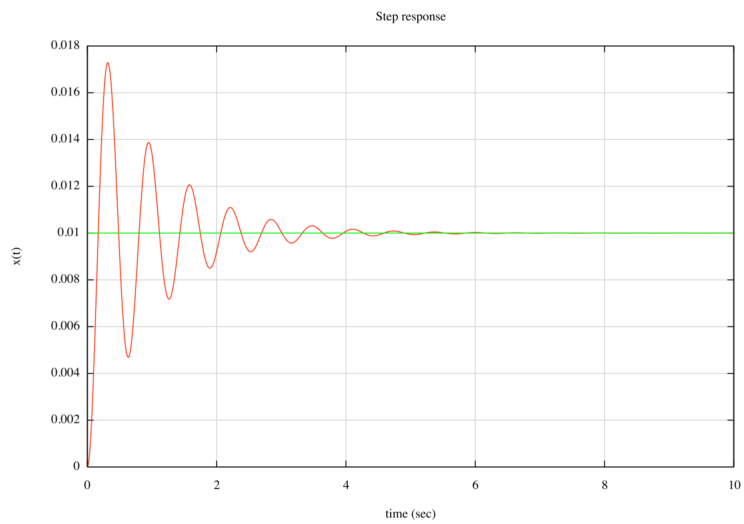
ME 360 System Dynamics Final Exam Winter 2009

You may use 1 formula sheet **(to be turned in)** and a calculator.

1. Estimate a model (differential equation) for the system for which the step response is given below. List each mechanical component's value. Sketch the system. Note that the steady state value has been plotted for your convenience in reading the graph.



2. A system $10\ddot{x} + 1100\dot{x} + 10,000x = \dot{f}(t)$ is excited by $f(t) = 20\sin(10t - \frac{\pi}{4})$.

   (a) Write the transfer function $\frac{X(s)}{F(s)}$

   (b) What is the magnitude (not in dB) of the frequency response (transfer) function at the frequency of interest?

   (c) What is the phase of the frequency response (transfer) function at the frequency of interest?

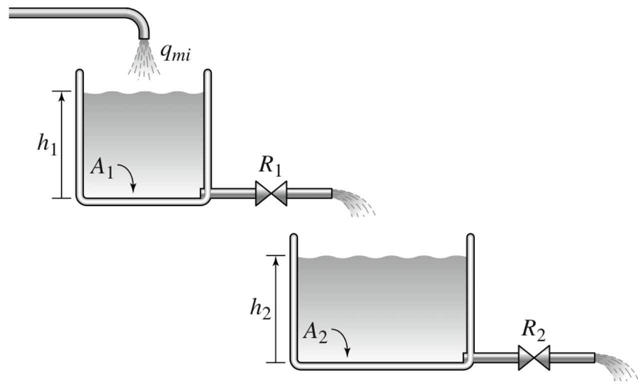
   (d) Using this information directly, what is $x(t)$.

   (e) Sketch the bode plot of the system and label all points of interest with their values. **Use a straight edge.**

3. Develop a model of the two liquid heights in the system shown in the figure below. The inflow rate $q_{mi}(t)$ is a mass flow rate. Using the values $R_1 = R$, $R_2 = 3R$, $A_1 = A$ and $A_2 = 4A$, determine

   (a) The transfer function $\frac{H_2(s)}{Q_{mi}(s)}$

   (b) The state space model presuming outputs h_1, h_2, and q_{mo}.



$F(s)$	$F(t)$
$sX(s) - x(0)$	$\dot{x}(t)$
$s^2X(s) - sx(0) - v(0)$	$\ddot{x}(t)$
$\frac{a}{s^2+a^2}$	$\sin(at)$
$\frac{s}{s^2+a^2}$	$\cos(at)$
1	$\delta(t)$
$\frac{1}{s}$	$u(t)$
$\frac{1}{s^2}$	t
$\frac{1}{s-a}$	e^{at}
$\frac{1}{s^n}$	$\frac{t^{n-1}}{(n-1)!}$