Process Control, 3P4 Your name: ____________

Tutorial 4 - Monday Student number: ____________

This tutorial, leading into assignment 3, has two main goals: become proficient at using the Laplace transform; and understanding more about sensors, an important goal of this course.

Question 1 [4]

Partial fraction expansion is a topic you have learned about in your prior high school and university math courses.

$$Y(s) = \frac{s+5}{(s+1)(s+4)} = \frac{\alpha_1}{(s+1)} + \frac{\alpha_2}{(s+4)}$$

$\alpha_1 =$ $\alpha_2 =$

Question 2 [8]

Another one:

$$Y(s) = \frac{1}{s(s+4)(s+5)} = \frac{\alpha_1}{s} + \frac{\alpha_2}{(s+4)} + \frac{\alpha_3}{(s+5)}$$

$\alpha_1 =$ $\alpha_2 =$ $\alpha_3 =$ $\mathcal{L}^{-1}[Y(s)] = y(t) =$

Question 3 [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 4 [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.
   - Ramp back down to a starting point of 25 units, decreasing by 2 units per minute.
2. Derive the Laplace transform of $F(s) = \mathcal{L}[f(t)]$. Refer back to the definition of the Laplace transform, if necessary.