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Section B

Department BE(Civil)

Subject introduction to earth quake

Date 29/06/2020

Semester 8th

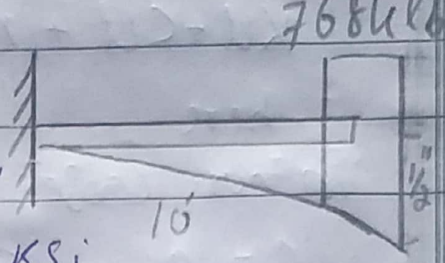
instructure: Engr Yaseen

Important

MOTOWOTOFLSO H/W-C/WO Date:........./........./20........

Q1

given Data:



distance = 1/2"
E = 29000 KSi
I = 150 in^4
δ = Deflection due To 768klb
L = 10 ft

required:

natural Time Period = ?
equation of motion = ?
Amplitude = ?
graph of vibration of displacement with Time = ?
graph of vibration of equivalent static force with Time = ?

Solution:

as we knew that from genral Equation of motion for SD self Degree of freedum system

$Ku + c\dot{u} + m\ddot{u} = P(T)$

here

in our case system is undamped

$c = 0$ so under going free

vibration $P(T) = 0$

Hence general EOM become

$Ku + m\ddot{u} = 0$ ——— ①

Now we know that

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

Put value

$= \frac{3 \times 2900 \times 150}{(10 \times 12)^3}$

$=$ **7.55 K/in**

9062.5 lb/ft

Important

Now we mass (m)

$m = F/g = \frac{7684}{32.2} = \boxed{238.64 slug}$

Now we find w_n

$w_n = \sqrt{K/m} = \sqrt{\frac{96025}{238.64}}$

$= \boxed{20.1 rad/sec}$

Now put value in equation 1

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

$\boxed{90625u + 31.06u = 0}$

Now find Time Period

$T_n = 2\pi/w_n = 2\pi/20.1$

$= \boxed{0.313 sec}$

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M T W T F S   H/W -C/W   Date:........./........./20........

Now we also know That from General solution To The ~~freed~~ EOM for undamped free vibration

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

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

$$\dot{u}(0) = 0$$

$$u(t) = \left(\frac{1}{24}\right) \times \cos(20.1t)$$

Equivalent static force at any Time "t" is

$$f_s(t) = K \cdot u(t) = \frac{90625 \times \cos(54.9t)}{24}$$

$$= ~~3776.042t~~$$

$$= ~~3776\cos t~~$$

$$= \boxed{3776.042\cos 54.9t}$$

Important

Best Quality Notes

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Now we find Amplitude of dynamic displacement u_o for undamped free vibration

