McGill University
Department of Civil Engineering and Applied Mechanics
CIVE 603 – Structural Dynamics
HM#4
Group assignment by

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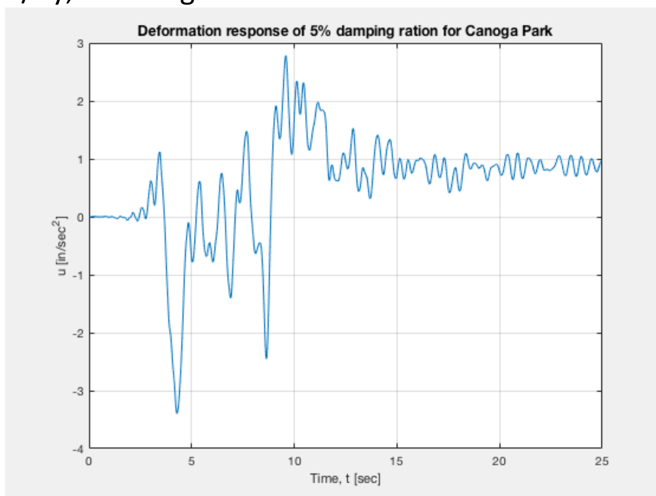
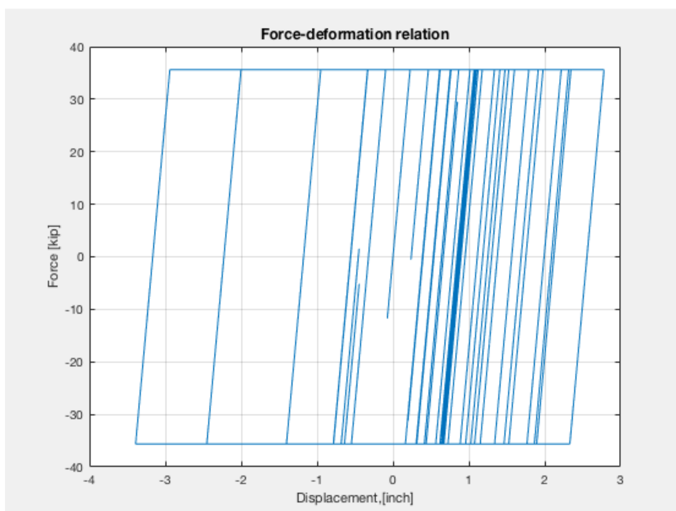
Problme1:

1. By setting Ry=1, we first get the elastic response and get the u0 = 1.8084 in, then set the Ry = 8, and uy =u0/Ry, we can get



2. The Force-deformation relation is shown as below:



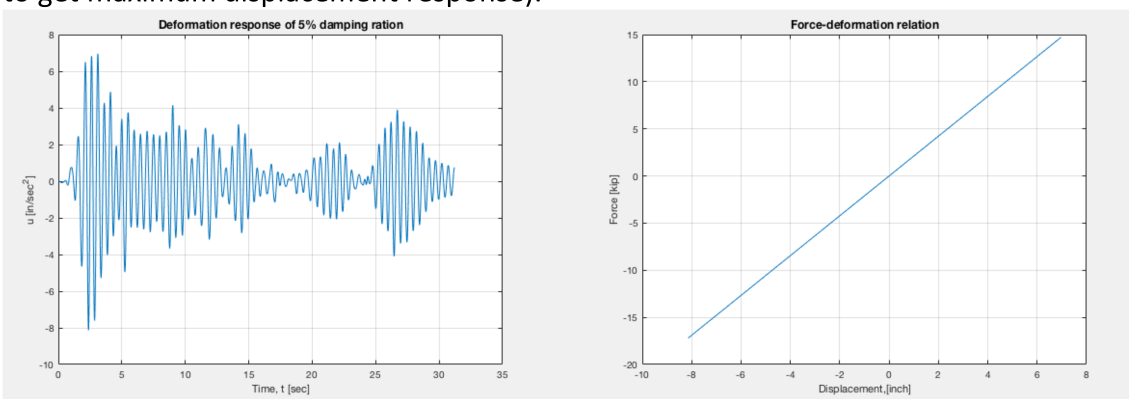
3. By the Command<max(abs(u))>, we get the maximum deformation umax = 3.38
   μ = umax/uy = umax/(u0/Ry) = 14.96

