Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–IV (NEW) EXAMINATION – WINTER 2020

Subject Code:3140510 **Date:15/02/2021**

Subject Name:Numerical Methods in Chemical Engineering

Time:02:30 PM TO 04:30 PM **Total Marks:56**

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

MARKS

Q.1 **(a)** Discuss bracketing methods & open methods. **03**

(b) Fit the straight line that best fits to the following data: **04**

x	0	1	2	3	4
y	1	1.8	3.3	4.5	6.3

(c) Fit a second degree parabola to the following data **07**

x	1	2	3	4
y	1.7	1.8	2.3	3.2

Q.2 **(a)** Find the percentage error in the area of an ellipse when errors of 2% and 3% are made in measuring its major axes respectively. **03**

(b) Perform three iterations of the bisection method to obtain the root of the equation $2\,sinx - x = 0$, correct up to three decimal places. **04**

(c) Find the root of $x^3 - 2x - 1 = 0$ correct up to three decimal places using Secant method (starting from $x_0 = 1.5$ and $x_1 = 2$). **07**

Q.3 **(a)** Explain the Gauss Jordan method to solve the system of linear equations. **03**

(b) Solve the following system of equations by Gauss Elimination method: **04**

$$x + 3y + 2z = 5$$
$$2x + 4y - 6z = -4$$
$$x + 5y + 3z = 10$$

	(c)	Find a root of the equation $x^3 + x - 1 = 0$ correct up to four decimal places by using Newton-Raphson iteration formula.	**07**
Q.4	**(a)**	Find the largest eigen value of the matrix $A = \begin{bmatrix} 3 & -5 \\ -2 & 4 \end{bmatrix}$	**03**
	(b)	Solve the following system of equations by Gauss Jacobi method: $6x + 2y - z = 4$, $x + 5y + z = 3$, $2x + y + 4z = 27$	**04**
	(c)	Solve the following system of equations by Gauss Siedel method: $x + 2y + z = 0$, $3x + y - z = 0$, $x - y + 4z = 3$. Starting with (1,1,1)	**07**
Q.5	**(a)**	Use the Euler's method to find y (0. 1), given that $\frac{dy}{dx} = \frac{y-x}{y+x},\ y(0) = 1$, Taking h = 0.2	**03**
	(b)	Apply 4^{th} order Runge Kutta Method to compute y for $x = 0.1$, given that $\frac{dy}{dx} = 2x + y,\ y(0) = 1,$ h=0.1	**04**
	(c)	Evaluate $\int_0^6 \frac{dx}{1+x^2}$ by using (1) Trapezoidal rule (2) Simpson's 1/3 Rule (3) Simpson's 3/8 Rule	**07**
Q.6	**(a)**	Discuss in brief about boundary value problems.	**03**
	(b)	Using Newton's divided difference formula, evaluate f(8) from the following data:	**04**

x	4	5	7	10	11	13
f(x)	48	100	244	900	1210	2028

	(c)	Use the Taylor series method to find y (0.2), given that $\frac{dy}{dx} = 2y + 3e^x,\ y(0) = 1$. Taking h=0.1.	**07**

Q.7 **(a)** Derive formula for Trapezoidal Rule of numerical integration. **03**

(b) By Simpson's 3/8 rule, evaluate $\int_0^1 \frac{sinx}{x}\, dx$ taking $h = \frac{1}{6}$. **04**

(c) Use Lagrange's interpolation formula to find the value of y when $x = 12$, if the values of x and y are given below: **07**

x	11	13	14	18	20	23
y	25	47	68	82	102	124

Q.8 **(a)** Derive formula for Simpson's 1/3 Rule of numerical integration. **03**

(b) Find cosh(0.56) from the following table using Newton's forward interpolation method. **04**

x	0.5	0.6	0.7	0.8
y	1.127626	1.185465	1.255169	1.337435

(c) Use Milne's predictor-corrector method to find y(0.4) for $y' = x + y^2$, y(0)=1 with h=0.1 **07**

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (NEW) EXAMINATION – WINTER 2021

Subject Code:3140510 **Date:03/01/2022**

Subject Name:Numerical Methods in Chemical Engineering

Time:10:30 AM TO 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

MARKS

Q.1 **(a)** Define following: **03**
i) Truncation error ii) Round off error iii) Absolute Error

(b) Find the percentage error in calculating the area of a rectangle when an error of 3% is made in measuring each of its sides. **04**

(c) Derive a recurrence formula for finding Square root of N, using Newton Raphson method and hence compute square root of 10. **07**

