Ex/SC/MATH/PG/DSE/TH/04/A18/2025

MASTER OF SCIENCE EXAMINATION, 2025

(2^{nd} Year, 1^{st} Semester)

MATHEMATICS

PAPER : DSE 04

[Computational Fluid Dynamics - I (Theory)]

Time : 1 *Hour* 15 *Minutes* — *Full Marks* : 24

Symbols / Notations have their usual meanings

Answer *any* **two** questions.

1. Write the Navier-Stokes equations for a two-dimensional incompressible viscous fluid in non-dimensional form using primitive variables. Sketch the control volume for the x-momentum equation and discretize only the x-momentum equation using a staggered grid arrangement for the SIMPLE formulation. 4+2+6=12

2. Derive the computational scheme of the finite volume method to solve the one-dimensional convection-diffusion equation. Use a central differencing scheme to interpolate the dependent variable at the control volume face. 12

3. Compute the steady state temperature distribution from the governing equation

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right)+q=0$$

in a large plate of thickness $L = 2$ cm with constant thermal conductivity $k = 0.5$ W/m·K and uniform heat generation $q = 1000$ kW/m^3. The faces A and B in the x-direction are at temperatures of 100 °C and 200 °C respectively. Assuming that y- and z-directions are so large that temperature gradients are significant in the x-direction only. Consider a unit area in the yz-plane and the five control volumes, giving $\delta x = 0.004$ m. 12

★ ★ ★