Problem2:

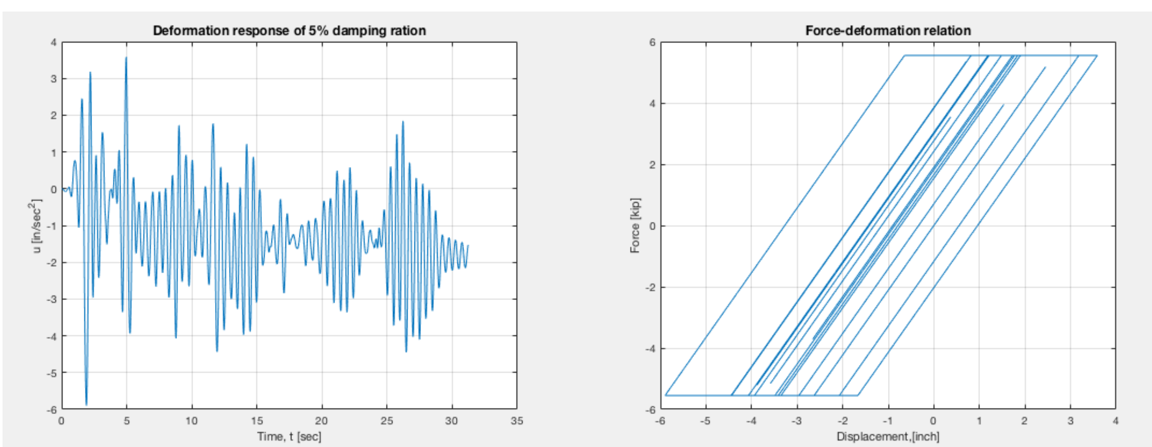
1. Tn = 2*Pi *(w/(k*g))^0.5 = 0.502s
   ξ = 2%
   uy = fy/k = 2.628 in

2. No, when the system vibrate at larger amplitude, it means the system is no longer elastic, and the force-deformation relationship is not linear, and the k is changed and Tn = 2*Pi *(w/(k*g))^0.5 is also changed. But the ξ keeps the same.

3. In corresponding system, the u0 = 8.187 in (By assuming an elastic response in the code to get maximum displacement response).

