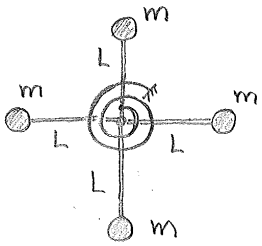
Theory exam in Structural Dynamics 2011-03-01 kl. 13-15

The test consists of 6 questions giving the maximum of 15 points. Each question should be answered on a separate paper. No helping aids are permitted on this test, except calculator. Do not forget to write your name on each submitted paper.

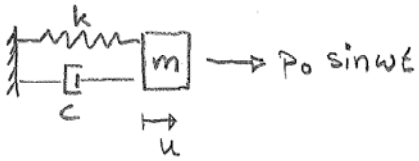
1) (2 p)

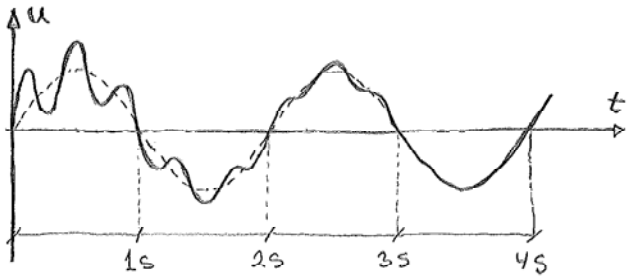


A simple model of a fan is made up of four (weightless) rigid bars and four point masses. The bars are rigidly connected to each other and attached to a frictionless joint. A torsion spring with the spring constant k_θ (Nm/rad) is connected to the bars in the joint. Determine the equation of motion and the natural frequency of the system.

2) (2 p)

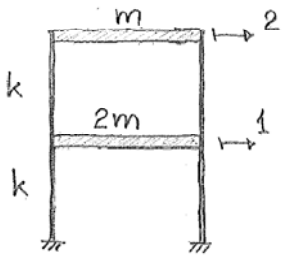
A damped single dof system, according to the Figure, has a forcing frequency ω. The response, in terms of displacement versus time, is shown below:





Determine approximately ω and the natural frequency ω_n for the system.

3) (3 p)



The two-storey shear building is governed by the equations

$$\mathbf{m}\ddot{\mathbf{u}} + \mathbf{k}\mathbf{u} = \mathbf{p}_0 \sin \omega t$$

with the following matrices

$$\mathbf{m} = \begin{bmatrix} 2m & 0 \\ 0 & m \end{bmatrix} \qquad \mathbf{k} = \begin{bmatrix} 2k & -k \\ -k & k \end{bmatrix} \qquad \mathbf{p}_0 = \begin{bmatrix} 0 \\ p_0 \end{bmatrix}$$

It is subjected to a stationary sinusoidal load in dof 2. Determine, without using modal analysis, the stationary vibration amplitude in dof 1 and 2 if the forcing angular frequency ω^2=k/m.

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4) (3p)

Show that the building in question 3) has the natural frequencies

$$\omega_1^2 = (1 - \frac{1}{\sqrt{2}})\frac{k}{m} \quad \text{and} \quad \omega_2^2 = (1 + \frac{1}{\sqrt{2}})\frac{k}{m}$$

Also determine the corresponding modes (eigen-vectors). They need not be normalized.

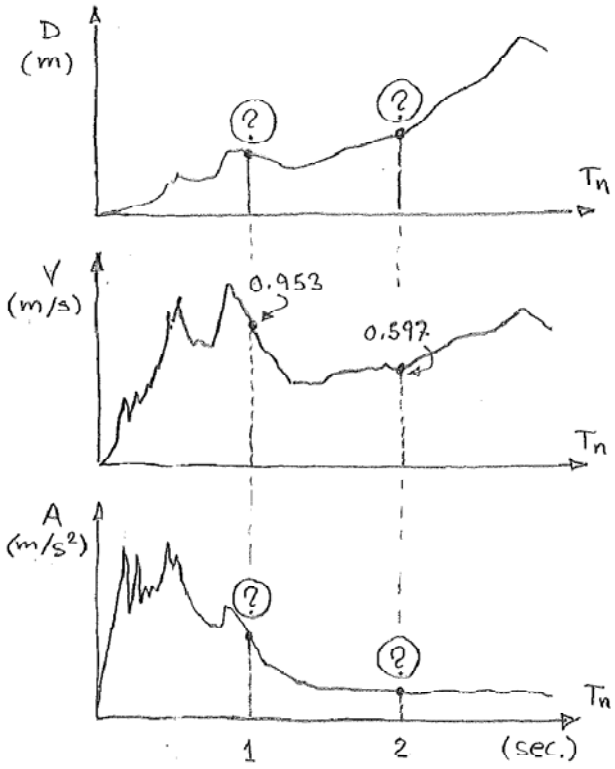
5) (3 p)

Assume linear deflection of the shear-building in question 3) using $\Psi_1 = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ and determine an approximation of the first natural frequency ω_1^2 by setting up the Rayleigh quotient.

Improve the approximation of ω_1^2 by assuming that the second mode is $\Psi_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.
Use Ψ_1 and Ψ_2 as Ritz vectors.

6) (2 p)

The response spectrum (ζ=0.02) for the El Centro earth quake is shown below in terms of pseudo displacements, velocities, and accelerations.



Calculate the four values with question marks; *D(1), D(2), A(1),* and *A(2).*

Also give a short explanation of the difference between response history and response spectrum.