INDUSTRIAL AUTOMATION
(AEIE 3223)

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) What type of control system uses feedback to adjust the output in order to maintain a constant set point?
(a) Open-loop control (b) Closed-loop control
(c) Hybrid control (d) None of the above.

(ii) The top level of the automation pyramid is known as
(a) Manufacturing Execution Systems (MES)
(b) Enterprise Resource Planning (ERP)
(c) Supervisory level
(d) Control level.

(iii) What type of control system adjusts the output based on the accumulated error over time?
(a) Proportional control (b) Integral control
(c) Derivative control (d) All of the above.

(iv) What is the function of the Industrial Internet of Things (IIoT) in industrial automation?
(a) To connect industrial devices and systems to the internet
(b) To collect and analyze data from industrial processes
(c) To provide remote monitoring and control of industrial processes
(d) All of the above.

(v) The process with transfer function $G(s) = \frac{K}{s}$ is an example of a
(a) Linear lag system (b) Purely capacitive system
(c) Exponential transfer lag system (d) First-order lag system.

(vi) For modelling of a stirred tank heater system principle of _____ conservation need to be considered.
(a) total mass (b) momentum
(c) total energy (d) both (a) and (c)

(vii) What type of control system uses a mathematical model of the process to make decisions?
(a) Model-based control (b) Fuzzy control
(c) Neural network control (d) All of the above.

(viii) Two interacting level tanks when connected in series, the overall system response become a _____ system
(a) Zero order (b) 1st order
(c) 2nd order (d) Integral system

(ix) Switching of the communication packets among different network segments by defining the suitable path is the function of
(a) Repeater (b) Router
(c) Bridge (d) Gateway

(x) The half-duplex mode of communication is used in
(a) Radio (b) Walkie-Talkies
(c) Keyboard (d) Telephone.

Fill in the blanks with the correct word

(xi) Number of degrees of freedom of a running train is _____.

(xii) The Laplace transform of ramp signal is _____.

(xiii) The standard for long distance analog signal transmission in process industry is _____.

(xiv) The full form of SCADA is _____.

(xv) The _____ variable is a function of the manipulated variable and the disturbances.

Group - B

2. (a) An empty vessel of capacity C is being pressurized at pressure P_2 by the compressor of pressure P_1, through a valve of resistance R. (i) Derive the transfer function of the process and the time lag of the process (ii) Evaluate the transient response of the model for step input and (iii) Calculate Steady state value of the response and value at time lag. *[(CO2)(Analyse/HOCQ)]*

(b) Demonstrate a typical distillation column dynamics with mathematical modeling of column plate. *[(CO1)(Understand/LOCQ)]*

(3 + 2 + 2) + 5 = 12

3. (a) Distinguish distance velocity lag from process transfer time lag with proper diagram. *[(CO1)(Understand/LOCQ)]*

(b) A blending process have 2 inputs; input 1 comprised of mixture sample A & B. Pure A is coming through input 2 of mass fraction and mass flow rate x_2, w_2 respectively. Mass fraction and mass flow rate of A in input1 are x_1 and w_1 respectively. At blender outlet mass fraction and mass flow rate of A are x and w respectively. The blending process is operating with w_1 = 600 kg/min, w_2 = 2

kg/min and $x_1 = 0.05$. The liquid volume and density are constant, 2 m^3 and 900 kg/m^3, respectively.

(i) Calculate the initial steady-state value of the exit composition x(0).

(ii) Calculate the exit composition response to a step response, if inlet concentration x_1 increases from 0.05 to 0.075. Use initial steady composition calculated in part (i). *[(CO2)(Apply/IOCQ)]*

(2 + 2) + (3 + 5) = 12

Group - C

4. (a) Derive the transfer function of the differential equation $\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y = 2u(t)$; for initial conditions $\frac{dy}{dt}(0) = y(0) = 0$. Evaluate the transient response of the derived model. *[(CO3)(Analyse/IOCQ)]*

(b) Derive state transfer function from state space equations. *[(CO3)(Analyze/IOCQ)]*

