Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December-January 2021

Course: Introduction to CFD **Semester: I**
Program: M. Tech. CFD **Time: 03 hrs.**
Course Code: ASEG 7001 **Max. Marks: 100**

SECTION A

Instructions: This Section has 05 questions and all questions are compulsory. Scan and upload all the correct answer(s).

S. No.		Marks	CO
Q 1	Which of the following physics is (are) governed by elliptic partial differential equation(s). i. Steady, inviscid supersonic flow ii. Unsteady, inviscid subsonic flow iii. Unsteady heat conduction, iv. Boundary layer flow v. Steady, incompressible, inviscid flow	**04**	**CO1**
Q 2	The solution of Navier-Stokes equations for flow over an expansion corner using a finite difference method requires i. Transformation of physical domain into a rectangular domain ii. Transformation of governing equations onto computational plane iii. Discretization of derivatives in the physical plane iv. Integration of fluxes at grid points v. Solution of governing equations in the physical domain	**04**	**CO2**
Q 3	In context to the solution of one-dimensional unsteady scalar advection equation using FTBS scheme, which of the following statements are correct? i. Numerical dissipation is minimized for a CFL number of 1. ii. Numerical dispersion is minimized for a CFL number of 1.	**04**	**CO2**

	iii. The scheme is unstable for CFL number more than 1 iv. Diffusion error is the dominating error for a CFL number of less than 1. v. Dispersion error is not reduced by reducing the mesh size.		
Q 4	The numerical dissipation or artificial viscosity i. Produces wiggles in shock wave ii. Makes the shock waves thicker iii. Stabilizes the solution iv. De-stabilizes the solution v. Diminishes large gradients	**04**	**CO2**
Q 5	Which of the following schemes is used to solve elliptic partial differential equations or a system of equations? i. Successive Over-relaxation ii. Lax Wendroff Method iii. Successive Under-relaxation iv. MacCormack Technique v. Pure Gauss-Seidel	**04**	**CO4**
SECTION B **Instructions: This Section has 05 questions and all questions are compulsory. Scan and upload the answers. The answer should be of short type (up to 200 words or equivalent numbers).**			
Q 6	Discuss the various continuum models, widely used to derive governing equations of fluid flow. Demonstrate the law of conservation of mass emanating from each of these models.	**10**	**CO1**
Q 7	Find the values of *a*, for which the following system of equation is hyperbolic. $$\frac{\partial u'}{\partial x} + a\frac{\partial v'}{\partial y} = 0$$ $$\frac{\partial u'}{\partial y} - \frac{\partial v'}{\partial x} = 0$$	**10**	**CO1**
Q 8	Discretize the following model equations with mentioned schemes i. $\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = 0$ (FTBS)	**10**	**CO2**

	ii. $\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = f$ (SOCD) iii. $\frac{\partial T}{\partial t} - \alpha \frac{\partial^2 T}{\partial x^2} = 0$ (Crank Nicolson Method) iv. $\frac{\partial u}{\partial t} + a \frac{\partial u}{\partial x} = 0$ (Lax Method)		
Q 9	Discuss the explicit McCormack time marching algorithm for the solution of one-dimensional, non-linear wave given below. $$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} = 0$$	**10**	**CO3**
SECTION-C **Instructions: This Section has 02 questions and all questions are compulsory. Scan and upload the answer. The answer should be of long type (up to 500 words or equivalent numbers).**			
Q 10	Analyze the stability of the following explicit schemes for the solution of the scalar advection equation hence deduce the stability criterion for this scheme. a) $u_i^{n+1} = \left(\frac{u_{i+1}^n + u_{i+1}^n}{2}\right) - c \frac{\Delta t}{\Delta x} \frac{u_{i+1}^n - u_{i-1}^n}{2}$ b) $u_i^{n+1} = (u_i^n) - c \frac{\Delta t}{\Delta x} \frac{u_{i+1}^n - u_{i-1}^n}{2}$	**20**	**CO3**
Q 11	Consider the problem of source-free transient heat conduction in an insulated rod (length = 0.5m) whose ends are maintained at constant temperatures of 0 °C and 200 °C respectively. Calculate the temperatures at a minimum of 5 internal points in the rod after 5 iterations using an explicit scheme. The transient distribution of heat is governed by, $$\frac{\partial T}{\partial t} - \alpha \frac{\partial^2 T}{\partial t^2} = 0;\ \alpha = 0.001\ m^2/s.$$ Choose an appropriate time step.	**20**	**CO4**