GUJARAT TECHNOLOGICAL UNIVERSITY

BE SEMESTER 5 – OLD PAPER – S22 TO S26 – QUESTION BANK

Subject Name & Code: Instrumentation and Process Control - 3150504

Chapter 1 – Introduction of Process Control

Repeated Questions:

1. Process Control Concepts (Theory):

- **Q.** Discuss the importance of process control in chemical industry / industry. **(WINTER 2023, 4 Marks; SUMMER 2024, 4 Marks)**
- **Q.** Differentiate Open loop and closed loop control system. **(SUMMER 2022, 4 Marks OR; SUMMER 2024, 3 Marks)**
- **Q.** Differentiate Feedback and feed forward control system with example / Differentiate Feed-forward and Feed-back control. **(WINTER 2024, 4 Marks OR; WINTER 2025, 4 Marks)**
- **Q.** Merits and demerits of Feed-back control strategy / Why negative feedback systems are used in Process Control? **(WINTER 2022, 4 Marks OR; SUMMER 2025, 4 Marks)**

Other Important Questions:

1. Control Strategies and Definitions (Theory):

- **Q.** Advantages of automatic control of a process. **(WINTER 2025, 3 Marks)**
- **Q.** What is open loop control system? **(WINTER 2023, 3 Marks OR)**
- **Q.** Merits and demerits of Feed-forward control strategy. **(WINTER 2022, 4 Marks)**
- **Q.** Explain significance of deviation variables. **(WINTER 2023, 4 Marks)**
- **Q.** Define dead zone and dead time lag. **(SUMMER 2022, 3 Marks)**
- **Q.** Define: Gain, Transportation Lag, Time Constant. **(WINTER 2024, 3 Marks)**

Chapter 2 – Laplace Transforms

Repeated Questions:

1. Laplace Transforms and Theorems:

- **Q.** Give the Laplace transform for the following: sin kt, cosh kt, e^{-at} sin kt / cosh(kt), cos(t), sin(kt) / cos kt, sinh kt, e^{-at} / e^{-2t} sin t, δ(t), t^2e^t. **(WINTER 2022, 3 Marks; WINTER 2023, 3 Marks; WINTER 2024, 3 Marks; SUMMER 2026, 3 Marks)**
- **Q.** Find the Laplace transform of f(t) = 1 & f(t) = t. **(SUMMER 2022, 4 Marks)**
- **Q.** State and prove Initial-Value Theorem / Final value theorem / statements for initial value theorem and final value theorem. **(SUMMER 2023, 4 Marks; WINTER 2024, 4 Marks; SUMMER 2026, 4 Marks)**

2. Solution of Differential Equations by Laplace Transform (Numerical):

- **Q.** Solve the differential equation by Laplace transform: $d^2x/dt^2 + 2\,dx/dt + x = 1$, x(0) = x'(0) = 0 / $d^2x/dt^2 + 4\,dx/dt + 3x = 1$ given x(0) = x'(0) = 0 / $dx/dt + x = 1$, x(0) = 0. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks; WINTER 2025, 4 Marks)**

Other Important Questions:

1. Definitions and Theorems (Theory):

- **Q.** Define step and input function. **(SUMMER 2022, 3 Marks)**
- **Q.** Explain Impulse input in detail. **(SUMMER 2023, 3 Marks)**
- **Q.** State and prove translation of transform. **(WINTER 2025, 3 Marks)**

2. Numerical Problems:

- **Q.** Solve $dx/dt + 3x = 0$, x(0) = 2 **(SUMMER 2022, 3 Marks)**
- **Q.** Solve the following differential equation by Laplace transform: $d^3x/dt^3 + 2\,d^2x/dt^2 - dx/dt - 2x = 4 + e^{2t}$, x(0) = 1, x'(0) = 0, x'' = −1 **(SUMMER 2022, 7 Marks)**
- **Q.** Find the inverse Laplace Transform of the function: $\bar{x}(s) = (4s + 5) / ((s - 1)^2(s + 2))$ **(SUMMER 2022, 7 Marks OR)**
- **Q.** If the Laplace transform of a function 4 / [s(s + 2)(s + 4)] is time domain, as t → ∞, Determine the final value of the response. **(WINTER 2022, 4 Marks)**
- **Q.** Determine the x(t) for $x(s) = 1 / [s^2(s + 1)]$ **(SUMMER 2026, 7 Marks)**

