Mechanical System Dynamics

Exam Simulation

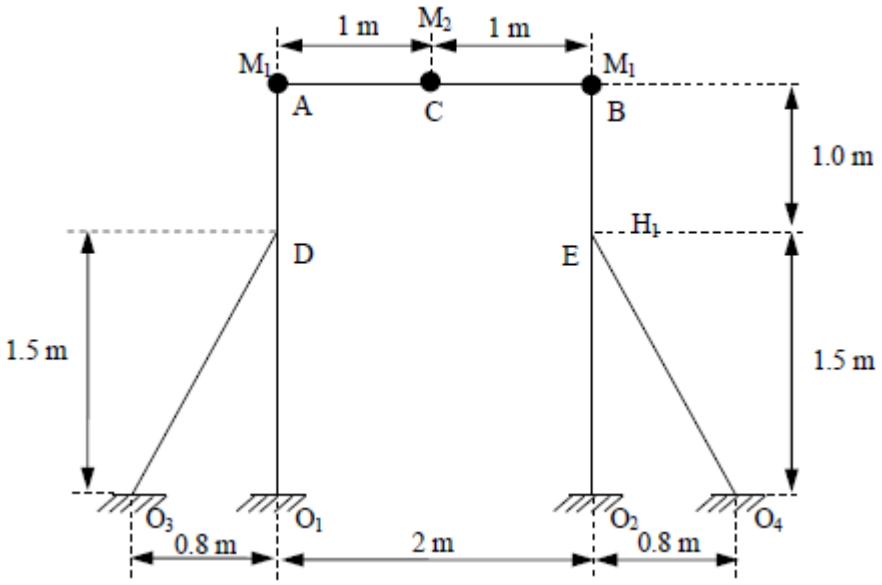

Figure 1. Structure.

Structural properties:

Beams O_1A, AB and O_2B:

$m_1 = 33.50$ kg/m $\quad EA_1 = 8.85E8$ N $\quad EJ_1 = 3.10E6$ N·m^2

Beams O_3D and O_4E:

$m_2 = 10.30$ kg/m $\quad EA_2 = 2.72E8$ N $\quad EJ_2 = 6.55E5$ N·m^2

Mass and Mass Moment of Inertia of lumped masses in A, B and C:

$M_1 = 20$ kg $\quad I_1 = 0.04$ kg·m^2 $\quad M_2 = 50$ kg $\quad I_1 = 0.1$ kg·m^2

Assume a Rayleigh model for damping, say $[C] = \alpha\cdot[M]+\beta\cdot[K]$, with coefficient $\alpha = 1$ s^{-1} and coefficient $\beta = 1E\text{-}5$ s.

1. Build a FEM model for the structure depicted in Figure 1, reliable in the frequency range 0 – 200 Hz. Save the figure of the undeformed structure in a file .fig as SNxxx1.fig where S is the first letter of your surname, N is the first letter of your name and xxx are the last three numbers of your ID number (Matricola) (example: Bruni Stefano 123456: BS456).
2. Compute the first 3 natural frequencies and mode shapes. Save the results in three files .fig as SNxxx2.fig, SNxxx3.fig and SNxxx4.fig. Obtain the modal mass and stiffness for the first 3 mode shapes.
3. Compute the Frequency Response Function in the band 0 – 200 Hz (resolution: 1 Hz) of vertical displacement of C and horizontal displacement of E due to a vertical force applied in C. Save the results as SNxxx5.fig and SNxxx6.fig. **Comment the results** (see table 1).
4. Compute the steady-state response of the horizontal acceleration of B due to a periodic force applied in the horizontal direction in A. The time history of the force is reported in Figure 2 (T = 0.1 s and F_{max} = 1E5 N). Neglect any contribution of the external force for harmonics higher than the third. Save the result as SNxxx7.fig. Moreover, identify the values of period T that produce a resonance condition for the structure in the frequency range 0 – 200 Hz (consider just the first three harmonics of the external force). **Describe your reasoning** (see table 1).
5. Compute the Frequency Response Function in the band 0 – 200 Hz (resolution: 1 Hz) of the axial load of the upper end of O_3D beam due to a horizontal force applied in C. Save the result as SNxxx8.fig.

6. Define a structural change able to increase at least of 40% the first natural frequency of the system without introducing elements in the space enclose by the main structure O_1ABO_2 and without increasing the mass of the system more than 10%. Any change of material is not allowed, all constraints must be applied at the level of points O_1, O_2, O_3 and O_4. If the section of one or more beam is changed, the inertial and stiffness parameters m, EA, EJ must be modified consistently with the change in shape and/or size of the section itself, i.e. if k^2 is the ratio between the modified value of parameter EJ and the original one, the modified values of parameters EA and m will be obtained by multiplying the original values by k. Save the result as SNxxx9.fig. **Briefly describe the changes implemented**.

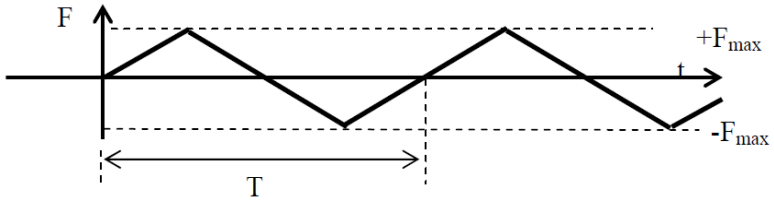

Figure 2. Time history of the horizontal periodic force applied in A.

Table 1

Surname	**Name**		**ID number/ code SNxxx**		
1.					
File name .inp					
2.					
1st Natural Frequency [Hz]		m_{m1} [kg]		k_{m1} [N/m]	
2nd Natural Frequency [Hz]		m_{m2} [kg]		k_{m2} [N/m]	
3rd Natural Frequency [Hz]		m_{m3} [kg]		k_{m3} [N/m]	
3.					
Maximum amplitude of the vertical displacement in C					
Maximum amplitude of the horizontal displacement in E					
Comment figures SNxxx5 and SNxxx6					
4.					
5.					
Maximum amplitude of axial load					
6.					
File name .inp					
1st Natural Frequency [Hz] for the modified structure					

SUBMISSION OF RESULTS:
Create a MATLAB file with the commands needed to solve the exercise and save it as SNxxx.m (e.g. for Bruni Stefano 123456: BS456.m).
Compress all the results to be submitted (SNxxx.m, *.inp, and .fig files) in a file saved as SNxxx.zip (or SNxxx.rar) that must be submitted by uploading it on Beep, following the instructions below reported:

- Connect to website https://beep.metid.polimi.it/ and login by using your Person Code and Password;
- Select the course “Dinamica dei Sistemi Meccanici” and select the Tab “Consegne”;
- Select the folder “Test_15_06_2015” and select the Tab “Aggiungi” and “Documento singolo”;
- Fill the field “Titolo” with the code SNxxx (e.g. for Bruni Stefano 123456 BS456);
- Select your compressed file SNxxx.zip by clicking on “Sfoglia” and corfirm the upload by clicking on “Pubblica”