BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
Second Semester 2017-2018
Mid-Semester Test
CHE F342: Process Dynamics and Control

Time: 90 minutes | 5^{th} **March 2018** | **Maximum Marks**: 90

Note: This question paper consists of two parts. Part A and Part B are to be answered in separate answer books. Part B question paper can be obtained after submitting Part A answer book. Time limit for Part-A is 40 minutes (approx.).

PART-A (Closed Book, 45 Marks)

1. (***15 Marks***) Two liquid streams with flowrates q_1 and q_2 and temperatures T_1 and T_2 respectively, flow through two separate pipes. These streams mix together directly and flow out through another pipe as shown in Fig Q1. We want to maintain q_3 and T_3.
   Assuming all the three pipes are fully occupied by the liquid:
   (a) Find out disturbances and manipulated variables.
   (b) Develop the mathematical model of the system.
   (c) Draw feedback control loops for controlling q_3 and T3 and outline the advantages and limitations of feedback control.
   (d) Draw feedforward controller for controlling T_3 and outline the advantages and limitations of feedforward control.

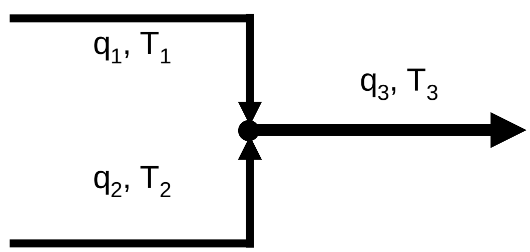

Fig. Q1

2. (***15 Marks***) Obtain the state-space model of the system consisting of two interacting tanks as shown in Fig. Q2. The desired output is the difference in the levels of the two tanks. Determine the state transfer function matrix and make the block diagram representation of the process.

   Data: $A_1 = 2A_2 = 1$; $4R_1 = R_2 = 2R_3 = 2$; q_i is the volumetric flow rate.

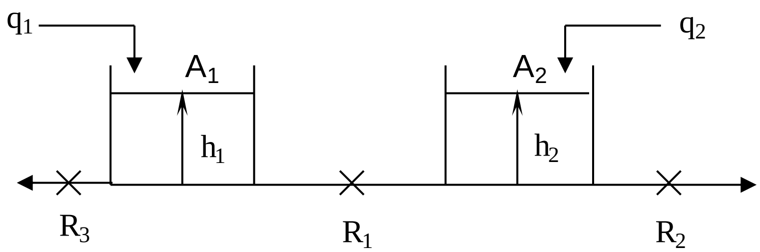

Fig. Q2

3. (***15 Marks***) Consider a CSTR as shown in Fig. Q3, where exothermic reaction A → B occurs. The reaction rate follows $r = kC_AC_B$ with $k = k_0 \exp(-E/RT)$. The pump discharges at a constant rate.

   (a) Develop the mathematical model of the system. Discuss the advantages and limitations of theoretical and empirical modeling.

   (b) Perform the Control Degrees of Freedom Analysis. Clearly state the control objectives, show CV-MV pairing and draw the control loops.

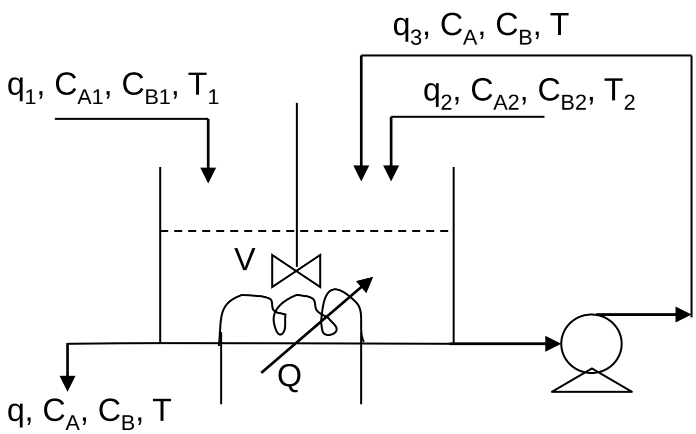

Fig. Q3

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Part-B (Open Book, 45 Marks)

Note:

- **No Photocopies/Xerox can be used. Only Hand-written Class Notes and Text Book (Seborg et al., 2011) are allowed.**
- **Approximate time limit is 50 minutes.**

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1. (***25 Marks***) A system shown in Fig. Q1 consists of an inlet flow, a truncated conical tank and a pump. The diameter of the tank at the bottom is 1 m and that at the top (where height = 3 m) is 4 m. At steady state $q_i = q_o = 3\ m^3/hr$, and h = 1 m.
   a. Obtain the transfer function that relates the level in the tank to the changes in the inlet flowrate. What type of process is it?
   b. After what time the tank will overflow if a unit step change is given in q_i?

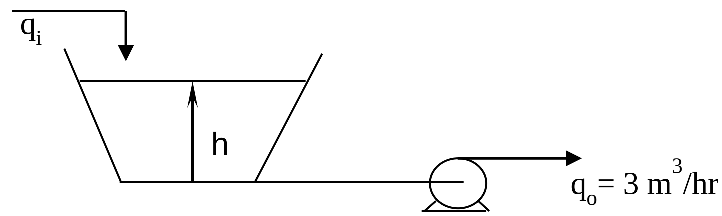
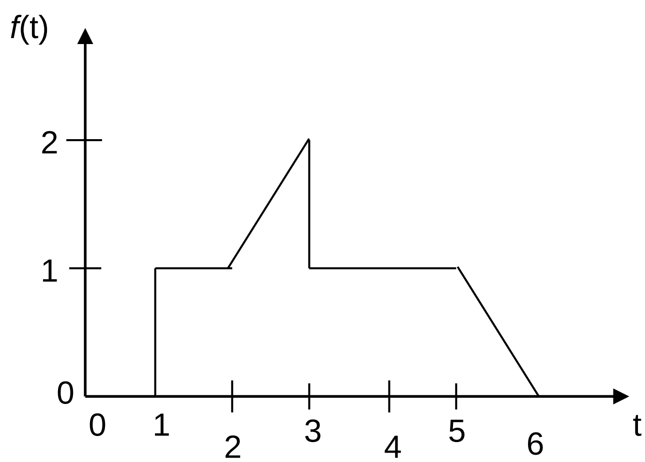


Fig. Q1

2. (***10 Marks***) Solve the following differential equation using Laplace Transforms. Assume the variable(s) to be in deviation form.

$$\frac{d^2y}{dt^2} + 4y = 2e^{-t}$$

3. (***10 Marks***) Express the function $f(t)$ given below in the t-domain and obtain its Laplace Transform.



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