CM416 Exam 1
December 16, 1998, 7pm-9pm

1. (20 pts) The response of the production of A in a reactor is known to follow a first order system with a time constant of 10 hours. Data obtained for this process is shown in Figure 1 where the initial concentration is given by Ca(0)=5 g/li. What will be the steady state concentration of Ca for this first order system?

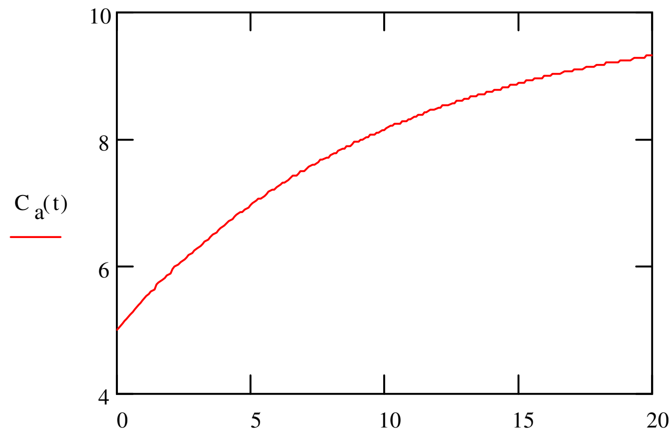

Figure 1. Response of a first order system.

2. Given a second order system described by the following,

$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = u$$

Use a proportional feedback control,

$$u = k_c\left(x_{set} - x\right)$$

   a) (20 pts) With the proportional control in place, what is the steady state as a function of k_c and x_{set} ?
   b) (20 pts) With the proportional control in place, determine the damping coefficient, ζ, and the natural period, τ_n, as a function of k_c.

3. (20 pts) The following equations describe the concentration and temperature changes in a reactor:

$$\frac{dC}{dt} = \alpha\left(C_{in} - C\right) - k\exp\left(\beta/T\right)C$$
$$\frac{dT}{dt} = \alpha\left(T_{in} - T\right) + \gamma\exp\left(\beta/T\right)C$$

Using the following set of parameters:

α	2
β	-0.01
k	1
γ	600

linearize both equations with respect to C, C_{in}, T, T_{in} at the following operating conditions:

C	0.60
T	680
Cin	0.9
Tin	500

4. (20 pts) Determine the minimum value of K such that the system described by the equations below is stable.

$$\frac{dx}{dt} = (4 - K)y - x$$

$$\frac{dy}{dt} = 2(x - y)$$

(**Bonus:** 5 pts) Explain how the system shown in Figure 2 is self-regulating for the liquid level in the tank.

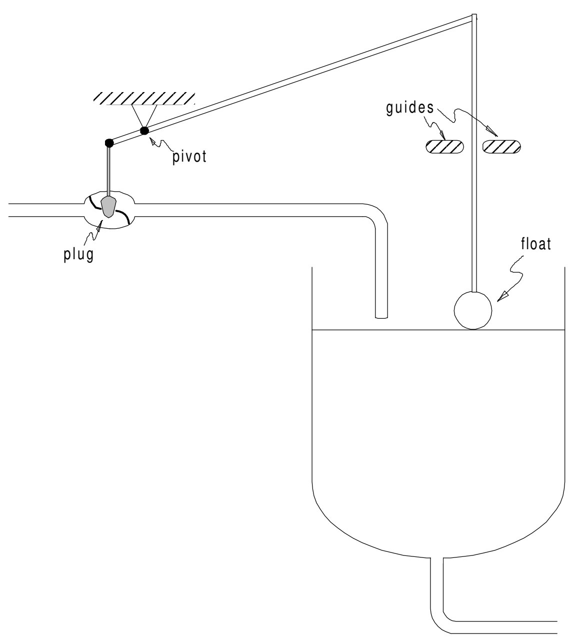

Figure 2. Level Regulating System