

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination November 2018

B. Tech in Chemical Engineering/ Mechanical Engineering, Semester V

Roll No.....

CHE508: PROCESS INSTRUMENTATION AND CONTROL

Max. Marks: 80

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

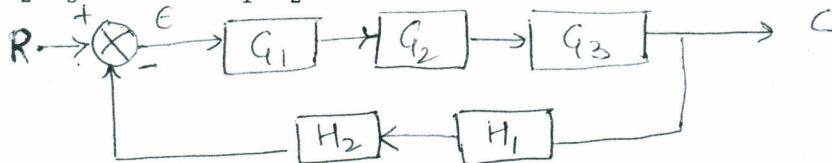
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- i. An example of an open-loop second order under damped system is:
(a) liquid level in a tank
(b) U-tube manometer
(c) Thermocouple in a Thermowell
(d) Two non-interacting first order systems in series
- ii. The second order system with the transfer function $\frac{4}{s^2+2s+4}$ has a damping coefficient of:
(a) 2.0 (b) 0.5 (c) 1.0 (d) 4.0
- iii. In a steady state response of a second order system

$$\frac{Y(s)}{X(s)} = \frac{1}{\tau^2 s^2 + 2\tau\epsilon s + 1}$$

Amplitude Ratio is equal to

- iv. What is the overall transfer function (C/R) of the following block diagram if $G = G_1 \cdot G_2 \cdot G_3$ and $H = H_1 \cdot H_2$.



- (a) $\frac{1}{1+GH}$ (b) $\frac{G}{1+GH}$ (c) $\frac{H}{1+GH}$ (d) $\frac{G}{1-GH}$
- v. Match the measured process variables with the list of measuring devices given below:

Measured process variable

- (A) Temperature (B) Pressure

(C) Flow

(D) Liquid Level

(E) Composition

Measuring Devices

1. Bourdon tube element

2. Orifice plates

3. Infrared analyzer

4. Displacer devices

5. Pyrometer

(a) A - 5; B - 1; C - 2; D - 4; E - 3

(b) A - 3; B - 1; C - 4; D - 2; E - 5

(c) A - 1; B - 3; C - 4; D - 2; E - 5

(d) A - 3; B - 1; C - 2; D - 4; E - 5

vi. Routh test criteria

(a) is applicable only to those systems with polynomial characteristic equation

(b) does not prove any information about the actual location of roots

(c) both (a) and (b)

(d) none of these

vii. The response of a first order system $[G(s) = \frac{1}{\tau s + 1}]$ to an unit step change in input is given by

(a) $\frac{1}{\tau} (1 - e^{-t/\tau})$

(b) $1 - e^{-t/\tau}$

(c) $\frac{e^{-t/\tau}}{\tau}$

(d) $1 + e^{-t/\tau}$

viii. Response of a linear control system for a change in load is called

(a) Transient response

(b) Sinusoidal response

(c) servo problem

(d) Regulatory problem

ix. Consider the following transfer function

$$G_p(s) = \frac{5}{(2s + 1)^4}$$

The crossover frequency (in rad/s) of the process is

(a) 20

(b) 0.1

(c) 0.5

(d) 0.05

x. A first order system with unity gain and time constant τ is subjected to a sinusoidal input of frequency $\omega = 1/\tau$. The amplitude ratio for this system is

(a) 1

(b) 0.5

(c) $1/\sqrt{2}$

(d) 0.25

Q.2 Short answer type questions (4 questions @ 2.5 marks)

10

a. Is driving a car mostly feed-forward or feedback control?

b. A step change of magnitude 3 is introduced into the transfer function

$$\frac{Y(s)}{X(s)} = \frac{10}{2s^2 + 0.3s + 0.5}$$

Determine the overshoot and the radian frequency of oscillation.

c. A control system has the transfer function

$$G_c = \frac{10(0.5s+1)}{s} \text{ (PI controller)}; G_p = \frac{1}{2s+1}; G_m = G_f = 1$$

Find the characteristic equation and its roots, and determine whether the system is stable.

- d. Write methods used to identify the tuning parameters of the feedback control system.

