Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

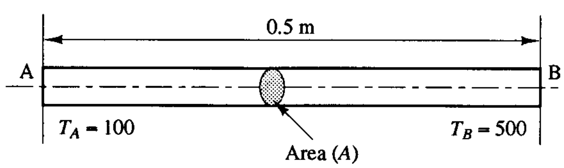
End Semester Examination, December 2018

Programme Name: M. Tech. CFD | **Semester : I**
Course Name : Introduction to CFD | **Time : 03 hrs.**
Course Code : ASEG 7001 | **Max. Marks: 100**
Nos. of page(s) : 04
Instructions: Assume any missing data appropriately.

SECTION A

S. No.		Marks	CO
Q 1	What are various applications of Computational Fluid Dynamics? Discuss the importance of Computational Fluid Dynamics as a a. Research tool b. Design tool	**4**	**CO1**
Q 2	Write down second order accurate finite difference stencils for discretization of the following derivatives. a. $\frac{\partial^2 u}{\partial y^2}$ b. $\frac{\partial u}{\partial y}$	**4**	**CO2**
Q 3	Define *numerical diffusion and dispersion.* Discuss the effect of numerical diffusion and dispersion on the solution of the one-dimensional scalar wave equation using the explicit Forward in Time and Backward in Space (FTBS) scheme. Suggest methods to alleviate the diffusive error.	**4**	**CO3**
Q 4	Write formulae for approximation of surface integrals of fluxes over a control volume face using following methods. a. Trapezoidal Method b. Simpson's Method	**4**	**CO2**
Q 5	Elucidate the need of grid and equation transformation for the solution flow over complex geometries using finite difference method.	**4**	**CO2**

	SECTION B		
Q 6	Discuss the explicit McCormack time marching algorithm for the solution of transient Euler equations in 2-dimensions.	**10**	**CO3**
Q 7	Analyze the stability of the following explicit for the solution of the scalar advection equation hence deduce the stability criterion for this scheme. $$u_i^{n+1} = \frac{u_{i+1}^n + u_{i-1}^n}{2} - c\frac{\Delta t}{\Delta x}\frac{u_{i+1}^n - u_{i-1}^n}{2}$$	**10**	**CO3**
Q 8	Consider the following system of equations $$\frac{\partial u_1}{\partial t} + \frac{\partial u_2}{\partial x} = 0,$$ $$\frac{\partial u_2}{\partial t} + \frac{\partial u_3}{\partial x} = 0,$$ $$\frac{\partial u_3}{\partial t} + 4\frac{\partial u_1}{\partial x} - 17\frac{\partial u_2}{\partial x} + 8\frac{\partial u_3}{\partial x} = 0.$$ Classify this system of equations as hyperbolic or elliptic, based on the eigenvalue method.	**10**	**CO1**
Q 9	Derive the third order accurate finite difference stencil for the first order derivative $\left(\partial u/_{\partial x}\right)_{i,j}$ using variable (u) values on one-sided points only. ***OR*** Consider the viscous flow of air over a flat plate. At a given station in the flow direction, the variation of the flow velocity, u, in the direction perpendicular to the plate (the y direction) is given at discrete grid points equally spaced in y direction with Δy = 2.54 mm. **y (mm)** — **u (m/s)** 0 — 0 2.54 — 45.72 5.08 — 87.41 7.62 — 125.0 Imagine that the values of ***u*** listed above are discrete values at discrete grid points located at ***y*** = 0, 2.54, 5.08 and 7.62 mm the same nature as would be obtained from	**10**	**CO2**

	a numerical finite difference solution of the flow field. For viscosity coefficient, μ =1.7895 x 10^{-5} kg/m-s, using these discrete values; Calculate the shear stress at the wall $\boldsymbol{\tau_w}$ three different ways, namely: a. Using a first order one sided difference b. Using the second order one sided difference c. Using the third order one sided difference		
	SECTION-C		
Q 10	Apply the law of conservation of momentum to an infinitesimally small control volume of fluid fixed in space and deduce the momentum equation in divergence form. Transform the equation to integral form valid over a finite control volume Ω with surface area S.	**20**	**CO1**
Q 11	Consider the problem of source-free heat conduction in an insulated rod whose ends are maintained at constant temperatures of 100 °C and 500 °C respectively. The one-dimensional problem sketched in Figure below, is governed by $$\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$$ Calculate the steady state temperature distribution in the rod. Thermal conductivity k equals 1000 W/m/K; cross-sectional area A is 10 x 10^{-3} m^2. Use at least 5 control volumes with appropriate interpolation scheme.  ***OR*** Solve the Laplace equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ numerically, using the Gauss-Seidel Iterative scheme with five-point discretization formula, for the following mesh with uniform spacing and with boundary conditions as shown in the figure below. Obtain	**20**	**CO4**

	the results correct to two decimal places by iterating up to five steps or until convergence.