Chapter 3 – Response of First Order Systems

Repeated Questions:

1. Thermometer and Mixing Process:

- **Q.** Derive the transfer function of mercury thermometer (as first order system). Determine the response equation of mercury thermometer for step/ramp function. List the assumptions and justify them. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2023, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2025, 7 Marks; SUMMER 2026, 7 Marks)**
- **Q.** A thermometer numerical problem (Time constant, initial temp, step change, find temp at time t). **(SUMMER 2023, 7 Marks OR; WINTER 2023, 7 Marks OR; SUMMER 2026, 7 Marks OR)**
- **Q.** Derive transfer function of the Mixing process / Explain first order system by giving physical example of mixing process. **(SUMMER 2023, 4 Marks; WINTER 2024, 7 Marks; SUMMER 2026, 4 Marks)**

2. Interacting and Non-interacting Systems:

- **Q.** Differentiate between Interacting systems and Non-interacting system. **(WINTER 2022, 4 Marks; SUMMER 2023, 7 Marks; WINTER 2025, 3 Marks; SUMMER 2026, 4 Marks OR)**
- **Q.** Derive the transfer function for two interacting / non-interacting first order liquid level systems. **(SUMMER 2024, 7 Marks OR; WINTER 2024, 7 Marks OR)**

3. Time Constant and Transportation Lag:

- **Q.** Derive transfer function for transportation lag. / Explain Transportation lag with transfer function. **(SUMMER 2022, 3 Marks OR; SUMMER 2025, 3 Marks; SUMMER 2026, 3 Marks)**
- **Q.** Define Time Constant. / Define a first order system. **(WINTER 2023, 3 Marks; WINTER 2023, 3 Marks)**

Other Important Questions:

1. Theory and Derivations:

- **Q.** Give resistance capacitance lag for following systems: (1) Liquid filled thermometer (2) Liquid level in a tank (3) Mixing tank. **(SUMMER 2024, 3 Marks)**
- **Q.** Summarize the time constant of first order system: Thermometer, Liquid-level process and Mixing process. **(WINTER 2022, 3 Marks)**
- **Q.** Differentiate between transfer lag and transportation lag. **(WINTER 2025, 4 Marks)**
- **Q.** Derive the transfer function for 'loading' system where second tank will be load by first tank. **(WINTER 2025, 7 Marks OR)**
- **Q.** Derive and plot the response of impulse function for first order system $Y(s)/X(s) = 1/(\tau s + 1)$ **(SUMMER 2025, 4 Marks)**
- **Q.** Prove that for liquid level system with constant flow outlet the step change in initial flow rate gives response as a ramp function which grows without limit. **(SUMMER 2025, 7 Marks)**
- **Q.** Show that the ultimate change in height H(t) for a unit step change in initial flowrate Q(t) is simply resistance R. **(SUMMER 2025, 3 Marks)**

2. Numerical Problems:

- **Q.** A Storage tank contains a liquid which is pumped by a centrifugal pump at a steady rate. Liquid enters the tank at volumetric flow rate 200 Liter/hr and liquid level reaches steady-state value of 40 cm. If input flow rate is suddenly increased to 300 Liter/hr, Find level response and liquid level after 1 minute... [Data truncated in source – refer to the original question paper] **(WINTER 2024, 7 Marks OR)**

Chapter 4 – Second Order Systems

Repeated Questions:

1. Second Order System – Theory and Derivations:

- **Q.** Define second order system. Derive the transfer function of U-Tube Manometer in which pressure P is acting in one limb and other limb is open to the atmosphere / mercury manometer. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks; WINTER 2025, 7 Marks)**
- **Q.** Explain the significance of Damping coefficient. **(SUMMER 2023, 3 Marks; WINTER 2023, 4 Marks OR)**
- **Q.** Explain in details the terms used to describe an underdamped system / Discuss characteristics of underdamped step response for second order system / Explain the overshoot, decay ratio and response time for second order underdamped system. **(WINTER 2023, 7 Marks OR; SUMMER 2024, 7 Marks OR; WINTER 2024, 4 Marks; SUMMER 2026, 3 Marks)**