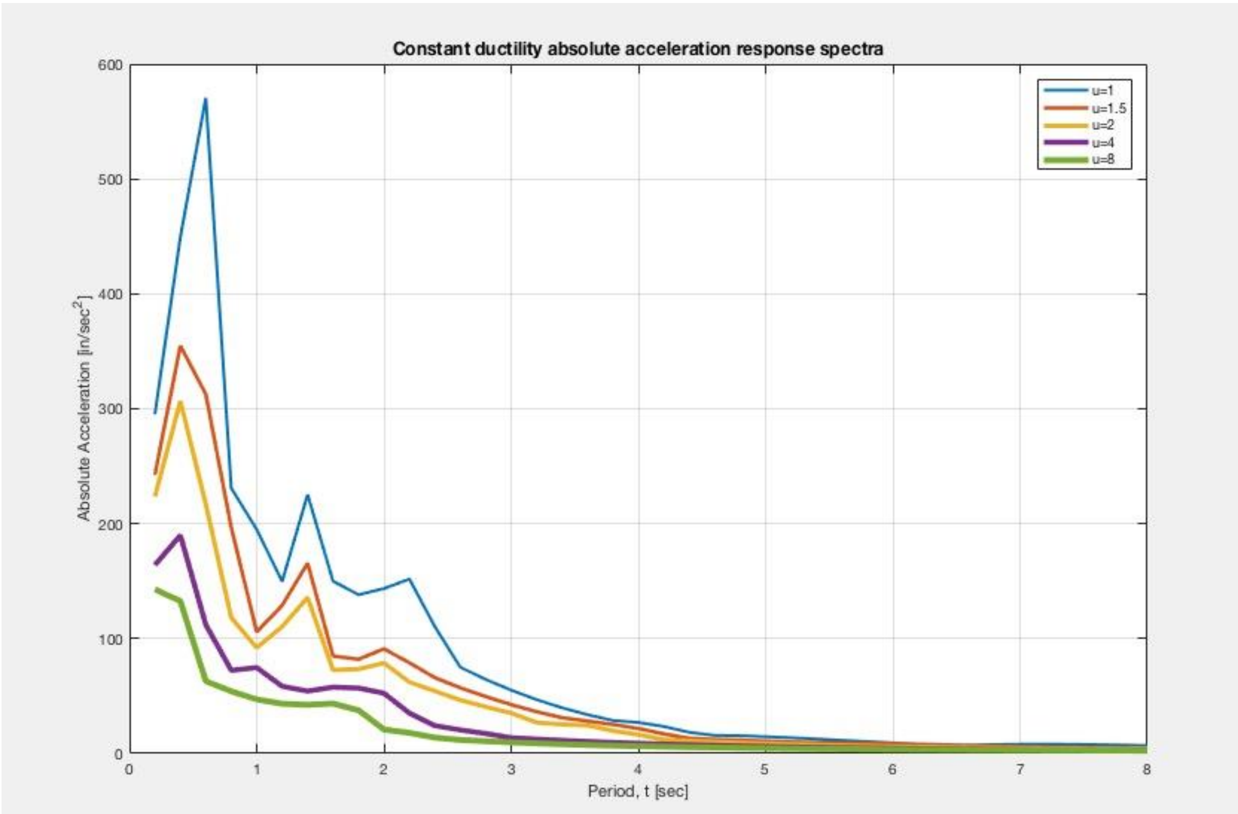


by setting the uy = fy/k = 2.628 in, we can get:



Ry = u0/uy = 8.187/2.628 = 3.115;
fy = 1/Ry = 0.321;

Problem3:

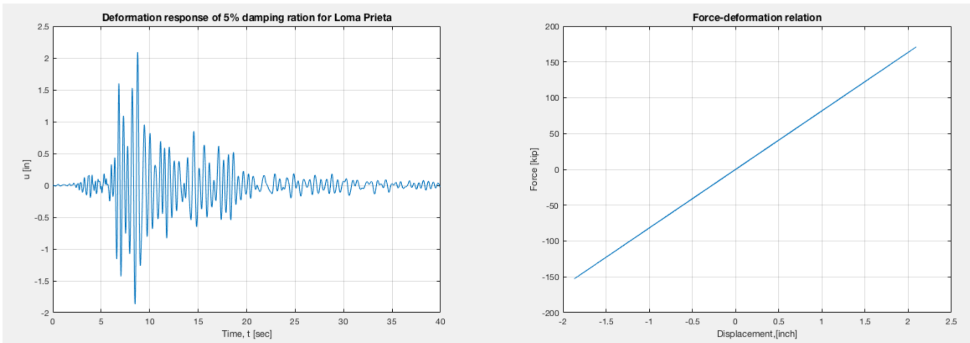


Constant ductility absolute acceleration response spectra
u=1
u=1.5
u=2
u=4
u=8
Absolute Acceleration [in/sec^2]
Period, t [sec]
0
100
200
300
400
500
600
0
1
2
3
4
5
6
7
8

Problem5:

