

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Backlog), November-December 2015

B. Tech in Chemical Engineering, Semester V

Roll No.....

CHE501: PROCESS DYNAMICS AND CONTROL

Time: 3 hours

Max. Marks: 100

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) 10

- i. At the corner frequency, phase angle (ϕ) for the sinusoidal response of a first order system is
(a) $+45^\circ$ (b) -45° (c) -90° (d) $+90^\circ$
- ii. For first order system, the corner frequency is frequency corresponding to
(a) $\tau\omega = 0$ (b) $\tau\omega = 1$ (c) $\tau\omega = \text{infinite}$ (d) $\tau\omega = 1.414$
- iii. 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
- iv. For proportional-integral-derivative (PID) control system there is
(a) no offset
(b) rise of the controlled variable is arrested more quickly
(c) controlled variable returned rapidly to original value with little or no oscillation
(d) all of these
- v. With a damping coefficient more than 1, the second order will be
(a) under damped (b) oscillatory
(c) overdamped (d) critically damped
- vi. The radian frequency ω (radian/time) is equal to
(a) $\frac{\sqrt{1-\varepsilon^2}}{\tau}$ (b) $\frac{2\pi}{T}$ (c) both (a) and (b) (d) none of these
Where T is period of oscillation.
- vii. A certain thermocouple has a specific time constant of 2 sec. if process temperature changes abruptly from 800 to 900°C, then temperature reading in an indicator attached to the thermocouple after 6s will be approximately
(a) 660°C (b) 900°C (c) 890°C (d) 895°C
- viii. Time constant of a first order system is defined as the time taken for the system's output reach 63.2% of its ultimate value offer
(a) a step change in input
(b) an impulse change in input

- (c) a ramp change in input
 (d) a sinusoidal change in input
- ix. Write the overall transfer function for change in setpoint.
- x. 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) $1 + e^{-t/\tau}$

Q.2 Short answer type questions (4 questions @ 2.5 marks) 10

- (i) Write methods used to identify the tuning parameters of the feedback control system.
- (ii) Draw a neat block diagram of cascade control system
- (iii) A system has a transfer function

$$\frac{Y(s)}{X(s)} = \frac{10}{(s^2 + 1.6s + 4)}$$

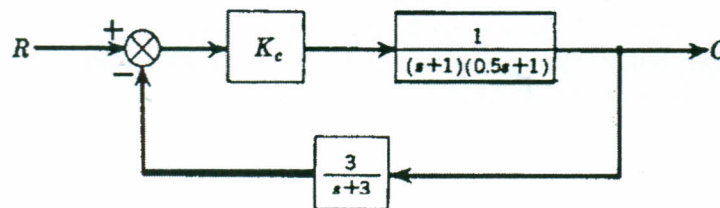
A step input of 4 units magnitude is introduced in this system. Find percent overshoot.

- (iv) 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.

- Q.3A Write the characteristic equation and construct the Routh array for the control system as shown in figure given below. Is the system stable for (a) $k_c = 9.5$ and (b) $k_c = 11$? 05



- Q.3B When frequency response analysis is used? Find the frequency response of a first order system 05

- Q.4A Prove that Mercury bulb thermometer is a first order lag system and is described by the following Transfer Function 05

$$G(s) = \frac{\bar{y}(s)}{\bar{f}(s)} = \frac{K_p}{\tau_p s + 1}$$

- 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 1.7

Q.5A Consider two non-interacting tanks are connected in series. The time constants are $\tau_2 = 1$ and $\tau_1 = 0.5$; $R_2 = 1$. Find the response of the level in tank 2 if a unit step change is made in the inlet flow rate to tank 1. 05

Q.5B Determine the tuning parameter of PID controller using Zeigler-Nicholas tuning method by considering the process 05

$$G_p = \frac{e^{-1.02s}}{s+1}; G_m = G_f = 1; \omega_{co} = 2 \text{ rad/min}$$

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

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

Q.7A Derive a design equation for feedforward controller in stirred tank heater. 05

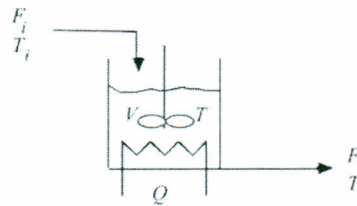
Q.7B What do you understand by linearization? Write steps involve in linearization by taking example of non-isothermal CSTR. 10

OR

Q.7B Explain bode diagrams? Construct bode plot for second order system by taking all asymptotic considerations. 10

Q.8 Explain Nyquist plot of First order system 10

Q.9 Consider a perfectly mixed stirred-tank heater, with a single feed stream and a single product stream, as shown in figure. Assuming that the flow rate and temperature of the inlet stream can vary, the tank is perfectly insulated, and the rate of heat added per unit time (Q) can vary. 15



(a) Develop a model to find the tank liquid temperature as a function of time.

(b) Derive the transfer function of a stirred tank heater.

(c) Consider a heater with a constant liquid volume of $V = 50$ liters and a constant volumetric flow rate of $F = 10$ liters/minute. For liquid water, the other parameters are $\rho C_p = 1$ kcal/liter $^{\circ}\text{C}$. Calculate the process gain and time constant.

OR

Q.9 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. 15