

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), November 2017

B. Tech in Chemical Engineering, Semester V

Roll No.....

CHE508: Process Instrumentation 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.

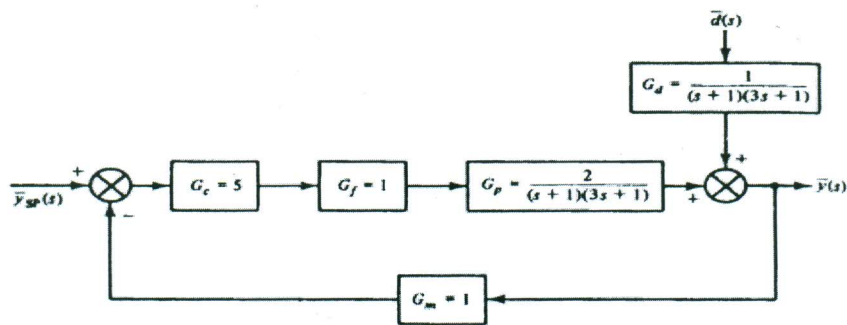
Q.1A	Objective type multiple choice questions (10 questions @ 1 mark)	10
i.	Bode diagram is a graphical representation of (a) logarithm of A.R. versus logarithm of frequency and phase angle versus logarithm of frequency (b) A.R. versus logarithm of frequency and phase angle versus logarithm of frequency (c) logarithm of A.R. versus frequency and phase angle versus frequency (d) A.R. versus frequency and phase angle versus frequency	
ii.	Amplitude ratio and phase angle for sinusoidal response of a proportional integral control with a transfer function $k_c \left(1 + \frac{1}{\tau s}\right)$ respectively are (a) $k_c \sqrt{1 + \frac{1}{(\tau\omega)^2}}$ and $\tan^{-1}(-\tau\omega)$ (b) $k_c \sqrt{1 + \frac{1}{\tau\omega}}$ and $\tan^{-1}(-\tau\omega)$ (c) $k_c \sqrt{1 + \frac{1}{(\tau\omega)^2}}$ and $\tan^{-1}\left(-\frac{1}{\tau\omega}\right)$ (d) none of these	
iii.	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) $\frac{1}{\tau} \left(1 - e^{-t/\tau}\right)$ (b) $1 - e^{-t/\tau}$ (c) $\frac{e^{-t/\tau}}{\tau}$ (d) $1 + e^{-t/\tau}$	
iv.	With a damping coefficient more than 1, the second order will be (a) under damped (b) oscillatory (c) overdamped (d) critically damped	
v.	Phase angle (ϕ) for the sinusoidal response of a controller with a transfer function k_c is (a) 0° (b) -45° (c) -30° (d) -90°	
vi.	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. The percent overshoot is (a) 20 (b) 30 (c) 25 (d) 35	

vii.	Time constant of mercury in glass thermometer is (a) $\frac{mc}{hA}$ (b) $\frac{hA}{mc}$ (c) $mchA$ (d) $\frac{1}{mchA}$	
viii.	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	
ix.	Transfer function of proportional plus derivative (PD) control is: (a) $\frac{P(s)}{E(s)} = K_C + \tau_D s$ (b) $\frac{P(s)}{E(s)} = K_C(1 + \tau_D s)$ (c) $\frac{P(s)}{E(s)} = \frac{K_C}{\tau_D s + 1}$ (d) $\frac{P(s)}{E(s)} = \frac{1}{K_C(\tau_D s + 1)}$ Where K_C is gain and τ_D is derivative time	
x.	If tanks are connected non-interacting, transfer function relating inlet flow to outlet flow is (a) $\frac{Q_2(s)}{Q(s)} = \frac{1}{\tau s + 1}$ (b) $\frac{Q_2(s)}{Q(s)} = \tau s + 1$ (c) $\frac{Q_2(s)}{Q(s)} = \left(\frac{1}{\tau s + 1}\right)^2$ (d) $\frac{Q_2(s)}{Q(s)} = \frac{2}{\tau s + 1}$	

