Process Control, 3P4 Your name: ____________

Tutorial 4 - Friday Student number: ____________

This tutorial helps for assignment 3, helping you become more comfortable with transfer functions, and assists your understanding of feedback controllers and block diagrams.

Question 1 [8]

The following questions refer to a first order system: $G_p(s) = \dfrac{y(s)}{u(s)} = \dfrac{\text{gain}}{(\text{time constant})s + 1} = \dfrac{K_p}{\tau s + 1}$

1. What are the units for a time constant?
2. What are the units for a gain?
3. Can a process have a negative gain?
4. Give an example of a process that has a time constant of zero.
5. Can a process have a zero gain? Explain why or why not.

Question 2 [8]

1. Draw the following input, $f(t)$, as a function of time (this is the actual input to a batch reaction, commonly used in the pharmaceutical industry, or many companies with batch systems).
   - Start at 25 units at time time zero; ramp up by 1 unit per minute; keep ramping up for 60 minutes.
   - Remain at the current position for 30 minutes, keeping the input constant.
   - Jump suddenly down to the starting point.
2. Derive the Laplace transform of $F(s) = \mathcal{L}\left[f(t)\right]$.

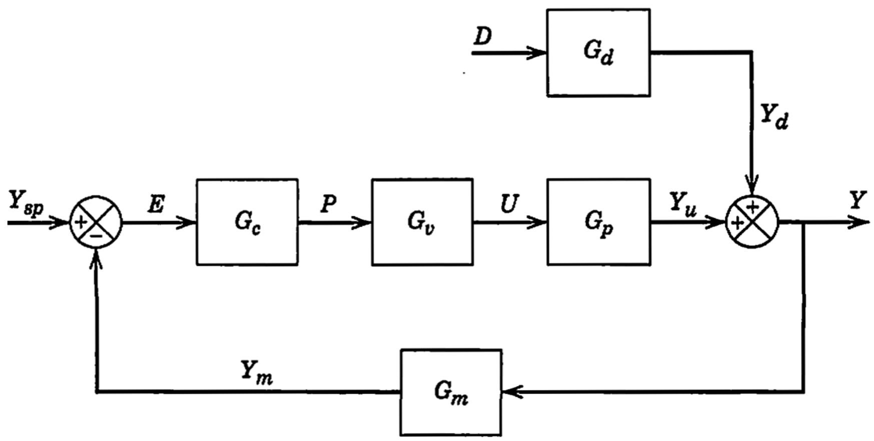
Question 3

Below is the standard feedback control diagram for any process, G_p, which has an input U and output Y_u. There are other transfer functions, such as G_c, which takes the set point value, Y_{sp} and *subtracts* from it the measurement from the sensor, Y_m. The controller then issues a signal to the valve to open or close, via the value P. The valve also has a (fast) transfer function, G_v, which creates the actual process input signal U.

Our measurement on the process, Y, is made up of two parts, Y_d and Y_u. The transfer function G_m represents the dynamics of the sensor (measurement), a similar idea to the transfer function for the thermocouple in question 2 of assignment 3.

Each of the transfer functions for the *systems* are in Laplace form, i.e. G_p should actually be written as $G_p(s)$. Each of the transfer functions for the *signals* are in Laplace form, i.e. Y should actually be written as $Y(s)$.

Today's task is simple: become comfortable with the notation in the block diagram - we are going to see and use this many times, which is why we drop off the (s) parts on the *systems* and *signals*.



1. Derive an expression which gives the output $Y(s)$ for a given valve input signal $P(s)$ and a given disturbance signal $D(s)$. Your answer should be $Y(s) =$ ____
2. Derive a single transfer function which gives the output $Y(s)$ for a given input $Y_{\text{sp}}(s)$. For this part of the question, assume input D, and consequently Y_d are both zero (for today). Your answer: $\dfrac{Y(s)}{Y_{\text{sp}}(s)} = \ldots$