Name: _____ ID: _____

Addis Ababa Institute of Technology
School of Chemical and Bio-Engineering
CBEg 6142 Advanced Process Control

Assignment III Submission Date: _____

1. The control objective of a constant capacity exothermic reactor with a cooling jacket shown in **FIGURE Q1** is to maintain the reaction temperature T at 160 ^{o}C. The cooling water has temperature of 20 ± 5 ^{o}C.

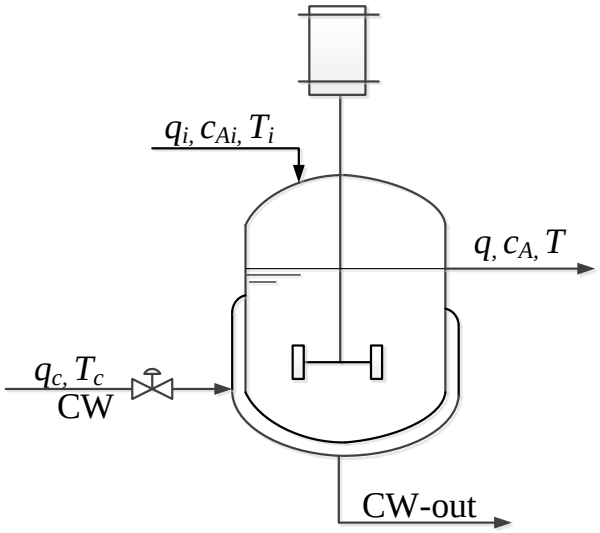

FIGURE Q1

a. Construct a simple feedback control system to address the control objective using schematic diagram.

[5 marks]

b. After some time of operation it was noticed that variations in the surrounding temperature and the cooling water temperature cause significant deterioration in the control performance. Propose advanced control strategy to address this problem and show your proposal using schematic diagram.

[20 marks]

2. The block diagram of a process is shown in **FIGURE Q2** with the transfer functions in place. Q_s and T represent the manipulated and controller variables of the process, respectively.

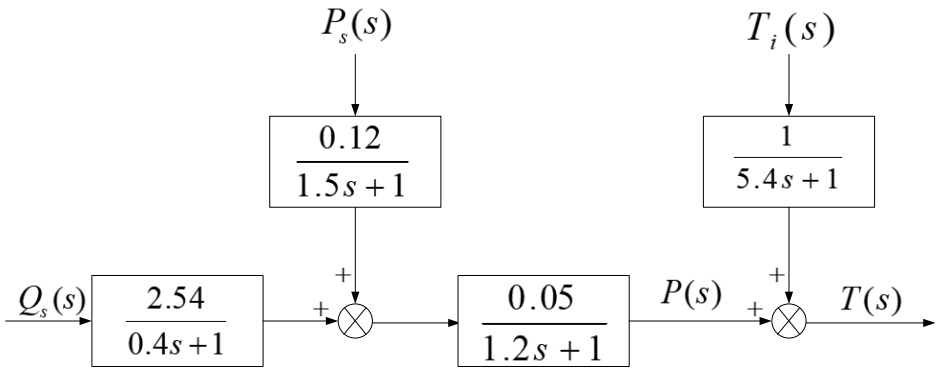

FIGURE Q2

Assume the $G_v = G_t = 1$

a. Construct a simple feedback control system to controller the output variable T using the block diagram.

[5 marks]

b. For a simple feedback controller determine the range of K_C for which the closed-loop system will be stable.

[5 marks]

c. Construct a cascade controller using block diagram and propose the type of controllers and settings.

[5 marks]

d. Compare the response of the processes for servo and regulator problems using simulation.

[10 marks]

3. The block diagram shown in **FIGURE Q3** the open-loop transfer function of a process. The disturbance variable is measurable.

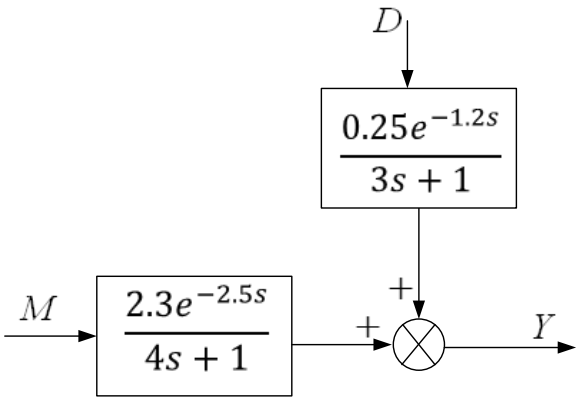

FIGURE Q3

a. Design a feedback controller using the direct synthesis controller assuming $\tau_c = \theta$, where θ is the time delay for the manipulated variable and τ_c is the time constant of the desired response.

