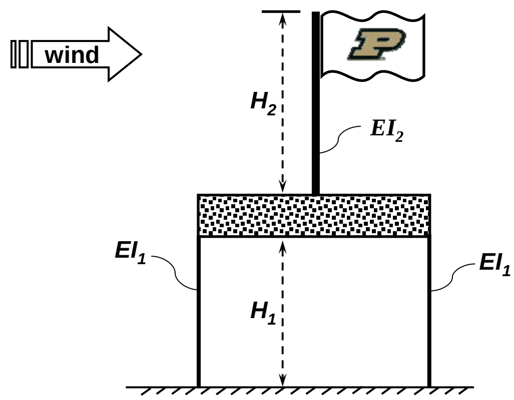
CE573 – Structural Dynamics
Sample Questions

1) The total wind drag acting on a flag of mass ***m*** can be represented as ***f(t)***. The flag is hoisted to a massless flagpole which is rigidly connected at its base to a rigid massless girder. The girder is supported by two columns. Column connections, at both ends, are rigid. The columns and the flagpole resist forces via bending. Their properties are shown on the figure.

   Assume that the flag can be lumped as a point-mass at the tip of the flag-pole. Ignore gravity.

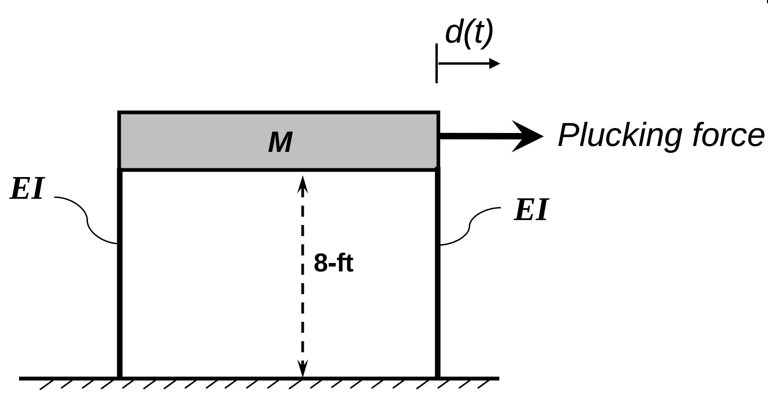
   a) Write the differential equation of motion for the system.
   b) Write the expression for the natural frequency of the system.



2) At the Bowen Laboratory, a single-story test structure with heavy roof has been subjected to dynamic tests. The structure is 8-ft tall and is supported by four concrete prismatic columns (E = 3,000 ksi). The columns have a cross-section of 12-in by 12-in. An elevation view of the structure is shown below.

   In one of the tests, the structure was pulled statically with 40 kip force causing it to deflect 0.10 inches at its roof level. The load was then removed instantaneously and the displacement response of the structure was recorded. It was found that at the end of first swing, which took 0.5 seconds to complete, the structure came within 0.02 inches of the release location (i.e. it deflected 0.08 inches from its undisturbed, vertical position). Ignore the mass of the columns and the gravity.

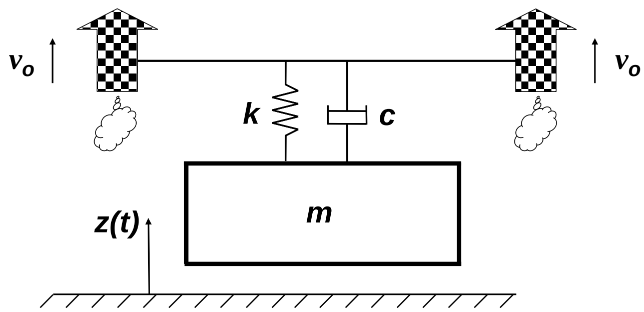
   a) Find the damping ratio of the structure.
   b) Find the mass of the slab.
   c) Find the minimum number of full-cycles the structure needs to go through such that its deflections are reduced to no more than ±0.01 inches about its equilibrium position.



