

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Which of the following devices converts physical parameters into electrical signals?
 - a) Actuator
 - b) Transducer
 - c) Amplifier
 - d) Oscillator

2. In a PID controller, what does the "D" stand for?
 - a) Direct
 - b) Differential
 - c) Derivative
 - d) Discrete

3. What is the primary function of a PLC?
 - a) Data storage
 - b) Process control
 - c) Signal amplification
 - d) Power supply regulation

4. Which communication protocol is commonly used in industrial automation?
 - a) HTTP
 - b) FTP
 - c) HART
 - d) SMTP

5. What is the purpose of a feedback loop in a control system?
 - a) To amplify the signal
 - b) To reduce noise
 - c) To provide system stability
 - d) To increase power supply

6. In which type of control system is the output independent of the input?
 - a) Open-loop
 - b) Closed-loop
 - c) Feedback
 - d) Feedforward

7. What is the Ziegler-Nichols method used for?
 - a) Signal filtering
 - b) System modelling
 - c) PID controller tuning
 - d) Data acquisition

8. Which sensor is commonly used for temperature measurement?
 - a) LVDT
 - b) Thermocouple
 - c) Strain gauge
 - d) Tachometer

9. What does SCADA stand for?
 - a) Supervisory Control and Data Acquisition
 - b) System Control and Data Analysis
 - c) Supervisory Computation and Data Administration
 - d) Systematic Control and Data Automation

10. Which of the following is a non-contact type of sensor?
 - a) Thermistor
 - b) RTD
 - c) Ultrasonic sensor
 - d) Strain gauge

11. What does the term "span" refer to in instrumentation?
 - a) The range of the input signal
 - b) The difference between maximum and minimum values of the measured variable
 - c) The width of the control signal
 - d) The delay in the feedback loop

12. Which component in a control system is responsible for executing control actions?
 - a) Sensor
 - b) Transmitter
 - c) Controller
 - d) Actuator

13. What is the term for the measure of a system's ability to maintain stability in the presence of disturbances?
 - a) Sensitivity
 - b) Robustness
 - c) Precision
 - d) Accuracy

14. Which control strategy uses a model to predict future outputs and minimize error?
- a) PID control
 - b) Adaptive control
 - c) Model Predictive Control (MPC)
 - d) Feedforward control
15. In which type of system is a transfer function used to describe the input-output relationship?
- a) Analog system
 - b) Digital system
 - c) Dynamic system
 - d) Static system
16. What is the purpose of a signal conditioner?
- a) To amplify signals
 - b) To convert signals to a desired form
 - c) To filter noise
 - d) All of the above
17. Which device is used to measure pressure?
- a) Potentiometer
 - b) Thermocouple
 - c) Manometer
 - d) Oscilloscope
18. What does an LVDT measure?
- a) Temperature
 - b) Pressure
 - c) Displacement
 - d) Velocity
19. Which of the following is an example of an analog-to-digital converter?
- a) DAC
 - b) ADC
 - c) PLC
 - d) PID
20. In a control system, what is the purpose of a compensator?
- a) To introduce additional poles and zeros
 - b) To adjust the gain
 - c) To improve the system's stability and performance
 - d) To convert analog signals to digital

21. Which of the following is a characteristic of an ideal operational amplifier?
- a) Infinite bandwidth
 - b) Zero input impedance
 - c) Finite gain
 - d) Low output impedance
22. What does the term "slew rate" refer to in an operational amplifier?
- a) Maximum output voltage
 - b) Maximum rate of change of output voltage
 - c) Input offset voltage
 - d) Bandwidth
23. Which device is used to measure flow rate?
- a) Thermistor
 - b) Turbine flow meter
 - c) Capacitive sensor
 - d) Inductive sensor
24. What is the primary function of a relay in a control system?
- a) Signal amplification
 - b) Switching
 - c) Signal conditioning
 - d) Data transmission
25. What is the Nyquist criterion used for?
- a) Determining system stability
 - b) Calculating control gains
 - c) Designing compensators
 - d) Measuring signal strength
26. What is a Bode plot used to analyze?
- a) Time domain response
 - b) Frequency domain response
 - c) Spatial domain response
 - d) Thermal response
27. What is the purpose of a dead zone in a control system?
- a) To filter noise
 - b) To prevent chattering
 - c) To increase sensitivity
 - d) To reduce response time

28. Which of the following materials is commonly used for RTD (Resistance Temperature Detector) elements?
- a) Copper
 - b) Platinum
 - c) Nickel
 - d) Iron
29. What is the Laplace transform primarily used for in control engineering?
- a) Time domain analysis
 - b) Signal amplification
 - c) Frequency domain analysis
 - d) System modeling and analysis
30. What does the term "hysteresis" refer to in control systems?
- a) The delay in the system response
 - b) The tendency of a system to oscillate
 - c) The dependence of the system's state on its history
 - d) The system's sensitivity to external noise

PART II – Short Answer Questions [20 marks]

This part has 4 short Answer Questions. Answer all the questions. Each question carries 5 marks.

1. What are the steps involved in implementing a Genetic Algorithm for PID optimization?
2. What is the role of a Distributed Control System (DCS) in industrial automation? Discuss the advantages and key features of a DCS compared to traditional control systems.
3. Explain the importance of a control valve's Cv rating.
4. Discuss the concept of feedback control and feedforward control in industrial processes. Provide examples of situations where each control strategy is most effective.

SECTION B: Case Study [50 marks]

Choose either Case I or Case II from this section. Each case study carries 50 marks. The mark for each question is indicated in the brackets

Case I: Optimization of Control System for a Chemical Plant Heating System

A chemical plant employs an electric heating system to maintain precise temperatures in multiple reaction vessels. The current control system uses a basic on/off control strategy implemented via a PLC. Recent performance reviews have highlighted issues with temperature stability and energy inefficiency. The plant has decided to upgrade the control system to enhance temperature control and reduce energy consumption.

Analyze the existing heating control system for the chemical plant and propose a comprehensive optimization strategy to improve temperature stability and energy efficiency. Your answer should cover the following aspects:

1. Current System Analysis **(10 Marks)**
2. Optimization Strategy **(15 Marks)**
3. Implementation Plan **(15 Marks)**
4. Expected Outcomes **(10 Marks)**

Case II: Control System Optimization for a Chemical Plant

You have been assigned as a control engineer to optimize the control system of a chemical manufacturing plant. The plant produces various chemical products, and precise control of temperature, pressure, and flow rates is crucial to ensure product quality and safety. However, the existing control system is outdated and has limitations. Describe the steps you would take to assess the existing system, propose improvements, and implement the necessary changes to enhance the plant's control capabilities.

1. What are the key challenges and limitations of the existing control system in the chemical plant? **(5 marks)**
2. How would you assess the performance of the current control system and identify areas that need improvement? **(10 marks)**
3. Outline the steps involved in proposing and implementing control system improvements? **(15 marks)**
4. What control strategies and technologies would you consider to enhance temperature, pressure, and flow control? **(10 marks)**
5. What benefits can the chemical plant expect to achieve after the control system optimization is complete? **(10 marks)**

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