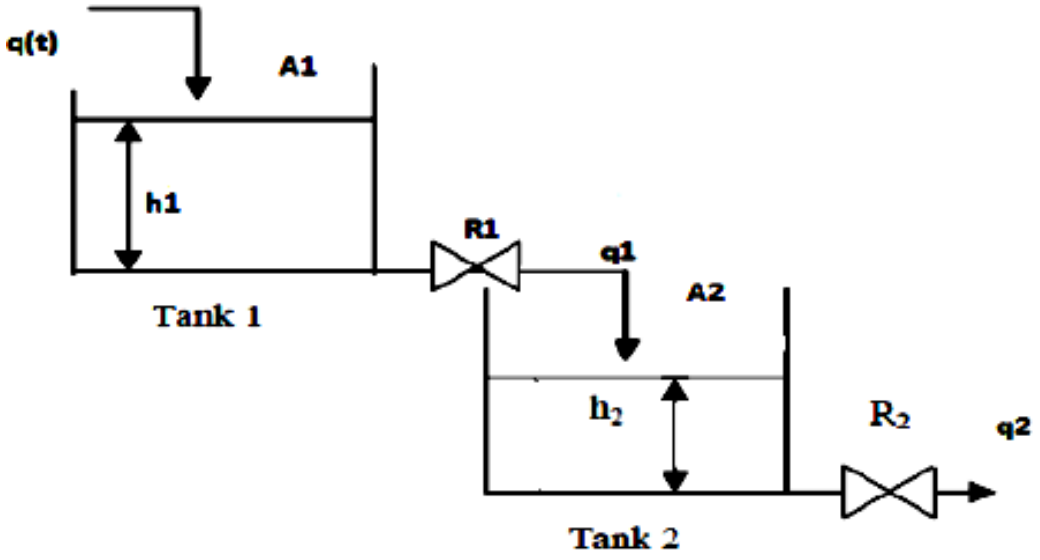
(c) Calculate the transfer function from the given state equations;

$$x' = \begin{vmatrix} 0 & 1 \\ -2 & -3 \end{vmatrix} x + \begin{vmatrix} 0 \\ 2 \end{vmatrix} u \quad \text{and} \quad y = \begin{vmatrix} 3 & 0 \end{vmatrix} x$$ *[(CO3)(Apply/IOCQ)]*

(2 + 3) + 3 + 4 = 12

5. (a) Hot water of mass flow rate W_h with temperature T_h and cold water of mass flow rate W_c with temperature T_c is mixed in a blending tank of liquid height h. Out flow rate is W with temperature T. Mixer liquid density is ρ and temperature is T_R. Derive the model of this multi-input system. *[(CO3)(Analyse/IOCQ)]*

(b) Evaluate the overall transfer function of the given non-interacting water reservoirs. *[(CO3)(Evaluate/HOCQ)]*



6 + 6 = 12

Group - D

6. (a) How feed forward control is different from feedback control? Suggest a feed forward control scheme to control the level of a liquid tank. *[(CO4)(Apply/IOCQ)]*

(b) Define ratio control. Implement ratio control in Ammonia production from Nitrogen and Hydrogen, and explain the scheme with proper diagram.

[(CO4)(Apply/IOCQ)]

(2 + 4) + (1 + 5) = 12

7. (a) Explain model reference adaptive control with necessary block diagram and analyze MIT rule. *[(CO5)(Analyse/IOCQ)]*

(b) When should you use artificial intelligence based controllers? What are layers in neural network? *[(CO5)(Remember/LOCQ)]*

(c) Define integral action time. *[(CO4)(Understand/LOCQ)]*

6 + (2 + 2) + 2 = 12

Group - E

8. (a) Name different components of industrial network used in distributed control system and describe the same. *[(CO6)(Understand/LOCQ)]*

(b) Describe bus topology of DCS architecture with suitable schematic diagram.

[(CO6)(Remember/LOCQ)]

8 + 4 = 12

9. (a) How does master-slave mechanism differ from carrier sense multiple access with collision detection mechanism used for media access control?

[(CO6)(Analyse/IOCQ)]

(b) Explain with suitable diagram the importance of group display of DCS.

[(CO6)(Understand /LOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.38	52.08	13.54

Course Outcome (CO):

After the completion of the course students will be able to

1. Learn and familiarize with the automation technologies which typically exist in industry.
2. Explain the concept of process modeling, process dynamics and process instrumentation.
3. Understand and develop the transfer function, state space models, time series models and empirical models fromprocess data.
4. Explain feedback and feedforward control schemes and learn the controller design.
5. Understand advanced control strategies- internal model control, cascade control, model predictive control and batch process control.
6. Acquire knowledge about the distributed control system and its function.

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