Class of Structure of Dynamics

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Homework #5 (Total Points 100/100)

| $\alpha_1 : 11^{th}$ *digit of your student ID* |

For Example if your student ID:

40044404135

$\alpha_1 : 5 \quad if\ \alpha_1 = 0 \Rightarrow \alpha_1 = 1$

Note: If the 11th digit of the student number is zero, the number 1 should be used for α_1.

PROBLEM1:

Two identical pendulums, each with mass m and length l, are connected by a spring of stiffness k at a distance d from the fixed end, as shown in Figure 1.

a) Derive the equations of motion of the two masses.
b) Find the natural frequencies and mode shapes of the system.
c) Find the free-vibration response of the system for the initial conditions $\theta_1(0) = a$, $\theta_2(0) = 0$ $\dot{\theta}_1(0) = a$, and $\dot{\theta}_2(0) = 0$

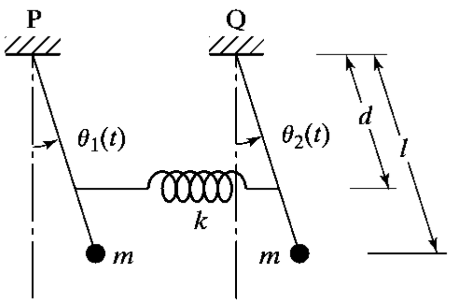

Figure 1-Two pendulums connected by a spring

PROBLEM2:

The floor masses and story stiffnesses of the three-story shear frame are shown in Figure 2.

a) Derive the equations of motion of the three masses.
b) Find the natural frequencies and mode shapes of the system.
c) Find the free-vibration response of the system for the initial conditions:

$$v(0) = \begin{Bmatrix} 0.1 \times \alpha_1 \\ 0 \\ 0 \end{Bmatrix} in\,, \ \dot{v}(0) = \begin{Bmatrix} 1 \times \alpha_1 \\ 0 \\ 0 \end{Bmatrix} \frac{in}{Sec}$$

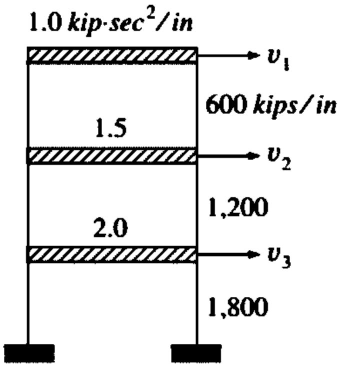

Figure 2- Three-story shear frame

PROBLEM3:

Consider the system shown in Figure 3, where $m = 70\ ton$ and $k = 6000\ kN/m$.

d) Derive the equations of motion of the foure masses.
e) Find the natural frequencies and mode shapes of the system.
f) Find the free-vibration response of the system for the initial conditions:

$$v(0) = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 2 \times \alpha_1 \end{Bmatrix} cm\ ,\ \dot{v}(0) = \begin{Bmatrix} 1 \times \alpha_1 \\ 0 \\ 2 \times \alpha_1 \\ 0 \end{Bmatrix} \frac{m}{Sec}$$

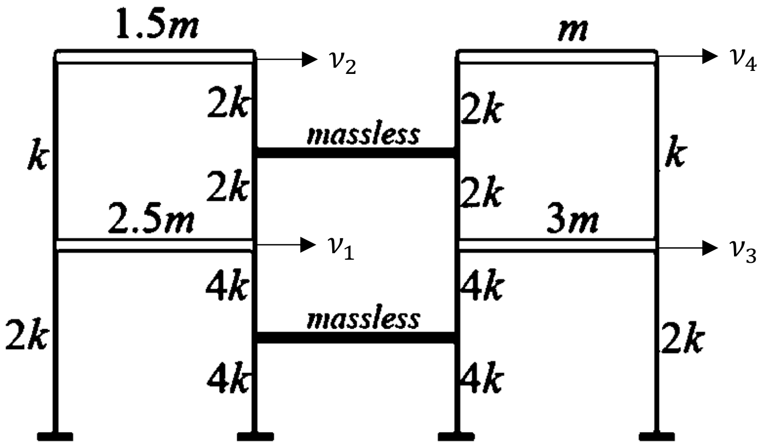

Figure 3

Hint: Static condensations : $k = k_{tt} - k_{to}\, k_{oo}^{-1}\, k_{ot}$, $k' = \begin{bmatrix} k_{tt} & \vdots & k_{to} \\ \cdots & \vdots & \cdots \\ k_{ot} & \vdots & k_{oo} \end{bmatrix}$

Good luck