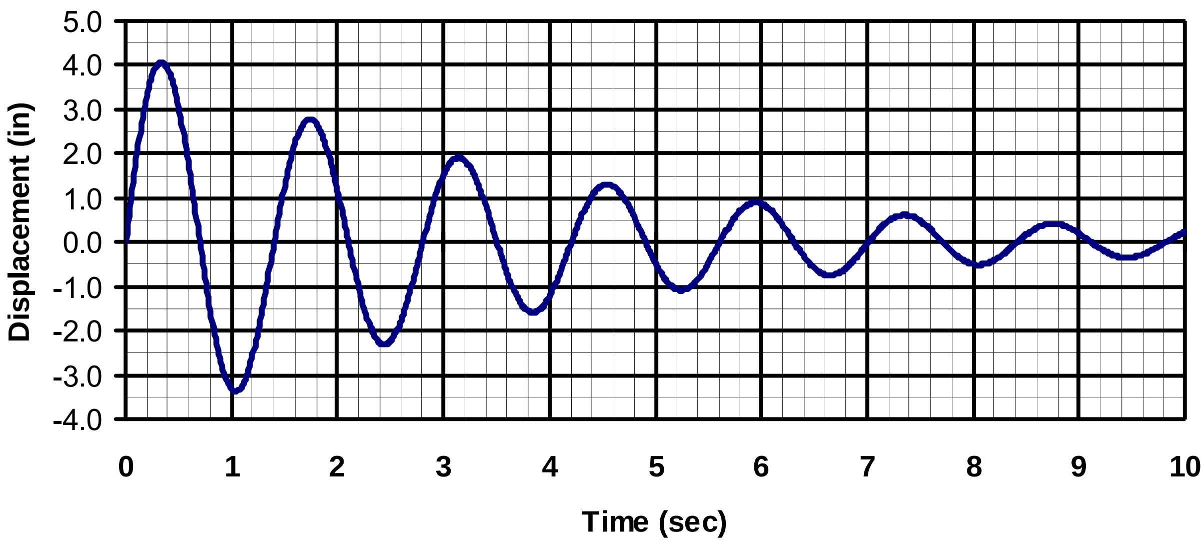
3) You are asked to review a space elevator. This elevator can be idealized as a chamber (mass *m*) supported from above by a linear spring (stiffness *k*) and a linear viscous dashpot (damping constant *c*) which are both attached to a set of rockets (see illustration below). The rockets fly up vertically at a constant speed v_o. Ignore the effect of gravity.

a) Write the governing differential equation of motion for the elevator chamber.

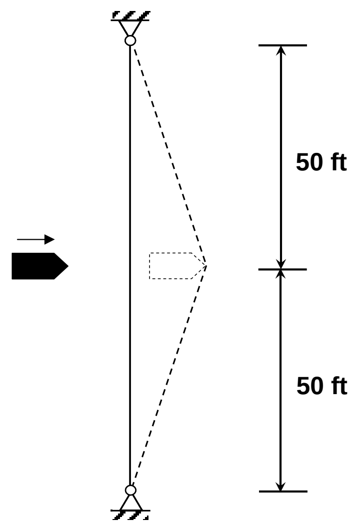
b) Solve the differential equation of motion to find the expression for the distance travelled by the elevator chamber, i.e. *z(t)*, as the rockets lift off vertically with a speed v_o =50 m/sec. Assume that the chamber has a mass 1000 kg and is initially at rest. Use k = 4000 N/m and c = 2000 N·sec/m.



4) A viscously damped structure is set into free vibration with an initial velocity. The resulting damped oscillations are recorded and shown below. Determine the natural period of vibration and the damping ratio as fraction of the critical damping from the record.



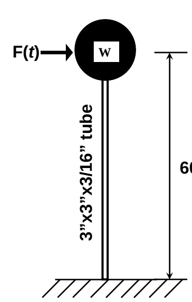
5) A rigid vehicle weighing 2000 lb, moving horizontally at a velocity of 12 ft/sec, is stopped by a barrier consisting of wire ropes stretched between two rigid anchors 100 ft apart. The wire ropes have a total cross-sectional area of 1.25 in^2 and a modulus of elasticity of 26,000 ksi, and are stretched to an initial tension of 1000 lb. The vehicle moves normal to the barrier and strikes it at mid-height. Find the maximum deflection of the barrier. Assume ideal conditions, that is, a rigid vehicle, weightless barrier, no friction, no damping, and perfectly elastic ropes.



6) A 60-in long 3 in x 3 in x 3/16 in tube cantilever structure supports a 2000-lb weight attached at the tip. The properties of the tube are as follows: cross-sectional area, A = 2.02 in^2 ; moment of inertia, I = 2.60 in^4; section modulus, S = 1.73 in^3; and, modulus of elasticity, E = 29,500 ksi.

The system is subjected to a sinusoidal force at the tip, acting horizontally in one of the planes of symmetry. The force has an amplitude of 250 lb and oscillates at 3 cycles per second. Assuming that the system is damped to 2 percent of critical damping, find the maximum steady-state tip displacement and the maximum steady-state bending stress in the cantilever.

Treat the attached weight as concentrated at the tip of the support structures and neglect the weight of the tube. Neglect P-Δ effects, that is, neglect the bending moment due to the eccentricity of the gravity force on the tip load with respect to the base of the cantilever.



7) A package weighing 50 lb is suspended in a box, as shown below, by two springs with a stiffness of 250 lb/in each. The box is placed inside a truck that produces vertical harmonic vibrations during transport of amplitude y(*t*) = 1.5 sin(4*t*) in. Determine the maximum steady-state displacement, velocity and acceleration experienced by the package. Ignore the transient response. Ignore damping.