Second Exam. CM416
January 27, 1997 (6:30-8:30pm)
Open-Books/Open-Notes

Name:_____ **Box No.:**_____

1. (20pts) The process reaction curves of the system to be controlled are shown in Figure 1 where flow rate is the manipulated variable and temperature is the output variable. Obtain the PI control parameters using Cohen-Coon prescribed tuning rules. (Note: use the method discussed in class for obtaining the process parameters)

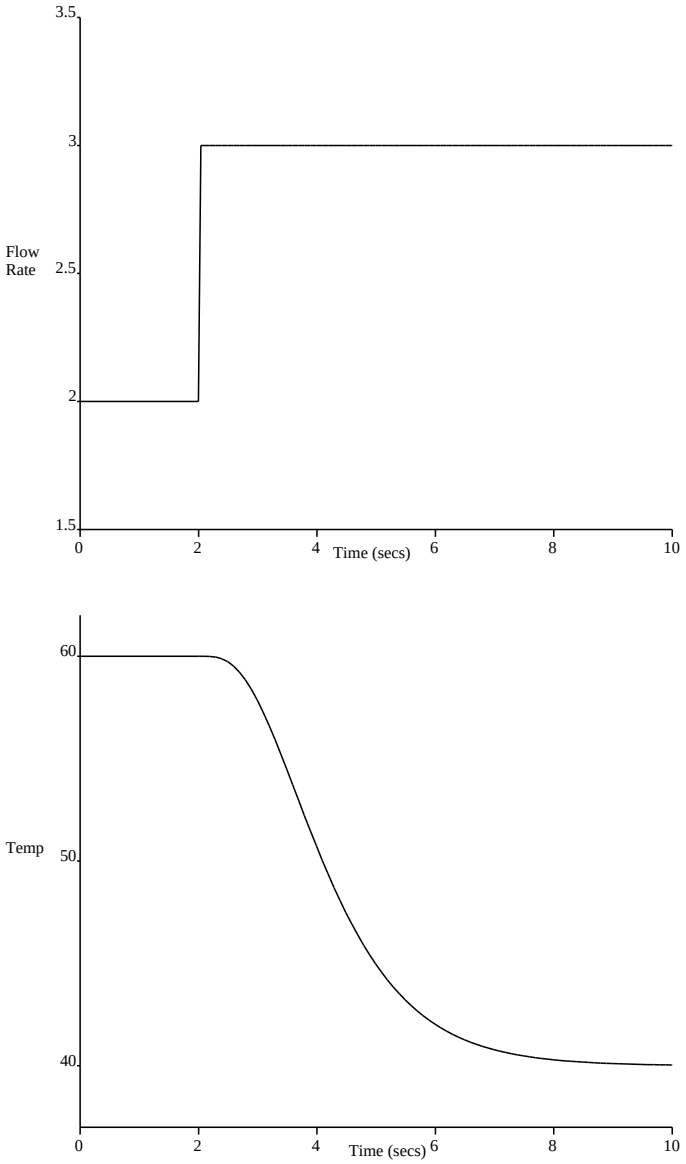

Figure 1: Process reaction curve for y in response to a step change in input u.

2. Suppose the transfer function of a process is given by

$$G_p = \frac{-s + a}{(s + b)(s + c)}$$

where a, b and c are all positive real numbers.

(a) (15 pts) Using a proportional controller having gain, K_c, show that the characteristic polynomial of the closed loop transfer function is given by

$$s^2 + (b + c - K_c)s + (bc + aK_c)$$

(Assume the sensor and actuator transfer functions to be 1.)

(b) (15 pts) What are the controller tunings for a PI controller for this process as prescribed by the Ziegler-Nichols method ? (Hint: the ultimate period is $2\pi/\omega$, where ω is the frequency in radians per second.)

3. (20pts) Given the following set of equations,

$$\begin{aligned} \frac{dx_0}{dt} &= -\frac{3}{5}x_0 - \frac{4}{5}x_1 + u \\ \frac{dx_1}{dt} &= x_0 \\ y &= \frac{1}{5}x_0 + \frac{2}{5}x_1 \end{aligned}$$

with initial conditions $x_0(0) = x_1(0) = 0$. Obtain the transfer function from $\bar{u}(s)$ to $\bar{y}(s)$.

4. (15pts) The internal model control structure is shown in Figure 2. Obtain the transfer functions from setpoint $\bar{y}_{sp}(s)$ and disturbance $\bar{d}(s)$ to output $\bar{y}(s)$.

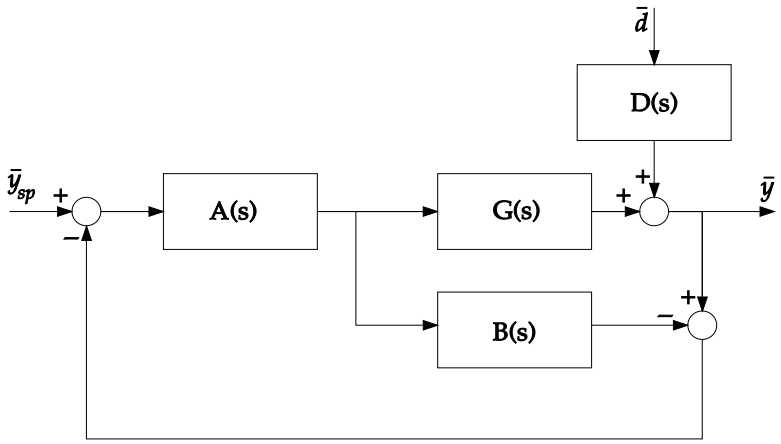

Figure 2: The Internal Model Control Structure.

5. (15pts) Use the Routh-Hurwitz method to determine the range of k such that the following characteristic polynomial will have no roots having positive real parts:

$$s^4 + 2s^3 + (6 - k)s^2 + (k - 2)$$

6. (Bonus:10pts) Find the Laplace transform of

$$f(t) = \frac{k}{(\alpha e)^{\beta t}}$$

where α, β and k are all positive real constants.