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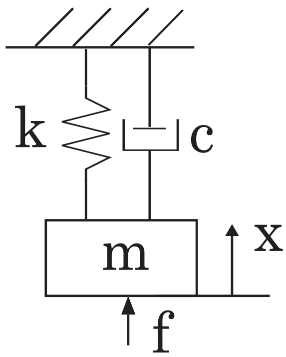
Session 1 : One DOF Systems and Response Spectra

Exercise 1

Consider the following one-degree-of-freedom (1 DOF) system



- Write the equation of motion in the time domain. Give the expression of ω_n and of ξ
- For this system
  a) Give the expression of the impulse response and represent it using the following numerical values: $m = 1\,kg$, $k = 16\,N/m$, $c = 0.1\,Ns/m$). Give the values of ω_n, ω_d and ξ.
  b) Give the expression of the harmonic force response and represent it using the Bode diagram (plot both the amplitude and the phase)
  c) Repeats points a),b) and c) with the following successive values of damping: $c = 0.1\,Ns/m$, $c = 0.5\,Ns/m$, $c = 10\,Ns/m$. What are the corresponding values of ξ? Plot the respective responses on the same Bode diagram (both amplitude and phase)

Exercise 2

Consider the same 1-DOF system as in the previous exercise and a value of $c = 0.1\,Ns/m$. Use Duhamel's integral to compute the response of the system to:

a) A harmonic force of the form $f(t) = sin(\omega t)$ where $\omega = \omega_n$

b) A harmonic force of the form $f(t) = sin(\omega t)$ where $\omega = 0.95\omega_n$

c) A random force generated from a gaussian distribution of mean 0 and variance $\sigma = 1$ (use the functions `randn` and `conv` in Matlab/Octave.

Consider the recorded base acceleration signals given in the $input.mat$ file, corresponding to typical earthquakes in the Bosphorus area in Turkey. The first column corresponds to the time domain vector, and the eight others to eight different earthquake signals.

Exercise 3

a) Plot the time domain accelerations of the different earthquakes.

b) Perform a Fourier transform of the acceleration signals (using fft function in Matlab) to determine the frequency range of excitation of the earthquakes

c) Compute the relative displacement response spectrum S_u for each earthquake signal, plot all the response spectra on a single graph and compare. Use different values of the damping factor ξ from 0.01 to 0.05 and discuss the effect of the damping factor. (use the impulse response and Duhamel's integral to compute the response for each period of the one dof system)

d) Transform the relative displacement spectrum in the pseudo-acceleration spectrum corresponding to S_e in the Eurocodes ($S_e = \omega_n^2 S_u$) and plot all spectra on the same graphs.