Registration No :

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B.Tech.
PCE6I102

6th Semester Regular Examination 2017-18
PROCESS DYNAMICS & CONTROL
BRANCH : CHEM
Time : 3 Hours
Max Marks : 100
Q.CODE : C210

Answer Part-A which is compulsory and any four from Part-B.
The figures in the right-hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.
Answer all parts of a question at a place.

Part – A (Answer all the questions)

Q1. Answer the following questions : **(2 x 10)**

(a) A typical example of a physical system with under-damped characteristics is a

i. U-tube manometer
ii. Spring-loaded diaphragm valve
iii. CSTR with first order reaction
iv. Thermocouple kept immersed in a liquid filled thermowell

(b) The time constant of a first order system with resistance R and capacitance C is

i. R+C
ii. R-C
iii. RC
iv. 1/RC

(c) The transfer function of a process is $\frac{1}{16s^2+8s+4}$. If a step change is introduced into the system, then the response will be

i. Under damped
ii. Critically damped
iii. Over damped
iv. None of these

(d) The transfer function of an ideal proportional plus reset controller is

i. $K_c\left(1+\frac{1}{Ts}\right)$
ii. $K_c(1+Ts)$
iii. $\frac{K_c}{(1+Ts)}$
iv. $\frac{K_c}{\left(1+\frac{s}{T}\right)}$

(e) An ideal PID controller has the transfer function $\left[1+\frac{1}{0.5s}+0.2s\right]$. The frequency at which the magnitude ratio of the controller is 1, is

i. $0.5/0.2$
ii. $0.2/0.5$
iii. 0.2×0.5
iv. $\frac{1}{\sqrt{0.2\times0.5}}$

(f) The offset introduced by the proportional controller with gain K_c in response of first order system can be reduced by

i. Reducing value of K_c
ii. Introducing integral control
iii. Introducing derivative control
iv. None of these

(g) A first order system with a time constant of 1 min is subjected to frequency response analysis. At an input frequency of 1 rad/min, the phase shift is

i. 45^o
ii. -90^o
iii. -180^o
iv. -45^o

(h) The system has the transferfunction $G(s)=\frac{1}{s+5}$. The value of corner frequency will be

i. 1/5
ii. 5
iii. 1
iv. None of these

(i) An amplitude ratio (AR) of unity corresponds to ______ decibel.

i. 0
ii. 1
iii. 10
iv. 20

(j) Which of the following controller requires minimum stabilizing time?

i. PI controller
ii. PD controller
iii. P controller
iv. PID controller

Q2. Answer the following questions : (2 x 10)

(a) Write the general needs of a control system in any chemical process industry.

(b) Solve: $\frac{dx}{dt}+3x=0$, x(0)=2.

(c) Solve: $\frac{d^2x}{dt^2}+4x=2e^{-t}$, $x(0)=x'(0)=0$.

(d) Sketch the function: $f(t)=u(t)-2u(t-1)+u(t-3)$

(e) Define forcing function. Write any four examples of forcing function.

(f) A thermometer having a time constant of 0.1 min is at a steady state temperature of 90°F. At time t=0, the thermometer is placed in a temperature bath maintained at 100°F. Determine the time needed for the thermometer to read 98°F.

(g) The unity feedback control system is given a step change of magnitude 0.5 to the set point. Determine the offset, where the overall transfer function of the closed loop control system is

$$\frac{C(s)}{R(s)} = \frac{4}{6s^2 + 0.3s + 1}$$

(h) Draw the block diagram for a process whose output and inputs are related by the equation: $T'(s) = \left[Q(s) + \omega c T_i'(s)\right] \frac{1/\omega c}{\tau s + 1}$

(i) State the Routh Array stability criterion.

(j) Differentiate between corner frequency and cross over frequency.

