Name:

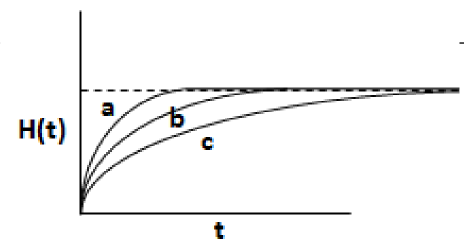
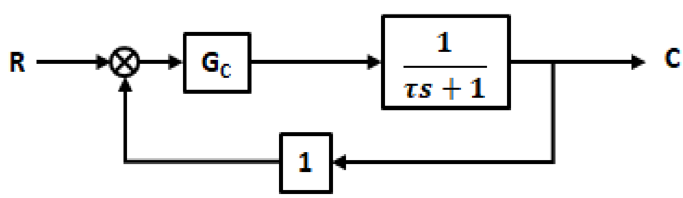
Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Set – 1 End Semester Examination, May 2019

Programme Name: B. Tech. APE Gas **Semester : VI**
Course Name : Process Dynamics Instrumentation and Control **Time : 03 hrs**
Course Code : GNEG 389 **Max. Marks : 100**
Nos. of page(s) : 4
Instructions: Assume the appropriate value of missing data if any.

SECTION A

S. No.		Marks	CO
Q 1	 Write down the steps of developing a mathematical model of any physical process. There are three different tanks (1, 2, 3) of three different cross-sectional area ($A_1 > A_2 > A_3$). The 1st order dynamic response of these three tanks for unit step change in flow rate is shown in the given figure. Map the response (a, b, c) with the three tanks (1, 2, 3)?	5	CO1
Q 2	Write the transfer functions of proportional, proportional integral, and proportional integral derivative controllers.  Draw the responses of a servo problem for the control system with each of these three controllers.	5	CO5
Q 3	Write the different elements of a typical instrument. Draw it for a thermometer.	5	CO6
Q 4	What is fail-safe condition for a control valve? Draw a schematic of a fail-safe pneumatic control valve which is used to control fuel supply for heating a tank.	5	CO2

SECTION B (Q 5 has internal option)

Q 5	If G_C is K_C, (proportional controller) in the control system given in below figure, then find out the offset for servo problem with unit step change.	10	CO2

<table>
<tr><td></td><td>

OR

If $G_C = K_C(1+1/\tau_I s)$ then prove there will be no offset for the servo problem.</td><td></td><td></td></tr>
<tr><td>Q 6</td><td>If the input is 5Sin(10t) and $K_C = 0.05$ in the system shown in problem 5 then find the amplitude ratio and phase lag in the output signal.</td><td>**10**</td><td>**CO3**</td></tr>
<tr><td>Q 7</td><td>If G_C is K_C (proportional controller) in the system given in problem 5, then prove that system is unstable at $K_C = 18$. (6)

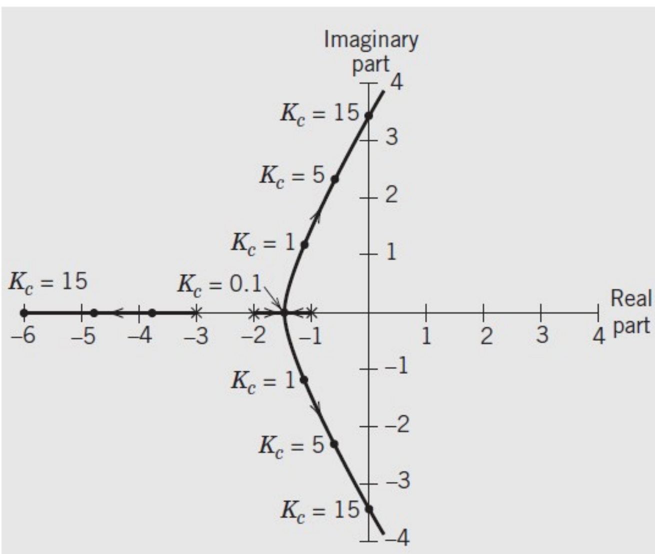
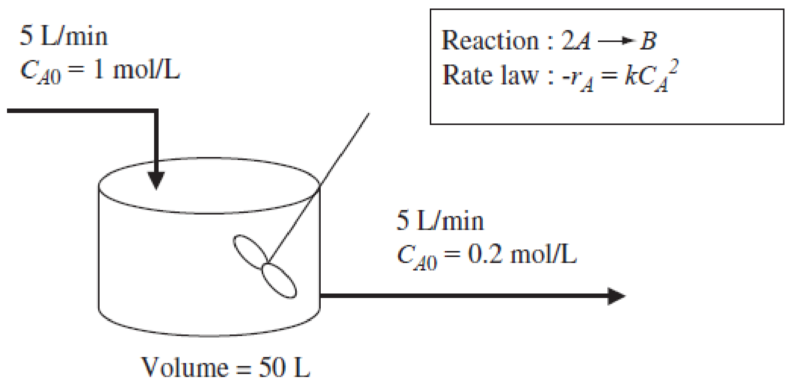


Figure Root locus diagram for third-order system.