Q.2 **(a)** Discuss bracketing methods & open methods. **03**

(b) Find a root of the equation $x^3 - 4x - 9 = 0$, using the bisection method up to fourth approximation. **04**

(c) Solve the following system of equations by Gauss Siedel method: **07**

$$5x + y - z = 10$$
$$2x + 4y + z = 14$$
$$x + y + 8z = 20$$

OR

(c) Using Secant Method, solve $xe^x - 1 = 0$, correct up to three decimal places between 0 and 1. **07**

Q.3 **(a)** Derive the normal equations to fit a straight line y = a + bx using least square method. **03**

(b) Find a real root of the equation $3x + sinx - e^x = 0$ by the method of false position correct to four decimal places. **04**

(c) Using Gauss Elimination method solve the system of equations: **07**

$$2x + y + z = 10$$
$$3x + 2y + 3z = 18$$
$$x + 4y + 9z = 16$$

OR

Q.3 **(a)** Find the inverse of A = $\begin{bmatrix} 2 & 6 & 6 \\ 2 & 7 & 6 \\ 2 & 7 & 7 \end{bmatrix}$ **03**

(b) Fit a straight line to the following data: **04**

x	0	1	2	3	4
y	1	1.8	3.3	4.5	6.3

(c) Use Lagrange's interpolation formula to find the value of y when $x = 10$, if the values of x and y are given below: **07**

x	5	6	9	11
y	12	13	14	16

Q.4 **(a)** Write short note on Newton's Forward Interpolation. **03**

(b) Using Newton's divided difference formula, evaluate f(9) from the following data: **04**

x	5	7	11	13	17
f(x)	150	392	1452	2366	5202

(c) Use Newton's forward interpolation formula, find the value of f(1.6). **07**

x	1	1.4	1.8	2.2
f(x)	3.49	4.82	5.96	6.5

OR

Q.4 **(a)** Derive formula for Trapezoidal rule of numerical integration. **03**

(b) Following table shows speed in m/s and time in second of a car **04**

t	0	12	24	36	48	60	72	84	96	108	120
v	0	3.60	10.08	18.90	21.60	18.54	10.26	5.40	4.50	5.40	9.00

Using Simpson's 1/3 rule find the distance travelled by the car in 120 second.

(c) Using Taylor's series method, solve $\frac{dy}{dx} = x + y$, starting from $x = 1, y = 0$ and carry $to\ x = 1.2\ with\ h = 0.1$ **07**

Q.5 **(a)** Evaluate $\int_0^1 e^{-x^2}\,dx$ by trapezoidal rule with $n = 10$. **03**

(b) Apply 4th order Runge Kutta Method to compute y for $x = 0.2$, given that $\frac{dy}{dx} = y - \frac{2x}{y},\ y(0) = 1$ **04**

(c) Find y(4.4) given $5xy' + y^2 - 2 = 0\ \ with\ y(4) = 1, y(4.1) = 1.0049$, $y(4.2) = 1.0097,\ y(4.3) = 1.0143$. **07**

OR

Q.5 **(a)** Explain the method of finite difference approximations to partial derivatives. **03**

(b) By Simpson's 3/8 rule, evaluate $\int_0^1 \frac{sinx}{x}\,dx$ taking $h = \frac{1}{6}$ **04**

(c) Write the general linear partial differential equation of the second order in two independent variables. Also determine whether the following partial differential equations are elliptic, parabolic or hyperbolic? **07**

1. $\frac{\partial^2 u}{\partial x^2} + 4\frac{\partial^2 u}{\partial x\,\partial y} + 4\frac{\partial^2 u}{\partial y^2} - \frac{\partial u}{\partial x} + 2\frac{\partial u}{\partial y} = 0$
2. $(1 + x^2)\frac{\partial^2 u}{\partial x^2} + (5 + 2x^2)\frac{\partial^2 u}{\partial x\,\partial t} + (4 + x^2)\frac{\partial^2 u}{\partial t^2} = 0$

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (NEW) EXAMINATION – SUMMER 2021

Subject Code:3140510 Date:06/09/2021

Subject Name:Numerical Methods in Chemical Engineering

Time:02:30 PM TO 05:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

MARKS

Q.1 **(a)** Differentiate between accuracy and precision with appropriate example. **03**

(b) Derive the relation between number of iterations and absolute error for bisection method. **04**

(c) Derive the equation for Newton's forward difference polynomial. **07**

Q.2 **(a)** Using Descartes rule of sign find maximum number of positive and negative roots of the following equation. **03**

$$f(x) = 2x^7 - x^5 + 4x^3 - 5 = 0$$

(b) Explain algorithm for finding the root of an equation using Newton-Raphson method. **04**

(c) A chemical reaction A→B takes place in a CSTR. The following model describes the system **07**

$$\frac{C_{in} - C_A}{\tau} - \frac{k\sqrt{C_A}}{K + C_A} = 0$$

where, k=1, K=0.25, C_{in}=1 and τ=0.25. Report C_A obtained after third iteration of Secant method. Consider C_A=0 and C_A=1 as two initial guesses for Secant method.

