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 **PRESIDENCY UNIVERSITY**

  **Bengaluru**

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| **Ph.D. Course Work End Term Examinations – JAN-FEB 2025** |
| **Date:** 03 – 02- 2025 **Time:** 09:30 am – 12:30 pm |

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| **School:** SOE | **Program:** Ph.D. |
| **Course Code:** MEC801 | **Course Name:** Computational Fluid Dynamics |
| **Semester**:  | **Max Marks**: 100 | **Weightage**: 50% |

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| **CO - Levels** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| **Marks** |  |  | **50** | **50** |  |

**Instructions:**

1. *Read all questions carefully and answer accordingly.*
2. *Do not write anything on the question paper other than roll number.*
3. ***Books, notes and data handbooks are allowed.***
4. *Make suitable assumptions wherever required with justification.*

**1** For the control volume shown in figure 1, show how the one-dimensional steady-state diffusion term $\frac{∂}{∂x}\left(Γ\frac{∂ϕ}{∂x}\right) $is discretized to obtain its discretized equation $\left(Γ\frac{∂ϕ}{∂x}\right)\_{e}A\_{E}-\left(Γ\frac{∂ϕ}{∂x}\right)\_{w}A\_{w}$ for central grid nodal point P.



Figure 1.

**[25] (CO3) [Application]**

**2** Consider the generic transport equation for a scalar quantity $ϕ$, and its finite volume formulation using a standard cell-centered grid in which $ϕ $is defined at the cell centroid and velocity field values are taken at the faces of the control volume. For convection-dominated problems, upwind interpolations are commonly used to approximate the value of $ϕ $at face centers. A quadratic upwind interpolation (QUICK) scheme can be derived using polynomial fitting. Show that the QUICK interpolation formulation on a uniform Cartesian grid is given by

$$ϕ\_{f}=\frac{6}{8}ϕ\_{U}+\frac{3}{8}ϕ\_{D}-\frac{1}{8}ϕ\_{UU}$$

**[25] (CO3) [Application]**

**3** In the cross section illustrated in Figure 2, the surface 1–4–7 is insulated (adiabatic). The convective heat transfer coefficient at surface 1–2–3 is 28 W/m² °C. The thermal conductivity of the solid material is 3.5 W/m² °C. The temperature at nodes 3, 6, 7, 8, 9 is held constant at 100 °C. Using Gauss-Seidel iteration, compute the temperature at nodes 1, 2, 4, and 5.



Figure 2

 **[25] (CO4) [Application]**

 **4** Use a von Neumann stability analysis to show for the wave equation that a simple explicit Euler predictor using central differencing in space is unstable. The difference equation is

$$u\_{j}^{\left(n+1\right)}=u\_{j}^{n}-C\frac{Δt}{Δx}\left(\frac{u\_{j+1}^{n}-u\_{j-1}^{n}}{2}\right)$$

Now show that the same difference method is stable when written as the implicit formula:

$$u\_{j}^{\left(n+1\right)}=u\_{j}^{n}-C\frac{Δt}{Δx}\left(\frac{u\_{j+1}^{\left(n+1\right)}-u\_{j-1}^{\left(n+1\right)}}{2}\right)$$

**[25] (CO4) [Application]**