Name:

Enrolment No:

UPES — UNIVERSITY WITH A PURPOSE

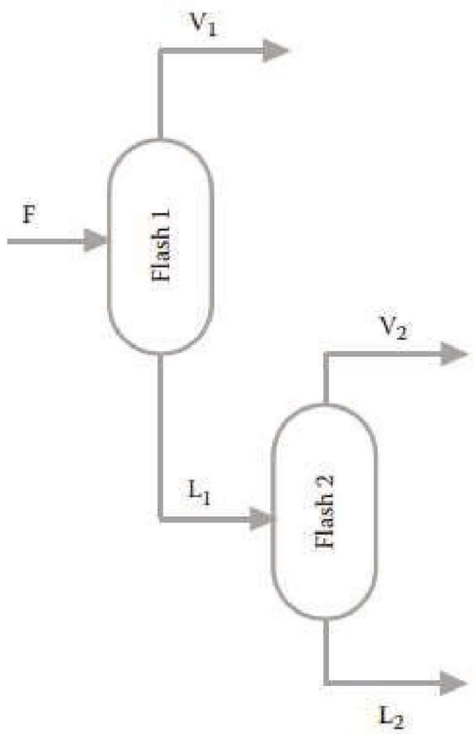
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Numerical Methods in Chemical Engineering **Semester: V**
Program: B. Tech CE+RP **Time: 03 hrs.**
Course Code: MATH 311 **Max. Marks: 100**

Instructions:

SECTION A (12×5 =60 M)
Answer all the questions, Q2 has an internal choice

S. No.		Marks	CO
Q 1	The Ergun equation is used to describe the flow of fluid through a packed bed . ΔP is the pressure drop, ρ is the density of the fluid , G_o is the mass velocity, D_p is the diameter of the particles within the bed, μ is the fluid viscosity, L is the length of the bed and ε is the void fraction of the bed. $$\frac{\Delta P \rho D_P}{G_o^2 L}\frac{\varepsilon^3}{1-\varepsilon}-150\frac{1-\varepsilon}{(D_P G_o/\mu)}-1.75=0$$ Experiments are carried out on a packed bed to estimate the void fraction of the bed, ε. The best fit values of the dimensionless parameters of the bed are reported as, $\frac{D_P G_o}{\mu}=1000$ and $\frac{\Delta P \rho D_P}{G_o^2 L}=10$. Use an open iterative scheme of your choice to estimate the value of ε using an initial guess of 0.25. Do *Three* iterations.	**12**	**CO2**
Q2	Derive a general algorithm to fit a polynomial of n^th order, $y=a_o+a_1x+a_2x^2+........+a_nx^n$ using the least square method. OR, Find the value of y at x = 21 from the following table using Newton's interpolation formula. x: 20, 23, 26, 29 y: 0.342, 0.3907, 0.4384, 0.4848	**12**	**CO3**
Q3	Develop a general algorithm and write a MATLAB code to solve the system of non-linear equation using the fixed point iteration method	**12**	**CO6**

Q4	Using finite difference (central difference in space) method to solve the differential equation $\frac{d^2y}{dx^2} - 2y = x^2 - 2x - 4,\ 0 < x < 1$ With the Dirichlet boundary conditions At $x = 0,\ y = 0$ At $x = 1,\ y = -1$ If x = 1 m. Take $\Delta x = \frac{1}{3}$ to find the values of y at all nodes.	**12**	**CO4**
Q5	Shown in Figure below is a schematic of a separation system consisting of two flash tanks in series. Experimental data are available on streams F, V_1, V_2, and L_2 as shown in Table below. The feed rate, F, is 1000 kg/min. 	**12**	**CO1**

Stream Mass Fractions

	Mass Fraction			
Component	F	V_1	V_2	L
Methanol	0.3	0.71	0.44	0.08
Ethanol	0.4	0.27	0.55	0.39
Butanol	0.3	0.02	0.01	0.53

Write mass balances on each of the three components using the supplied data. Use LU decomposition method to find the flowrates, V_1, V_2, and L_2 for two different feed rates, F of 1000 kg/min and 1400 kg/min.

SECTION B (20 × 2 = 40 M)

Answer all the questions

Q6 Consider a large metal plate of thickness L = 4 cm and thermal conductivity k = 28 W/m °C in which heat is generated uniformly at a constant rate of $\dot{g} = 5\times10^6 W/m^3$. One side of the plate is maintained at 0°C by iced water while the other side is subjected to convection to an environment at T = 30°C with a heat transfer coefficient of h = 45 W/m²°C. Considering a total of three equally spaced nodes in the medium, two at the boundaries and one at the middle, estimate the exposed surface temperature of the plate under steady conditions using the finite difference approach. — **20** — **CO4**

The heat transfer equation can be given as, $\frac{d^2T}{dx^2} + \frac{\dot{g}}{k} = 0$

Assumptions **(a)** Heat transfer is one-dimensional since the plate is large relative to its thickness. **(b)** Thermal conductivity is constant. **(c)** Radiation heat transfer is negligible

Q7 Consider the 1-D convection-diffusion equation:

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} = \alpha\frac{\partial^2 T}{\partial x^2}, \quad 0 \le x \le 1$$

Where, $u = 0.1$, $\alpha = 0.01$, T(0, t) = 0; T(x,0) = 50 sin(πx)

Show solution for one time step using the following methods — **20** — **CO5**

(a) Euler forward in time and central difference in space

(b) Euler backward in time and central difference in space

(c) A second order Runge- Kutta in time and central difference approximation in space. Use $\Delta x = 0.25$ and $\Delta t = 0.5$.