OR

(c) You are designing a spherical tank to hold water for a small village in a developing country. The volume of liquid it can hold can be computed as: **07**

$$\mathrm{V} = \pi \mathrm{h}^2 \frac{[3\mathrm{R} - \mathrm{h}]}{3}$$

Where V=volume (m^3), h=depth of water in tank (m), and R = the tank radius (m). If R=3 m, what depth must tank be filled so that it holds 30 m^3? Assume initial value of h = 2 m. Use three iterations of the Newton-Raphson method and calculate absolute error after each iteration.

Q.3 **(a)** Discuss about the pitfalls of Gauss elimination method and techniques for improvement. **03**

(b) Explain algorithm for finding the root of an equation using False-Position method. **04**

(c) The relationship between stress 'τ' and the strain 'γ' for a pseudoplastic fluid can be expressed by the following equation: **07**

$$\tau = \mu\gamma^n$$

The following data come from a 0.5% hydroxethylcellulose in water solution. Using linear least square method, Estimate the parameters 'μ' and 'n'.

γ	50	70	90	110	130
τ	6.01	7.48	8.59	9.19	10.21

OR

Q.3 **(a)** Explain the algorithm for Gauss-Jordan method. **03**

(b) Derive formula for Trapezoidal rule for numerical integration. **04**

(c) An investigator has reported the data tabulated below for an experiment to **07**

determine the growth rate of bacteria k (per d), as a function of oxygen concentration C (mg/L). It is known that such data can be modeled by the following equation:

$$k = \frac{k_{max} C^2}{C_s + C^2}$$

Where C_s and k_{max} are parameters. Use a transformation to linearize this equation. Then use linear regression to estimate C_s and k_{max} and predict the growth rate at C = 2 mg/L.

C	0.5	0.8	1.5	2.5	4
k	1.1	2.4	5.3	7.6	8.9

Q.4 **(a)** Discuss about convergence criteria for the Gauss-Siedel method. **03**

(b) Derive equations to fit a straight line ($y = a_0 + a_1 x$) with the least square method. **04**

(c) A nutrient is administered by diluting it with water. The flowrate, Q (ml/min) and the nutrient concentration C (µg/ml) both vary with time. The total amount of nutrient delivered in one hour is: **07**

$$m = \int_0^{60} Q(t)C(t)dt$$

The following data is given:

t (min)	0	10	20	30	40	50	60
Q(t) (ml/min)	52	45	48	46	53	50	47
C(t) (µg/ml)	1.2	1.5	2.4	1.9	2.0	2.2	1.6

Using Simpson's 1/3 rule calculate total amount of nutrient introduced to water in 1 hour.

OR

Q.4 **(a)** Explain about the system of ill-conditioned equations using appropiate example. **03**

(b) Consider the following data: **04**

x	0.2	0.3	0.4	0.5
y	0.83	1.15	1.42	1.7

Using Lagrange interpolation to compute, value of y at x=0.325

(c) Find the isothermal work done on the gas as it is compressed from V_1 = 22 L to V_2 = 2L using Simpson's 1/3 rule. **07**

$$W = \int_{V_1}^{V_2} P\, dV$$

Use following data for calculation purpose.

V, L	2	7	12	17	22
P, atm	12.20	3.49	2.04	1.44	1.11

Q.5 **(a)** **03**

1. List out the interpolation methods, which can be used when data points are available at unequal interval.
2. Differentiate between interpolation and regression technique.

(b) Explain Milne's predictor-corrector method. **04**

(c) Consider the RL circuit model is given by **07**

$$\frac{dI}{dT} = \frac{V}{L} - \frac{IR}{L}$$

Where inductance L=2, resistance R=2.5, voltage V=5. The initial value of current at t=0 is I(0)=0. Compute the value of I at t=2 using Euler's method with step size of 0.5.

