BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : IV**
BRANCH: CHEM. ENGG. / CEP&P **SESSION : SP/19**

SUBJECT: CL4005 NUMERICAL METHODS FOR CHEMICAL ENGINEERS
TIME: 3 Hours **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Graphically explain the Bisection method, Regula Falsi method and Newton-Raphson method in details. [2]

Q.1(b) For turbulent flow of a fluid in a hydraulically smooth pipe, Prandtl's universal resistance law relates the friction factor ***f*** and the Reynold's number Re, according to the following relationship [4]

$$\frac{1}{\sqrt{f}} = -0.40 + 4Log_{10}(Re\sqrt{f})$$

Compute ***f*** for Re=10^5, using the Bisection method lower guess 0.002, upper guess 0.01. Do three iterations Report your results in tabular form.

Q.1(c) A circle of radius 2 units is intersected at two points, *A* and *B* by the curve, $e^x + y = 1$. Using an appropriate numerical technique, determine the co-ordinates of point *A* **OR** point *B*. Report all intermediate values in a tabular form as explained in the class. [6]

Q.2(a) Compute inverse matrix of the following matrix using LU decomposition method. [6]

$$\begin{bmatrix} 1 & -1 & 2 \\ 2 & -2 & 3 \\ 1 & 1 & 1 \end{bmatrix}$$

Q.2(b) The following equations is obtained after a finite difference technique is applied to a particular problem [6]

$$x_1 + x_2 + x_3 = 6$$
$$2x_1 + 3x_2 + 4x_3 = 20$$
$$3x_1 + 4x_2 + 2x_3 = 17$$

Solve these linear set of equations using Gauss-Jordan technique and also obtain the inverse of the co-efficient matrix.

Q.3(a) (x_n, y_n), (x_{n-1}, y_{n-1}) and (x_{n-2}, y_{n-2}) using these data points (equispaced base points) along Newton's backward differences prove that [2]

$$y(x) = y_n + \alpha \nabla y_n + \frac{\alpha(\alpha+1)\nabla^2 y_n}{2!}, where\ \alpha\ is\ defined\ as\ \alpha = \frac{x - x_n}{\Delta x}$$

Q.3(b) Find the Newton divided difference polynomial which interpolates the points (1.6, 2), (2, 8), (4, 8), (4.5, 2). [4]

Q.3(c) Write a pseudo programming code for the Newton divided difference polynomial. [6]

Q.4(a) Derive the formula for a_0 and a_1 for linear fitting of set of data. [2]

Q.4(b) It is known that the tensile strength of a plastic increases as a function of the time it is heat treated. The following data are collected [4]

Time	10	15	20	25	40	50	55	60	75
Tensile strength	5	20	18	40	33	54	70	60	78

Fit a straight line to this data and use the equation to determine the tensile strength at a time of 32 min.

Q.4(c) The following table gives the effect of the aromatics concentration, C_A , on the rate , r_A, of coke formation on a metal plate during pyrolysis of naphatha in a jet stirred reactor, at 1083K. Determine the order of the reaction using the expression $r_A = kC_A^n$. Also determine the regression coefficient. [6]

10^4 *C_A(kmol/m^3)	1.79	2.03	2.22	2.47	2.97	3.39	4.95	7.37	9.01	9.83	10.07
10^2 *r_A(kg/m^2 – hr)	0.28	0.32	0.36	0.40	0.49	0.59	0.99	1.55	2.00	2.25	2.60

Q.5(a) Prove that the trapezoidal rule is given by $\int_{x_0}^{x_n} y dx = \frac{h}{2}(y_0 + y_1 + y_3 + \cdots + y_n)$ [2]

Q.5(b) Velocity vs. time data for a car are given below. Find distance traversed by the car using a suitable numerical scheme. [4]

Velocity (km/hr)	0	22	30	27	18	7	0
Time (hr)	0	2	4	6	8	10	12

Q.5(c) Radial velocity profile of a water flow in a pipe (R=5 cm) is given in the table below: [6]

Radial distance from center, r(cm)	0	1	2	3	4	5
Velocity, u (cm/s)	4	3.84	3.36	2.56	1.44	0

Q.6(a) Given $\frac{dy}{dx} + \frac{y}{1+x} = 0$ subjected to $y(0) = 2$. Find the value of $y(1.5)$ using Runge-Kutta 4th order method. Take h=0.5. [6]

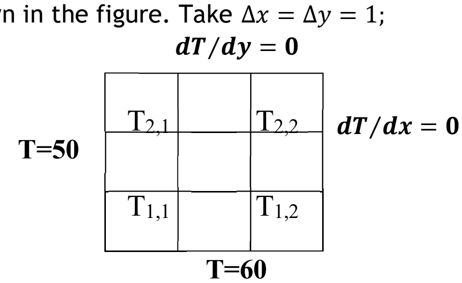
Q.6(b) Solve the boundary value problem $\frac{d^2y}{dx^2} + \frac{4x}{1+x^2}\frac{dy}{dx} + \frac{2}{1+x^2}y = 0$, with boundary condition $y(0)$=1 and $y(2)$=0.2. Take h=0.5. [6]

Q.6(c) [6]

Q.7(a) Exemplify parabolic and elliptic equations. [2]

Q.7(b) Briefly describe Neumann boundary condition for the solution of boundary value problem. [4]

Q.7(c) Solve the Laplace equation, $\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$, for all 4 interior nodes of the figure below. The boundary conditions in each face are shown in the figure. Take $\Delta x = \Delta y = 1$; [6]



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