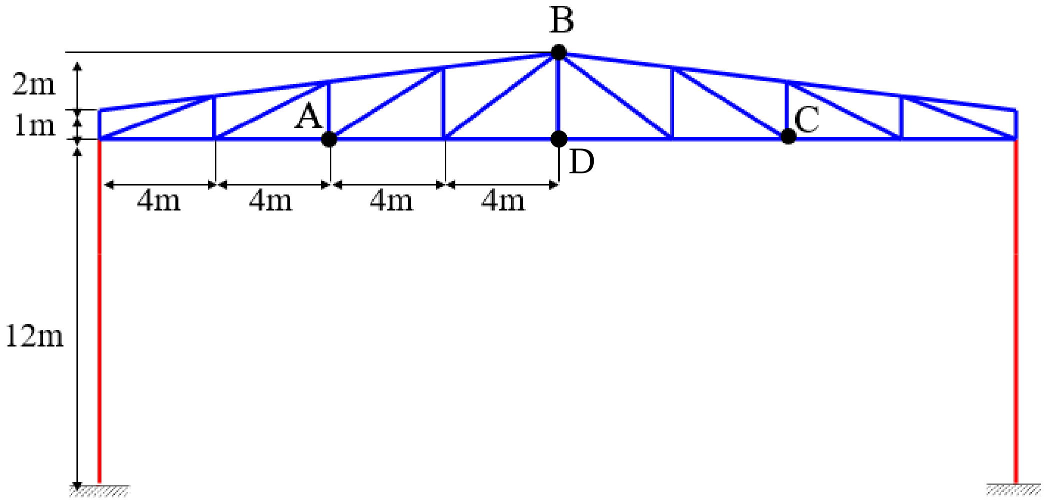
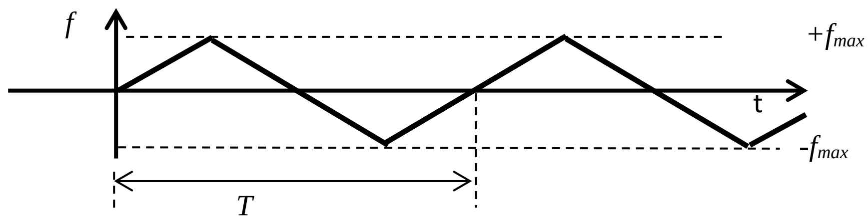
Dynamics of Mechanical Systems Academic year 2022-2023

Yearwork



Consider the structure shown above, representing a hangar portal frame. All beams are made of steel ($E=2.06e11\ N/m^2$, $\rho=7800\ kg/m^3$). Beams in blue colour have IPE240 cross section ($A=3.912e-3\ m^2$, $I_y=3.892e-5\ m^4$) and beams in red colour have IPE500 cross section ($A=0.01155\ m^2$, $I_y=4.82e-4\ m^4$). Damping is defined according to the proportional damping assumption: $[C]=\alpha[M]+\beta[K]$, with $\alpha=0.2\ s^{-1}$ and $\beta=8.0e-5$ s.

1. Define a FE model of the structure in the 0-20 Hz frequency range. Print the undeformed structure
2. Compute and print the first 4 natural frequencies of the structure and their modal shapes.
3. Compute and print the Bode diagrams of the frequency response functions for a unit input force applied at point A in vertical direction considering as output the horizontal and vertical displacements of point B. Compute and print the Bode diagrams (in linear scale) of the frequency response functions for the same input force considering as outputs the horizontal and vertical acceleration of point B.
4. Compute and print the Bode diagrams of the frequency response functions for a unit horizontal displacement applied in phase at the base of both pillars, considering as output the horizontal reaction force and clamping moment in the clamp of the left pillar.
5. Compute and print the time history for time t=[0:1e-3:1.5] (in seconds) of the vertical displacement and acceleration of point D produced by a vertical force applied at D having the periodic waveform shown below with period T=0.3s and amplitude f_{max}=1000 N.



For the same input, find values of the period in the range 0.1 s ≤ T ≤ 0.5 s producing a resonance of the system.

6. Plot the Bode diagrams of the horizontal and vertical acceleration of points B and C for the excitation produced by an unbalanced mass **m_s=5kg** having eccentricity ε=5mm and rotating around point A with angular speed Ω=2πf (f=[0:0.01:20]). You can get a hint on how to solve this point from Section 3.3 in: *Meirovitch L., Fundamentals of Vibrations, Mc Graw-Hill International Edition, 2001* or in: *Lieven N. A. J., Forced Response, in Encyclopedia of Vibration, S. Braun et al. Editors, Academic Press 2001, available as e-book in POLIMI e-book resources.*
7. Define a modified design of the structure to reduce by a factor 2 at least (reduction to 50% of original value) the clamping moment in the clamp of the left pillar under the excitation condition described at point 4. In defining the modified design, consider the following constraints:

a. The distance between the two pillars and their height cannot be changed. The space delimited by the two pillars, the floor and the roof must remain clear to allow proper use of the hangar;
b. the increase of the structure's total **mass** shall not exceed 5%;
c. no change of material properties can be used, i.e. material shall remain the same;
d. changes in the sections of the beams are possible, but a standardised section (types IPE, HPE or HPM) shall be used;

Note: All Bode diagrams to be plotted in linear scale in the 0-20 Hz frequency range with frequency resolution 0.01 Hz.