

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

**CLASS: MTECH/PRE-PHD  
BRANCH: MECHANICAL**

**SEMESTER : I  
SESSION : MO/2025**

**SUBJECT: ME521 COMPUTATIONAL METHODS IN ENGINEERING**

**TIME: 3 Hours**

**FULL MARKS: 50**

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
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.

- |  |                | CO | BL |           |                |   |   |   |      |   |     |   |   |   |     |
|--|----------------|----|----|-----------|----------------|---|---|---|------|---|-----|---|---|---|-----|
| Q.1(a) Solve the system of linear equations using the Gaussian elimination method.<br>$x + 2y + 3z = 9$<br>$4x + 5y + 6z = 24$<br>$7x + 8y + 9z = 48$  | [5]            | 1  | 2  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.1(b) Consider the following stress tensor and find the principal stresses and directions of this stress state.<br>$\sigma = \begin{bmatrix} 6 & 2 \\ 2 & 3 \end{bmatrix}$  | [5]            | 2  | 2  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.2(a) Find the real root of the equation $x^4 - x - 10 = 0$ , after three iterations by Newton-Raphson's method. Assume initial guess 1.6.  | [5]            | 2  | 3  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.2(b) Find the Lagrange interpolating polynomial that passes through these points (1, 1), (2, 4) and (3, 9).  | [5]            | 3  | 3  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.3(a) The river flow velocity is measured at different point across a river's cross-section at regular intervals. The river is divided into 4 equal segments along depth. The data given below. Using Simpson's 1/3 rule, estimate the total flow rate (m <sup>3</sup> /s) across the cross-section of the river.   | [5]            | 3  | 5  |           |                |   |   |   |      |   |     |   |   |   |     |
| <table border="1" style="margin: auto; border-collapse: collapse;"> <thead> <tr> <th style="padding: 5px;">Depth (m)</th> <th style="padding: 5px;">Velocity (m/s)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 5px;">0</td> <td style="text-align: center; padding: 5px;">2</td> </tr> <tr> <td style="text-align: center; padding: 5px;">1</td> <td style="text-align: center; padding: 5px;">1.75</td> </tr> <tr> <td style="text-align: center; padding: 5px;">2</td> <td style="text-align: center; padding: 5px;">1.5</td> </tr> <tr> <td style="text-align: center; padding: 5px;">3</td> <td style="text-align: center; padding: 5px;">1</td> </tr> <tr> <td style="text-align: center; padding: 5px;">4</td> <td style="text-align: center; padding: 5px;">0.5</td> </tr> </tbody> </table> |                |    |    | Depth (m) | Velocity (m/s) | 0 | 2 | 1 | 1.75 | 2 | 1.5 | 3 | 1 | 4 | 0.5 |
| Depth (m)  | Velocity (m/s) |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| 0  | 2              |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| 1  | 1.75           |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| 2  | 1.5            |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| 3  | 1              |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| 4  | 0.5            |    |    |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.3(b) Approximate the integral of $f(x) = \exp(-x^2)$ over the interval (-1, 1) using Gauss-Legendre Quadrature with n=3.   | [5]            | 3  | 4  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.4 Consider the logistic growth equation, $\frac{dy}{dt} = 0.5 y \left(1 - \frac{y}{100}\right)$ , take initial condition, $y(0) = 10$ and step size 0.1. Calculate y up to 3 iterations using Euler's method.  | [10]           | 4  | 4  |           |                |   |   |   |      |   |     |   |   |   |     |
| Q.5 Solve the diffusion equation $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + 1$ , when $0 \leq x \leq L$ , with boundary conditions $u(0, t) = 0$ , $u(L, t) = 0$ and initial condition $u(x, 0) = 0$ . Find the solution for $u(x, t)$ .   | [10]           | 4  | 5  |           |                |   |   |   |      |   |     |   |   |   |     |