2. Numerical Problems:

- **Q.** A step change of magnitude 4 is introduced into a system having the transfer function $Y(s)/X(s) = 16 / (1.5s^2 + 2.4s + 6)$. Determine: Percent overshoot, Rise time, Period of oscillation, Natural period of oscillation. **(SUMMER 2023, 7 Marks OR; SUMMER 2024, 7 Marks)**

Other Important Questions:

1. Theory and Derivations:

- **Q.** Define: overshoot, decay ratio, response time and period of oscillations. **(SUMMER 2022, 4 Marks OR)**
- **Q.** Discuss Overshoot in process control with suitable example. **(SUMMER 2025, 4 Marks)**
- **Q.** For second order critically damped system find the value of Y(t) for unit step change in X(t). $Y(s)/X(s) = 1 / (\tau^2 s^2 + 2\varepsilon\tau s + 1)$ **(SUMMER 2025, 7 Marks)**
- **Q.** Derive the transfer function of damped vibrator as second order system and find the critically damped step response. **(SUMMER 2026, 7 Marks)**

2. Numerical Problems:

- **Q.** The transfer function of a control system is given by $G(s) = 1 / (1 + 5s)^2$. Determine the value of damping factor (ζ) and predict the output response for unit step change in input. Find the output response after 30 second. **(WINTER 2022, 7 Marks OR)**
- **Q.** For a second order transfer function with $\tau = 1$ and $\zeta = 0.8$, being distributed with a sine wave input 3 sin (0.5). Determine the form of the response after transient have decayed and steady state oscillations are established. **(WINTER 2025, 7 Marks)**

Chapter 5 – The Control Systems

Repeated Questions:

1. Control System Concepts (Theory):

- **Q.** Explain Servomechanism type problem and Regulator problem / Discuss Servo and Regulatory mechanism / Differentiate between servo-type and regulator-type problem. **(SUMMER 2022, 4 Marks; WINTER 2022, 3 Marks OR; WINTER 2022, 3 Marks; WINTER 2023, 4 Marks; SUMMER 2024, 4 Marks; WINTER 2024, 4 Marks OR; WINTER 2025, 4 Marks OR; SUMMER 2026, 4 Marks; SUMMER 2026, 4 Marks OR)**
- **Q.** Distinguish between Negative Feedback and Positive Feedback / Explain negative and positive feedback control systems. **(SUMMER 2022, 3 Marks; SUMMER 2023, 4 Marks OR; WINTER 2023, 4 Marks; SUMMER 2024, 3 Marks)**
- **Q.** Explain component parts of Block diagram of a simple control system with figure / With neat sketch explain the various parts of control system / Discuss the various components of a control system with example. **(SUMMER 2023, 7 Marks; SUMMER 2024, 3 Marks OR; SUMMER 2026, 3 Marks OR)**
- **Q.** Discuss the rules for reduction of block diagram with example of each. **(SUMMER 2026, 7 Marks OR)**

2. Stirred-Tank Heater:

- **Q.** Explain various component and variable of control system for stirred-tank heater / Develop a transfer function relating the tank outlet temperature to changes in the inlet temperature considering mixed tank heater system. **(WINTER 2022, 7 Marks; WINTER 2025, 4 Marks)**

Other Important Questions:

1. Transfer Functions and Control Terms:

- **Q.** Obtain the overall transfer function of a servo mechanism negative feedback control system. **(WINTER 2023, 7 Marks)**
- **Q.** Explain the following in control system: 1. Load Variable 2. Set Point 3. Control Variable. **(WINTER 2024, 3 Marks OR)**
- **Q.** Find the overall transfer function C(S)/U(S) for change in load R = 0 for given control system. [Diagram required – refer to the original question paper] **(SUMMER 2025, 3 Marks)**
- **Q.** Draw Piping and instrumentation diagram for control system of heat exchanger with suitable labelling. **(SUMMER 2025, 4 Marks)**

