0.0488} \ln\left[\frac{7.337}{0.5}\right]$$

$J = 8.1$ or 8 cycle