Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (NEW) EXAMINATION – SUMMER 2024

Subject Code:3140510 Date:20-07-2024

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)** Differentiate between accuracy and precision with appropriate example. **03**

(b) Find the percentage error in the area of an ellipse where an error of 1% is made in measuring its major and minor axis. **04**

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

x	0	1	2	3	4
y	1	1.8	1.3	2	6.3

Q.2 **(a)** Use Descartes' rule of signs to find the number of positive, negative and imaginary roots of the function: $x^6 - x^5 - 10x + 7 = 0$ **03**

(b) Find root of the equation $x^3 - 2x - 5 = 0$ using the bisection method correct upto three decimal places. **04**

(c) Air at 25 ^oC and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is e = 0.0015 mm. Density of air at 25 ^oC and 1 atm is 1.23 kg/m^3. Calculate the friction factor using the Colebrook equation **07**

$$\frac{1}{\sqrt{f}} = -2.0\log\{\frac{\frac{e}{D}}{3.7} + \frac{2.51}{Re\sqrt{f}}\}$$

Determine the pressure drop in 1 m section of the tube using the relation

$$\Delta P = \frac{fLV^2f}{2D}$$

OR

(c) Solid particles having a diameter of 0.12 mm, shape factor Φ_s =0.88 and a density of 1000 kg/m^3 are to be fluidized using air at 2.0 atm and 25^oC. The voidage at minimum fluidization is 0.42. The viscosity of air under these conditions is $1.845*10^{-5}$ kg/m.s. The molecular weight of air is 28.97 g/mol. The diameter of the particle is $1.2*10^{-4}$ m. Estimate the minimum fluidization velocity using newton Raphson method. **07**

The Ergun equation for packed bed is given below.

$$[\frac{1.75\ \rho(1-e_{mf})}{\Phi_s d_p\ e_{mf}^3}]v_{mf}^2 + [\frac{150\ \mu(1-e_{mf})^2}{\Phi_s^2 d_p^2\ e_{mf}^3}]v_{mf} - (1-e_{mf})(\rho_p - \rho)g = 0$$

Q.3 **(a)** Define Eigen values and Eigen vectors. **03**

(b) Find numerically the largest Eigen value and corresponding Eigen Vector of the following matrix using power method. **04**

$$A = \begin{bmatrix} 1 & 6 & 1 \\ 1 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

(c) Given the values **07**

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

Determine f(9).

OR

Q.3 **(a)** Discuss the pitfalls of Gauss - Elimination method and techniques for improving solutions. **03**

(b) Solve the following system of simultaneous equations by Gauss seidal method **04**
20x + y -2z = 17, 3x + 20y -z = -18, 2x - 3y + 20z = 25

(c) The function y= sinx is tabulated below **07**

x	0	π/4	π/2
y	0	0.70711	1.0

Using Lagrange's interpolation formula find the value of sin(π/6)

Q.4 **(a)** State the formulas for Trapezoidal Rule, Simpsons 1/3rd rule, Simpsons 3/8th rule. **03**

(b) Solve the following system of equations by Gauss Elimination method: **04**
$2x + y + z = 10$
$3x + 2y + 3z = 18$
$x + 4y + 9z = 16$

(c) Given that y = ln x, and **07**

x	4.0	4.2	4.4	4.6	4.8	5.0	5.2
y	1.3863	1.4351	1.4816	1.5261	1.5686	1.6094	1.6487

Evaluate $\int_4^{5.2} \ln x \, dx$ using simpsons 3/8 rule.

OR

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

(b) Apply Gauss Jordan to solve the equations **04**
10x + y + z = 12
x +10y + z = 12
x + y + 10z = 12

(c) Evaluate $\int_0^6 \frac{1}{1+x} dx$ taking h=1 using Simpson 1/3 rule. **07**

Q.5 **(a)** Discuss in brief about initial and boundary value problems. **03**

(b) Prove the following **04**
(i) $\Delta = E - 1$
(ii) $\nabla = 1 - E^{-1}$

(c) Using Euler's method, find an approximate value of y corresponding to x = 0.1 for the following equation. **07**

$$\frac{dy}{dx} = \frac{y - x}{y + x}$$

Take y(0)=1 and h=0.02

OR

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

(b) Given that **04**

x	1.0	1.1	1.2	1.3	1.4	1.5	1.6
y	7.989	8.403	8.781	9.129	9.451	9.750	10.031

Find $\frac{dy}{dx}$ at x=1.1

(c) Using Runge Kutta method of fourth order, solve the following at x=0.2 and 0.4. Take y(0)=1 **07**

$$\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2}$$

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE –SEMESTER -IV (NEW)EXAMINATION- SUMMER 2024

Subject Code:3140510 Date:

Subject Name: Numerical Methods in Chemical Engineering

Time: Total Marks: 70

Instructions:

5. **Attempt all questions.**
6. **Make suitable assumptions wherever necessary.**
7. **Figures to the right indicate full marks.**