Chapter 6 – Controllers and Final Control Elements

Repeated Questions:

1. Controller Modes (Theory):

- **Q.** What is offset? Explain P, PI and PID controller / Derive equation of Offset for PI controller / Derive overall transfer function of PID control. **(SUMMER 2022, 4 Marks OR; WINTER 2022, 3 Marks OR; SUMMER 2023, 7 Marks; SUMMER 2026, 3 Marks)**
- **Q.** Discuss / Write a short note on: ON/OFF controller. Discuss applications. **(WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks OR; SUMMER 2025, 3 Marks; WINTER 2025, 3 Marks OR; SUMMER 2026, 3 Marks OR)**
- **Q.** Explain the merits and demerits of Proportional, Integral and Derivative action in a feedback controller / Advantages and disadvantages of P-control / PI-control. **(WINTER 2023, 7 Marks; WINTER 2024, 3 Marks; WINTER 2024, 4 Marks)**
- **Q.** Derive and discuss the transfer function for PI & PD controller / Write in brief about PD controllers and its transfer function. **(SUMMER 2024, 4 Marks OR; WINTER 2025, 4 Marks)**

2. Final Control Elements:

- **Q.** Explain difference between Air to open and Air to close valve with neat sketch. **(SUMMER 2023, 4 Marks; SUMMER 2024, 4 Marks)**

Other Important Questions:

1. Controllers (Theory):

- **Q.** What is controller gain? **(WINTER 2023, 3 Marks)**
- **Q.** What is controller? Explain its importance in close loop control system. **(WINTER 2024, 3 Marks)**
- **Q.** Discuss the selection criteria for the controller based on the Offset value. **(SUMMER 2025, 3 Marks)**

2. Final Control Elements:

- **Q.** Discuss in detail about Pneumatic control valve with figure. **(SUMMER 2025, 7 Marks)**

Chapter 7 – Transient Response of Simple Control Systems

Repeated Questions:

None identified.

Other Important Questions:

1. Numerical Problems:

- **Q.** The set point of the control system shown in figure below is given a step change of 0.1 unit. Determine: (a) The maximum value of C and (b) The offset. [Diagram required – refer to the original question paper] **(SUMMER 2022, 7 Marks)**

Chapter 8 – Stability

Repeated Questions:

1. Routh Criterion and Nyquist Criterion:

- **Q.** Determine the stability by the Routh criterion: $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$ / $s^4 + 3s^2 + 5s^2 + 4s + 2 = 0$. **(SUMMER 2022, 7 Marks OR; SUMMER 2024, 7 Marks)**
- **Q.** Discuss the Nyquist stability criteria. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks OR; WINTER 2025, 3 Marks)**
- **Q.** Determine the stability criteria of the system shown below for which PI controller is used. Use $\tau_1 = 1$, $\tau_2 = 1/2$, $\tau_3 = 1/3$, $K_c = 5$ and $\tau_I = 0.25$. [Diagram required – refer to the original question paper] **(SUMMER 2025, 4 Marks; WINTER 2025, 7 Marks)**

Other Important Questions:

1. Theory:

- **Q.** Define stability for a control system. **(WINTER 2023, 3 Marks OR)**
- **Q.** Write the statements of Routh Theorem. **(SUMMER 2023, 4 Marks)**
- **Q.** Describe the importance of root locus method in brief. **(SUMMER 2022, 4 Marks)**