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

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

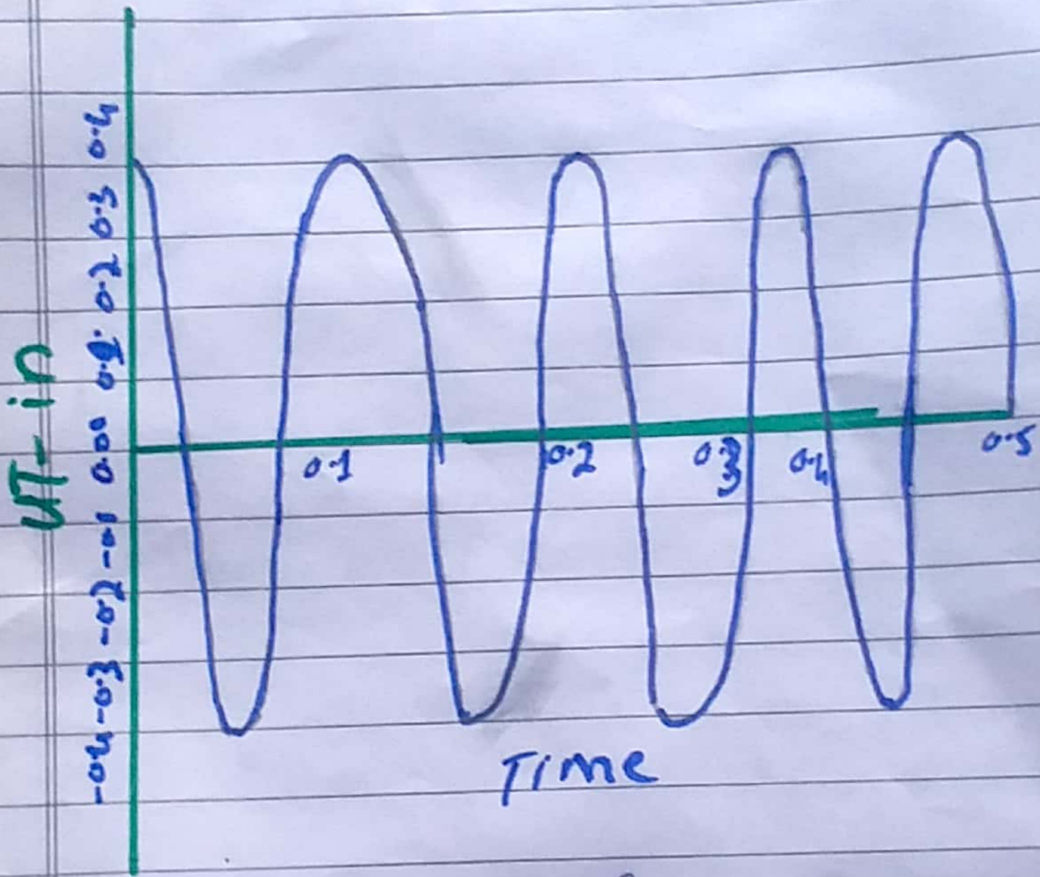
$$= 1/24 = 0.042 \, ft$$

Now ~~Apt~~ Amplitude of equivalent static force

$$Ku = 90625 \times \frac{1}{24} = \boxed{3776.042 \, lb}$$

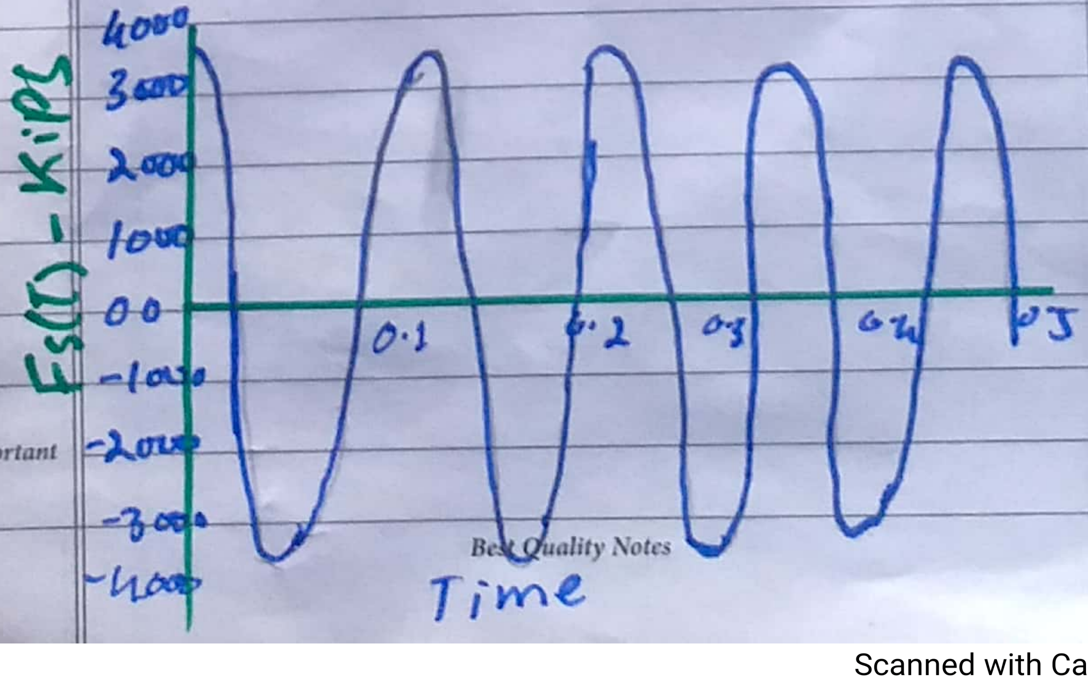
portant

undamped free vibration



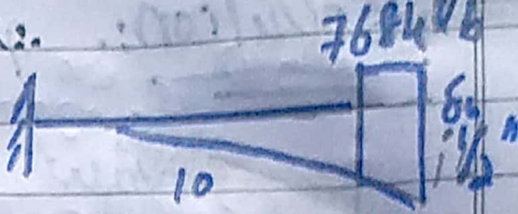
variation of displacement with Time.

undamped free vibration



variation of equivalent force with time

Q2 given Data:.



distance = 1/2"

E = 29000 KSi

I = 150 in^2

S = 7684 lb

L = 10 ft

Damping ratio = ζ = 4 %

required:.

(1) develop and solve the equation of motion for vibration at free end = ?

(ii) also develop equation showing vibration in the equivalent of static force with time = ?

(3) draw graph the ~~val~~ variation of displacement with time and the variation of equivalent static force with time = ?

Solution:. for Part 1 and 2

Now we know that from Equation of motion for damped vibration

$$Ku + C\dot{u} + m\ddot{u} = 0 \quad \text{—— (1)}$$

we know that

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

$$= 7.55\,K/in$$

$$= 90625\ lb/ft$$

Now mass

$$m = F/a = \frac{7684}{32.2} = ~~238~~\ 238.64\ slug$$

