PROCESS CONTROL
(AEIE 3101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The dynamics of a second order system is $9\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 1 = 0$. The system is
(a) Overdamped (ξ=1.5) (b) Underdamped (ξ=0.5)
(c) Underdamped (ξ=0.33) (d) Critically damped.

(ii) The response of interacting capacities is always
(a) Overdamped (b) Underdamped
(c) Critically damped (d) Any of the following.

(iii) The process transfer function is given by $\frac{2e^{-0.4s}}{3s+2}$. The time constant and dead time for the process are respectively
(a) 1.5 sec, 0.2 sec (b) 1.5 sec, 0.4 sec
(c) 0.4 sec, 3 sec (d) 3 sec, 0.2 sec.

(iv) Proportional gain of a PID controller can be expressed in terms of proportional band (PB) as
(a) PB (b) PB/100 (c) 100/PB (d) 100×PB.

(v) The transfer function of a controller is given by $G_c(s) = 2 + 0.5s$. $G_c(s)$ is a
(a) PID controller (b) P controller
(c) PI controller (d) PD controller.

(vi) In case of integral control action, as the gain of the controller increases, its damping ratio
(a) increases (b) decreases
(c) remain same (d) do not have any effect.

(vii) Which of the following control action is used to limit the operation of the process between two values by low select switch and high select switch?
(a) Ratio control (b) Adaptive control
(c) Override control (d) Feedforward Control.

(viii) Which of the following statement is true for PLC?
(a) PLC was developed to replace microprocessor
(b) Wiring between the devices and relays are done in PLC program
(c) PLC application involves extensive wiring between devices and relays
(d) All of these.

(ix) For PLC ON-delay timer, the Q bit resets when?
(a) IN changes to zero
(b) ACC value ≥ PT value
(c) PT value ≥ ACC value
(d) Both (a) and (b).

(x) An air-to-open valve assembly may be formed with which of these actuator / valve body combinations?
(a) Reverse-acting actuator, direct-acting valve body
(b) Direct-acting actuator, direct-acting valve body
(c) Direct-acting actuator, reverse-acting valve body
(d) (a) or (c).

Fill in the blanks with the correct word

(xi) Feedforward control scheme is commonly used with _____.

(xii) The primary function of the positioner in a control valve is to provide _____ feedback to the controller.

(xiii) The specific components of valve body performing the work of throttling of fluid flow are collectively referred to as the _____.

(xiv) The current output from controller is sent to pneumatic control valve through _____.

(xv) Offset error is the inherent features of _____ controller.

Group - B

2. (a) Consider a liquid tank fitted with a linear valve of resistance $\boldsymbol{R}$ at the outlet having outflow $\boldsymbol{F_0}$. Assuming area of the tank as $\boldsymbol{A}$, compute the transfer function of the tank if input flow rate to the tank is $\boldsymbol{F_i}$. *[(CO1)(Understand/LOCQ)]*
(b) Compute the dynamic response of the above process for a sudden change of $\boldsymbol{F_i}$ by 3 unit and draw the dynamic response. *[(CO1)(Apply/IOCQ)]*
(c) How will the response change if the area of the tank is doubled? *[(CO1)(Analyse/IOCQ)]*
6 + 4 + 2 = 12

3. (a) Show that two non-interacting tanks always result in an over damped or critically damped second order system. *[(CO1)(Evaluate/HOCQ)]*
(b) Draw the P&I diagram for a level control loop following ISA standard. *[(CO1)(Understand/LOCQ)]*
(c) Explain underspecified process with respect to degrees of freedom. *[(CO2)(Understand/LOCQ)]*
6 + 4 + 2 = 12

Group - C

4. (a) Why is it necessary to control a reverse action type process with a direct action type controller in order to achieve the control objective? *[(CO1)(Analyse/IOCQ)]*

