GUJARAT TECHNOLOGICAL UNIVERSITY

BE-5 SEMESTER – OLD PAPER – S22 TO S25 – QUESTION BANK

Subject Name & Code:

Instrumentation and Process Control- 3150504

Chapter 1: Introduction to Process Control

Repeated Questions:

1. **Discuss Servo and Regulatory mechanism/problem.**
   - (Summer 2023, Q1(c)) - 07 Marks
   - (Summer 2024, Q2(b)) - 04 Marks
   - (Summer 2022, Q3(b)) - 04 Marks
   - (Winter 2024, Q4(b)) - 04 Marks
2. **Discuss the importance/significance of process control in the (chemical) industry.**
   - (Summer 2024, Q1(b)) - 04 Marks
   - (Winter 2023, Q1(b)) - 04 Marks
3. **Differentiate between Open loop and Closed loop control system.**
   - (Summer 2024, Q2(a)) - 03 Marks
   - (Summer 2022, Q4(b)) - 04 Marks
4. **Draw the general block diagram of a simple control system and explain each term/variable.**
   - (Summer 2024, Q3(a)) - 03 Marks
   - (Winter 2022, Q2(c)) - 07 Marks (for stirred-tank heater)
   - (Winter 2024, Q3(a)) - 03 Marks (Define Load, Set Point, Control Variable)

Other Important Questions:

- Explain control logic, block diagrams, control structures (feedback vs. feedforward). (Conceptual from syllabus)
- (Summer 2023, Q4(c)) - Explain component parts of a Block diagram of a simple control system with figure. - 07 Marks
- (Winter 2024, Q3(b)) - Differentiate between Feed-forward control and Feed-back control. - 04 Marks

Chapter 2: Laplace Transforms

Repeated Questions:

1. **Find the Laplace Transform of given functions (e.g., cos, sin, exp, hyperbolic, impulse).**
   - (Winter 2022, Q1(a)) - 03 Marks
   - (Winter 2023, Q2(a)) - 03 Marks
   - (Winter 2024, Q1(a)) - 03 Marks
2. **State and prove/apply Initial Value Theorem and Final Value Theorem.**
   - (Summer 2023, Q1(b)) - 04 Marks
   - (Winter 2022, Q1(b)) - 04 Marks
   - (Winter 2024, Q1(b)) - 04 Marks
3. **Solve differential equations using Laplace Transforms.**
   - (Winter 2023, Q1(c)) - 07 Marks: $d^2x/dt^2 + 4dx/dt + 3x = 1$
   - (Summer 2022, Q2(c)) - 07 Marks: $d^3x/dt^3 + 2d^2x/dt^2 - dx/dt - 2x = 4 + e^{2t}$
   - (Winter 2024, Q1(c)) - 07 Marks: $dx/dt + x = 1$
4. **Find the Inverse Laplace Transform.**
   - (Summer 2022, Q2(c) OR) - 07 Marks: $(4s+5)/((s-1)^2(s+2))$

Other Important Questions:

- (Summer 2022, Q1(b)) - Find Laplace transform of $f(t)=1$ & $f(t)=t$. - 04 Marks
- (Summer 2022, Q2(a)) - Solve $dx/dt + 3x = 0$, $x(0)=2$. - 03 Marks

Chapter 3: Response of First Order Systems

Repeated Questions:

1. **Derive the transfer function for a Mercury in Glass Thermometer.**
    - (Summer 2022, Q1(c)) - 07 Marks
    - (Winter 2022, Q1(c)) - 07 Marks
    - (Summer 2024, Q1(c)) - 07 Marks
    - (Winter 2023, Q2(c)) - 07 Marks
    - (Winter 2024, Q2(b)) - 04 Marks (Assumptions)
2. **Derive the transfer function and step response for a Mixing Process/Tank.**
    - (Summer 2023, Q2(b)) - 04 Marks
    - (Winter 2024, Q2(c)) - 07 Marks
3. **Define Time Constant. Explain its significance.**
    - (Winter 2023, Q1(a)) - 03 Marks
    - (Winter 2024, Q2(a)) - 03 Marks (Part of definition)
4. **Numerical on First Order System Response (Thermometer/Liquid Level).**
    - (Summer 2023, Q2(c) OR) - 07 Marks: Thermometer in sinusoidal bath.
    - (Winter 2023, Q2(c) OR) - 07 Marks: Thermometer immersion time calculation.
    - (Winter 2024, Q2(c) OR) - 07 Marks: Liquid level response in a tank.

