Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2019

Programme Name: B. Tech (CE+RP) **Semester : VIII**
Course Name : Process Modelling and Simulation **Time : 03 hrs**
Course Code : CHEG440 **Max. Marks : 100**
Nos. of page(s) : 02
Instructions: 1) Answer the questions section wise in the answer booklet. 2) Assume suitable data wherever necessary. The notations used here have the usual meanings.

SECTION A (Total Marks: 3 x 10 = 30)

- Attempt ***all*** the questions.

S. No.		**Marks**	**CO**
Q 1	The instantaneous flow rate of oil flowing through a pipe is reported as follows: Time, min: 0, 15, 30, 45, 60, 75, 90, 105, 120 Flow rate, kg/min: 45, 35, 30, 30, 33.33, 38.33, 43.33, 50, 60 Calculate the total quantity of oil flowing in the pipe during the two-hour period using Simpson's one-third rule.	**10**	**CO3**
Q 2	Schematically represent the structure of a simple artificial neural network and explain the terms involved.	**10**	**CO5**
Q 3	Explain in detail about boundary conditions and initial conditions with suitable examples.	**10**	**CO1**

Time, min	0	15	30	45	60	75	90	105	120
Flow rate, kg/min	45	35	30	30	33.33	38.33	43.33	50	60

SECTION B (Total Marks: 2 x 20 = 40)

- Attempt ***any two*** questions.

Q 4	i) 10,000 kg/h of acid having a specific heat of 0.35 kcal/kg.K enters a well-agitated tank containing 10,000 kg of acid and leaves at the same rate in a steady state process. The inlet and outlet temperatures of the acid are 443 K and 363 K, respectively. This is maintained by cooling water, flowing at 8000 kg/h having a heat capacity of 4187 J/kg.K. The inlet temperature of water is 298 K. (a) Calculate the outlet temperature of water. (b) If cooling water suddenly fails, what is the temperature of the acid in the tank after 30 min?	**10**	**CO3**
	ii) Write down the unsteady-state heat conduction equation for one-dimensional slab without heat generation and convert it into IVP ODE.	**10**	**CO2**

Q 5	i) Distinguish between sequential modular and equation-based strategy used for process flowsheet simulation. ii) Develop a set of model equations for a weak acid and strong base pH system.	**10** **10**	**CO4** **CO2**
Q 6	Develop a mathematical model for a jacketed CSTR, where an irreversible, exothermic reaction is carried out as $A \xrightarrow{k} B$. Draw a neat sketch showing all the model parameters and state the assumptions clearly.	**20**	**CO2**
SECTION-C (Total Marks: 1 x 30 = 30)			
Q 7	Develop a dynamic model for the bioreactor using the growth rate expression proposed by Monod. Draw a neat sketch showing all the model parameters and state the assumptions clearly. Using Euler method, calculate the biomass concentration (x) and the substrate concentration (S) using a step size of 1 for $0 \le t \le 7$ h for a given data. S(0) = 1.0, x(0) = 1.0. Plot concentrations *vs*. time. Data: $\mu_m = 0.53\, h^{-1}$; $K_m = 0.12\, g/litre$; $D = 0.3\, h^{-1}$; $S_f = 4.0\, g/litre$; $Y = 0.4$	**30**	**CO2** **CO3**

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Programme Name: B. Tech (CE+RP) — **Semester : VIII**
Course Name : Process Modelling and Simulation — **Time : 03 hrs**
Course Code : CHEG440 — **Max. Marks : 100**
Nos. of page(s) : 03
Instructions: 1) Answer the questions section wise in the answer booklet. 2) Assume suitable data wherever necessary. The notations used here have the usual meanings.

SECTION A (Total Marks: 2 x 10 = 20)

➢ Attempt ***all*** the questions.

S. No.		Marks	CO
Q 1	Explain the working of a simple artificial neural network with a neat diagram.	10	CO5
Q 2	Discuss the techniques used for the process flowsheet simulation.	10	CO4

SECTION B (Total Marks: 2 x 20 = 40)

➢ Attempt ***any two*** questions.

