ASSIGNMENT-1

1. Consider a non-interacting tanks system as shown in Figure 1. The cross-section areas of the two tanks are A_1 and A_2,respectively. Our objective is to control the liquid level in tank 2, h_2. To achieve three possible manipulated variables, F_1, F_2, and F_3 can be considered.

   a) Draw a closed-loop block diagram using a PI controller considering each of the three manipulated variables (F_1, F_2, and F_3).
   b) Derive the corresponding closed-loop response to load and/or setpoint changes.
   c) Evaluate the closed-loop static gains for each of the three cases.
   d) Determine the corresponding closed-loop transfer functions for changes in the load (G_{load}) and/or setpoint (G_{SP}).

   Assumptions:
   - Transfer functions of measuring devices and control valves are equal to unity.
   - Flowrates of the free streams are linear functions of the liquid level.

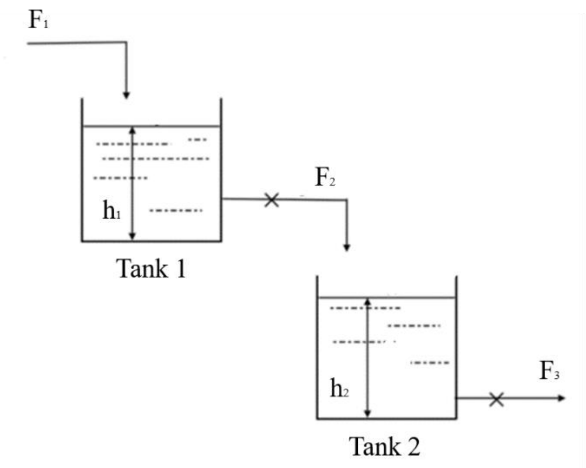

Figure 1

2. Consider the following systems which are feedback-controlled with a proportional controller. Find the range of values of the proportional gains K_c that produce stable (if it is possible) closed-loop responses. Also, identify the characteristic equations. Assume $G_m = G_f = 1$.

(a)

$$G_p(s) = \frac{10}{2s - 1}$$

(b)

$$G_p(s) = \frac{2}{0.1s + 1}$$

(c)

$$G_p(s) = \frac{10}{2s^2 + 3s - 4}$$

(d)

$$G_p(s) = \frac{1}{3s^3 + 2s^2 + s - 5}$$

(e)

$$G_p(s) = \frac{1}{10s^3 + 2s^2 + s - 5}$$

3. Draw the root locus of a closed-loop system with the following characteristics:
   Process: $G_p(s) = \frac{1}{(s+1)(2s+1)}$
   Controller: $G_c(s) = K_c$
   Measuring device: $G_m(s) = 1$
   Final control element: $G_f(s) = 1$
   Indicate the segments of the root locus (i.e, values of K_c) yields (a) overdamped, (b) critically damped, and (c) underdamped closed-loop responses.

4. Determine the gain of a proportional controller that produces a closed-loop response for a second-order system with $\frac{1}{4}th$ decay ratio. The process is given below:
$$G_p(s) = \frac{1}{s^2 + 3s + 1}$$
   and $G_m = G_f = 1$

5. Consider the system of the stirred tank heaters shown in Figure 2. The objective is to maintain temperature T_3 at the desired set point values using one of the stream flowrates Q_1 or Q_2 as the manipulated variable. Make necessary computations and decide which manipulated variable is superior using the minimum offset as the selection criterion. The following information is given:
   a) Flowrates F_1, F_2, and F_3 remain constant at their steady-state values.
   b) Temperature T_1 is the main disturbance.
   c) The dynamics of the two heaters are given by the following equations:
$$\bar{T}_2(s) = \frac{1}{4s+1}\bar{T}_1(s) + \frac{0.2}{4s+1}\bar{Q}_1(s)$$
$$\bar{T}_3(s) = \frac{1}{10s+1}\bar{T}_2(s) + \frac{0.1}{10s+1}\bar{Q}_2(s)$$
   d) Consider a 10% step increase in the value of the disturbance T_1 to compute the offset of the closed-loop responses.
   e) The controller is proportional, while the thermocouples and control valves have transfer functions equal to unity.
   f) The following restrictions must be satisfied by the controller gain as shown:
$$100 \geq K_c \geq 0.1$$

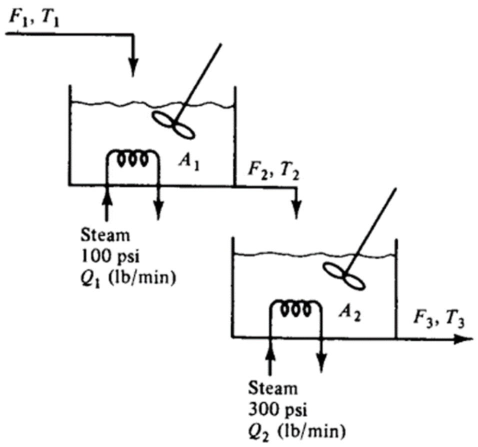

Figure 2