OR

Q.5 **(a)** Differentiate between bracketing and open methods to solve non-linear algebraic equations. **03**

(b) Explain in brief about ordinary differential equation - boundary value problems. **04**

(c) Hot ball is exposed to atmosphere, where it loses heat to the atmosphere and Newton's Law of Cooling gives relation between Temperature (T) and time (t): **07**

$$\frac{dT}{dt} = -0.5(T - 30)$$

Initial temperature of ball is 80 ˚C. Calculate ball temperature at time t=2 using RK-4 method with step size of 2.

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (NEW) EXAMINATION – SUMMER 2022

Subject Code:3140510 Date:29-06-2022

Subject Name:Numerical Methods in Chemical Engineering

Time:10:30 AM TO 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1 **(a)** Explain following terms: 1) Significant figures, 2) Truncation Error. **03**

(b) Define: 1) Absolute error, 2) Relative error, 3) Percentage error, 4) Inherent Error. **04**

(c) Evaluate sum $S = \sqrt{4} + \sqrt{6} + \sqrt{8}$ to four significant digits and find absolute & relative errors. **07**

Q.2 **(a)** Describe intermediate value properties. **03**

(b) Find the root of equation $x \log_{10} x = 1.2$ correct upto four decimal places using bisection method. **04**

(c) Enlist limitations of Newton-Raphson Method also find root of the function $x^4 - x = 10$ upto three decimal places using Newton-Raphson method. **07**

OR

(c) Solve following equation using Newton Raphson technique starting with $x_0 = 0.5 \; and \; y_0 = 1.5$, carry out two iterations. **07**

$$\sin x - y = -0.9793$$
$$\cos y - x = -\,0.6703$$

Q.3 **(a)** Explain Gauss elimination method with its pitfalls. **03**

(b) Solve the system of equation using Gauss Jordan method. **04**

$2x + y + z = 10; 3x + 2y + 3z = 18; x + 4y + 9z = 16$

(c) Solve following set of equation using jacobi's iteration method correct up to three decimal places. $x_0 = y_0 = z_0 = 0$ **07**

$$20x + y - 2z = 17$$
$$3x + 20y - z = -18$$
$$2x - 3y + 20z = 25$$

OR

Q.3 **(a)** Give the normal equation to fit the straight line y = a + bx to n observations. **03**

(b) Find the eigen-values and eigenvectors of the matrix **04**

$$\begin{bmatrix} 5 & 4 \\ 1 & 2 \end{bmatrix}$$

(c) The pressure and volume of a gas are related by the equation $pV^{\gamma} = k$, γ and k being constants. Fit this equation to the following set of observations: **07**

p (kg/cm^2)	0.5	1.0	1.5	2.0	2.5	3.0
V (lts)	1.62	1.00	0.75	0.62	0.52	0.46

Q.4 **(a)** Establish Newton's backward interpolation formula. **03**

(b) If P is pull required to lift a load W by means of a pulley block, find a linear law of form $P = mW + C$ connecting P & W, using following data. **04**

P	12	15	21	25
W	50	70	100	120

(c) Obtain the density of a 26% solution of H_3PO_4 in water at 20 °C during using Lagrange's interpolation formula can we perform the same calculation using Newton's forward difference interpolation formula? Yes or No? **07**

y (Density)	1.0764	1.1134	1.2160	1.3350
x % H_3PO_4	14	20	35	50

OR

Q.4 **(a)** Write an algorithm for trapezoidal rule. **03**

(b) Using Newton's backward difference formula, construct an interpolating polynomial of degree 3 for the data: $f(-0.75) = -0.0718125, f(-0.5) = -0.02475, f(-0.25) = 0.3349375, f(0) = 1.10100$. **04**

(c) Evaluate $\int_0^{0.6} e^{-x^2}$ using the trapezoidal rule and Simpson's 1/3rd rule, taking h = 0.1 **07**

Q.5 **(a)** Discuss in brief about the boundary value problem. **03**

(b) Compute the value of $\int_{0.2}^{1.4}(\sin x - \log x + e^x)dx$ using Simpson's 3/8 rule. **04**

(c) Using Euler's method, find an approximate value of y corresponding to $x = 1$, given that $dy/dx = x + y$ and $y = 1$ when $x = 0$. **07**

OR

Q.5 **(a)** Describe Milne's predictor-corrector method. **03**

(b) Apply the Runge - Kutta fourth order method to find an approximate value of y when $x = 0.2$ given that $dy/dx = x + y$ and $y = 1$ when $x = 0$. **04**

(c) Solve by Taylor's series method the equation $\frac{dy}{dx} = \log(xy)$ for y(1.1) and y(1.2), given y(1) = 2. **07**

****