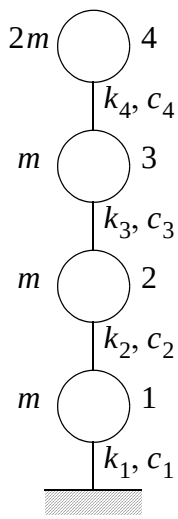
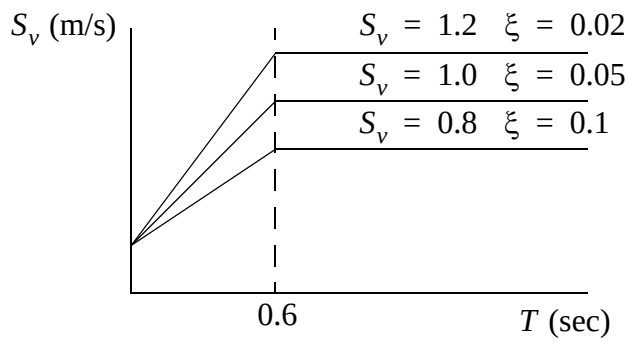
Examination, December 9, 2004

1.561 Motion-Based Design

Problem #1 (50%)





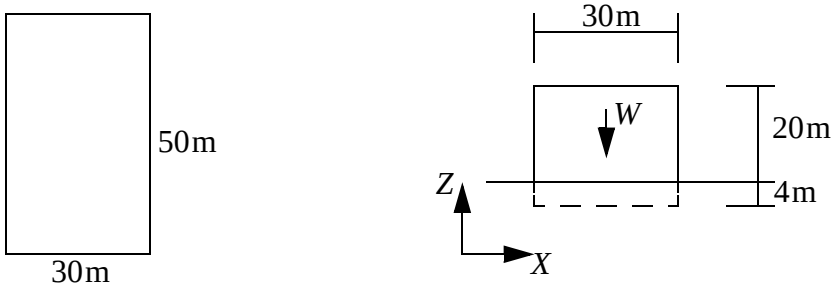
Consider the 4 DOF system shown. Take $m = 10000\ \mathrm{kg}$.

1. Determine the stiffness distribution such that the maximum displacement at node 4 (the top node) is 0.075m for the pseudo-spectral velocity plot shown above. Assume 5% damping for the fundamental mode.

2. Suggest values for c_1, c_2, c_3, c_4 that produce 5% damping for the fundamental mode.

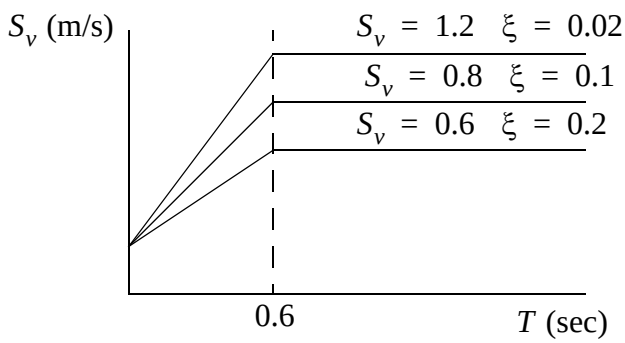
3. Design a tuned mass damper to be attached to node 3 that will produce an equivalent damping ratio of 10% for the first mode.

Problem #2 (30%)



Plan Elevation

You are retained to design a retrofit seismic isolation scheme for the building shown above. Assume the structural system is a 3D reinforced concrete rigid frame with columns spaced at 10m intervals in both the X and Y directions, and a floor height of 4m. There is one level below ground, and the columns rest on footings placed at this sub-level. The design criteria for the spectral velocity recommended for this particular site is shown below.



Take the total building weight as 1000 kN, and the maximum relative motion between the building and the ground as 0.3m. Describe and document, with simple calculations, how you would specify an appropriate isolation system. The owner is also interested in knowing what the maximum acceleration due to the design seismic excitation would be. Comment.

Problem #3 (10%)

Assuming you have properly designed a base isolation system, would you place damping devices in:

a) the structure

b) the bearing system

Elaborate on your choice.

Problem #4 (10%)

Consider a SDOF system subjected to periodic excitation with a frequency equal to the fundamental frequency of the system. To limit the motion, a TMD is incorporated. Recommend values for m_d, k_d, and c_d such that the following constraints are satisfied:

$$a\big|_{max} \le 5\frac{\hat{p}}{m}$$

$$u_d\big|_{max} \le 5u\big|_{max}$$

Hint: See Section 4.2