Q 3	Develop a mathematical model for a tubular reactor, where an irreversible reaction is carried out as $A \xrightarrow{k} B$ isothermally. Draw a neat sketch showing all the model parameters and state the assumptions clearly.	20	CO2
Q 4	i) 20,000 kg/h of sulphuric acid having specific heat of 0.5 kcal/kg.K enters a well-agitated tank containing 20,000 kg of acid and leaves at the same rate in a steady-state process. The inlet and outlet temperatures of the acid are 443 K and 363 K, respectively. This is maintained by cooling water, flowing at 16,000 kg/h having a heat capacity of 4187 J/kg.K. The inlet temperature of water is 298 K. (a) Calculate the outlet temperature of water. (b) If cooling water suddenly fails, what is the temperature of the acid in the tank after 60 min?	10	CO3
	ii) Distinguish among independent variables, dependent variables, and parameters with suitable examples.	10	CO1
Q 5	i) Consider the following non-linear ODE-BVP $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} - 3y^3 = 0$ $x = 0: \frac{dy}{dx} = 0;\ x = 1: y(x = 1) = 3$ Using the finite difference method, convert the ODE-BVP problem into a set of non-linear algebraic equations for 4 internal grid points.	10	CO3
	ii) Consider a separation system as shown in Fig. 1. By setting up the mass		

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<td>balances, calculate the mass flow rates of each outlet streams (x_1, x_2 and x_3) using Gauss elimination method.

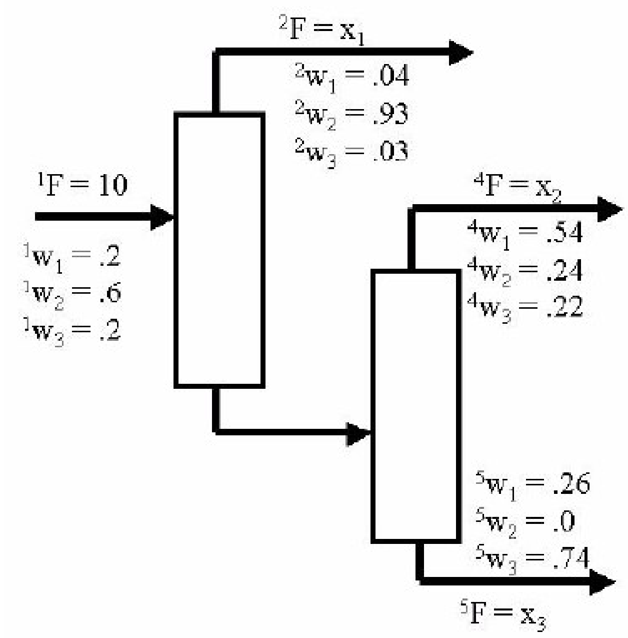

Fig. 1: A Separation system</td>
<td>10</td>
<td>CO3</td>
</tr>
<tr>
<td colspan="4">SECTION-C (Total Marks: 2 x 20 = 40)
➢ Attempt <u>all</u> the questions.</td>
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<td>Q 6</td>
<td>Develop a dynamic model for the bioreactor using the growth rate expression proposed by Monod. Draw a neat sketch showing all the model parameters and state the assumptions clearly.</td>
<td>20</td>
<td>CO2</td>
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<td>Q 7</td>
<td>The Van de Vusse reaction operated in a continuous stirred tank reactor is given as follows:
$A \xrightarrow{k_1} B \xrightarrow{k_2} C$
$2A \xrightarrow{k_3} D$

The component material balance equations are described as:
$\frac{dC_A}{dt} = -k_1 C_A - k_3 C_A^2 + \frac{F}{V}\left(C_{Af} - C_A\right)$
$\frac{dC_B}{dt} = k_1 C_A - k_2 C_B + \frac{F}{V} C_B$

(i) Compute the steady state values of C_A and C_B using the given data.
(ii) Perform three iterations employing the fourth-order Runge–Kutta method for dynamic study and plot the values of C_A and C_B as a function of time.</td>
<td>20</td>
<td>CO3</td>
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	Data: Reactor volume (V) = 1 l Feed flow rate (F) = 25 l/h Feed concentration of reactant A(C_{Af}) = 10 mol/l Kinetic constant (k_1) = 50 h^{-1} Kinetic constant (k_2) = 100 h^{-1} Kinetic constant (k_3) = 10 l/mol.h		