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 to maintain a constant set point?
(a) Open-loop control (b) Closed-loop control
(c) Hybrid control (d) None of the above

(ii) Which of the following correctly represents the order of the thermometer?
(a) Second order (b) Third order
(c) First order (d) Zero order

(iii) The process with transfer function $G(s) = \frac{K}{\tau s+1}$ is an example of a
(a) Type 0 system (b) Type 1 system
(c) Type 2 system (d) Type $-1/\tau$ system

(iv) 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

(v) If the process transfer function has a denominator of s^2+2s+1, what does this suggest about the system's dynamics?
(a) The system has a first-order behaviour (b) The system is critically damped
(c) The system is underdamped (d) The system has no damping

(vi) A PID controller has the transfer function $2 + \frac{0.4}{s} + 3s$. The proportional band for the controller is
(a) 200% (b) 100%
(c) 75% (d) 50%

(vii) Cascade control is characterized by
(a) One controller providing a set point for another controller
(b) The presence of a “lead/lag” relay or function block
(c) The presence of a “dead time” relay or function block
(d) Two controllers whose outputs are selected either by high or low value

(viii) 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

(ix) In a DCS, what is the purpose of the communication network?
(a) To connect the sensors and actuators to the controllers
(b) To allow controllers to communicate with the central control room
(c) To store the data generated by the controllers
(d) To ensure that the process equipment works at full capacity

(x) What does the term "fieldbus" refer to in a DCS?
(a) A type of field device
(b) A bus used for communication between controllers and field devices
(c) A monitoring tool for field devices
(d) A server that stores control algorithms

Fill in the blanks with the correct word

(xi) The Laplace transform of the ramp signal is _____.

(xii) In the state equation, A represents the _____ matrix and B represents the _____ matrix.

(xiii) In the presence of an integral controller, the error in the controlled system is supposed to be _____.

(xiv) In a state space model, the state vector x(t) contains the values of the _____ of the system at time t.

(xv) A _____ sensor detects the current temperature inside the furnace and sends the data to the control system.

Group - B

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

(b) A blending process has 2 inputs: input 1 comprised of mixture samples A & B. Pure A comes through input 2 of mass fraction and mass flow rate x_2, w_2 respectively. The mass fraction and mass flow rate of A in input1 are x_1 and w_1 respectively. At the blender outlet mass fraction and mass flow rate of A are x and w respectively. The blending process operates with w_1= 600kg/min, w_2=2kg/min, and x_1=0.05. The liquid volume and density are constant, $2m^3$ and $900kg/m^3$, respectively.

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

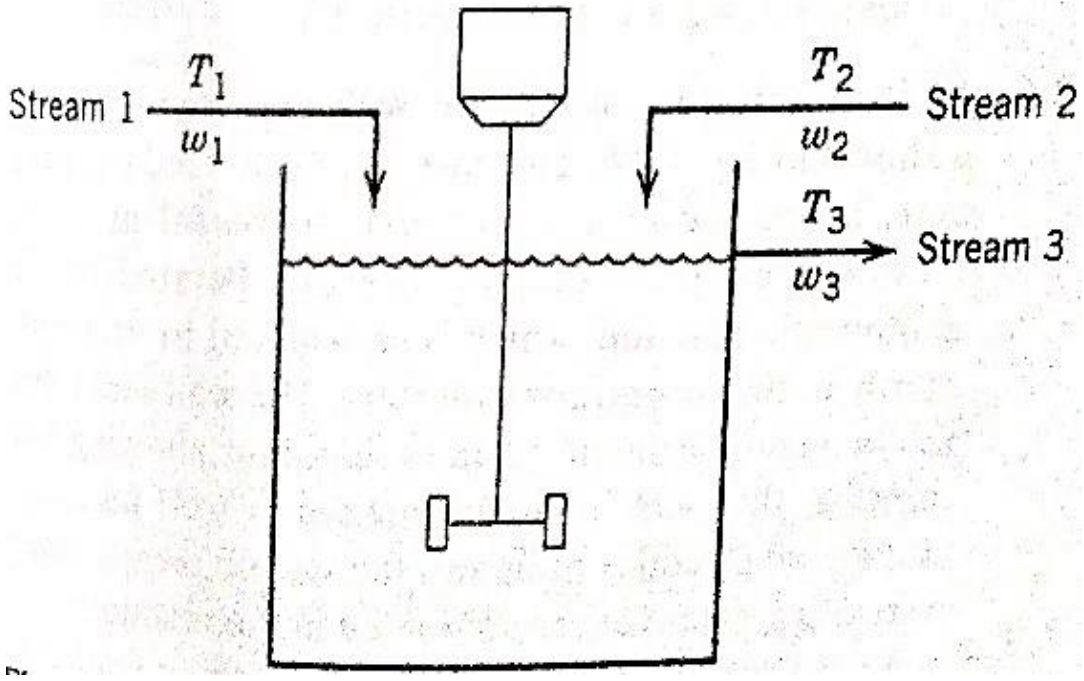
(ii) Calculate the exit composition response to a step response, if inlet concentration x_1 increases from 0.05 to 0.075. Use the initial steady composition calculated in part (i). *[(CO2) (Apply/IOCQ)]*

