Name _____ Section _____

ES205
Examination II
April 29, 2008

Problem	Score
1	/30
2	/35
3 (short answer)	/35
Total	/100

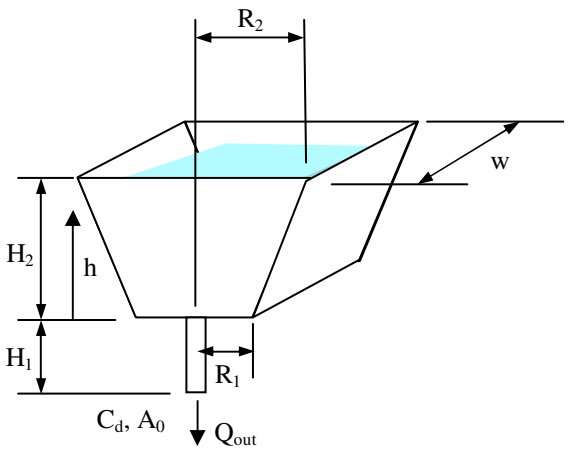
Show all work for credit
AND
Turn in your signed help sheet
AND
Stay in your seat until the class ends
(Translation: I am not going to let you leave early,
so you might as well check your answers!)

30 pts

ES205 Examination II **Problem 1** April 29, 2008

In the tank draining lab we assumed a uniform cross sectional area. The tank was actually tapered similar to the figure shown, except in lab the tank was tapered in both directions. For the tank shown determine

a) the equation of motion for the height of fluid in the tank as measured from the bottom of the tank.
b) If you created a Simulink model for this system how would you ensure that the flow out stops when $h < 0$?



35 pts

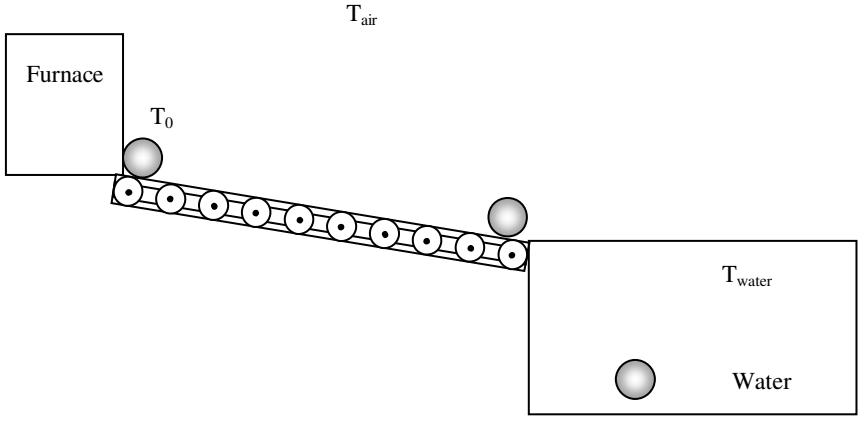
ES205 Examination II **Problem 1** April 29, 2008

Stainless steel ball bearings (ρ = 8085 kg/m^3, k = 15.1 W/(m-K) C_p = 0.480 kJ/(kg-K) having a diameter of 1.2 cm (Volume = V = 9.05x10^{-7} m^3, Area = A = 4.52x10^{-4} m^2) are to be quenched in water. The balls leave the oven at a uniform temperature of T_0 = 900 C and are exposed to air at T_{air} = 30 C for a while before they are dropped into water at T_{water} = 25 C. The heat transfer coefficient in the air is h_1 = 125 W/(m^2-K). When placed in the water the ball bearing causes the water immediately surrounding the rod to boil, giving rise to a heat transfer coefficient of h_2 = 5600 W/(m^2-K).

Determine

a) a differential equation for the temperature of the ball bearing when it is in the air
b) a differential equation for the temperature of the ball bearing when it is in the water
c) how long was the ball bearing in the air assuming that after the ball bearing is placed in the water, the boiling stops when the rod reaches a temperature of 100 ºC after t_2 = 3.3 seconds?

Do not solve for a numerical answers or plug in numbers. Just give me a list of unknowns and clearly derived equations. Assume ρ, V, A, C_p, k, T_0, h_1, h_2, T_{air}, T_{water} and t_2 are all known (and write your equations in terms of the symbols – **do not plug in numbers**). State any other assumptions you need to make while solving this problem.



Problem 2.1 (8 pts)
A system is found to have the differential equation $\ddot{x} + 25x = 10f(t)$.

a) What is the transfer function for this system?

b) What is the steady state response, x(t) if $f(t) = 10$

c) Use the transfer function method to determine the steady-state response if $f(t) = 5\ \sin(2t)$

Problem 2.2 (2 points)
What two Matlab m-files are required when you use rkf45 to numerically solve differential equations? Just describe their basic content in words.

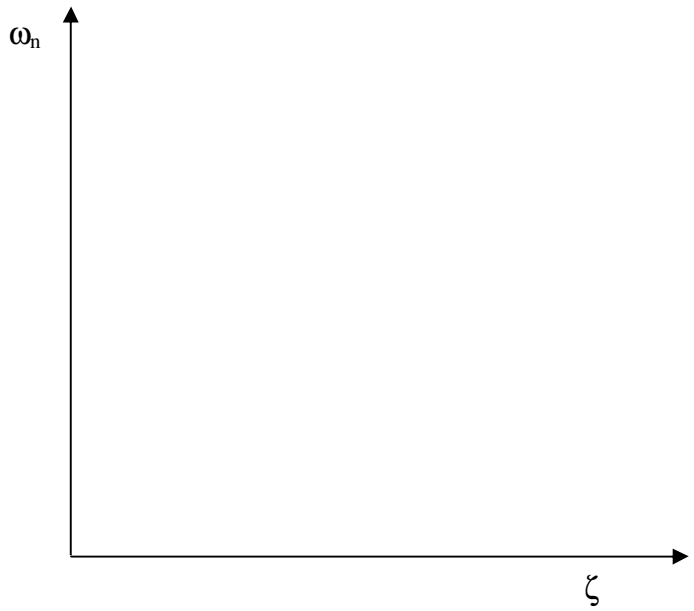
File 1:

File 2:

Problem 2.3 (15 pts)
A second order system has the following performance specifications:

- Percent overshoot must be greater than 16% (assume for exactly 16% overshoot $\zeta = 0.5$)
- 2% settling time must be less than 8 seconds but greater than 2 seconds.
- Period of oscillation must be greater than 1 second

Sketch the design space with clear labeling.



Problem 2.4 (10 pts)
A laboratory notebook for a secret project was burned in a fire. The only two scraps of paper remaining are shown below and you know that they refer to the same vibrating system. Determine the natural frequency and damping ratio for the system. To save time, set up the equations but do not solve.