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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2020

Course: Computational Fluid Dynamics **Semester: VII**
Program: B. Tech. ASE **Time: 03 hrs.**
Course Code: ASEG 4002 **Max. Marks: 100**

SECTION A

Instructions: This Section has 06 questions and all questions are compulsory. Select all the correct answer(s).

S. No.		Marks	CO
Q 1	The solution contains dispersion error if the leading term in the truncation error is i. Second order derivative ii. Third order derivative iii. Fourth order derivative iv. Fifth order derivative v. Sixth order derivative	**05**	**CO2**
Q 2	For the solution of elliptic equations using relaxation techniques, i. The convergence is faster for Jacobi method when compared to Gauss-Seidel method. ii. The convergence is faster for successive over-relaxation when compared to pure Gauss-Seidel method. iii. The convergence is faster for successive under-relaxation when compared to pure Gauss-Seidel method. iv. Under-relaxation can be used in conjunction with Jacobi method to decrease the number of iterations for convergence. v. Over-relaxation can be used in conjunction with Gauss-Seidel method to decrease the number of iterations for convergence	**05**	**CO3**
Q 3	For the numerical simulation of flow over a complex geometry using finite difference methods require i. Guessing of primitive variable values at all internal computational nodes ii. Transformation of governing equations to computational plane iii. Transformation of body-fitted grid to rectilinear grid iv. Integration of fluxes at grid points	**05**	**CO2**

	v. Interpolation of variable values at computational nodes		
Q 4	The following scheme(s) is(are) unconditionally bounded i. UDS ii. CDS iii. QUICK iv. MUSCL v. Second Order Upwind	**05**	**CO2**
Q 5	Consider the solution of one-dimensional unsteady scalar advection equation. The accuracy of a numerical solution can be enhanced by i. By reducing mesh size ii. By increasing CFL number (below 1) iii. By increasing CFL number beyond 1 iv. By reducing time step v. By choosing higher order schemes	**05**	**CO3**
Q 6	The function used to approximate the variation of a variable inside an element is called a/an i. Test function ii. Shape function iii. Interpolation Function iv. Weight function v. Trial function	**05**	**CO3**

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 1	Consider the following system of equations $$\frac{\partial u_1}{\partial t} + \frac{\partial u_2}{\partial x} = 0,$$ $$\frac{\partial u_2}{\partial t} + \frac{\partial u_3}{\partial x} = 0,$$ $$\frac{\partial u_3}{\partial t} + 4\frac{\partial u_1}{\partial x} - 17\frac{\partial u_2}{\partial x} + 8\frac{\partial u_3}{\partial x} = 0.$$	**10**	**CO1**

	Classify this system of equations as hyperbolic or elliptic using the eigenvalue method for classification of system of linear partial differential equations.		
Q 2	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 $\boldsymbol{u}$ listed above are discrete values at discrete grid points located at $\boldsymbol{y}$ = 0, 2.54, 5.08 and 7.62 mm the same nature as would be obtained from 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	**10**	**CO2**
Q 3	Illuminate the need of a body fitted coordinate system for the solution of governing flow equations using finite difference method. Explain thus, the philosophy of elliptic grid generation around an airfoil.	**10**	**CO3**
Q 4	Define the CDS interpolation scheme for the evaluation of fluxes at face centre using the nodal values on a structured finite volume grid. Find the order of accuracy of this scheme and discuss its advantages and disadvantages.	**10**	**CO3**
Q 5	Consider the 2-dimensional transient heat conduction equation given below. The Crank-Nicolson discretization of the equation results in a pentadiagonal system of equations. Demonstrate an algorithm to solve the system of equations iteratively. $$\frac{\partial T}{\partial t} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right)$$	**10**	**CO3**

SECTION-C

Instructions: This Section has 02 questions and only 01 question needs to be answered. Scan and upload the answer. The answer should be of long type (up to 500 words or equivalent numbers).

Q 1 (Marks: **20**, **CO4**)

Consider the following non-linear wave equation

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = 0$$

or

$$\frac{\partial u}{\partial t} + \frac{\partial F}{\partial x} = 0 \quad \text{with } F = \frac{1}{2}u^2$$

The following initial and boundary conditions may be used:

$$u(x,0) = 1 \quad 0 \le x \le 2$$

$$u(x,0) = 0 \quad 2 \le x \le 4$$

Write a program to solve the above equation using MacCormack Technique with 41 grid points wherein the length of the domain is 4 m. Hint: Take a time step Δt = 0.05 seconds and report or plot the results after 20 time steps or iterations.

OR

A property ϕ is transported by means of convection and diffusion through the one-dimensional domain sketched in Figure below. The governing equation is given by

$$\frac{d}{dx}(\rho u \phi) = \frac{d}{dx}\left(\Gamma \frac{d\phi}{dx}\right)$$

and the boundary conditions are ϕ_0 =1 at x = 0 and ϕ =0 and at $x = L$. Using 10 equally spaced cells calculate the distribution of ϕ as a function of x for u = 4 m/s using UDS for convection and diffusion. Take L=2.0 m, ρ=1.25kg/m^3 and Γ=0.1 kg/m.s