Other Important Questions:

- (Summer 2023, Q1(a)) - Give Significance of Damping co-efficient. (Also relates to Ch 4) - 03 Marks
- (Summer 2023, Q2(a)) - Explain Impulse input in detail. - 03 Marks
- (Summer 2025, Q1(a)) - Explain Transportation lag with transfer function. - 03 Marks
- (Summer 2025, Q1(b)) - Derive and plot the response of impulse function for first order system. - 04 Marks
- (Summer 2025, Q1(c)) - Prove ramp response for liquid level system. - 07 Marks
- (Summer 2024, Q1(a)) - Give resistance capacitance lag for systems (Thermometer, Level, Mixing). - 03 Marks
- (Winter 2022, Q2(a)) - Summarize time constant for Thermometer, Liquid-level, Mixing process. - 03 Marks
- (Summer 2023, Q3(a)) - Place a transfer function in standard first-order form, identify time constant and gain. - 03 Marks

Chapter 4: Second Order Systems

Repeated Questions:

1. **Define a second order system. Derive the transfer function of a U-Tube Manometer.**
   - (Summer 2024, Q2(c)) - 07 Marks
   - (Summer 2022, Q3(c)) - 07 Marks
   - (Winter 2024, Q3(c)) - 07 Marks
2. **Explain/Discuss the characteristics of an underdamped second-order step response (Overshoot, Decay Ratio, etc.).**
   - (Summer 2024, Q3(c)) - 07 Marks
   - (Winter 2023, Q3(c)) - 07 Marks
   - (Winter 2024, Q3(b)) - 04 Marks
3. **For a given second-order transfer function, determine: % Overshoot, Rise Time, Period of Oscillation.**
   - (Summer 2023, Q4(c)) - 07 Marks: $Y(s)/X(s) = 16/(1.5s^2 + 2.4s + 6)$
   - (Summer 2024, Q3(c)) - 07 Marks: *Same transfer function*
4. **Differentiate between Interacting and Non-Interacting systems.**
   - (Summer 2023, Q2(c)) - 07 Marks
   - (Winter 2022, Q2(b)) - 04 Marks

Other Important Questions:

- (Summer 2025, Q2(c)) - For a critically damped system, find Y(t) for a unit step change. - 07 Marks
- (Winter 2022, Q2(c) OR) - Find damping factor (ζ) and output response for $G(s) = 1/(1+5s)^2$. - 07 Marks

Chapter 5: The Control Systems (Block Diagrams, Feedback)

Repeated Questions:

1. **Draw and explain the block diagram of a control system (with negative/positive feedback).**
    - (Summer 2024, Q3(a)) - 03 Marks (Positive feedback)
    - (Summer 2023, Q4(c)) - 07 Marks (Components with figure)
2. **Differentiate between Negative and Positive Feedback.**
    - (Summer 2022, Q4(a)) - 03 Marks
    - (Summer 2023, Q3(b)) - 04 Marks
3. **Explain Servo (set-point change) and Regulator (load change) problems.**
    - *(This is heavily repeated from Chapter 1, but is a core part of this chapter's syllabus)*
    - (Summer 2024, Q2(b)) - 04 Marks
    - (Winter 2024, Q4(b)) - 04 Marks
4. **Find the overall transfer function for a given block diagram (for set-point or load change).**
    - (Summer 2025, Q3(a) OR) - 03 Marks (For load change, R=0)
    - (Winter 2023, Q4(c)) - 07 Marks (For servo mechanism)

Other Important Questions:

- (Summer 2025, Q3(b)) - Draw Piping and Instrumentation Diagram (P&ID) for a heat exchanger. - 04 Marks
- Development of block diagrams for processes. (Conceptual from syllabus)

Chapter 6: Controllers and Final Control Elements

Repeated Questions:

1. **Explain/Describe Proportional (P), Proportional-Integral (PI), and Proportional-Integral-Derivative (PID) controllers.**
    - (Summer 2022, Q5(b)) - 04 Marks (Explain P, PI, PID)
    - (Winter 2023, Q3(c)) - 07 Marks (Merits/Demerits of P, I, D actions)
    - (Winter 2024, Q4(b)) - 04 Marks (Advantages/Disadvantages of PI-Control)
2. **Derive the transfer function for PI, PD, and PID controllers.**
    - (Summer 2024, Q3(b) OR) - 04 Marks (PI & PD)
    - (Winter 2022, Q4(a)) - 03 Marks (PID)
3. **Explain Air-to-Open and Air-to-Close control valves.**
    - (Summer 2024, Q3(b)) - 04 Marks
    - (Summer 2023, Q4(b)) - 04 Marks
4. **What is Offset? Explain its significance for different controller types.**
    - (Summer 2022, Q5(b)) - 04 Marks
    - (Summer 2025, Q3(a)) - 03 Marks (Selection criteria based on Offset)
    - (Summer 2023, Q3(c) OR) - Derive equation of Offset for PI controller. - 07 Marks

Other Important Questions:

- (Summer 2024, Q3(a) OR) - Discuss ON/OFF controller. - 03 Marks
- (Winter 2022, Q4(a)) - Write a short note: ON/OFF controller. - 03 Marks
- (Summer 2025, Q4(c)) - Discuss in detail about Pneumatic control valve with figure. - 07 Marks
- (Winter 2024, Q4(a)) - What is a controller? Explain its importance in a close loop control system. - 03 Marks
- (Winter 2024, Q3(a)) - Advantages/Disadvantages and application of P-Control. - 03 Marks

Chapter 7: Transient Response of Simple Control Systems

Repeated Questions:

1. **Analyze Proportional Control for set-point change (Servo Problem) and load change (Regulator Problem).**
    - (This is the core concept of the chapter. Many questions from Chapters 5 & 6 are applications of this).
2. **Numerical on finding maximum value and offset for a given control system.**
    - (Summer 2022, Q5(c)) - 07 Marks: The set point is given a step change of 0.1 unit. Determine the maximum value of C and the offset.

Other Important Questions:

- (Conceptual questions on the response of systems with P, PI control under different conditions, as covered in the syllabus).

Chapter 8: Stability

Repeated Questions:

1. **Determine the stability of a system using the Routh-Hurwitz criterion for a given characteristic equation.**
    - (Summer 2024, Q4(c)) - 07 Marks: $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$
    - (Summer 2022, Q4(c)) - 07 Marks: $s^4 + 3s^2 + 5s^2 + 4s + 2 = 0$ (Note: likely a typo in the paper, should be $s^4 + 3s^3$...)
    - (Winter 2024, Q4(c)) - 07 Marks: $s^3 + 3s^2 + 2s + K = 0$
    - (Winter 2022, Q3(c) OR) - 07 Marks: $S^4 + 20S^3 + 15S^2 + 2S + K = 0$
2. **Explain the Nyquist stability criterion.**
    - (Summer 2024, Q4(c) OR) - 07 Marks
    - (Winter 2022, Q4(c)) - 07 Marks
3. **Explain Gain Margin and Phase Margin.**
    - (Summer 2022, Q5(a)) - 03 Marks (Significance)
    - (Summer 2023, Q4(a)) - 03 Marks
    - (Winter 2023, Q4(b)) - 04 Marks

Other Important Questions:

- (Summer 2025, Q3(c)) - Determine stability using Root Locus for $G(s) = Kc/((s+1)(0.5s+1))$. - 07 Marks
- (Winter 2023, Q4(c)) - Determine stability for $G(s) = Kc/(s(s+1)(s+2))$ - 07 Marks
- (Summer 2025, Q4(b)) - Determine stability for a system with a PI controller using Routh criterion (Numerical). - 04 Marks

Chapter 9: Frequency Response Analysis

Repeated Questions:

1. **What are Bode diagrams? Explain the graphical rules for plotting them.**
   - (Summer 2024, Q4(b) OR) - 04 Marks
2. **Plot the Bode diagram for a given transfer function (e.g., first-order or second-order system).**
   - (Summer 2022, Q5(c)) - 07 Marks: $1/((s+1)(s+5))$
   - (Summer 2025, Q4(c)) - 07 Marks: Draw Bode plots for AR = $1/\sqrt{(\tau^2\omega^2+1)}$ (First-order system)
3. **Discuss Phase Margin and Gain Margin using stability criteria for Bode diagram.**
   - (Summer 2024, Q4(b)) - 04 Marks

Other Important Questions:

- (Winter 2024, Q4(c) OR) - Explain frequency response analysis of a first-order system by Bode diagram. - 07 Marks
- Explain the concept of transportation lag in frequency response. (Conceptual from syllabus).

Chapter 10: Controller Tuning and Advanced Controllers

Repeated Questions:

1. **Explain the Ziegler-Nichols method for controller tuning.**
    - (Summer 2023, Q5(c)) - 07 Marks
    - (Winter 2023, Q4(b)) - 04 Marks
2. **Explain the Cohen-Coon controller tuning method.**
    - (Summer 2025, Q2(c) OR) - 07 Marks
3. **Explain advanced control strategies like Cascade, Feed-forward, and Ratio control.**
    - (Winter 2024, Q4(a)) - 03 Marks (Cascade control)
    - (Summer 2025, Q5(c)) - 07 Marks (Ratio control)
    - (Winter 2022, Q4(b)) - 04 Marks (Objective and applications of Ratio control)

Other Important Questions:

- (Winter 2022, Q4(b)) - Discuss advantages/limitations of Internal Model Control (IMC). - 04 Marks
- Introduction to DCS, PLC, SCADA (also covered in Chapter 18).

Chapter 11: Introduction to Process Measurement

Repeated Questions:

1. **Define/List the Static and Dynamic characteristics of an instrument.**
    - (Summer 2023, Q5(a) OR) - 03 Marks (List static & dynamic characteristics)
    - (Winter 2023, Q5(a)) - 03 Marks (Define: Drift, hysteresis, speed of response)
    - (Winter 2023, Q5(a) OR) - 03 Marks (Define: Accuracy, precision, reproducibility)
    - (Winter 2022, Q4(c)) - 07 Marks (Discuss various static characteristics)
2. **Define key terms: Accuracy, Span, Drift, Error.**
    - (Summer 2023, Q4(a)) - 03 Marks (Accuracy, Span, Drift)
    - (Summer 2025, Q5(a)) - 03 Marks (Span, Drift, Error)

Other Important Questions:

- (Summer 2024, Q5(b)) - Explain any two static and dynamic characteristics of an instrument. - 04 Marks

Chapter 12: Temperature Measurement

Repeated Questions:

1. **Explain the principle, construction, and working of an Optical Pyrometer.**
    - (Summer 2023, Q5(b) OR) - 04 Marks (with schematic)
    - (Winter 2022, Q5(c)) - 07 Marks
    - (Winter 2023, Q5(c)) - 07 Marks
2. **Explain the principle and working of a Thermocouple (Seebeck/Peltier effect).**
    - (Summer 2025, Q4(a) OR) - 03 Marks (Peltier effect)
    - (Winter 2022, Q5(b)) - 04 Marks (Seebeck effect)
    - (Winter 2024, Q5(b)) - 04 Marks
3. **Discuss the Pressure Spring Thermometer (Filled System Thermometer).**
    - (Summer 2022, Q4(c)) - 07 Marks
    - (Summer 2024, Q5(c)) - 07 Marks
4. **Discuss the Bimetallic Thermometer.**
    - (Summer 2024, Q5(a)) - 03 Marks
5. **Discuss errors and effects in thermometers (Dip effect, etc.).**
    - (Summer 2023, Q5(a)) - 03 Marks (Dip effect in filled system thermometer)

Other Important Questions:

- (Summer 2025, Q5(a) OR) - Discuss Wet bulb thermometer for humidity measurement. - 03 Marks (Also related to Ch 16)

Chapter 13: Pressure Measurement

Repeated Questions:

1. **Explain the construction and working of a Bourdon Tube Pressure Gauge.**
   - (Summer 2023, Q5(a)) - 03 Marks
   - (Winter 2023, Q5(c) OR) - 07 Marks
2. **Explain the construction and working of a Bellows Pressure Gauge.**
   - (Summer 2022, Q3(c) OR) - 07 Marks (Bellows differential pressure element)
   - (Summer 2025, Q5(c)) - 07 Marks (Bellow electrical pressure gauge)
3. **Explain various manometers and vacuum gauges (McLeod, Pirani).**
   - (Winter 2022, Q5(c) OR) - 07 Marks (McLeod gauge)
   - (Winter 2024, Q5(c) OR) - 07 Marks (Pirani vacuum gauge)

Other Important Questions:

- U-tube manometer transfer function (This is covered under **Chapter 4: Second Order Systems** as it involves dynamics).

Chapter 14: Liquid Level Measurement

Repeated Questions:

1. **Explain the principle and working of the Bubbler System.**
    - (Summer 2023, Q5(b)) - 04 Marks
    - (Winter 2024, Q5(c)) - 07 Marks
2. **Explain the principle and working of the Displacement Float Gauge.**
    - (Summer 2025, Q5(b)) - 04 Marks
3. **Discuss the Rotameter.**
    - (Summer 2024, Q5(c) OR) - 07 Marks
    - (Summer 2023, Q5(c) OR) - 07 Marks
    - (Summer 2025, Q5(b) OR) - 04 Marks

Other Important Questions:

- (Summer 2025, Q5(a) OR) - Discuss the principle of liquid level measurement in a bubbler system. - 03 Marks
- (Winter 2022, Q5(a)) - Explain methods for direct measurement of liquid level. - 03 Marks
- (Summer 2023, Q5(b)) - Give classification of liquid level measurement systems. - 04 Marks

Chapter 15: Flow Measurement

Questions from this Chapter:

- The **Rotameter** is a key flow measurement device and is heavily covered in **Chapter 14** questions.
- (Summer 2025, Q4(b) OR) - Draw figure for capillary type viscometer with suitable labelling. - 04 Marks (Also related to Ch 17)
- Principles of Head flow meters (Orifice, Venturi, Pitot tube). (Conceptual from syllabus)

Chapter 16: Humidity & pH Measurement

Questions from this Chapter:

- (Summer 2025, Q5(a) OR) - Discuss Wet bulb thermometer for humidity measurement. - 03 Marks
- (Winter 2022, Q5(b) OR) - Discuss dry bulb and wet bulb method for measurement of humidity. - 04 Marks
- Principles of hygrometers and pH measurement. (Conceptual from syllabus)

Chapter 17: Density & Viscosity Measurement

Questions from this Chapter:

- (Winter 2024, Q5(b) OR) - List various instruments used for Viscosity measurement and explain working of any one. - 04 Marks
- (Summer 2025, Q4(b) OR) - Draw figure for capillary type viscometer. - 04 Marks
- Principles of hydrometers. (Conceptual from syllabus)

Chapter 18: Introduction to Advanced Topics (PLC, DCS, SCADA)

Repeated Questions:

1. **Describe/Explain PLC, DCS, and SCADA.**
    - (Summer 2024, Q4(a)) - 03 Marks (PLC & SCADA)
    - (Summer 2022, Q5(a)) - 03 Marks (PLC, DCS, SCADA)
    - (Summer 2023, Q5(b) OR) - 04 Marks (PLC & DCS)
    - (Winter 2023, Q5(b)) - 04 Marks (SCADA)
2. **Discuss the advantages/disadvantages and applications of DCS (Distributed Control System).**
    - (Summer 2024, Q4(a) OR) - 03 Marks (Advantages/Disadvantages of DCS)
    - (Winter 2022, Q5(a)) - 03 Marks (Advantages of DCS)
    - (Winter 2023, Q5(b)) - 04 Marks (Advantages/Disadvantages of DCS)
    - (Winter 2024, Q5(a)) - 03 Marks (Advantages with application of DCS)
    - (Summer 2025, Q4(c) OR) - 07 Marks (Discuss DCS in detail)

Other Important Questions:

- Introduction to computer process control. (Conceptual from syllabus)

****