BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
Second Semester 2016-2017
Mid-Semester Test
CHE F342: Process Dynamics and Control

Time: 90 minutes **10th March 2017** **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. Time limit for Part-A is 40 minutes (approx.).

PART-A (Closed Book, 45 Marks)

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1. (***15 Marks***) Develop a dynamic model of the variable holdup jacketed CSTR system shown in Fig. Q1 where a first-order exothermic reaction A → B takes place. Perform the control degree of freedom analysis and suggest an appropriate control strategy for this system by showing the control loops.

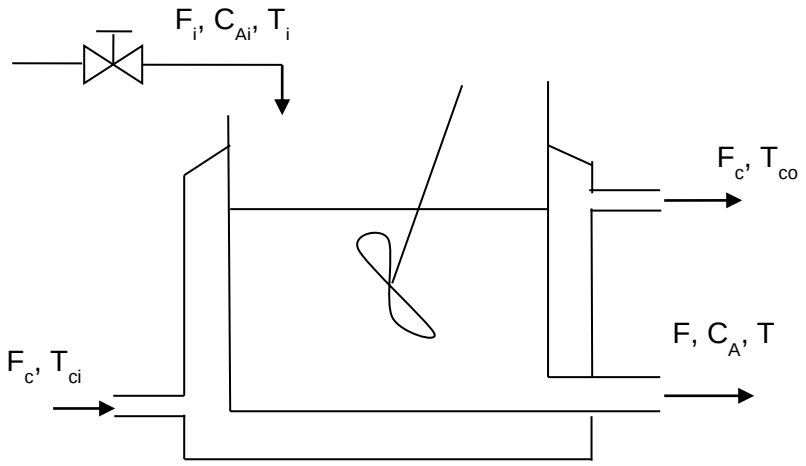

Fig. Q1

2. (***10 Marks***) Sketch the composite function: f(t) = S(t) – 2 S(t-1) + S(t-3) and obtain its Laplace Transform. S(t) is the unit step function.
3. (***20 Marks***) Answer the following questions briefly:
   (a) What is the objective of a plant? Identify the requirements to meet this objective.
   (b) Classify the variables involved in process control and define them.
   (c) What are the control schemes used in process industries? What are their characteristics? Mention their merits and demerits.
   (d) What is the necessity of linearization? Why do we linearize a system around its steady state values?
   (e) Outline the characteristics of a first-order system.

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Inverse Laplace transforms

	F(s)	$L^{-1}[F(s)] = f(t)$
1.	$\frac{1}{s}$	1
2.	$\frac{1}{s^2}$	t
3.	$\frac{1}{s^{n+1}} \quad n = 0, 1, 2, \ldots$	$\frac{t^n}{n!}$
4.	$\frac{1}{s-a}$	e^{at}
5.	$\frac{1}{s^2+a^2}$	$\frac{\sin at}{a}$
6.	$\frac{s}{s^2+a^2}$	cos at
7.	$\frac{1}{s^2-a^2}$	$\frac{\sinh at}{a}$
8.	$\frac{1}{s^2-a^2}$	cosh at

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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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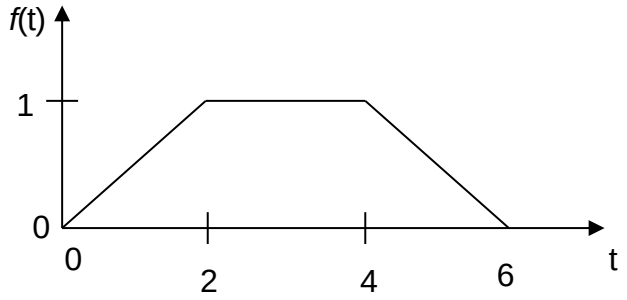
1. (***10 Marks***) Express the function *f*(t) given below in the t-domain and obtain its Laplace Transform.



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

$$2\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + y = \delta(t)$$

3. (***15 Marks***) Find the transfer function between the liquid level h (in cm) and the inlet flowrate qi (in cm^3/s) for a tank of cross-sectional area A (= 100 cm^2). The outlet flowrate q (in cm^3/s) is related to the liquid level as $q = 3\sqrt{h}$. The steady state values for q_i and h are 18 cm^3/s and 36 cm, respectively. Also find the time (in seconds) at which the tank will begin to overflow when a step change of 4 cm^3/s is given in the inlet flowrate. The tank capacity is 5 liters.

4. (***10 Marks***) Obtain the state transfer function matrix and block diagram representation for the system whose dynamic model is given below.

$$\frac{dx_1}{dt} + 2x_1 + x_2 = u_1$$

$$\frac{dx_2}{dt} - x_1 = u_2$$

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