If root locus is given in below figure, then to explain it draw the responses for different values of K_C for the step change in servo problem. (4)</td><td>**10**</td><td>**CO3**</td></tr>
<tr><td>Q 8</td><td>What is hysteresis and which static property it affects? (2) How do you make the instrument reading when you know static error and true value? (2) What is the span of a measuring instrument? (2) What is least accuracy and root squire accuracy? (2) What is measuring lag and which dynamic characteristic it affects? (2)</td><td>**10**</td><td>**CO6**</td></tr>
<tr><td colspan="4">

SECTION-C

Q- 10 has internal choice</td></tr>
</table>

Q 9	For the reactor (CSTR) shown in figure determine the transfer function that relates the exit concentration from the reactor to changes in the feed concentration. The reaction rate law is $-r_A = k_C \times C_A{}^2$, where r_A is the production rate of C_A in moles per liter per minute. The rate constant is 2 (1/(mol/L-min)). The maximum variation allowed in exit stream is 5% of the steady state value. Suppose that as an operator you found that the feed concentration is suddenly tripled from 1 to 3 mol/L then how much maximum time you have to take a corrective measure by taking it back to 1 mol/L? Suppose that you took double that time in taking the correcting measure, then how many L of exit stream will be wasted?  	**20**	**CO1**
Q10	Design the P, PI and PID controller using Ziegler-Nichols tuning technique for a first order followed by a pipe of dead time of 2 (time units) with the transfer function $G_P = \left[\frac{2}{0.5s+1}\right]\left[e^{-2s}\right]$ and the transfer function of measuring element $H = \left[\frac{1}{2s+1}\right]$ and final control element is 1. Get amplitude ratio and phase angle for the process. Show the bode plot on plane paper qualitatively. Find the crossover frequency and gain margin with . **OR**	**20**	**CO4**
	Suppose you have gone to visit an industry as a consultant. There is a reactor operating at designed optimal pressure. The pressure is controlled using P controller. What is the easiest suggestion you will give to the operator at control panel? What will be its benefit and what will be its repercussions? If you get a liberty to change the controller itself which controller you will choose and what will be your logic? If you have also to tune the controller parameters, then what will be the simple criteria you will look for? How will you find out one single criterion? What variations in	**20**	**CO4**

	formulation of the above criterion will you make so that following cases can be handled: (i) the error is significant (ii) the error is very small and (iii) the error is persistent for a significant time		

Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Set 2 End Semester Examination, May 2019

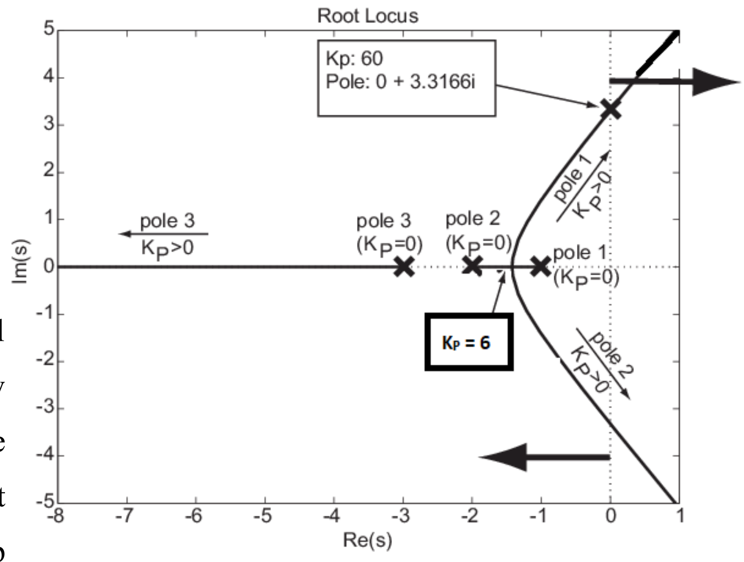
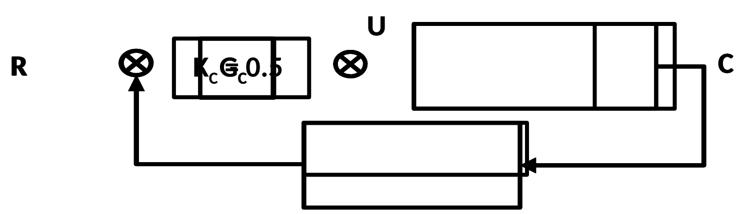
Programme Name: B. Tech. APE Gas **Semester : VI**
Course Name : Process Dynamics Instrumentation and Control **Time : 03 hrs**
Course Code : GNEG 389 **Max. Marks : 100**
Nos. of page(s) : 4
Instructions: Assume the appropriate value of missing data if any.