2. Numerical Problems:

- **Q.** The characteristic equation of control system is given as $S^4 + 20S^3 + 15S^2 + 2S + K = 0$. Determine 1. The value of K for which system is stable using both stability criteria. 2. Value of K for which system is marginally stable and Complex roots of the system. **(WINTER 2022, 7 Marks OR)**
- **Q.** Determine the stability of the control system having the open loop transfer function: $G(s) = K_c / [s(s + 1)(s + 2)]$ **(WINTER 2023, 7 Marks OR)**
- **Q.** The characteristics equation of control system is given as $s^3 + 3s^2 + 2s + K = 0$. Determine (1) The value of K for which system is stable system using Routh test (2) The value of K for which system is marginally stable (3) The frequency of system for sustain oscillations. **(WINTER 2024, 7 Marks)**
- **Q.** Determine stability using Root locus diagram for the open loop transfer function $G(s) = K_c / [(s + 1)(0.5s + 1)]$ **(SUMMER 2025, 7 Marks)**
- **Q.** The characteristics equation of control system is given as $s^3 + 6s^2 + 11s + 6(1 + K_c) = 0$. (1) Determine the value of K_c for which system is stable system using Routh test (2) Determine the roots of the characteristic equation when value of K_c for which the system is on the threshold of instability. **(SUMMER 2026, 7 Marks)**

Chapter 9 – Frequency Response analysis

Repeated Questions:

1. Bode Diagrams (Theory):

- **Q.** Discuss Phase margin and Gain margin using stability criteria for Bode diagram. / Explain gain margin and phase margin / Write significance of gain margin and phase margin. **(SUMMER 2022, 3 Marks OR; WINTER 2023, 4 Marks; SUMMER 2024, 4 Marks; WINTER 2025, 7 Marks OR; SUMMER 2026, 7 Marks OR)**
- **Q.** What are Bode diagrams? Explain the graphical rules for Bode diagrams. / Discuss Bode plot for first order system. **(SUMMER 2024, 4 Marks OR; WINTER 2024, 7 Marks OR; WINTER 2025, 7 Marks)**

Other Important Questions:

1. Frequency Response:

- **Q.** Explain the statement for sinusoidal response. "The output lags behind the input by an angle frequency f and the signal is attenuated". **(SUMMER 2023, 4 Marks)**
- **Q.** Plot the bode diagram for the system whose overall transfer function is 1 / [(s + 1)(s + 5)]. **(SUMMER 2022, 7 Marks OR)**

Chapter 10 – Controller tuning and advance controllers

Repeated Questions:

1. Controller Tuning and Ratio Control:

- **Q.** Discuss Ziegler-Nichols method for Controller tuning / Explain controller tuning using Ziegler-Nichols method. **(SUMMER 2023, 7 Marks; WINTER 2023, 4 Marks OR)**
- **Q.** What is the objective of ratio control system? Give Three applications in chemical industry. / What is ratio control? Give important applications of it in chemical industry. **(WINTER 2022, 4 Marks OR; SUMMER 2026, 4 Marks)**

Other Important Questions:

1. Controller Tuning and Advanced Control:

- **Q.** Explain the Cohen-Coon controller tuning method for setting of parameter in P, PI, and PID feedback control system. **(SUMMER 2025, 7 Marks OR)**
- **Q.** Discuss the advantages and limitations of Internal Model Control (IMC). **(WINTER 2022, 4 Marks)**
- **Q.** Explain the working of cascade control system. **(WINTER 2024, 3 Marks OR)**

Chapter 11 – Introduction of Process Measurement

Repeated Questions:

1. Instrument Characteristics:

- **Q.** Explain any two static and dynamic characteristics of an instrument / List the static and dynamic characteristics of Instruments. **(SUMMER 2024, 4 Marks; WINTER 2024, 3 Marks OR)**

Other Important Questions:

1. Instrument Characteristics:

- **Q.** Define: Accuracy, Span, Drift. **(SUMMER 2023, 3 Marks)**
- **Q.** Define: Drift, hysteresis and speed of response. **(WINTER 2023, 3 Marks)**
- **Q.** Discuss various static characteristics of instrument. **(WINTER 2022, 3 Marks OR)**

Chapter 12 – Temperature Measurement

Repeated Questions:

1. Thermometers and Thermocouples:

- **Q.** Discuss pressure spring thermometer with neat sketch. **(SUMMER 2022, 7 Marks; SUMMER 2024, 7 Marks)**
- **Q.** Discuss the principle of measurement in Bimetallic Thermometer / Explain the working principle and construction of bimetallic thermometer. **(SUMMER 2024, 3 Marks; WINTER 2025, 4 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Explain Seebeck effect of Thermocouple / Explain the working principle and construction of Thermocouples. **(WINTER 2022, 4 Marks; WINTER 2024, 4 Marks)**