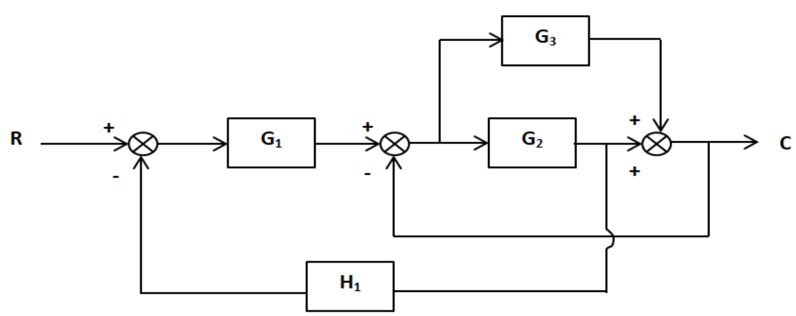
Part – B (Answer any four questions)

Q3. (a) A mercury thermometer having a time constant of 0.1 min is placed in a temperature bath at 100°F and allowed to come to equilibrium with the bath. At time t=0, the temperature of the bath begins to vary sinusoidally about its average temperature of 100°F with an amplitude of 2°F. If the frequency of oscillation is 10/π cycles/min, plot the ultimate response of the thermometer reading as a function of time. What is the phase lag? **(8)**

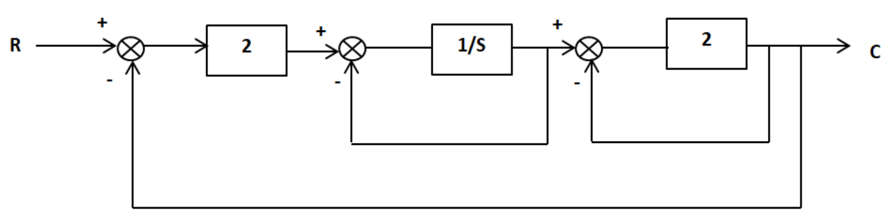
(b) A first order reaction $A \rightarrow B$ with the rate constant K is taking place in CSTR fed with A at concentration C_{AF} which remains unchanged. There are likely to be some deviations in feed rate (F) of A. Derive the transfer function between concentration of A in the outlet and feed rate of A assuming that volume V of reacting mixture remains unchanged. **(7)**

Q4. Determine the overall transfer function for the following block diagrams.

(a) **(8)**



(b) **(7)**



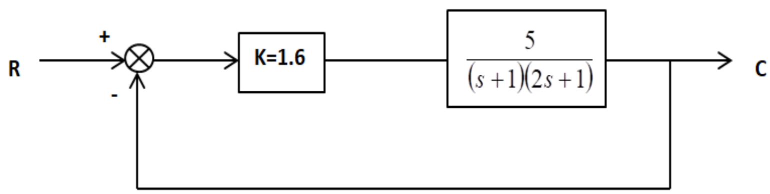
Q5. **(a)** Discuss the different modes of connecting the liquid tank system in series. **(5)**

(b) Two non-interacting tanks are connected in series. The time constants are $\tau_1 = 1$ and $\tau_2 = 0.5$, R_2=1. Sketch the response of the level in tank 2 if a unit step change is made in the inlet flowrate to tank 1. **(10)**

Q6. **(a)** The set point of the control system shown in figure is given a step change of 0.1 unit. Determine: **(10)**

Offset

Period of oscillation



(b) For the given characteristic equation $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$ determine the stability by Routh array criterion. **(5)**

Q7. For the control system of transfer function given by: $1/(s+1)^4$, determine the controller setting for a PI controller using C-C method and model the process reaction curve. **(15)**

Q8. The open loop transfer function of a control system is given by: **(15)**

$$G(s)H(s) = \frac{K}{s(s+6)(s^2+4s+13)}$$

Sketch the root locus and determine:

i) The breakaway points

ii) The angle of departure from the complex poles

iii)The stability condition

Q9. Plot the Bode diagram for the control system whose overall transfer function is given by: **(15)**

$$G(s) = \frac{10(0.5s+1)e^{-s/10}}{(s+1)^2(0.1s+1)}$$