Name_________________________

ChE 436 – Process Control
Final Exam – Part I – Closed Book, Closed Notes (30 min – 20 pts/100 pts)

Please answer the following two questions even if you've already indicated your responses on a homework assignment.

i. I attended ___________ college lecture(s) or equivalent lectures this semester. (2 required)

ii. Did you complete the course and instructor evaluation or will you complete it this semester? (replaces lowest homework score). Circle one: Yes / No

---

a. Please draw the block diagram for a feedback control loop with a PID controller with derivative on measurement. Include blocks for G_v, G_m, G_p, and G_L, and any other necessary blocks.

b. Why does offset typically occur with P-only control and not with PI control?

c. Show the standard form for both second order and first order transfer functions, and explain all terms.

d. Why is the time constant for first order systems at 63.2% of the total change to steady state?

e. The BYU heating plant uses variable frequency drives (VFD's) to control liquid flow rates through the pumps instead of valves. Why?

f. How do you test a system for non-linear behavior?

Name_________________________

g. Give two examples of final control elements.

h. Why do we use deviation variables in process control?

i. Why do we use transfer functions in process control?

j. Give an example of a non-self-regulating process.

k. What is derivative kick, and how do you eliminate it?

l. How does process dead time affect process control? (is it good or bad, and why?).

m. Give both the Laplace form and time-dependent forms of the PID equation with derivative on measurement.

n. On the first exam I asked you to discuss trade-offs of computer control with someone like Admiral Rickover. Admiral Rickover of the Nuclear Navy believed that human operators were more reliable than computers at that time. Now that you've completed a course in automation and control, how would you relate trade-offs of manual vs. computer control?

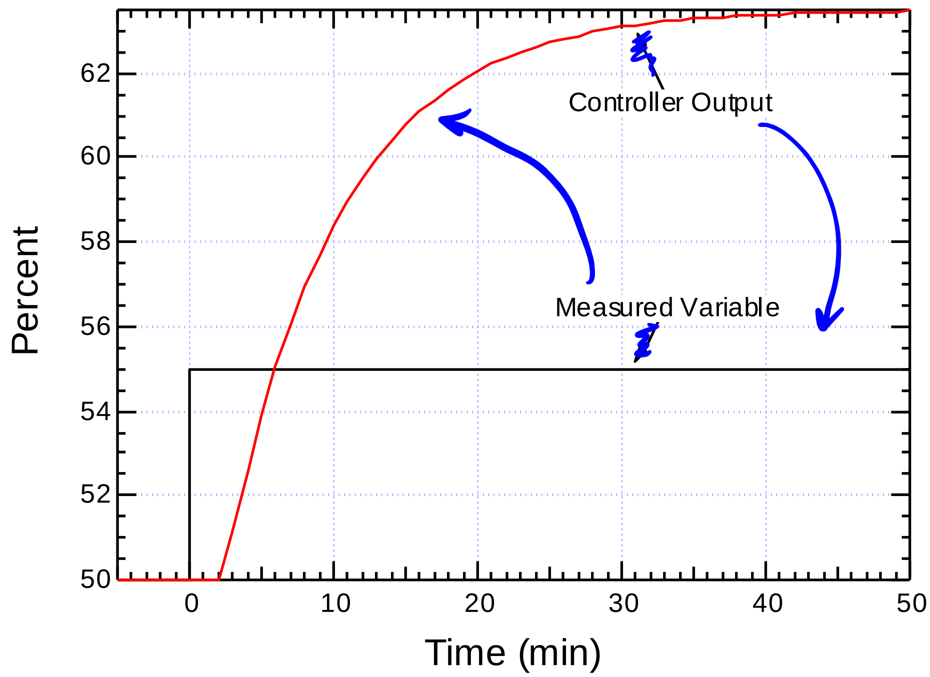
Name___________________________

ChE 436 – Process Control

Final Exam – Part II - Open Book, Closed Notes (except for 10 pieces of paper)

Part I	30 min (2:30-3:00)	20 pts
II - 1	15 min (3:00-3:15)	10 pts
II - 2	20 min (3:15-3:35)	15 pts
II - 3	50 min (3:35-4:25)	25 pts
II - 4	15 min (4:25-4:40)	10 pts
II - 5	50 min (4:40-5:30)	20 pts
Total	**180 min**	**100 pts**

1. (15 min – 10 pts/100 pts) A process has the following open loop response.

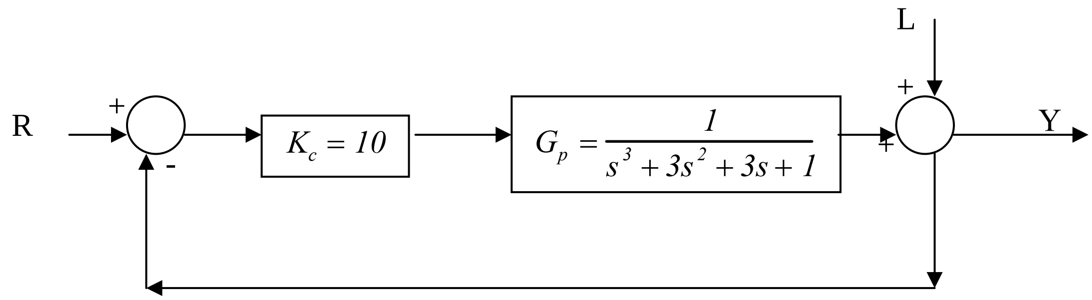


(a) Find the process parameters (K_p, τ_p, and θ_p) assuming a FOPDT model (and that the data are from a 1st order system).