			Marks	CO	Cognitive Level
Q.1	**(a)**	Differentiate between accuracy and precision with appropriate example.	**03**	CO1	R
	(b)	Find the percentage error in the area of an ellipse where an error of 1% is made in measuring its major and minor axis.	**04**	CO1	U
	(c)	Fit a second degree parabola to the following data. x: 0, 1, 2, 3, 4 y: 1, 1.8, 1.3, 2, 6.3	**07**	CO**5**	A
Q.2	**(a)**	Use Descartes' rule of signs to find the number of positive, negative and imaginary roots of the function: $x^6 - x^5 - 10x + 7 = 0$	**03**	CO**2**	U
	(b)	Find root of the equation $x^3 - 2x - 5 = 0$ using the bisection method correct upto three decimal places.	**04**	CO**2**	**U**
	(c)	Air at 25 °C and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is e = 0.0015 mm. Density of air at 25 °C and 1 atm is 1.23 kg/m^3. Calculate the friction factor using the Colebrook equation $$\frac{1}{\sqrt{f}} = -2.0\log\{\frac{\frac{e}{D}}{3.7} + \frac{2.51}{Re\sqrt{f}}\}$$ Determine the pressure drop in 1 m section of the tube using the relation $$\Delta P = \frac{fLV^2\rho}{2D}$$	**07**	CO**3**	A

		OR			
	(c)	Solid particles having a diameter of 0.12 mm, shape factor Φ_s =0.88 and a density of 1000 kg/m^3 are to be fluidized using air at 2.0 atm and 25^{o}C. The voidage at minimum fluidization is 0.42. The viscosity of air under these conditions is 1.845*10^{-5} kg/m.s. The molecular weight of air is 28.97 g/mol. The diameter of the particle is 1.2*10^{-4} m. Estimate the minimum fluidization velocity using newton Raphson method. The Ergun equation for packed bed is given below. $[\frac{1.75\ \rho(1-e_{mf})}{\Phi_s \mathrm{d}_p\ e_{mf}^3}]v_{mf}^2 + [\frac{150\ \mu(1-e_{mf})^2}{\Phi_s^2 d_p^2\ e_{mf}^3}]v_{mf}$ - $(1-e_{mf})(\rho_p - \rho)$g = 0	**07**	C O **3**	A
Q.3	**(a)**	Define Eigen values and Eigen vectors.	**03**	C O **3**	R
	(b)	Find numerically the largest Eigen value and corresponding Eigen Vector of the following matrix using power method. A = $\begin{bmatrix}1 & 6 & 1\\1 & 2 & 0\\0 & 0 & 3\end{bmatrix}$	**04**	C O 3	A
	(c)	Given the values x: 5, 7, 11, 13, 17 f(x): 150, 392, 1452, 2366, 5202 Determine f(9).	**07**	C O **4**	U
		OR			
Q.3	**(a)**	Discuss the pitfalls of Gauss - Elimination method and techniques for improving solutions.	**03**	C O **3**	R
	(b)	Solve the following system of simultaneous equations by Gauss seidal method 20x + y -2z = 17, 3x + 20y -z = -18, 2x - 3y + 20z = 25	**04**	C O **3**	A
	(c)	The function y= sinx is tabulated below x: 0, π/4, π/2 y: 0, 0.70711, 1.0 Using Lagrange's interpolation formula find the value of sin(π/6)	**07**	C O 4	U

Q.4	**(a)**	State the formulas for Trapezoidal Rule, Simpsons 1/3rd rule, Simpsons 3/8th rule	**03**	CO **4**	R
	(b)	Solve the following system of equations by Gauss Elimination method: $2x + y + z = 10$ $3x + 2y + 3z = 18$ $x + 4y + 9z = 16$	**04**	CO **3**	A
	(c)	Given that y = ln x, and x: 4.0, 4.2, 4.4, 4.6, 4.8, 5.0, 5.2 y: 1.3863, 1.4351, 1.4816, 1.5261, 1.5686, 1.6094, 1.6487 Evaluate $\int_4^{5.2} \ln x \, dx$ using simpsons 3/8 rule.	**07**	CO **4**	A
		OR			
Q.4	**(a)**	Derive formula for Trapezoidal Rule of numerical integration.	**03**	CO **4**	R
	(b)	Apply Gauss Jordan to solve the equations 10x + y + z = 12 x +10y + z = 12 x + y + 10z = 12	**04**	CO **3**	A
	(c)	Evaluate $\int_0^6 \frac{1}{1+x} dx$ taking h=1 using Simpson 1/3 rule.	**07**	CO **4**	A
Q.5	**(a)**	Discuss in brief about initial and boundary value problems.	**03**	CO **6**	U
	(b)	Prove the following (i) $\Delta = E-1$ (ii) $\nabla = 1-E^{-1}$	**04**	CO **4**	U
	(c)	Using Euler's method, find an approximate value of y corresponding to x = 0.1 for the following equation. $$\frac{dy}{dx} = \frac{y-x}{y+x}$$ Take y(0)=1 and h=0.02	**07**	CO 6	A
		OR			
Q.5	**(a)**	Explain Milne's predictor corrector method	**03**	CO 6	U
	(b)	Given that x: 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 y: 7.989, 8.403, 8.781, 9.129, 9.451, 9.750, 10.031 Find $\frac{dy}{dx}$ at x=1.1	**04**	CO **4**	U

	(c)	Using Runge Kutta method of fourth order, solve the following at x=0.2 and 0.4. Take y(0)=1 $$\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2}$$	**07**	CO **6**	A

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