PROCESS CONTROL
(AEIE 3101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Washing machine is an example of
(a) Close loop control (b) Open loop control
(c) Servo control (d) Regulatory control.

(ii) Find the time constant of the process $T(s) = 1/(4s+2)$
(a) 1 Sec (b) 4 Sec (c) 2 Sec (d) ½ Sec

(iii) In order to specify a process completely, the number of degrees of freedom should be
(a) Zero (b) Infinity (c) Process specific (d) None of them

(iv) A PID controller has the transfer function as $2+\frac{0.4}{s}$. The proportional band for the controller is
(a) 200% (b) 100% (c) 75% (d) 50%

(v) In a temperature control system, process variable varies from 40^0C to 120^0C. What will be the value of controller output for 60^0C?
(a) 12 mA (b) 20 mA (c) 8 mA (d) 4 mA

(vi) Air-to-close control valve has
(a) Reverse acting actuator and direct acting valve body
(b) Direct acting actuator and direct acting valve body
(c) Direct acting actuator and reverse acting valve body
(d) All of them

(vii) The dynamics of a second order system is given by $8\frac{d^2y}{dt^2}+3\frac{dy}{dt}+2y=3x$. The time constant for the system is
(a) 8/3 Sec (b) 3/8 Sec (c) 4 Sec (d) 2 Sec

(viii) Ratio control is a special case of
(a) Feedback control (b) Feed-forward control
(c) Feedback feed-forward control (d) Adaptive control

(ix) In cascade control, as a rule of thumb, the dominant time constant in the slave loop is _____ of the dominant time constant in the master loop.
(a) Less than one third (b) Greater than one third
(c) Same as (d) Independent

(x) Integral windup may occur for the process being controlled by
(a) P controller (b) PD controller
(c) PI controller (d) D controller.

Group- B

2. Draw a level tank with an input flow line and an outlet flow line fitted with a linear restrictor ***R***. Assume input flow rate as F_i and output flow rate as F_o. At any instant the liquid level in the tank is ***h***. Control objective for this process is to maintain the level at desired set point.
(a) What variable should you measure to satisfy the control objective? State the possible source of disturbances for the above process. What are the manipulated variables to be used to control the tank level? [(CO1) (Analyse/IOCQ)]

(b) Suggest the best control configuration for the above process and design the P&I diagram of the control loop for the above process. [(CO1)(Create/HOCQ)]

(2 + 2 + 2) + (2 + 4) = 12

3. (a) Define transportation lag ofa process. How will the transfer function of a 2nd order process be modified in presence of the dead time? Draw the dynamic responses of the process without and with dead time.
[(CO5) (Remember/LOCQ), (Understand/LOCQ)]
(b) Show that two non-interacting tanks always result in an over damped or critically damped second order system. [(CO1) (Create/HOCQ)]
(c) Design a P&I diagram for a temperature control loop as per the rules of ISA standard. [(CO1) (Create/HOCQ)]

(1 + 4) + 4 + 3 = 12

Group – C

4. (a) Why is a direct action type process must be controlled with a reverse action type controller to attain the control objective? [(CO2) (Analyse/IOCQ)]
(b) Define proportional band. How is offset varied with the variation of proportional band? [(CO5) (Understand/LOCQ),]
(c) Explain Ziegler-Nichol's continuous oscillation method of controller tuning and write down the tuning parameters. [(CO3) (Understand/LOCQ)]

4 + 3 + 5 = 12

5. (a) Why is step change in set-point not inevitable for a process controlled with PID or PD controller? How can such constraint be tolerated?
[(CO5) (Analyse/IOCQ), (Create/HOCQ)]

(b) Design an electronic PD controller and compute the proportional gain and derivative time. [(CO3) (Create/HOCQ)]

(c) Draw the blockdiagram of a close loop control system with controller transfer function $G_c=K_c$ and process transfer function $G_p=K_p/(sT_p+1)$ and the disturbance transfer function $G_d=K_d/(sT_p+1)$. 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 servo control system.
[(CO2) (Understand/LOCQ), (Evaluate/HOCQ)]
(2 + 2) + 3 + (1 + 4) = 12

Group – D

6. (a) Which type of control valve one should select for the process where a small percentage of the total pressure drop is permitted by the valve ? Draw the characteristics of the valve selected and explain the same. [(CO4) (Apply/IOCQ)]

(b) Describe cavitation that may occur in control valves. [(CO4) (Remember/LOCQ)]

(c) Explain the working of a pneumatic relay with a schematic diagram.
[(CO5) (Understand/LOCQ)]
4 + 3 + 5 = 12

7. (a) Distinguish between double seated control valve and single seated control valve.
[(CO4) (Apply/IOCQ)]

(b) How characteristic of installed valve deviates from the inherent valve characteristic? Suggest a strategy to overcome the above problem.
[(CO4) (Create/HOCQ)]

(c) Design a current to pressure converter and describe its operation.
[(CO4) (Create/HOCQ)]
4 + 4 + 4 = 12

Group – E

8. (a) Feed water at room temperature need to be heated to a specific temperature by a heat exchanger. Hot steam at constant temperature is to be used as the manipulated variable. Both feed flow rate and feed temperature might get changed at different working conditions. Suggest and describe the best suited control scheme with neat sketch. [(CO5) (Evaluate/HOCQ)]

(b) Explain with a suitable ladder diagram whether can an input device be addressed multiple times or not in a single program? [(CO6) (Analyse/IOCQ)]

(c) State the criteria must be satisfied by the secondary variables in the cascade control scheme. [(CO5) (Understand/LOCQ)]

5 + 4 + 3 = 12

9. (a) Describe sourcing type circuit diagram for PLC output module. [(CO6) (Remember/LOCQ)]

(b) Which control scheme is commonly used in blending process where two different blends are mixed to attained a desired blending composition and describe the scheme with neat sketch. [(CO5) (Apply/IOCQ)]

(c) A pump is used to fill the water to an overhead tank from the ground reservoir. How you can apply PLC ladder program to automate the said system with necessary protection (e.g., the dry run of the pump, overflow of the overhead tank)? [(CO6) (Apply/LOCQ)]

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25%	32.29%	36.46%

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

Department & Section	Submission Link
AEIE	https://classroom.google.com/c/NDAwOTI0MDc4OTE0/a/NDY0NTM2NDI2NTY5/details