Q.3A Derive Amplitude ratio and phase angle of second order system using frequency response analysis. 05

Q.3B Using Routh's test determine the value of K for which the system with the characteristic equation $(s+1)(s+2)(2s+1) + 5K = 0$ remain stable. 05

Q.4A The process reaction curve of a temperature control system gave the values
 $K = 10$; $\tau = 2 \text{ min}$; $t_d = 0.1 \text{ min}$
 Compute the settings of a PID controller using Cohen-Coon tuning methodology. 05

Q.4B For a given open loop transfer function 05

$$G_{OL} = \frac{0.8 k_c e^{-1.74s}}{(5s + 1)(10s + 1)(15s + 1)}$$

Tune P-only controller when gain margin is 2.7

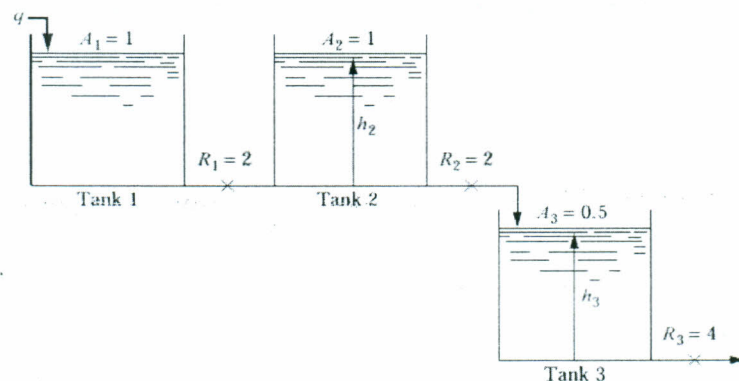
Q.5A Explain the root locus technique of stability analysis considering the following control system: 05

$$G_p = \frac{1}{(s + 1)(2s + 1)}; G_c = k_c; G_m = G_f = 1$$

Q.5B Derive a design equation for feedforward controller in stirred tank heater. 05

Q.6A What do you understand by cascade control system? Explain it by taking jacketed CSTR as an example. 05

Q.6B Find the transfer functions H_2/Q and H_3/Q for the three-tank system shown in Figure where H_2 , H_3 and Q are deviation variables. Tank 1 and Tank 2 are interacting. 05

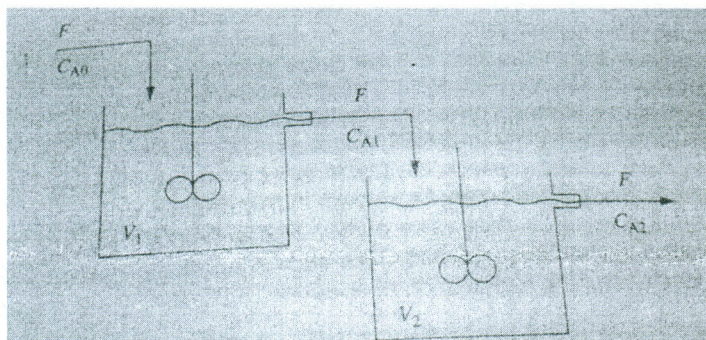


OR

Q.6B Explain 'smith predictor' or 'dead time compensator'. 05

Q.7 What are bode diagrams? Construct bode plot for first order system by taking all asymptotic considerations. 10

- Q.8 Consider two isothermal CSTR reactors in series. The reactor is well mixed. The chemical reaction is first-order, $r_A = -kC_A$ with $k = 0.040 \text{ min}^{-1}$. Volume of both reactors $V_1 = V_2 = 1.05 \text{ m}^3$. Derive the transfer function for both reactors and calculate the gain and the time constant. Other given data is: $F = 0.085 \text{ m}^3/\text{min}$; $(C_{A0})_{init} = 0.925 \text{ mole/m}^3$; $\Delta C_{A0} = 0.925 \text{ mole/m}^3$. 10



OR

- Q.8 Draw the block diagram of generalized closed loop system. Explain the effect of proportional controller for first order system. For simplification assume $G_m = G_f = 1$. Check the performance for servo test only. Conclude the remarks. 10

***** GOOD LUCK *****