

**INDUSTRIAL PROCESS CONTROL & INSTRUMENTATION
(CHEN 4111)**

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) In case of step response of a _____ second order system two complex conjugate roots are obtained
(a) critically damped (b) underdamped
(c) overdamped (d) pseudo
- (ii) Damped vibrator exhibits
(a) first-order dynamics (b) second order dynamics
(c) multicapacity system in series (d) none of these
- (iii) According to bode stability criteria, a system is unstable if the open loop frequency response exhibits an amplitude ratio exceeding unity at frequency for which phase lag is
(a) 0° (b) 45° (c) 90° (d) 180°
- (iv) The transfer function for a P-D controller is
(a) $K_c(1 + \tau_D s)$ (b) $K_c(1 + \frac{1}{\tau_D s})$
(c) $K_c \tau_D s$ (d) $K_c / \tau_D s$
- (v) Identify an unbounded input from inputs whose transfer functions are given below
(a) 1 (b) (1/s) (c) (1/s²) (d) 1/(s²+1)
- (vi) The volumetric flowrate of liquid measured by a magnetic flowmeter is
(a) Directly proportional to the induced voltage
(b) Directly proportional to the magnetic field strength
(c) Both (a) and (b)
(d) Independent of the induced voltage

- (vii) For the same operating conditions, the closeness of the output readings for the same value of input applied for a short period is known as
 (a) Reproducibility (b) Repeatability
 (c) Precision (d) Accuracy
- (viii) The control system in which the reactor pressure is controlled by the coordinated action of two control valves is known as
 (a) Auctioneering control (b) Ratio control
 (c) Feedforward control (d) Split-range control
- (ix) A transducer measures a range of 0-200 N with a resolution of 0.2% of full scale. What is the smallest change in force that can be measured by this transducer?
 (a) 0.1 N (b) 0.4 N (c) 0.2 N (d) 4 N
- (x) A step input of 5A is applied to an ammeter. The pointer swings to 5.16 A and finally comes to rest at 5.02 A. The percentage error and percentage overshoot are
 (a) 0.4% and 2.8% (b) 1% and 3.2%
 (c) 0.2% and 3% (d) 0.4% and 3.2%.

Group- B

2.

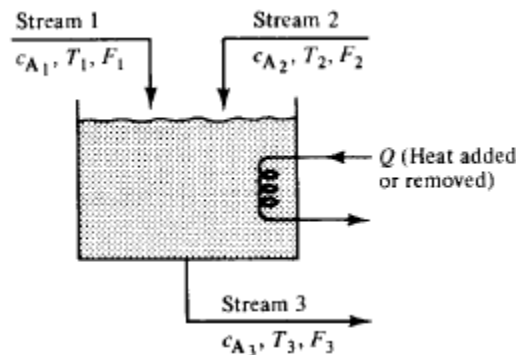


Fig.1

Frame mathematical model of the mixing process as shown in Fig. 1 and obtain state equations. Also mention input and output variables.

[[CO1] (Analyze/IOCQ)]

(10 + 2) = 12

3. (a) Show that a first-order system having a time constant τ , the response, following a step change reaches 63.2 % of its ultimate value when the time elapsed is equal to τ . [[CO1] (Remember/LOCQ)]
- (b) The unit impulse response of a first order process is given by $6e^{-0.5t}$. Calculate the gain and time constant of the process. [[CO2] (Evaluate/HOCQ)]
- (c) A pure capacitive system can be named as a pure integrator – justify.

[[CO1] (Analyze/IOCQ)]

4 + 4 + 4 = 12

Group - C

4. (a) For the control system shown in Fig.1, $\tau_1 = 1$ min., $\tau_m = 10$ sec. Find K_c so that the damping factor = 0.7 for the two cases.
 (i) $\tau_D = 0$ ii) $\tau_D = 3$ sec.