(b) Find PI tuning parameters for this system with standard IMC correlations.

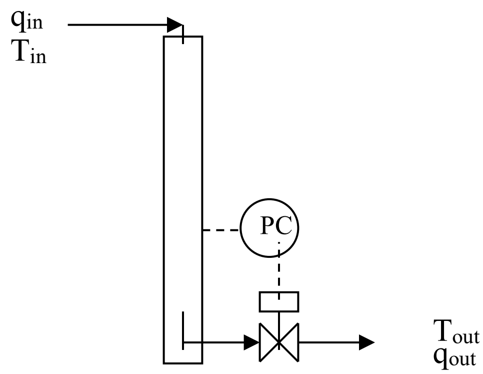
Name___________________________

2. (20 min – 15 pts/100 pts) Show mathematically that the following system is stable or unstable to a change in setpoint (R) or disturbance (L):



Name________________________

3. (50 min – 25 pts/100 pts) The schematic below shows a drop tube reactor, which is like a heated plug flow reactor. We are adding a pressure controller to the outflow line. The reactor can be approximated as a cylinder that is 1 m long and 5 cm in diameter. A diagram is shown below.



At steady state, the inlet flow rate is 30 liters/min at 300 K, and the reactor and outlet temperatures are 1200 K, regardless of the pressure.

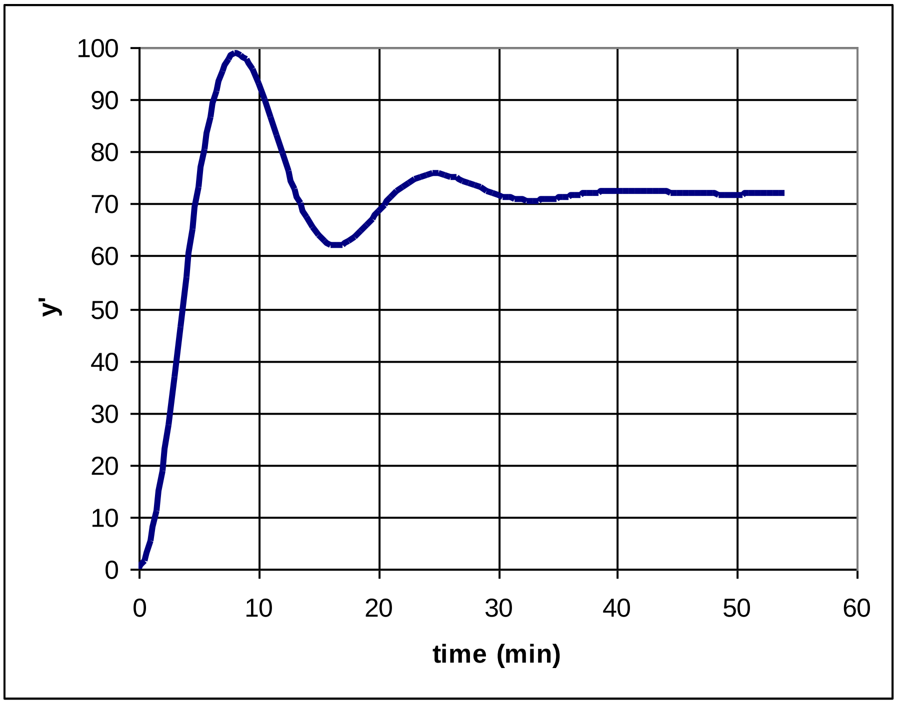
(a) Derive an expression for the dynamic change in pressure using a mass balance and the ideal gas law. The pressure drop across the reactor is negligible, and the temperature in the reactor can be assumed to be the same as the exit temperature. Only P, q_{in}, and q_{out} are the variables that change.

(b) Linearize this expression and put in deviation variables.

(c) Perform the Laplace transform of this equation to show an equation for P'(s) in terms of $Q_{in}'(s)$ and $Q_{out}'(s)$.

Name___________________________

4. (15 min – 10 pts/100 pts) For a process placed in manual mode, a step change of 6 in the controller output resulted in the following change in the process variable:



Assuming that the process is a second order function, find values for the process gain, time constant, and damping factor.

Name___________________________

5. (40 min – 20 pts/100 pts) For the following block diagram, find expressions for Y/Y_{sp}, Y/L_1, and Y/L_2.

Hints:
(1) Use the shortcut method for the inner loop to get X_1 as a function of E and L_1
(2) Derive an expression for Y as a function of X_1 and L_2
(3) Derive an expression for E as a function of Y_{sp} and Y
(4) Use (1)-(3) to derive the overall transfer functions