22.314/1.56/2.084/13.14 Fall 2006

Problem Set IX

Due 11/21/06

This problem set illustrates some features of seismic analysis. A response spectrum modal (lumped mass) method is to be used.

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1) Geometry, Properties, Supports: The reactor component of interest is represented by a pipe. The pipe is subjected to a seismic ground motion that acts parallel to the x-direction. The axis of the pipe in the z-direction.

The pipe has an outside diameter of 210mm, a wall thickness of 7mm, and a length of 3m. The pipe is made of a material with Young's modulus = 200 Gpa and density = 8500 kg/m^3. Liquid water (density = 750 kg/m^3) is present both inside and outside of the pipe. The added mass coefficient for the outside water is 1.1. Neglect direct treatment of fluid friction, fluid drag, and solid friction – these effects are incorporated in the damping matrix of item 2.

The support at z = 0 is fixed (zero displacement and zero slope). The support at the other end (z=L=3 m) is a roller (zero displacement, zero moment, and zero axial force).

2) Lumped Mass Treatment: Use two equal point masses (located at z = 1 m and at z = 2m). The total mass for the two points should equal the sum of the pipe mass, the internal liquid mass, and the added mass of the external liquid.

"Massless springs" should be chosen to give the same stiffness characteristics at the point masses as for a beam with the same supports (the resulting stiffness matrix has no zeros).

The damping matrix should have only two non-zero elements (located on the diagonal). These elements should be equal and should give 2% critical damping for vibraton at the system fundamental frequency.

3) Earthquake Characterization: The ground motion is characterized by the response spectrum of Fig 8 in Note M-32 {To provide legibility, use a multiple straight line set of segments given by:

$$\left[S_d = 560mm\right];\left[S_v = 1.15m/\sec\right];\left[S_a = 1.4g\right];$$

end points $\left(S_q, S_a\right) of \left(5mm, 1.4g\right) and \left(0.25mm, 0.33g\right)$

$$and \left[S_a = 0.33g\right]; where\ g\ is\ the\ acceration\ of\ gravity$$

4) Questions:

a) What is the fundamental undamped frequency?

b) What are the peak forces that act on the supports during the earthquake?