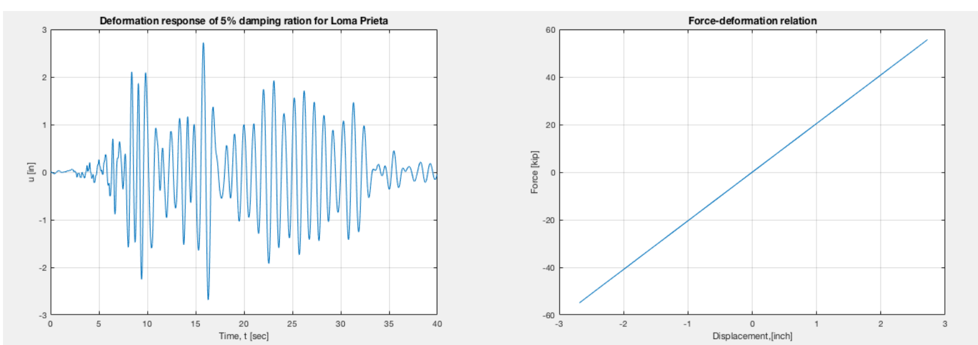
PartA

For Tn =0.5sec, the corresponding liner response is shown below:



k = m*wn^2
The maximum displacement u0 = 2.0923 in
The force demand f0 = k*u0 = m*wn^2*u0=171.08 kips

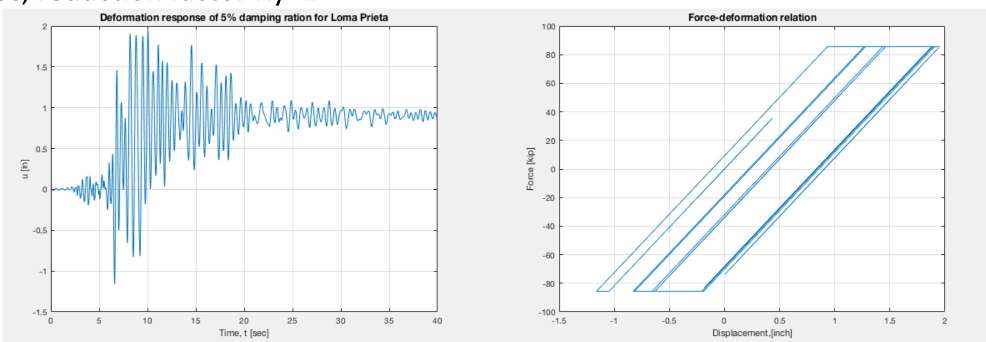
For Tn =1.0sec, the corresponding liner response is shown below:



The maximum displacement u0 = 2.723 in
The force demand f0 = k*u0 = m*wn^2*u0=55.66 kips