Now we find C

we know that

$$C = \zeta \times 2 m \omega_n \text{ ——— (11)}$$

$$= \frac{4}{100} \times 2 \times 238.64 \times \omega_n$$

First we find ω_n

$$\omega_n = \sqrt{K/m} = \sqrt{\frac{96025}{238.64}}$$

$$= \boxed{20.1 \text{ rad/sec}}$$

Now put in eq(11)

$$C = \frac{4}{100} \times 2 \times 238.64 \times 20.1$$

$$= \boxed{383.74 \text{ lb.sec/ft}}$$

Important

Now put these value in (1)

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

$$\boxed{90625u + 383.74\dot{u} + 238.64\ddot{u} = 0}$$

Now solution to the E.O.M for damped free vibration

$u(t) = e^{-\zeta\omega_n t}\left[u(0)\cos(\omega_D t) + \frac{1}{\omega_D}\left(u'(0) + u(0)\zeta\omega_n\right.\right.$
$\left.\times \sin \omega_D t\right)$

$\omega_D = 20.1$ rad/sec

$u(t) = e^{-0.04\times20.1t}\left\{\frac{1}{24}\times\cos(20.1t) + \frac{1}{20.1}\left[0 + \frac{1}{24}\times 0.04\times\right.\right.$
$\left.\left.20.1\times\sin(20.1t)\right]\right]$

$e^{-0.804t}\{0.042\cos(20.1t) + 0.0017\sin(20.1t)$

$$= \boxed{e^{-0.804t}\{0.042\cos(20.1t + 0.0017\sin 20.1t)}$$

portant

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Now we know that

$f(s) = K \cdot U(T)$

$K = 90625$

$f(s) = 90625\left(e^{-0.804} \times 0.042 \cos(20.1T) + 0.0017 \sin(20.1T)\right)$