   (b) Draw the block diagram of a close loop control system with controller transfer function (***TF***) $G_c(s) = \frac{K_c}{sT_i}$, process transfer function $G_P(s) = \frac{K_P}{sT_P+1}$ and the disturbance transfer function $G_d(s) = \frac{K_d}{sT_P+1}$. Assume ***TF*** for final control element and measuring element are unity. Compute the overall close loop gain and time constant. Compute the offset error if any for the system that experience a unit step change in set-point. *[(CO2)(Understand/LOCQ),(Evaluate/HOCQ)]*

3 + (3 + 4 + 2) = 12

5. (a) Describe the impact of a sustained error in a process when it is controlled by the PI controller. Suggest and implement any method for dealing with such a situation. *[(CO5)(Analyse/IOCQ)]*

   (b) Design an electronic PID controller and compute the controller parameters. *[(CO3)(Apply/IOCQ)]*

   (c) State the IAE performance criteria of a controller. *[(CO3)(Understand/LOCQ)]*

(2 + 4) + 4 + 2 = 12

Group – D

6. (a) Examine the impact of packing friction on control valve performance. *[(CO4)(Analyse/IOCQ)]*

   (b) Using the necessary diagram, explain the choked flow in a control valve. *[(CO4)(Analyse/IOCQ)]*

   (c) Describe cavitation and flashing that may occur in control valves with necessary diagram. *[(CO4)(Understand/LOCQ)]*

4 + 3 + 5 = 12

7. (a) Which type of control valve is most suitable for the process large changes in pressure drop are expected and a small percentage of the total pressure drop is permitted by the valve . Draw and explain the characteristics of the chosen valve. *[(CO4)(Create/HOCQ)]*

   (b) Explain working of a limit switch with necessary schematic diagram. *[(CO4)(Analyse/IOCQ)]*

   (c) State the disadvantages of steam guided control valve. *[(CO4)(Understand/LOCQ)]*

(1 + 3) + 5 + 3 = 12

Group - E

8. (a) Consider an jacketed heat exchanger unit which uses constant temperature superheated steam as the heat source. The unit is used to heat an incoming fluid whose temperature and flow rate may subjected to change. Which type of control scheme is best suited for this system and why? Draw the necessary P&I diagram for the control scheme and find the transfer function for the controller. *[(CO5)(Evaluate/HOCQ)]*

(b) Describe ratio control scheme with necessary schematic diagram.

[(CO4)(Remember/LOCQ)]

(1 + 2 + 3 + 2) + 4 = 12

9. (a) Realise the pushbutton switch and XOR logic using PLC ladder diagram.

[(CO6)(Analyse/IOCQ)]

(b) Create a PLC ladder logic diagram for the conveyor belt system using the instructions below. The start push button starts the conveyor belt. Bottles on the belt are detected by a proximity sensor and generates a pulse upon detection of each bottle. When 15 bottles are collected in a cartoon, a wrapping machine starts wrapping and remain on for 5 second. Stop switch stops the belt.

[(CO6)(Evaluate/HOCQ)]

(c) Describe operation sequences of PLC with necessary block diagram.

[(CO6)(Understand/LOCQ)]

(2 + 2) + 6 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.16	36.46	34.38

Course Outcome (CO):

After the completion of the course students will be able to

1. Develop mathematical model of the liquid, thermal and gas systems by their knowledge of Mathematics, Science and engineering and analyze the process response.
2. Explore the controller modes and analyse the close loop response of the 1st and 2nd order process in presence of P, PI, PD, PID controllers.
3. Design and simulate the ON-OFF, P, PI, PID controllers with the electronic components and software like simulink, LabVIEW etc.
4. Select the control valve necessary to provide engineering solutions of various societal, professional & environmental responsibilities if imposed.
5. Identify, formulate/model, analyze the process and provide solution using knowledge of complex control systems like feed forward, cascade, ratio, override, split range and multivariable process control.
6. Design and develop the ladder logic program in PLC for the solution of the sequential events performed in industry.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*