PartB

Tn =0.5 sec, reduction factor Ry=2



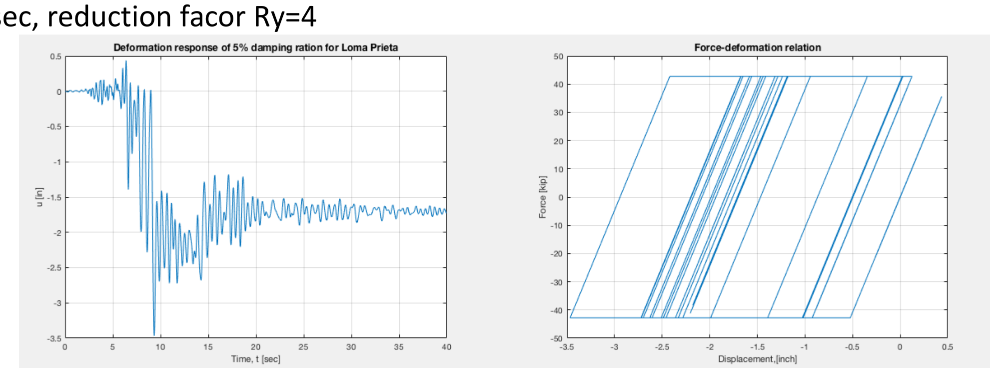
The maximum displacement umax = 1.95 in

uy=1.0465 in

fy=85.55kips

μ =1.86

Tn =0.5 sec, reduction facor Ry=4



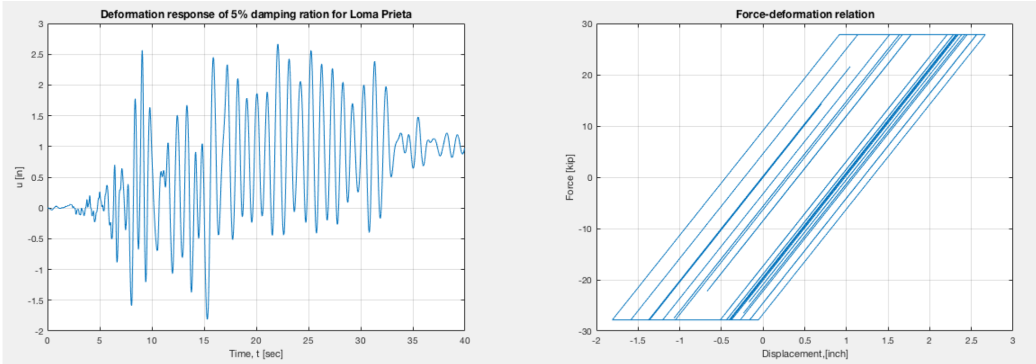
The maximum displacement umax = 3.47

uy=0.523 in

fy=42.77kips

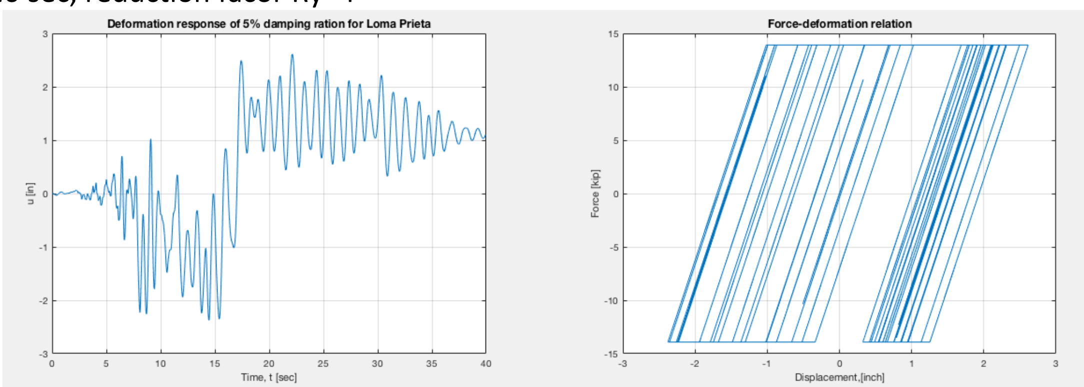
μ =6.64

Tn =1.0 sec, reduction facor Ry=2



The maximum displacement umax = 2.67
uy=1.362 in
fy=27.83kips
μ =1.96

Tn =1.0 sec, reduction facor Ry=4



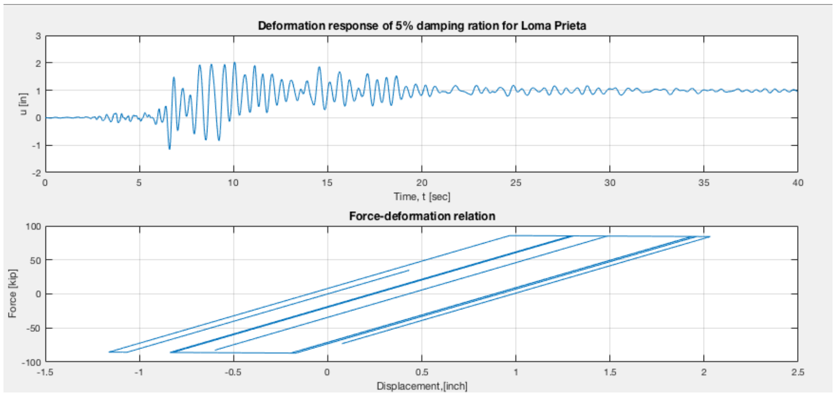
The maximum displacement umax = 2.61
uy=0.681 in
fy=13.92kips
μ =3.84

Conclusion:

As structural engineers, we should design structures looking for lower ductility demand because the ductility capacity should exceed the ductility demand.
When Ry equals to 4, the ductility demand is too high thus we eliminate these two cases first.
For Ry = 2, the properties and responses are similar, but when Tn = 1 sec, the yield force fy is much smaller than the case when Tn = 0.5sec, which means the cost of construction will be much lesser when Tn = 1 sec.
Thus, we should select the case when Tn = 1 sec and Ry = 2.