[10 marks]

b. Propose an advanced control strategy, and design the corresponding controller assuming the performance of the feedback control system in **part (a)** is unsatisfactory due to large and frequent disturbances.

[10 marks]

c. Construct the proposed control strategy with the transfer function and the controller in place using block diagram.

[5 marks]

4. The simplified block diagram of a feedback controlled process with unmeasured disturbance is given in **FIGURE Q4**.

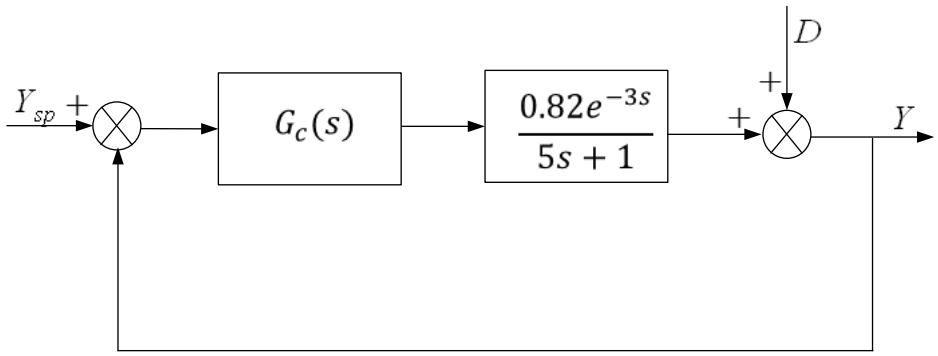

FIGURE Q4

a. Design an appropriate internal model controller, G_{IMC} for the process in **FIGURE Q5** assuming $\tau_c=\theta$, where θ is the time delay for the manipulated variable and τ_c is the time constant for the filter.

[10 marks]

b. Construct the internal model control system with the controller designed in **part (a)** and the plant transfer function in place.

[5 marks]

c. Design a simple feedback control system with the controller that can provide equivalent performance to the one designed **part (a)** and **part (b)**.

[10 marks]

5. A time delay dominant process with simple feedback control system is given in **FIGURE Q4**. The closed response of the process with PI and PID controllers was tested with numerous tuning approaches was tested and was found an acceptable.

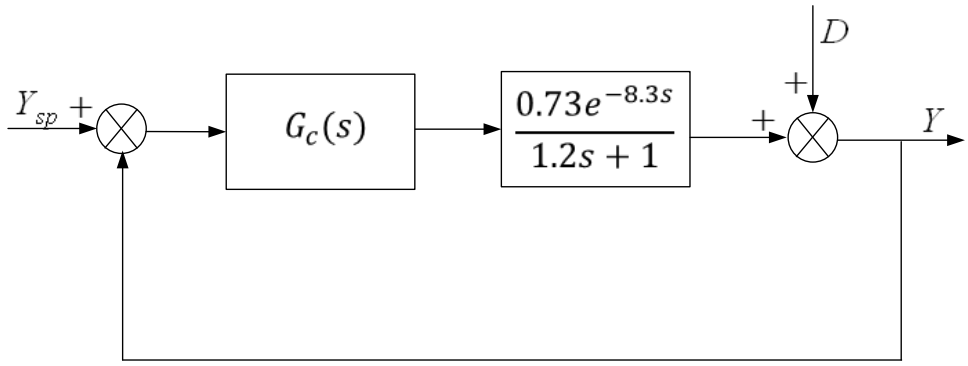

FIGURE Q4

a. Propose an advanced control strategy that will provide better control performance and construct the proposed control strategy using block diagram.

[15 marks]

b. Design the corresponding controller and compare the performance with simple feedback control system having a direct synthesis controller designed assuming $\tau_c=\theta/2$ using simulation for servo problem.

[10 marks]

6. The transfer function model of a 2×2 process is given in Eq. 1 where Y1 and Y2 are the output variables and U1 and U2 are the manipulated variables.

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \dfrac{0.5e^{-0.3s}}{2.3s+1} & \dfrac{1.2e^{-1.2s}}{4.2s+1} \\ \dfrac{-3e^{-1.1s}}{2.5s+1} & \dfrac{0.8}{1.2s+1} \end{bmatrix} \begin{bmatrix} U_1 \\ U_2 \end{bmatrix}$$

a. Determine whether it will be difficult to control this system using 2×2 multi-loop control system using condition number.

[5 marks]

b. Determine the appropriate pairing for a simple 2×2 multi-loop control system.

[10 marks]

c. Design physically realizable decouplers and compare the performance with and without decoupler using simulation for servo problem. Design the feedback controllers using direct synthesis method assuming $\tau_c=\theta$, where θ is the time delay for the manipulated variable and τ_c is the time constant for the desired response.

[10 marks]