Computer Assignment:

Due Dec 6^{th} , 2007

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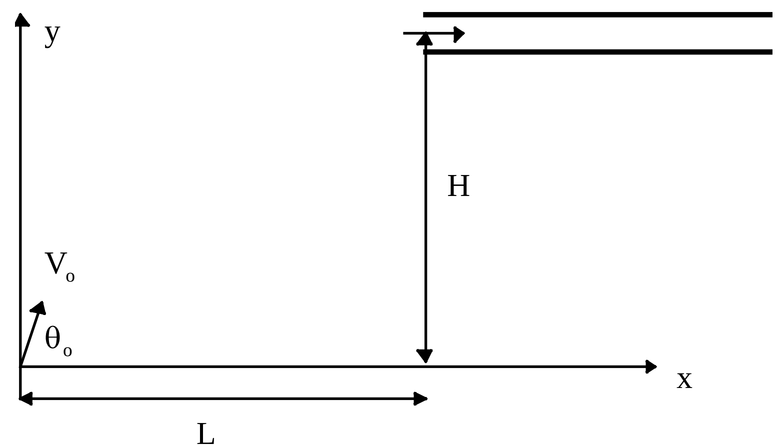
[1] As part of an assembly line process, you are asked to design a device that launches small machine components (pellets) through the air into a horizontal receiving tube (see figure).



Given:

- Mass of pellets: m = 0.5kg
- Drag coefficient: C = 0.01 to 0.03 kg/m depending on the shape of the pellets.
- Height at which the tube is located: H = 5m
- For space/safety reasons, the horizontal distance between the launching point and the receiving tube can be no more than: L = 10m.
- The pellets must enter the receiving tube smoothly with *essentially* zero vertical component of the velocity (or else the pellets will bounce off).

You are asked to determine a possible location for the launching device and the velocity with which the components must be shot out.

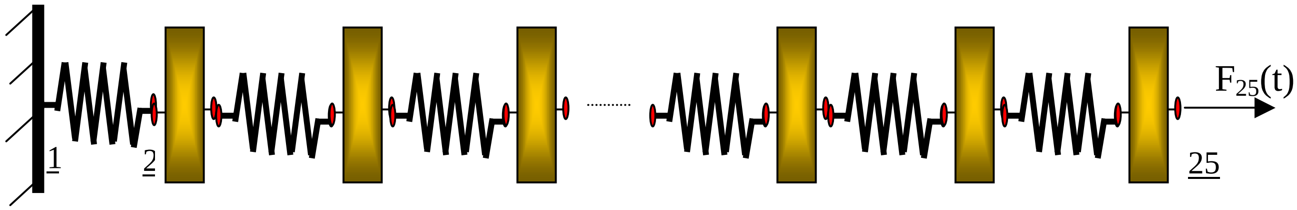
1. You can solve this problem analytically for the case of zero drag (C=0). Do this first. [5 points]

2. Next, adapt a MATLAB program to solve the cases with air drag. Establish the necessary time step to get reasonable accuracy by comparing the MATLAB results with the analytical results. The analytical solution with C=0 will also give you a clue as to what initial conditions might be appropriate for the subsequent numerical solutions with non-zero drag. In the numerical solutions, you should try to get the pellets to within 5% or better of the x and y location of the entry to the receiving tube, with a vertical velocity of magnitude no more than 0.1m/s. Choose a drag coefficient of C=0.02kg/m as a representative example. [15 points]

Your report should set out clearly:

- the statement of the problem,
- any assumptions you have made,
- the analytical solution for the zero drag case,
- a typical solution that works for the case with air drag; and
- the accuracy to which you have computed the solution.

[2]. A very long spring-mass system consisting of 12 springs and 12 masses is shown below. A force source acts at the very last node (node 25) as shown.



(2.i) [8 points] Obtain the first-order state equation for this system: $\dot{\underline{\mathbf{X}}} = \underline{\mathbf{A}}\underline{\mathbf{X}} + \underline{\mathbf{F}}$

Hint: The best way to do this is to first take a look at all the spring mass systems we have analyzed thus far, and to see if we can identify any pattern to the state equations. The pattern will enable you to fill in the $\underline{A}$ matrix quite easily. But you have to watch out for the end points. That is, the equations pertaining to the first spring stretch and the last mass might need to be handled specially because they are connected either to a wall or to a force source. But the equations pertaining to all the interior springs and masses can be readily generalized from analyzing any one interior mass and interior spring.

Adapt a MATLAB code to solve this system.

(2.ii) [3 points] Run the code for the parameters: all masses are 2kg and all springs have a spring constant of 20N/m. The force source is a pulse of magnitude 100N which starts at time 0 and stays on for 0.1s. Comment on the behavior of the system.

(2.iii) [4 points] Now just modify the mass of the tenth mass element to be 1000kg, with the rest of the parameters remaining the same. How does the system behave for the same force pulse as in case (2.ii)? Explain the behavior you observe.

[3.] We saw that a continuous length of coax cable can be modeled as a set of discrete capacitors and inductors in the transmission line arrangement discussed in class. A typical capacitance for a coaxial cable is 100 pF/meter (pF = picofarad; 10^{-12} farad). A typical inductance is 0.5 μH/meter (μH = microhenry, 10^{-6} henry). We want to analyze the behavior of a 200m segment of this cable. Let us "lump" the inductances and capacitances over each 10m segment into a discrete inductance and capacitance. You should have 20 inductors and 20 capacitors in your model. Modify the *tline64.m* file appropriately. (If your MATLAB edition is memory limited, you may want to lump every 12.5m segment which should give you 16 inductors and 16 capacitors in all). Let the input be a 1V pulse of 0.2 μs (ie 0.2×10^{-6}s) duration. Assuming a time step of 0.01μs, monitor the pulse propagation through the coax cable for a total duration of 3 μs. Figure out the speed (in m/s) with which the input voltage pulse propagates in this cable. [8 points]

[4] Consider the RLC tuner circuit discussed in class. Modify the tone_control.m program so that its output (a) is more bass (ie. low frequencies about 500Hz are emphasized) and (b) is mid-range (say about 1000Hz). What values of L and C did you use (do not change R values) for each? Explain how you decided on these values. Provide the time and frequency input and output plots for each case. [5 points]

The first four problems count for 10 points towards your overall course total. The fifth problem below is an extra credit problem and will only be considered provided: (a) your argument is correct or at least plausible, and (b) counting it will materially improve your overall course grade.

[5] Extra credit problem:

Choose any naturally-occurring or man-made phenomenon where a system appears to exhibit dynamic behavior that has parallels in the behavior of systems we have seen in class (exponential growth/decay, or growth to saturation; damped or undamped oscillations; resonance; weakly-coupled oscillations; pulse propagation). Make a concise argument as to why you think the system exhibits such behavior. If possible, identify system features that are analogs of energy storing, inertial, or damping elements. If really adventurous, set up the system equations and solve.