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

3. (a) What is process? Name any four-process plants and their final products. *[(CO1)(Remember/LOCQ)]*

(b) Represent the hierarchy of process control activities with a flow chart. Explain the importance of real-time optimization in process automation. *[(CO1)(Understand/LOCQ)]*

(c) A perfectly stirred, constant-volume tank has two input streams of the same liquid. Each stream's temperature and flow rate can vary with time. The specific heat capacity is C.



(i) Derive a dynamic model that will describe transient operation.

(ii) Simplify your model, if possible, to one or more differential equations by eliminating any algebraic equations. *[(CO1)(Analyse/IOCQ)]*

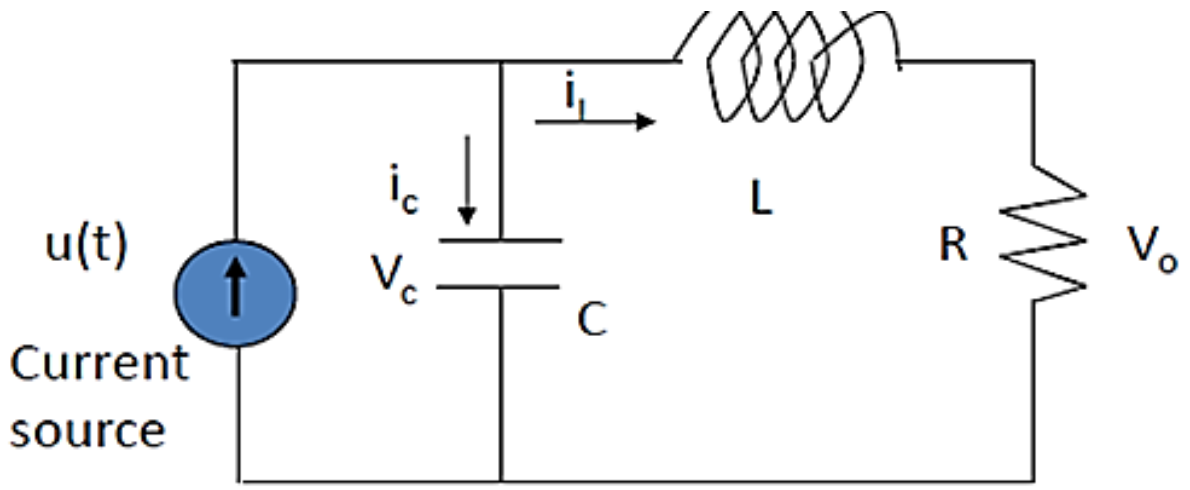
(1 + 2) + (2 + 2) + (3 + 2) = 12

Group - C

4. (a) Derive the transfer function for a level tank fitted with an inlet flow line and a linear resistance at the outlet. *[(CO3)(Apply/IOCQ)]*

(b) Compute the time response for the above system if input is increased by a step of ***A***. *[(CO3) (Analyse/IOCQ)]*

(c) Derive the state variable differential equations of the given RLC circuit. The state of the system is described by the capacitor voltage and inductor current.

