Name: BITS ID:

BITS Pilani, Pilani campus, Second semester, 2022-2023.
ME G515 Computational Fluid Dynamics- Comprehensive Examination.
Date: 15/05/2023, Duration: 180 min, Max. marks: 40.

Open book: only TB2, class slides, and handwritten class notes are permitted.
State your assumptions clearly and assume any missing data.

Q1. What do you understand by the following properties of discretisation schemes, conservativeness, boundedness and transportiveness? ` [3 marks]

Q2. Explain false diffusion in convection-diffusion problems with an example. [3 marks]

Q3. What do you understand by the checkerboard pressure problem? Does the Rhie-Chow interpolation method alleviate the problem? Justify your answer. [5 marks]

Q4. Explain the transient PISO algorithm with a flow chart. [5 marks]

Q5. Demonstrate how the discretisation of the diffusion term can be carried out for any unstructured grids with a cell-centred control volume arrangement. [6 marks]

Q6. Consider steady convection and diffusion of a property φ in a one-dimensional flow field in the absence of any sources. Take length L = 1.0 m, velocity at inlet, u= 1 m/s, density of fluid, ρ = 1.0 kg/m^3, and diffusion coefficient, Γ = 0.1 kg/m.s. The boundary conditions at the left and the right extremes are given, say $\varphi_0 = 1$ at x = 0 and $\varphi_L = 0$ at x = L.

(a) Write the relevant governing equations for the given problem. Also, construct the simple grid with 4 equally spaced cells to solve the problem numerically.
(b) Use central differencing and upwind differencing schemes respectively for the discretisation of diffusion and convection terms. Derive the discretised equations for middle and all the boundary nodes. Also, construct a table of relevant coefficients.
(c) Solve the above equations system and find out the φ distribution. [9 marks]

Q7. Consider 2D steady laminar flow of fluid of constant density and viscosity through a parallel plate channel (Length L and height h). The velocity at the inlet is u and the outlet is specified with outflow boundary condition.

(a) Write the relevant governing equations for the given problem. Also, construct a staggered grid arrangement with 4 equally spaced cells in both x- and y- directions to solve the problem numerically.
(b) Obtain the discretized forms of momentum equations. Use central differencing and upwind differencing schemes respectively for the discretisation of diffusion and convection terms. Derive the discretised equations for middle, boundary and corner nodes. Also, construct a table of relevant coefficients.
(c) Derive the equation for pressure correction and construct a table of coefficients.
(d) Outline the main steps to solve the problem using SIMPLE algorithm. [9 marks]