2. Pyrometers:

- **Q.** Explain working of optical pyrometer with schematic / Explain construction and working of optical pyrometer / Explain principle, construction and working of radiation pyrometer. **(WINTER 2022, 7 Marks; WINTER 2023, 7 Marks; SUMMER 2024, 4 Marks OR; WINTER 2025, 7 Marks OR; SUMMER 2026, 7 Marks OR)**

Other Important Questions:

1. Filled System Thermometers:

- **Q.** Discuss Dip effect in filled system thermometer. **(SUMMER 2023, 3 Marks OR)**

Chapter 13 – Pressure Measurement

Repeated Questions:

1. Pressure Measurement Methods:

- **Q.** List the various methods used in industrial process for pressure measurement. **(WINTER 2025, 3 Marks; SUMMER 2026, 3 Marks)**

Other Important Questions:

1. Pressure Gauges:

- **Q.** Discuss working of Bourdon Gauge. **(SUMMER 2023, 3 Marks)**
- **Q.** Write a note on Bellows differential pressure element with neat sketch. **(SUMMER 2022, 7 Marks OR)**
- **Q.** Explain construction and working of McLeod gauge. **(WINTER 2022, 7 Marks OR)**
- **Q.** Explain principle, construction and working of Pirani vacuum gauge. **(WINTER 2024, 7 Marks OR)**

Chapter 14 – Liquid Level Measurement

Repeated Questions:

1. Liquid Level Measurement Methods:

- **Q.** Give Classification of liquid level measurement systems / List the various methods used in industrial process for liquid level measurement. **(SUMMER 2023, 4 Marks; WINTER 2025, 3 Marks OR; SUMMER 2026, 3 Marks OR)**
- **Q.** Explain the principle of liquid level measurement in bubbler system / Discuss the working principle of bubbler system / Discuss the construction and working of bubbler system / Explain principle, construction and working of bubbler system. **(SUMMER 2022, 4 Marks; SUMMER 2024, 3 Marks OR; WINTER 2024, 7 Marks; WINTER 2025, 4 Marks OR; SUMMER 2026, 4 Marks OR)**

Other Important Questions:

1. Direct Measurement:

- **Q.** Explain method for direct measurement of liquid level. **(WINTER 2022, 3 Marks OR)**

Chapter 15 – Flow Measurement

Repeated Questions:

1. Variable Area Flow Meters:

- **Q.** Discuss construction and working of Rota meter. **(SUMMER 2023, 7 Marks OR; SUMMER 2024, 7 Marks OR)**

Other Important Questions:

None identified.

Chapter 16 – Humidity measurement & pH Measurement

Repeated Questions:

None identified.

Other Important Questions:

1. Humidity Measurement:

- **Q.** Highlight on hygrometer & hydrometer. **(SUMMER 2022, 3 Marks OR)**
- **Q.** Discuss dry bulb and wet bulb method for measurement of humidity. **(WINTER 2022, 4 Marks OR)**

Chapter 17 – Density & Viscosity Measurement

Repeated Questions:

None identified.

Other Important Questions:

1. Viscosity Measurement:

- **Q.** List the various instrument used for Viscosity measurement and explain working of any one. **(WINTER 2024, 4 Marks OR)**

Chapter 18 – Introduction to advance topics

Repeated Questions:

1. PLC, DCS and SCADA:

- **Q.** Describe PLC, DCS, and SCADA in brief / Explain PLC and DCS / Describe PLC and SCADA in brief. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2023, 3 Marks; SUMMER 2024, 3 Marks OR; SUMMER 2024, 3 Marks; WINTER 2024, 3 Marks; WINTER 2025, 7 Marks; SUMMER 2026, 7 Marks)**
- **Q.** Mention advantages and disadvantages of Distributed Control System / Discuss the advantages with application of DCS / Discuss the construction and working of Distributed Control System (DCS) with all merits and demerits. **(WINTER 2023, 4 Marks; SUMMER 2024, 3 Marks OR; WINTER 2025, 7 Marks; SUMMER 2026, 7 Marks)**

Other Important Questions:

None identified.

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