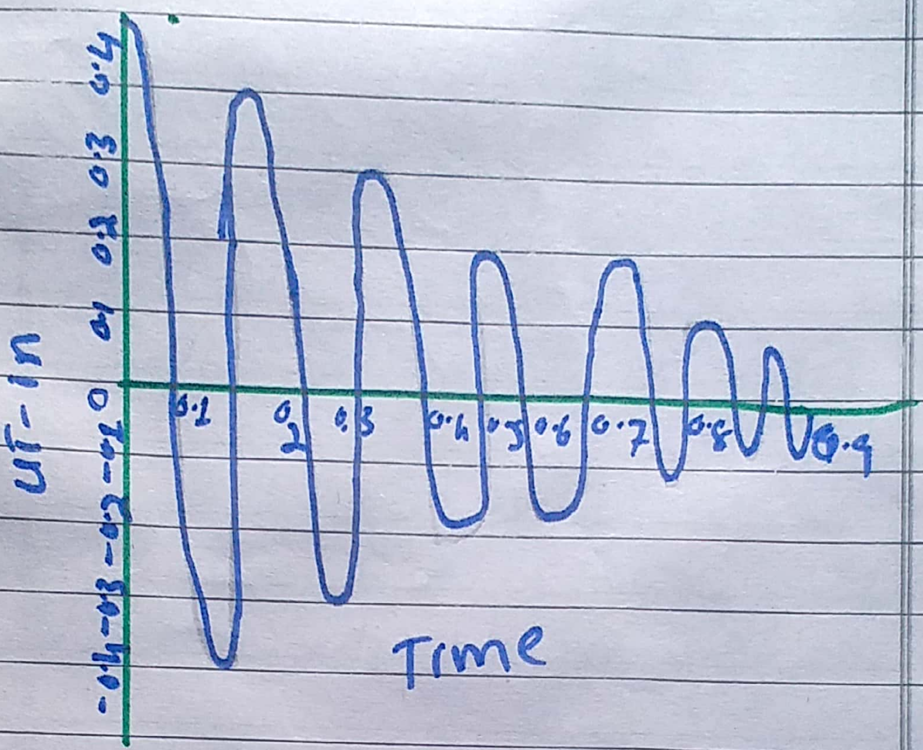
$= e^{-0.804}\left(90625 \times 0.042 \cos(20.1T) + 90625 \times 0.0017 \sin(20.1)\right)$

$Fs = e^{-804}\left(3806.25 \cos(20.1t) + 154.0625 \sin(20.1T)\right)$

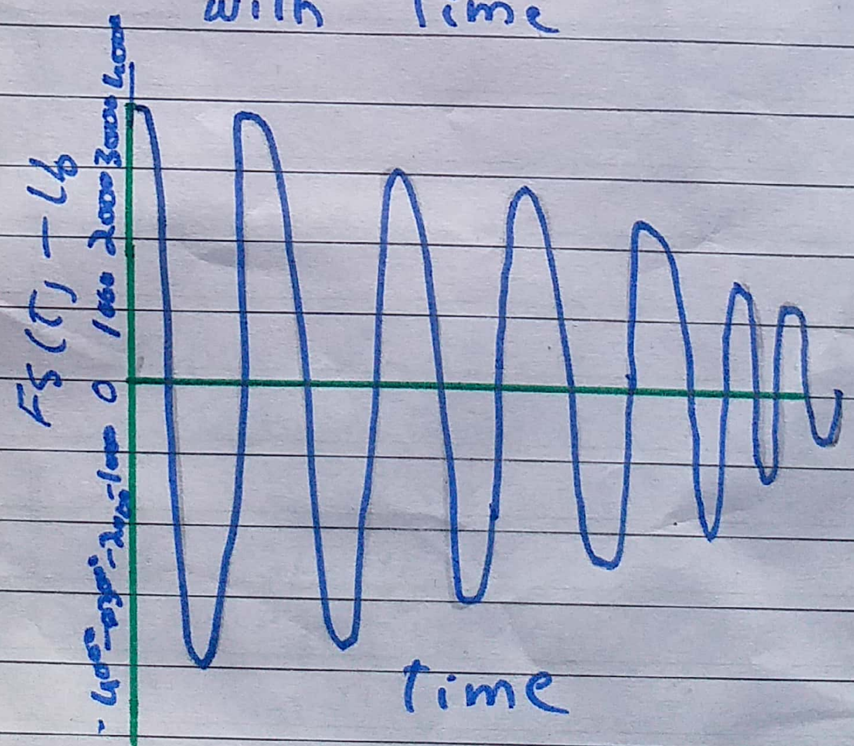
$Fs = e^{-804}\left(3806.25 \cos(20.1T) + 154.0625 \sin(20.1T)\right)$