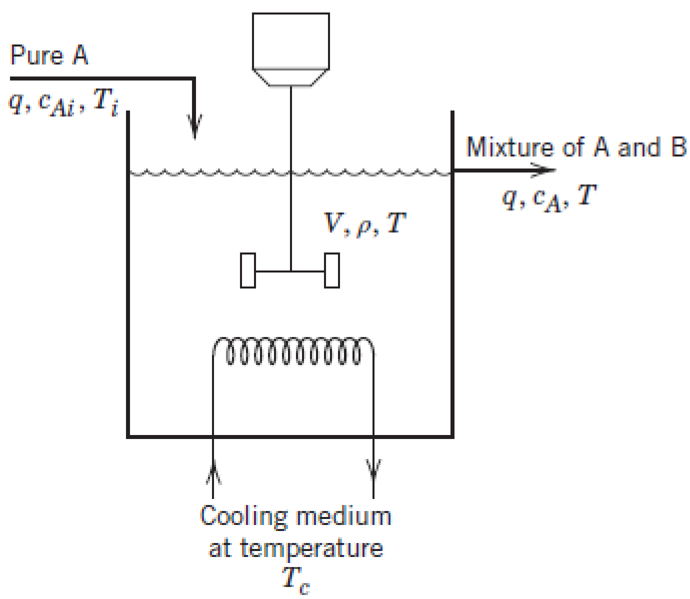
SECTION A

S. No.		Marks	CO
Q 1	What is the transfer function of transportation lag. If there is a gas flowing in the pipe of length 10 m with flow rate 2 m^3/s, what will be the transfer function?	**5**	**CO1**
Q 2	Plot the graph of (P vs ε) for proportional controller? Tell the limitation of the ideal curve against the real one. How does it effect by increasing the value of gain? In which condition it is converted into ON/OFF controller? Why is dead band created in ON/OFF controller?	**5**	**CO2**
Q 3	Write down names of 3 measuring instruments for following measuring variable: 1) Temperature 2) Flow 3) Pressure 4) Level 5) Composition.	**5**	**CO6**
Q 4	Pneumatic control valves are to be specified for the applications listed below. State whether an air to open or air to close valve should be specified for the following manipulated variables: (a) Steam pressure in a reactor heating coil. (b) Flow rate of reactants into a polymerization reactor. (c) Flow of effluent from a wastewater treatment holding tank into a river. (d) Flow of cooling water to a distillation condenser.	**5**	**CO6**

SECTION B (Q 5 has internal option)

S. No.		Marks	CO
Q 5	If G_C is K_C, (proportional controller) in the control system given in below figure, then find out the offset for servo problem with unit step change.	**10**	**CO2**

	OR If $G_C = K_C(1+1/\tau_I s)$ then prove there will be no offset for the servo problem.		
Q 6	In the system given in problem 6, if $H(s)=\frac{1}{0.1s+1}$, then find out whether the system is stable or not. (6) The root locus of a control system is given in below figure, then draw the responses for different values of K_C for the step change in servo problem to explain the root locus. (4)  	10	CO3
Q 7	 Find out open lopp transfer function. Find out phase crossover frequency and gain crossover frequency. Find out the gain margin and phase margin and check the stability. Find out what should have been the value of K_C to make the gain margin 1.7.	10	CO4
Q 8	What is hysteresis and which static property it affects? (2) How do you make the instrument reading when you know static error and true value? (2) What is the span of a measuring instrument? (2) What is least accuracy and root squire accuracy? (2) What is measuring lag and which dynamic characteristic it affects? (2)	10	CO6
	SECTION-C		
Q 9	Develop a mathematical model for the temperature for the given system. The heat	**20**	**CO1**

	$Q=(-\Delta H_R)(-r_A)V$ is being generated by reaction $-r_A=kC_A$ and by external heating. The operating conditions are as follows: $\rho=1000\,kg/m^3;\ q=1.667\times10^{-3};m^3/s;T_i=350\,K;T=500\,K;$ $V=0.1m^3;Cp=0.239\frac{kJ}{kg-K};C_{A,i}=1\frac{kmol}{m^3};C_A=0.5\frac{kmol}{m^3};$ $k=1.66\times10^{-11}s^{-1};-\Delta H_R=5\times10^4 kJ/kmol$ Calculate the required external heating/cooling rate required for the given condition using the developed model at steady state. If you have to design the control system such that it can take action for any disturbance in inlet temperature in Δt sec. The system is such that it can handle maximum disturbance of 10 K inside the reactor, whereas the usual disturbance in inlet temperature is 50 K.  		
Q10	Suppose you have gone to visit an industry as a consultant. There is a reactor operating at designed optimal pressure. The pressure is controlled using P controller. The operator asks you what will happen if he increases the value of K_C. What will be	**20**	**CO5**

	your answer? He also informed you that he tried once by increasing it but after certain value nothing was changing. What will be your logic? Then he told that another engineer had tried to put a PI controller but the system was becoming unstable because wrong value of reset rate? What will be your suggestion? If you have to suggest him to use PID controller what will be your major concern about the nature of inlet conditions to the system? Now suppose you have to fine tune the controller parameters, then what will be the simple criteria you will look for? How will you find out one single criterion? What variations in formulation of the above criterion will you make so that following cases can be handled: (i) the error is significant (ii) the error is very small and (iii) the error is persistent for a significant time		