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

i.	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.	
ii.	Write methods used to identify the tuning parameters of the feedback control system.	
iii.	Consider an isothermal batch reactor, where the following reactions with first order kinetics take place: $A \rightarrow B \rightarrow C$ Show that the concentration C_A of reactant A in the reacting mixture exhibits first order dynamic behavior with respect to the initial concentration, $C_A(t = 0)$. Identify the time constant.	
iv.	Draw a neat block diagram of Feedback control system	

Q.3A	When frequency response analysis is used? Derive Amplitude ratio and phase angle of second order system using frequency response analysis.	05
Q.3B	Consider the closed loop block diagram of the feedback system as shown in figure given below. For a set point step change of magnitude 2, do the following: (a) Derive an expression for the closed loop response in Laplace domain (b) Compute overshoot, decay ratio, ultimate value, offset and period of oscillation	05



Q.4A Using the bode stability criterion, find that the control system with the following open loop transfer functions are stable or unstable:

$$G_c = \frac{10e^{-3s}}{4s + 1}$$

05

Q.4B 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.

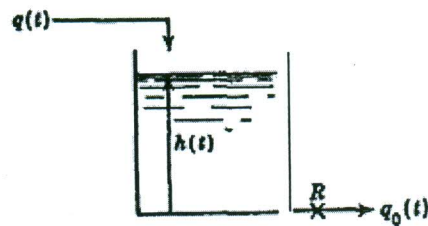
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Q.5A Write short note on P controller, PI controller and PID controller.

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Q.5B What is a first order system, and how do you derive the transfer functions of a liquid level tank.

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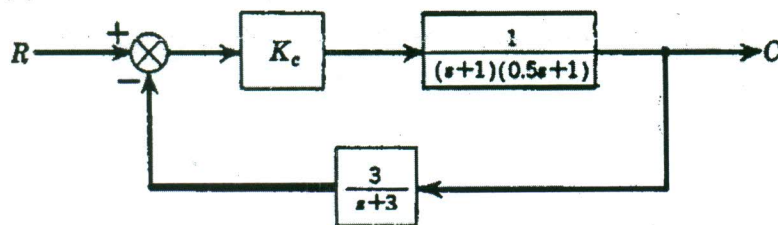


Q.6A Construct and explain Nyquist Plot for first order system.

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Q.6B 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) $k_c = 11$?

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OR

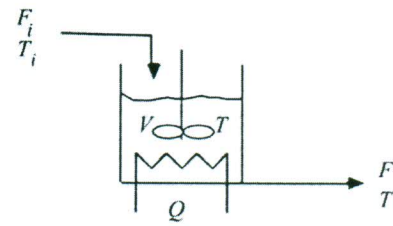
Q.6B Determine the tuning parameter of PID controller using Zeigler-Nicholas tuning method by considering the process

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

Q.7A A control system has the transfer function

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	$G_c = \frac{10(0.5s+1)}{s} \text{ (PI controller)} ; G_p = \frac{1}{2s+1} ; G_m = G_f = 1$ Find the characteristic equation and its roots, and determine whether the system is stable.	
Q.7B	Explain the root locus technique of stability analysis considering the following control system: $G_p = \frac{1}{(s+1)(2s+1)} ; G_c = k_c ; G_m = G_f = 1$ OR	10
Q.7B	For a given open loop transfer function $G_{OL} = \frac{0.8 k_c e^{-1.74s}}{(5s+1)(10s+1)(15s+1)}$ Tune P-only controller when gain margin is 1.7	10
Q.8	Develop a closed loop block diagram of a liquid level system. Consider P controller is apply on the system and assume first order dynamics of a control valve.	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.  (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. 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 °C. Calculate the process gain and time constant. OR	15
Q.9	What are bode diagrams? Construct bode plot for first order system by taking all asymptotic considerations.	15

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