

Ref. No.: Ex/EE/PC/B/T/412(O)/2025

B. E. ELECTRICAL ENGINEERING 4TH YEAR 1ST SEMESTER EXAMINATION,
2025

SUBJECT: - PROCESS INSTRUMENTATION AND CONTROL

Time: Three hours

Full Marks 100
(50 marks for each part)

Use a separate Answer-Script for each part

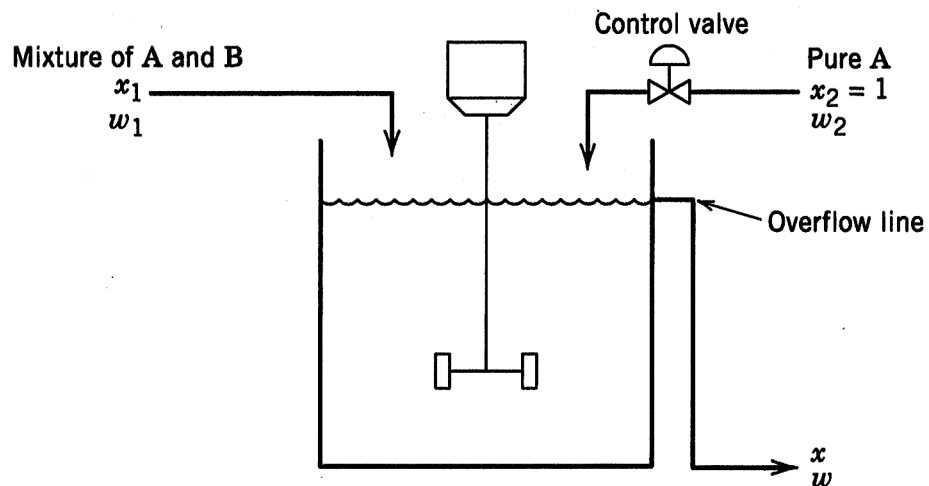
No. of Questions	PART I	Marks
	<i>Answer any THREE questions. Two marks reserved for neatness.</i>	
1. (a)	Draw the schematic of a process control loop and define transmitter gain, controller gain and gain of the final control element. Differentiate between self regulation type processes and non-self regulation type processes, citing suitable examples. Prove that the product of transmitter gain, final control element gain and process gain is a dimensionless quantity.	08
(b)	Describe in detail the operating principle of a pneumatic baffle-nozzle amplifier and derive its input-output relation. Can it be directly employed as a pneumatic proportional controller?	08
2. (a)	What are the advantages of employing digital controllers in a process control loop? Why choice of a proper sampling interval is so important in those process control loops?	03 +03
(b)	Give a detailed, step-by-step derivation of the output of a digital PD controller, employing backward difference algorithm. Also derive in detail how will this output get modified if the digital PD controller is designed with provision for anti-derivative kick?	06 +04
3. (a)	Describe the constructional details and operating principle of spring-diaphragm type pneumatic actuators. Differentiate between direct-acting and reverse-acting varieties.	08
(b)	What are electric actuators? With neat diagrams, explain the operating principles of motorized rotary actuator and solenoid actuator.	08

[Turn over

No. of Questions	PART I	Marks
4. (a)	How can relay auto-tuners be employed for automatic tuning of PID controllers? How does the relay characteristic get modified for a non-zero set point?	08
(b)	Demonstrate in detail, using Root Locus plot and Bode plot, how does the critical gain vary with time delay, for a delayed first order process controlled by a proportional controller.	08
5.	Write short notes on <i>any two</i> of the following:	8×2=16
(i)	Electro-pneumatic converters for actuators.	
(ii)	Electronic PID controllers using a single op-amp.	
(iii)	Bumpless transfer scheme for AUTO/MAN operation in process controllers.	

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Question No.	Question 1 is compulsory <u>Answer <i>Any Two</i> questions from the rest (2×20)</u>	Marks
Q1	Answer <i>any Two</i> of the following:	
(a)	With the help of a schematic diagram define the different process variables and control variables associated with an automatic process control system.	5
(b)	What are “Integral Balance” and “Instantaneous Balance” techniques of process modeling? Obtain the model of a “Liquid Surge Tank” using both the methods.	2+3
(c)	What is “Empirical Model”? How is it different from “Fundamental Model”?	5
(d)	What is <i>Process Time Lag</i> ? What are the main factors responsible for it?	5
Q2	(a) A continuous, stirred-tank blending system is shown in Figure Q2(a). (i) Write down the Steady-State Material and Component-A balance equations. (ii) Obtain the expression for the nominal flow rate of w_2 required to produce the desired output concentration x_{sp} . (iii) Suppose that inlet concentration x_1 varies with time. What are the different schemes that can be employed to ensure that the outlet composition x remains at or near its desired value x_{sp} ?	4 4 4

**Figure Q2(a)**

- (b) Describe the methods of determining the parameters of First-Order-Plus-Time-Delay (FOPTD) model from the process reaction curve. 8

- Q3 (a) Why PID controller is called a “Gain-Reset-Preact Controller”? 6
- (b) For a type-0 system, explain how PI-controller can eliminate the steady-state offset for a step input while P-controller can only reduce it. 4
- (c) What is *Set Point Kick*? 2
- Show, with the help of block diagrams, how the PID controller configurations need to be modified to eliminate such phenomena. 8
- Q4 (a) What is Ratio Control? 2
- With the help of schematic diagram discuss the different Ratio Control methods. 6
- (b) A Ratio Control scheme is to be used to maintain a stoichiometric ratio of H_2 and N_2 as the feed to an ammonia synthesis reactor. Individual flow controllers will be used for both the H_2 and N_2 streams. 4
- Draw a schematic diagram for the Ratio Control configuration.
- (c) What is *Inferential Control*? 2
- With the help of a block diagram discuss the function of a Soft Sensor in an Inferential Control Scheme. 6
- Q5 Write short note on **any two** of the followings:
- (a) Lumped and Distributed parameter modeling 10
- (b) Feed-forward control vs Feedback control 10
- (c) Cascade Control Scheme 10
- (d) Ziegler Nichols methods of PID controller tuning 10