Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2020

Programme Name: B. Tech. APE Gas **Semester : VI**
Course Name : Numerical Methods in Chemical Engineering **Time : 03 hrs**
Course Code : MATH 3028 **Max. Marks : 100**

Section A

1. Each Question will carry 5 Marks
2. Questions have **sub questions**
3. Type the answers is the space given for each answer

Q **A.1**	**1.1** A system of non-linear equations [A]*[X] = [B] can be represented as a system which is operating at a specific condition to obtain a desired outcome. Then a) A – System; X: Desired Outcome; B: Operating Condition b) A – Operating Condition; X: Desired Outcome; B: System c) A – System; X: Operating Condition; B: Desired Outcome d) A – Operating Condition; X: System; B: Desired Outcome	(2 Marks)	**CO1**
	1.2 Give the reasoning in 1-2 lines: Why iterative methods are better than direct methods if number of equations/unknowns for SLEs are high. Type the reasoning in terms of using terms "N: number of variables" "M: Number of iterations"	(3 Marks)	
QA.2	**2.1** In solving a non-linear equation, If the error in step i is ε_i and step i+1 is ε_{i+1} then then using the relation between ε_i and ε_{i+1} explain how Newton Raphson method is better than Successive Substitution method. Type the answer in 1-2 lines	(3 Marks)	**CO2**
	2.2 A system of non-linear equation (SNLEs): f_1(x1, x2, x3) = 0; f_2(x1, x2, x3) = 0; f_3(x1, x2, x3) = 0; can be converted into system of linear equations (SLEs) as $[A][X]^{(k+1)} = [B]$ in terms of the function vector [F] and Jacobian matrix [J] at $[X]^{(k)}$ then a) $[A] = [J]^T[J]$; $[B]= [J]^T[F]$ b) $[A] = [J]^T[F]$; $[B] =[J]^T[J]$ c) $[A] = [J]$; $[B] =[J] [X]^{(k)} - [F]$ d) $[A] = [J]$; $[B] =[J] [X]^{(k)} + [F]$	(2 Marks)	

QA.3	**3.1** In deriving any formula for numerical integration, we approximate the given function to a polynomial of limited order valid for a small range. Then we find the integral using this approximated polynomial for the small range. Then we sum such integrals for the entire range to find the overall integral. The accuracy and computational cost of a derived formula depends on two things. Explain these two things in short.	(5Marks)	**CO3**
QA. 4	In deriving any formula for solution of ODE-IVP using numerical method $\frac{dy}{dx} = f(x, y)$ $at\ x = 0 \quad y = y0$ we use the formula of marching ahead $y_{i+1} = y_i + h \times d_i$. The direction d_i keeps on changing from "step *i*" to "step *i* +1" thus to capture this movement of direction d_i **a)** In Adam Bashforth Family, we use the information of f_i generated at previous steps **b)** In Runge Kutta Family, we use at the information at the "step *i* +1" along with the information generated previous steps. **c)** In Runge Kutta Family, we use the information generated at the in-between points to "step *i*" and "step *i* +1" **d)** In Adam Moulton Family, we use at the information at the "step *i* +1" along with the information generated previous steps. Just type the correct options	(5 Marks)	**CO4**
QA. 5	In RK4 method using step size 0.2 $\frac{dy}{dx} = 5y$ $at\ x = 0 \quad y = 1$ The direction at initial point i is …., (then calculate $y_{i/2}$) The direction at half way point is …. following the direction at point i, (then calculate $y'_{i/2}$) The updated direction at half way point is …. following the previous direction obtained at halfway point. (then calculate y_{i+1}) The direction at next step is …… following the updated direction obtained at halfway point. Then the direction of RK4 method will be …….	(5 Marks)	**CO4**

QA. 6	In solving ODE-BVP we discretize the model equation and the boundary condition both if the boundary condition involves …….. Whereas, we don't discretize the model equation at boundary if the boundary condition involves ……… After discretization the ODE-BVP is converted into System of ……….. Equations While, PDE are converted into System of …….. Equations. Type the answers for fill in the blanks	(5 Marks)	**CO5**

Section B

1. Each Question will carry 10 Marks
2. All are file upload type

S. No.		Marks	CO
Q B.1	In the below system of linear equation assume any value of a_{12}, a_{23}, a_{31} and b_2 and solve the equation by gauss elimination method $\begin{bmatrix} a_{12} & 2 & 1 \\ 1 & 3 & a_{23} \\ a_{31} & 2 & 6 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 2 \\ b_2 \\ 3 \end{bmatrix}$ Write the steps as you are solving on MS Excel. Use your allowed calculator for calculations	**10**	**CO1** **CO6**
Q B.2	Find the root of the nonlinear equation given by $f(x) = \text{Sin}\left(A * e^{Bx}\right) = 0$ Using Newton-Raphson Method and using x = 0 upto 2 iteration Consider any positive value of A and B	**10**	**CO2**
Q B.3	Consider the radial profile of the mass flux of solid particles in a fluidized is given by $G_s(r) = \overline{G}_s\left[a + b\left(\frac{r}{R}\right)^5 + \left(\frac{r}{R}\right)^2\right]$ Where $b = \dfrac{\frac{1}{2}+\phi}{\frac{2}{7}-\phi^{2.5}}$ $a = \frac{1}{2} - \frac{2b}{7}$ Consider $\phi = \left(\frac{r_C}{R}\right)^2 = 0.81$ *or* $r_C = 0.9R$ Calculate the value of $\overline{G}_{s,c} = \frac{1}{\pi r_c^2}\int_0^{r_c} 2\pi r G_s(r)\,dr$ using trapezoidal rule. Assume any value of R. Divide the range of 0 to r_c into 4 parts. Compare the numerical solution with analytical solution:	**10**	**CO3**

	$G_c = \frac{\overline{G}_{pz}}{14\phi^{2.5} - 4}\left[2\phi + 5\phi^{2.5} + 3\phi^{3.5}\right]$		
Q B.4	$\frac{dy}{dx} = f\left(x, y\right)$ $at\, x = 0 \quad y = 1$ Consider any function which is non-linear in terms of y. Solve the ODE-IVP using Adam Moulton 2nd Order (Crack Nicolson Method)	**10**	**CO4 CO6**
Q B.5	Consider any function in below form $f\left(\frac{d^2y}{dx^2}; \frac{dy}{dx}, x, y\right) = 0$ $at\, x = 0 \quad y = 1$ $at\, x = 1 \quad \frac{dy}{dx} = 0$ Use finite difference method (step size = 0.25) to convert it into system of Non-Linear equations and describe the procedure to solve it. Use of constants are mandatory in the $f\left(\frac{d^2y}{dx^2}, \frac{dy}{dx}, x, y\right)$.	**10**	**CO4 CO6**

Section C

File upload type

Q C	Consider any function in below form $\frac{dy}{dt} = f\left(\frac{d^2y}{dx^2}, \frac{dy}{dx}, x, y\right)$ $at\, t = 0 \quad y = 0$ $at\, x = 0 \quad y = 1$ $at\, x = 1 \quad \frac{dy}{dx} = 0$ Use Method of lines (step size for x = 0.25) to convert it into system of ODE-IVP equations. Use of constants are mandatory in the $f\left(\frac{d^2y}{dx^2}, \frac{dy}{dx}, x, y\right)$.	**20**	**CO5**