Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2022

Course: Computational Fluid Dynamics **Semester: VI**
Program: B. Tech. ASE **Time : 03 hrs.**
Course Code: ASEG 4005P **Max. Marks: 100**

Instructions: Assume missing data, if any, appropriately. All the symbols used in the paper have their usual meaning in Fluid Mechanics and Computational Fluid Dynamics.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Discuss various types of boundary conditions implemented for solution of governing equations of fluid flows.	**4**	**CO1**
Q 2	Illustrate the Implicit and Explicit approaches for solution of one dimensional transient heat conduction equation.	**4**	**CO2**
Q 3	Formulate any two approximations for the evaluation surface integral of fluxes over the east face of a two-dimensional control volume.	**4**	**CO2**
Q 4	Discuss the advantages and disadvantages of unstructured grids over structured grids.	**4**	**CO2**
Q 5	What is artificial viscosity? Discuss the effect of artificial viscosity on the structure of a shock wave. Suggest ways to alleviate artificial viscosity.	**4**	**CO3**

SECTION B
(4Qx10M= 40 Marks)

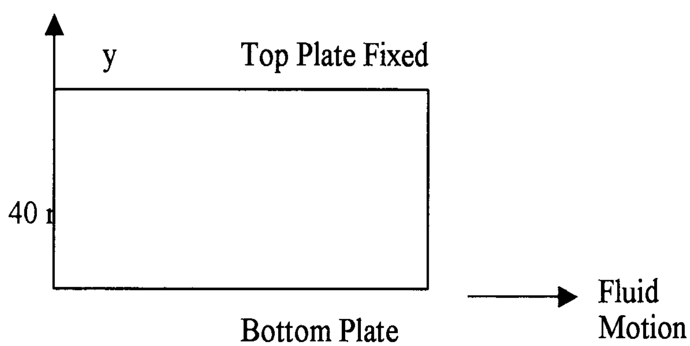
Q 6	Analyze the stability of the following explicit for the solution of the scalar advection equation hence deduce the stability criterion for this scheme. $$u_i^{n+1} = u_i^n - c\frac{\Delta t}{\Delta x}\frac{u_{i+1}^n - u_{i-1}^n}{2}$$	**10**	**CO3**
Q 7	Discuss an explicit time marching algorithm for the solution of transient Euler equations in two dimensions.	**10**	**CO3**

<table>
<tr><td>Q 8</td><td>Derive a second order accurate finite difference stencil for the first order derivative $\left(\partial u / \partial y\right)_{i,j}$ using variable (u) values on one-sided points only.</td><td>10</td><td>CO2</td></tr>
<tr><td>Q 9</td><td>Define the UPWIND interpolation scheme for the evaluation of fluxes at face centre using the nodal values on a structured finite volume grid. Find an expression for the artificial diffusivity introduced by this scheme.</td><td>10</td><td>CO2</td></tr>
<tr><td colspan="4" align="center">SECTION-C
(2Qx20M=40 Marks)</td></tr>
<tr><td>Q 10</td><td>Consider the Couette flow between parallel plates characterised by the parabolic equation

$$\frac{\partial u}{\partial t} - \nu \frac{\partial^2 u}{\partial y^2} = 0. \quad \nu = 0.000217 \text{ m}^2/\text{s}$$

Initial conditions at $t = 0$ $\begin{cases} u = u_0 = 40 \text{ m/s}, & y = 0 \\ u = 0, \quad 0 < y \leq h \end{cases}$

Boundary conditions at $t > 0$ $\begin{cases} u = u_o = 40 \text{ m/s}, & y = 0 \\ u = 0, & y = h \end{cases}$



Write a code in a programing language of your choice to solve the above equation using an explicit scheme for flowfield after 50 iterations with each time step of 0.1 second. Divide the one-dimensional domain into 41 grid points including the boundary points.

OR

Consider the problem of source-free transient 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,</td><td>20</td><td>CO4</td></tr>
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	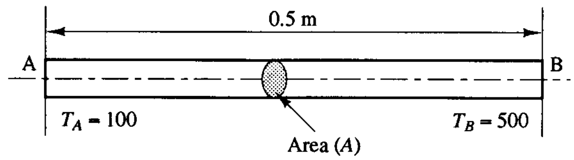 Calculate the temperatures at a minimum of 5 internal points in the rod after 5 iterations using the FTCS scheme. The transient distribution of heat is governed by, $$\frac{\partial T}{\partial t} - \alpha \frac{\partial^2 T}{\partial t^2} = 0; \alpha = 0.0002 \text{ m}^2/\text{s}.$$ Choose time step as large as possible.		
Q 11	(a) List two application of CFD in each of the following domains of science and engineering.[10] i. Biomedical engineering ii. Rocket Propulsion iii. Civil Engineering iv. Environmental Science v. Renewable Energy (b) Transform the following continuity equations into the form mentioned in bracket. [10] i. $\frac{\partial \rho}{\partial t} + \nabla.\left(\rho\vec{V}\right) = 0$ {Differential Non- Conservation Form} ii. $\frac{\partial}{\partial t} \iiint \rho \, d\Omega + \iint \rho\vec{V}.\overrightarrow{dS} = 0$ {Differential Conservation Form}	**20**	**CO1**