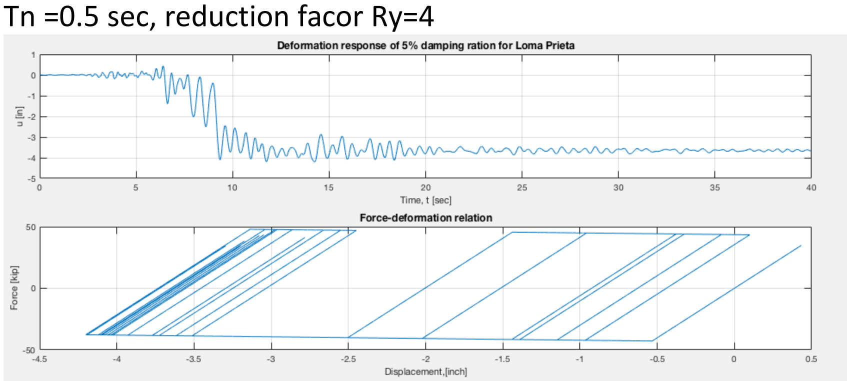
PartC:

Tn =0.5 sec, reduction facor Ry=2



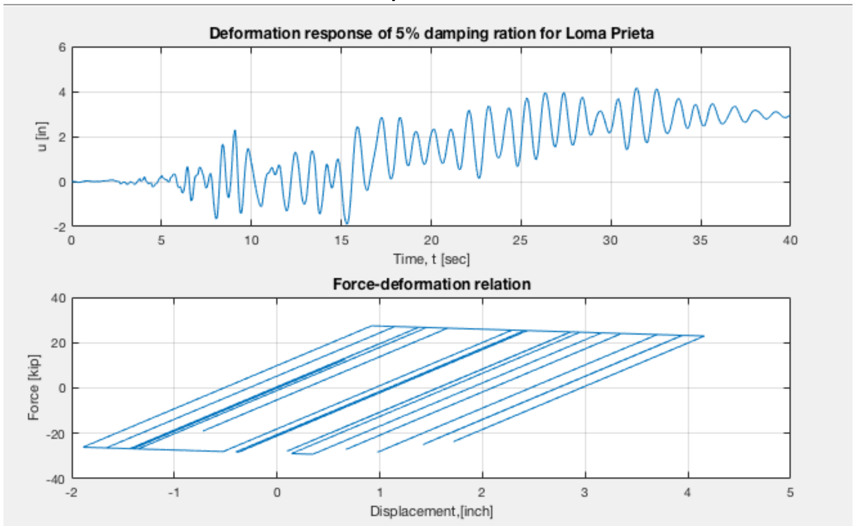
umax= 2.03
uy=1.065 in
fy=87.089kips
 μ =1.91

