A simple one-story steel portal frame has the properties shown in Fig. 1. The structure has a lateral elasto-plastic behavior. The yield shear force, \( V_y \), represents the necessary lateral force at the floor to simultaneously yield all columns of the portal frame. The frame is subjected to the S00E component of the accelerogram recorded at El Centro is provided with an example in a reference program package (see below)

![Figure 1 - Simple steel portal frame with lateral elasto-plastic behaviour.](image)

where

- \( m = \text{mass at the floor level} = 1 \text{ kN} - \text{s}^2/\text{mm} \)
- \( k = \text{lateral stiffness} = 39.5 \text{ kN/mm} \)
- \( \xi = \text{critical damping ratio} = 0.05 \)

a) Plot the first 5 seconds of the lateral displacement time-history at the floor level, \( x(t) \), for \( V_y = 490 \text{ kN} \) and \( V_y = \alpha \) (infinite). Use the average constant acceleration method with a time-step of 0.01s. You must hand in your computer code. (use one step correction if necessary)

b) Compare your results with the time history analysis predictions of the computer program NSPECTRA. The El Centro record is provided with the example in the program package.

c) Using the NSPECTRA program, determine the peak relative displacement of the frame for yield shear forces of 200, 490, 1000, 2000, 3000, 4000 and 6000 kN. Plot the results and comments on the validity of the equal-displacement principle in earthquake engineering.

The program NSPECTRA can be downloaded from the class website Software (zipped package). The package has a short instruction manual and two examples. You may use the first example with proper adjustments to solve part (b) and (c).