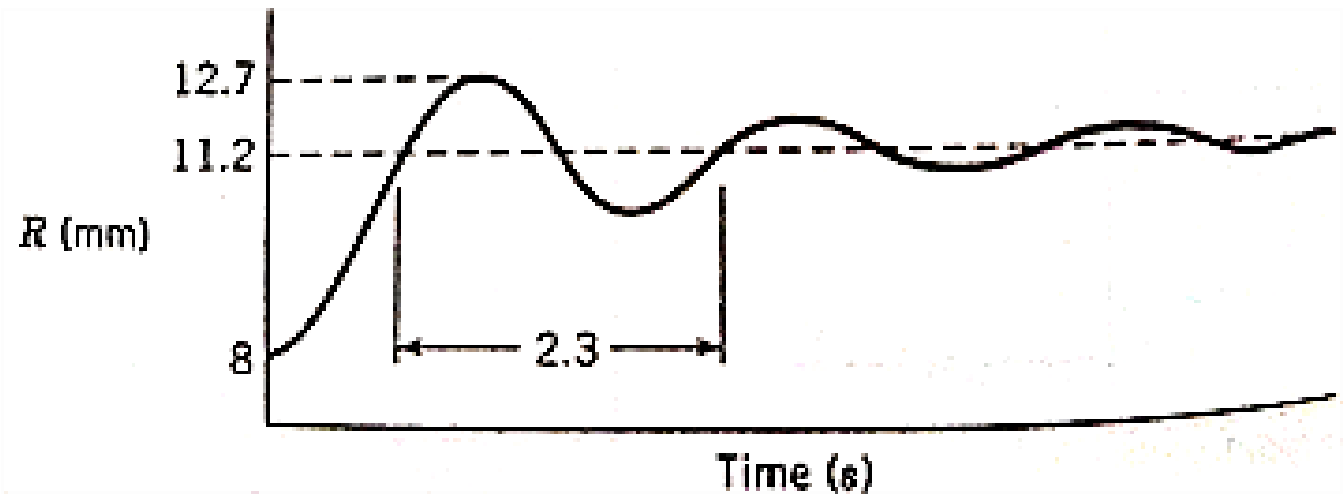


[(CO3)(Apply/IOCQ)]

3 + 4 + 5 = 12

5. (a) An operator introduces a step change in the flow rate q to a particular process at 3:05 AM, changing the flow from 500 to 520 gal/min. The first change in the process temperature T (initially at 120 deg F) comes at 3:08 AM. After that, the response in T is quite rapid, slowing down gradually until it appears to reach a steady state value of 124.7 deg F. The operator notes in the logbook that there is no change after 3:34 AM. What approximate transfer function might be used to relate temperature to flow rate for this process in the absence of more accurate information? What should the operator do next time to obtain a better estimate? *[(CO2)(Apply/IOCQ)]*

(b) A step change from 15 to 31 psi in actual pressure results in the measured response from a pressure-indicating element shown in Fig. below.
Assuming second-order dynamics, calculate all important parameters and write an approximate transfer function in the form $\frac{R1(s)}{P1(s)} = \frac{K}{\tau^2 s^2 + 2\delta\tau s + 1}$; where R1 is the instrument output deviation (mm), P1 is the actual pressure deviation (psi).



[(CO2)(Apply/IOCQ)]
6 + 6 = 12

Group - D

6. (a) What are the main stages of a data acquisition process in a computer-based system? *[(CO5) (Remember/LOCQ)]*
(b) Illustrate the steps to tune a PID controller using the Ziegler-Nichols method. *[(CO4) (Understand/LOCQ)]*
(c) What are the effects of increasing the proportional gain (Kp), integral gain (Ki), and derivative gain (Kd)? *[(CO4) (Understand/LOCQ)]*
3 + 3 + (2 + 2 + 2) = 12

7. (a) What are the challenges of integrating IoT into existing plant automation systems? *[(CO5)(Understand/LOCQ)]*
(b) How can IoT impact quality control in a plant automation setup? *[(CO5)(Understand/LOCQ)]*
(c) What types of AI technologies are commonly used in plant automation? *[(CO5)(Remember/LOCQ)]*
(d) What are the main benefits of integrating AI into plant automation? *[(CO5)(Understand/LOCQ)]*
3 + 3 + 3+ 3 = 12

Group - E

8. (a) Why is Plantwide control critical for efficient plant operation and how does Plantwide Control differ from Local Control? *[(CO6)(Understand/LOCQ)]*
(b) Write the recommended procedure to design a Plantwide control system. *[(CO6)(Analyse/IOCQ)]*
(c) Write the benefits and challenges of the implementation of Plantwide control. *[(CO6)(Understand/LOCQ)]*
(2 + 2) + 4 + (2 + 2) = 12

9. (a) Draw and describe the 5-level architecture of the distributed control system. *[(CO6) (Understand /LOCQ)]*
(b) Describe the ring topology of DCS architecture with a suitable schematic diagram. *[(CO6) (Understand/LOCQ)]*
(c) What is RTU in DCS? *[(CO6) (Understand/LOCQ)]*
5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	57.29	42.71	0