**Studio 3 ANSWER SHEET (submit to Canvas) CHE 461**

**Answer the highlighted questions as you work through Studio 3**

**1. Review of P-only control for the Kitchen Oven control loop**

**a.** Use the file you created last week (studio2b), or the provided file Studio3\_Ponly.slx, to run a servo (setpoint) change of +10 degrees at time = 2 when your controller gain ***Kc* = 0.25**. Create the YPE plots shown below by double-clicking on the Loop\_1\_plots “button box.” **Answer the three questions below:**

**i.** What is the mathematical definition of Error(t)?

**E(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**ii.** What is a ***key*** characteristic of the closed-loop response when a P-only controller is used? (Hint: this is a potential ***disadvantage***)

**iii.** List one or more potential ***advantages*** of using P-only control

**2. Add integral action to the control loop by adding a parallel I\_action block.**

**b.** Run your new PI control model with simulation **run time = 16** and check that you get the **same three plots shown below (YPE plots).**Then answer the following three questions:

**i.** Compare the closed-loop performance of the PI controller versus the P-only controller. **How did I-action change the closed-loop response?**

**ii.** Recall from Studio 2a (open-loop tests) that the required power input for a 10 degree temperature change was 2.5 kW. **What is the controller output when P-only control is used (part 1a)? What is the controller output when P- and I-action are both used?**

**iii.** What is a key advantage of using a PI controller, rather than P-only?

**c.** Now to try “tease apart” the individual contributions of the P-action and I-action from your PI servo experiment that you ran in part (**2b**). Run the plotting program **PIpartsP.m**, which shows the P- and I-action separately, along with the combined controller output (the individual P and I contributions sum up to the total controller output *P’*). Inspect your plot and answer the following four questions:

**i.** How is this plot related to the three plots shown in “YPEplots.p?”

**ii.** From about time = 6 to 10, the value of the P-part is negative. Why is this the case? (**Hint**: look at the *Y’* and *Error* plots)

**iii.** At time = 2 (the moment the setpoint changed) what is the value of the P-part and the I-part? Briefly explain why this is the case.

P-part = \_\_\_\_\_\_\_\_\_ I-part = \_\_\_\_\_\_\_\_\_\_

**iv.** At steady state, what is the value of the P-part and the I-part? Briefly explain why this is the case.

P-part = \_\_\_\_\_\_\_\_\_ I-part = \_\_\_\_\_\_\_\_\_\_

**3. Running simulations using the “PIDalpha” function block for a PI controller**

**b.** Run your Simulink model (step *Ysp* to 10 at *t* = 2) and you should get the same three plots shown for part **2b**. Confirm that the simulation was setup correctly by double clicking the Loop\_1\_ISE “button box.” You should get the same plot shown below with a value of **ISE = 81.25**. **Check this before continuing!**

**i**. Why does the ISE curve (shown to the left) initially increase, then eventually plateau to a constant value?

**ii**. For “good” control performance, would you desire a ***low*** or a ***high*** ISE value? Why?

**iii.** What does the ISE curve look like if you turn off the I-action (use a P-only controller)? Try it! (set to *Kc* = 0 in PIDalpha block). Why does the ISE curve have this shape?

**c.** Reset your PID controller to the **BASE CASE:** ***Kc* = 0.25, *τI* = 1.25, *τD* = 0,** then run the following experiments and answer the questions for each simulation:

**i.** **More Proportional Action.** Increase P-action by making *Kc* a factor of 4 larger (***Kc* = 1**). Keep integral and derivative action the same (***τI* = 1.25, *τD* = 0**). Look at YPE and ISE plots.

Relative to the **BASE CASE…**

What effect did this have on the closed-loop response (*y’* (oven temperature) vs *t*)? (**Check ISE = 23.12**)Do you think closed-loop performance improved? Why?

**ii.** **More Integral Action.** Reset your controller to have ***Kc* = 0.25.** Now increase the I-action by ***reducing*** *τI* by a factor of 5(***τI* = 0.25**).

Relative to the **BASE CASE…**

What effect did this have on the closed-loop response (*y’* (oven temperature) vs *t*)? (**Check ISE = 56.25**) Do you think closed-loop performance improved? Why?

**iii.** **Less Integral Action.** Keeping ***Kc* = 0.25**, reduce the I-action by ***increasing*** *τI* by a factor of 5(***τI* = 6.25**).

Relative to the **BASE CASE…**

What effect did this have on the closed-loop response (*y’* (oven temperature) vs *t*)? (**Check ISE = 194.01**) Do you think closed-loop performance improved? Why?