**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

Department of Chemical Engineering (S2)

B.Tech. (ChE), Mid Term Examination, Autumn Semester 2024-2025

**CHN-323 Computer Applications in Chemical Engineering** **Max Marks: 25, Time: 90 mins**

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**INSTRUCTIONS:**

1. Attempt all questions. Answer all parts of a question at single place.
2. Please check all pages of question paper (2 pages) and report the discrepancy, if any.
3. Return the MCQ sheet within first 15 min of the exam.
4. Make suitable assumptions wherever necessary.

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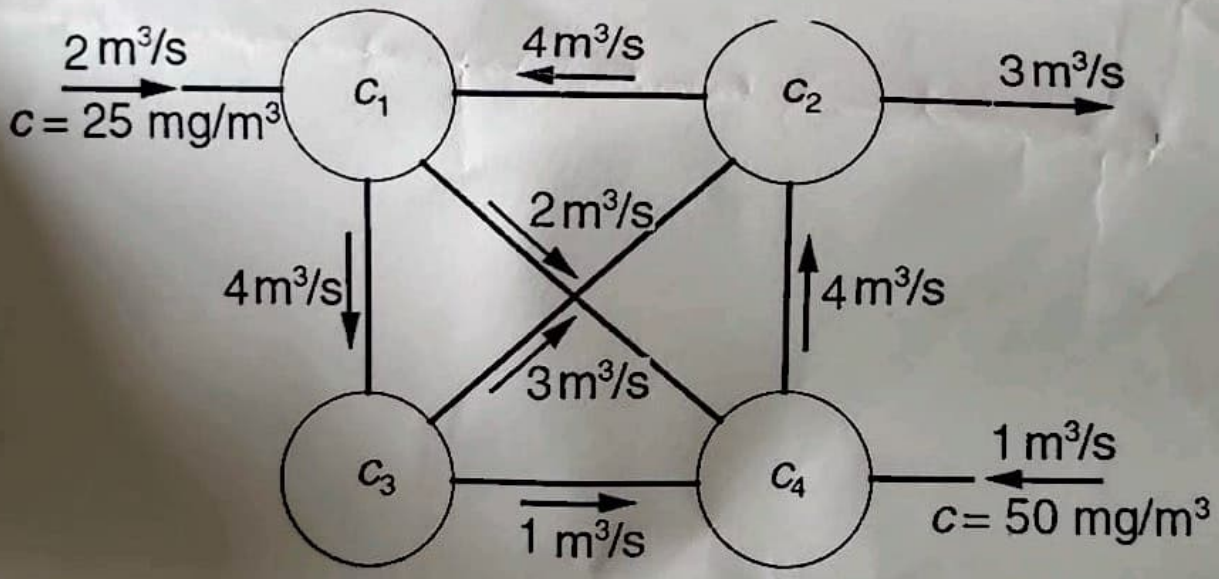
**Question 1: [5 marks]**

Four mixing tanks (denoted by circles in the figure below) are connected by pipes (denoted by lines). The fluid in the system is pumped through the pipes at the rates shown in the figure. The fluid entering the system contains a chemical of concentration $c$ as indicated. Determine the concentration of the chemical in the four tanks, assuming a steady state. Derive suitable equations in your answerscript. Write a MATLAB program to solve the derived equations.




**Question 2: [5 marks]**

Determine the value of $\lambda$ that satisfies the equation below:

$$\frac{1}{\sqrt{\lambda}} = -4\log_e\left(\beta + \frac{5}{\xi\sqrt{\lambda}}\right) + 2$$

The parameter $\beta$ varies in the range of 0.1-1.1 and the parameter $\xi$ varies in the range of 3000-4000.

(i) Write a MATLAB code for solving the above equation for $\lambda$.
(ii) Plot $\lambda$ vs $\beta$ for five different values of $\xi$.

(iii) Plot λ vs ξ for five different values of $\beta$.

Plotting should be done in MATLAB itself with proper labeling of axes and legends.

**Question 3: [10 marks]**

The relationship between stress σ and strain ε of some biological materials in uniaxial tension is

$$\frac{d\sigma}{d\varepsilon} = a + b\sigma$$

where a and b are constants. The following table gives the results of a tension test on such a material:

| ε | σ |
|---|---|
| 0 | 0 |
| 0.05 | 0.252 |
| 0.1 | 0.531 |
| 0.15 | 0.84 |
| 0.2 | 1.184 |
| 0.25 | 1.558 |
| 0.3 | 1.975 |
| 0.35 | 2.444 |
| 0.4 | 2.943 |
| 0.45 | 3.5 |
| 0.5 | 4.115 |

Write a program that computes dσ/dε and plots the tangent modulus dσ/dε versus σ. You can use the required finite difference formula form the given below:

$O(\Delta x^2)$ centered difference approximations:

$f'(x): \quad \{f(x+\Delta x) - f(x-\Delta x)\}/(2\Delta x)$

$f''(x): \quad \{f(x+\Delta x) - 2f(x) + f(x-\Delta x)\}/\Delta x^2$

$O(\Delta x^2)$ forward difference approximations:

$f'(x): \quad \{-3f(x) + 4f(x+\Delta x) - f(x+2\Delta x)\}/(2\Delta x)$

$f''(x): \quad \{2f(x) - 5f(x+\Delta x) + 4f(x+2\Delta x) - f(x+3\Delta x)\}/\Delta x^3$

$O(\Delta x^2)$ backward difference approximations:

$f'(x): \quad \{3f(x) - 4f(x-\Delta x) + f(x-2\Delta x)\}/(2\Delta x)$

$f''(x): \quad \{2f(x) - 5f(x-\Delta x) + 4f(x-2\Delta x) - f(x-3\Delta x)\}/\Delta x^3$

Determine values of a and b. Calculate root mean square error between the values of dσ/dε from this expression and actual data.