Tn =0.5 sec, reduction facor Ry=4



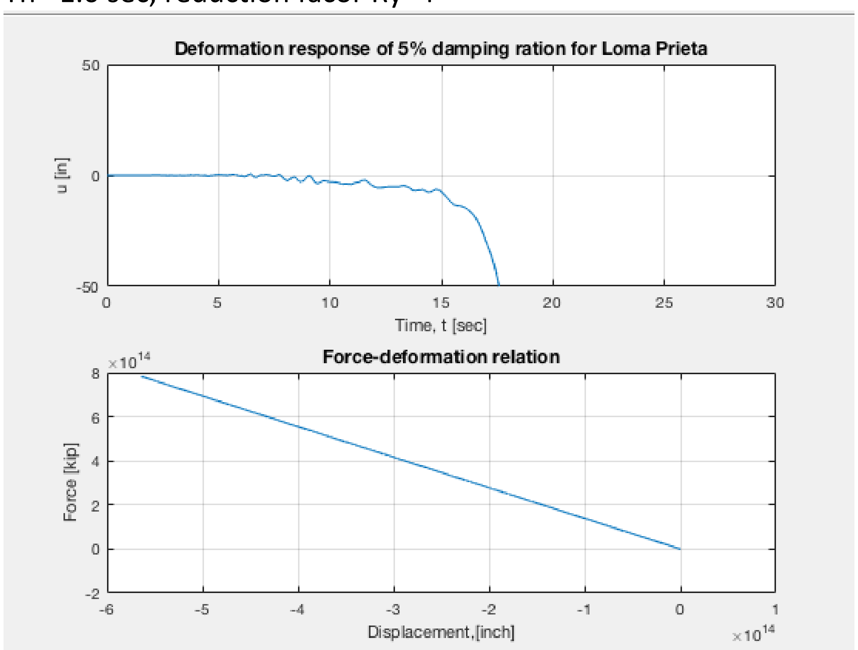
umax= 4.20
uy=0.5325 in
fy=43.545kips
 μ =7.89

Tn =1.0 sec, reduction facor Ry=2



umax= 4.16 in
uy=1.405 in
fy=28.723kips
μ =2.96

Tn =1.0 sec, reduction facor Ry=4



Conclusion:

Similarly from the part B, when Ry =4 and Tn =1.0 sec, the structure will collapse. When Ry =4, Tn= 0.5 sec, the ductility demand is too high.
When Ry =2, although when Tn= 0.5 sec, the yield force is higher than the case when Tn = 1 sec, the μ =1.91 is much lower than μ =2.96.
Thus we should choose Ry =2 and Tn= 0.5 sec.

oblem 4 :

$$m = \frac{W}{g} = \frac{10\ kips}{386.22} = 0.02589\ kips \cdot s^2/in$$

$$k = k_1 + k_2 = \frac{3EI}{L_1^3} + \frac{3EI}{L_2^3} = \frac{3\times 3\times10^3 \times \frac{1}{12}10^4}{(10\times12)^3} + \frac{3\times 3\times 10^3 \times \frac{1}{12}\times10^4}{(20\times12)^3}$$

$$= 4.883\ kip/in$$

$$T_n = 2\pi \cdot \sqrt{\frac{m}{k}} = 2\pi \cdot \sqrt{\frac{0.02589}{4.883}} = 0.4575\ S$$

$$A = 2.71 \times 0.25 \times 386.22 = 261\ in/s^2$$

$$U_{max} = \frac{m.A}{k} = 0.512\ in$$

Column 1 : $M_{max} = \frac{3EI}{L_1^2} \times U_{max} = 266.667$ kips-in

Column 2 : $M_{max} = \frac{3EI}{L_2^2} \times U_{max} = 66.667$ kips-in

b) $C_{cr} = 2m \cdot W_n = 2 \times 0.02589 \times \frac{2\pi}{T_n} = 0.7111$

$$\xi_{sp} = \frac{C}{C_{cr}} = \frac{0.1}{0.7111} = 14.1\ \%$$

$$\xi' = \xi_{sp} + \xi = 19.1\ \%$$

$$B = 1.400 - 0.248 \cdot \ln 19.1 = 0.668$$

$\therefore$ $S_a(T_n, 19.1) = B \cdot S_a(T_n, 5) = B \cdot 261\ in/s^2 = 174.348\ in/s^2$

$$U_{max} = \frac{m \cdot A'}{k} = 0.342\ in$$

(c)

~~Ry~~ $R_y = \mu + (1-\mu)\exp\left(\frac{-20T}{\mu}\right)$

$= 4 + (1-4)e^{\frac{-20\times 0.4575}{4}} = 3.695.$

$\therefore$ Lateral displacement:

$= \frac{u_{max}}{R_y} \cancel{\mu} = \frac{0.512}{3.695} \times 4 = 0.5543\ in$

Lateral force.

$\frac{m A}{R_y} = \cancel{6.775}\ 1.829$ kips.