Important

Damped free vibration

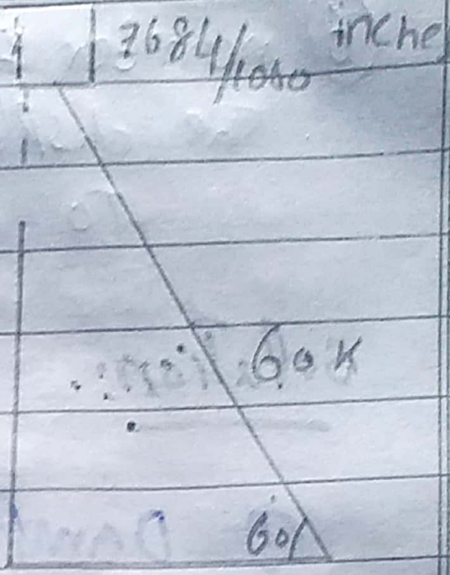


variation of displacement with Time



variation of Equivalant static force with Tim

Q3 Given Data:-



figure

load = f = 60 Kips

displace the tank by force

$= 7684/1000 = 7.684''$

Time Period = 3.57 sec

cycle = 7

Amplitude of displacement = 2.286 cm

$= \frac{2.286}{2.54}$

$= 0.9''$

required:-

① Damping ratio = ?

② Natural period of undamped vibration = ?

③ Stiffness of structure = ?

④ weight of tank = ?

⑤ Damping coefficient = ?

MOTOWOTOFOSO HAYO-CAWO Date:......../......../20........

(b) number of cycles to reduce the displacement amplitude to 0.5"

solution:.

① Damping ratio = δ =

as we know that

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

$$\delta = \frac{1}{2\pi j} \ln\left(\frac{u_1}{u_{i+1}}\right)$$

~~u_1 = 7.8'~~ u = 7.684"

after $j = 7$

u_{j+1} = 7+1 = 8

Now put these value in eq(1)

$$\delta = \frac{1}{2\pi \times 7} \ln\left(\frac{7.684}{0.9}\right)$$

important

$\boxed{\delta = 0.0487}$ = $\frac{0.0487 \times 100}{100}$ = $\boxed{4.87\%}$

(b) natural Period of undamped Vibration = T_n =

as we know that

7 cycle of vibration are complete in 3.57 sec

Time required to complete one cycle = 3.57/7

T_D = 0.51 sec

Now we know that

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

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

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

Important

$$T_n = T_D/\sqrt{1-\zeta^2} \quad \text{--- (1)}$$

Now Put in eq (1)

$T_n = 0.51\sqrt{1-(0.0487)^2}$

$T_n = 0.5087 = \boxed{0.51\ sec}$

③ **Stiffness of Structure**

K

as we know that

$K = \frac{f\cos\phi}{2} = \frac{60\times\cos 60}{2}$

$= \boxed{15\ Kips}\ = \boxed{18000\ lb/ft}$

④ **Weight of the tank**

as we know that

$w_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{K}{w/g}} = \sqrt{\frac{K\cdot g}{w}}$

Important

Now

$w = Kg/\omega_n^2$

$\omega_n = 2\pi/T_n$

$w = Kg / 4\pi^2/T_n^2 = \dfrac{Kg \cdot T_n^2}{4\pi^2}$

$= \dfrac{180000 \times 0.51^2 \times 32.2}{4 \times (3.14)^2}$

$= \dfrac{1507539.6}{39.4384} = \boxed{38225.2 lb} = \boxed{38.3K}$

(5) Damping co-efficient

as we know that

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

$c = \zeta \times 2m\omega_n = \zeta \times 2m(2\pi/T_n)$

put value

$= \dfrac{0.0487 \times 2 \times \frac{38225}{32.2}}{0.51}$

Important

$$w = 115.63 \, lb.sec/ft$$

⑥ No. of cycle To reduce displacement Amplitude from 7.684" To 0.9"

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

$$j = \frac{1}{2\times\pi\times 0.0487} \times \ln\left(\frac{7.684}{.9}\right)$$

$$j = 7.00 \text{ cycles}$$

Important