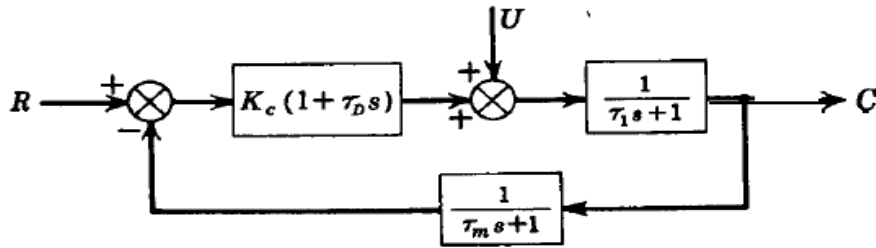


Fig. 1

- [(CO4) (Evaluate/HOCQ)]
- (b) Discuss Routh stability criteria. State the theorems of Routh test for stability.
 [(CO4) (Remember/LOCQ)]
- (c) Write down the expression for amplitude ratio and phase lag for unit step response from a 2nd order system. [(CO2) (Remember/LOCQ)]
6 + (2 + 3) + 1 = 12

5. (a) Obtain the impulse response from a 2nd order over-damped system.
 [(CO2) (Evaluate/HOCQ)]
- (b) Define cross over frequency. Plot the Bode diagram for the system whose overall transfer function is given below :
- $$\frac{1}{(s+1)(s+6)}$$

(Graph required)

[(CO4) (Remember/LOCQ)]

3 + (1 + 8) = 12

Group - D

6. (a) "Increase in dead time brings the closed loop response of the system closer to the brink of instability" Justify the claim. [(CO4) (Evaluate/IOCQ)]
- (b) "The classical feedback control system modified to accommodate for large dead time effects". Comment on the validity of the statement. [(CO5) (Analyze/IOCQ)]
- (c) Derive the closed loop transfer function for an IMC controller.
 (CO5) (Analyze/IOCQ)
4 + 5 + 3 = 12
7. (a) "Override control system causes a switch from one control loop to another when a process variable crosses a specific limit". Justify the claim with example.
 [(CO5) (Analyze/IOCQ)]
- (b) Comment on the validity of the term "equal percentage" in an equal percentage valve. [(CO6) (Analyze/IOCQ)]

- (c) Air containing ammonia is contacted with a solvent in a two plate absorption column. State the assumptions in deriving the model equations representing the system dynamics. Set up the mass balance equations for the two plates.

[(CO4) (Evaluate /HOCQ)]

5 + 3 + 4 = 12

Group - E

8. (a) The table below shows a set of measurements of a variable x grouped together. In each group i, there are n_i number of data. Obtain the correct value of x. From the ordinate values obtained from the error probability versus distribution curve, obtain the chi-square value and comment on the goodness of fit of data.

| | | | | | | | | | | |
|----|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Xi | 0.90- 0.92 | 0.92- 0.94 | 0.94- 0.96 | 0.96- 0.98 | 0.98- 1.00 | 1.00- 1.02 | 1.02- 1.04 | 1.04- 1.06 | 1.06- 1.08 | 1.08- 1.10 |
| ni | 1 | 2 | 3 | 8 | 20 | 23 | 21 | 12 | 4 | 2 |
| Yi | 0.062 | 0.1 | 0.11 | 0.3 | 0.85 | 0.99 | 0.875 | 0.55 | 0.13 | 0.07 |

[(CO6) (Evaluate/HOCQ)]

- (b) “Repeatability and reproducibility both refer to the measure of closeness with which a variable can be measured again and again” Justify the claim.

[(CO6) (Analyze/LOCQ)]

9+3= 12

9. (a) Explain the mechanism of generation of output signal from secondary windings of an LVDT when an alternating current is applied to the primary winding. Differentiate between induction and resistive type pressure transducers.

[(CO5) (Understand/LOCQ)]

- (b) “Nutating disk type flowmeter is a positive displacement flowmeter”. Justify the statement with explanation of the working principle. [(CO5)(Analyze/IOCQ)]

(3 + 5) + 4 = 12

| | | | |
|-------------------------|-------|------|-------|
| Cognition Level | LOCQ | IOCQ | HOCQ |
| Percentage distribution | 18.6% | 37.1 | 44.2% |

Course Outcome (CO):

After the completion of the course students will be able to

1. Formulate mathematical models explaining the static and dynamic behavior of chemical processes.
2. Solve equations arising out of dynamic behavior of systems using Laplace transformation.
3. Develop the concept of stability and apply the stability criteria suitably.
4. Apply knowledge of the control strategies for different control configuration and controller tuning.

5. Specify the required instrumentation for measurement of various process parameters in chemical process plants and understanding working principles.

| Department & Section | Submission Link |
|---------------------------------|---|
| CHE | https://classroom.google.com/c/NDAwOTA2MDQ3MDU4/a/NDYzODUyMDA1NzY2/details |