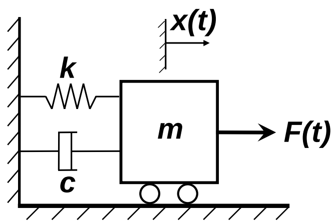
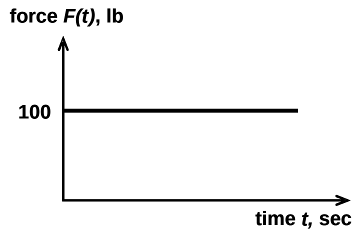
CE 573 – Structural Dynamics
Homework # 1
due 11 September 2009, Friday, 1:30pm

1) List three "obvious" and three "not so obvious" dynamic systems you see around. What are the different parts that make each system "dynamic"?





2) Consider the mass-spring-dashpot system shown in the figure on the left loaded by a constant force, as graphed on the right. The system has the following parameters:

Mass, m = 45 lb/(ft/sec/sec)
Stiffness, k = 2,000 lb/ft

with at-rest initial conditions (i.e., velocity $\left.\frac{dx(t)}{dt}\right|_{t=0} = 0$ and displacement $x(0) = 0$).

For the following tasks, use the average-acceleration method. Pick a "reasonable" time-step. (Recommendation: do a simple free vibration simulation to identify the period of the system and choose the time-step accordingly.)

Carry out simulations and graph your numerical solutions for the duration t = 0 to t = 5.0 sec.

Please keep your write-up concise and make sure your graphs are intelligible (which is more than legible).

a) Assume that there is no damping in the system, i.e. c = 0.
   i. Solve for and plot the displacement history, i.e. *x(t)* vs. *t*, of the mass.
   ii. On the same plot, include the "static deflection" corresponding to the given forcing function. What are your observations?
   iii. Compare the maximum force in the spring in the dynamic response with the maximum spring force in the "static" case.
   iv. Plot displacement vs. velocity, i.e. *x(t)* vs. *dx(t)/dt*. (This plot shows the so-called 'state-space' of the system.)

b) Assume that the system has damping in the amount of c = 60 lb/(ft/sec) (which corresponds to 10% of the critical damping value).
   i. Solve for and plot the displacement history of the mass.
   ii. How does the damped response compare with what you got in part (a)? You may want to plot damped and undamped cases on the same graph.
   iii. Prepare a separate plot of *normalized* displacement, velocity, and acceleration response histories. ("Normalized" means that the values are scaled to have a maximum absolute amplitude of 1.0.) Summarize your observations.
   iv. Plot *x(t)* vs. *dx(t)/dt*. What are your observations? Compare with the plot for the undamped case.

c) Plot
   1) displacement histories, and
   2) displacement vs. velocity histories,

for damping ratios of 0%, 10%, 50%, 100%, 200%, 500% of the critical damping collectively and study them. Summarize your observations.

d) What is the maximum displacement and maximum force in the spring in each case (undamped, 10%, 50%, 100%, 200%, 500% of critical damped)?

e) [CHALLENGE] Modify your algorithm so that it would allow use of “elasto-plastic” spring. Consider the same loading scenario and system but with an elasto-plastic spring that has the same initial stiffness as the one in elastic case above, but limit the maximum force the spring could develop to 50% of the maximum force in undamped case above. Assume that the spring yields with no stiffness once the force in the spring reaches that “yield strength” (hence the “elasto-plastic” behavior). Compare your results with the results you have found above? Also comment on how much difference viscous damping makes on top of the “hysteretic” damping the yielding of the spring generates.

NB Do not discard your electronic files.