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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2021

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

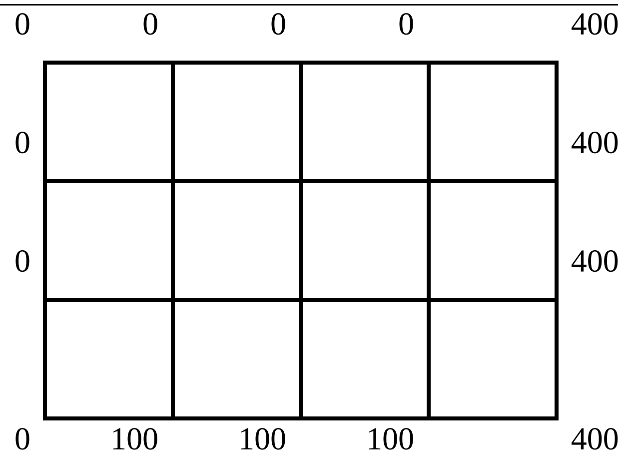
SECTION A

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

S. No.		**Marks**	**CO**
Q 1	A non-conservative form of governing equations for fluid flows is obtained with the following model(s) of flow: i. Infinitesimally small fluid element moving in space ii. Infinitesimally small fluid element fixed in space iii. Finite control volume moving in space iv. Finite control volume fixed in space v. Molecular approach	**05**	**CO1**
Q 2	The following aerodynamic flows are governed by hyperbolic partial differential equations i. Steady Inviscid Supersonic Flow ii. Steady Boundary Layer Flow iii. Unsteady Inviscid Flow iv. Steady, Subsonic Inviscid Flow v. Incompressible Inviscid Flow	**05**	**CO1**
Q 3	For a Neumann boundary condition, i. The value of primitive variable is known ii. The value of the derivative of primitive variable is known iii. The values of primitive variable and its derivative is known iv. Neither the value of primitive variable nor the its derivative is known	**05**	**CO1**

	v. The value of primitive variable is computed as a part of solution		
Q 4	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**	**CO2**
Q 5	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 6	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**
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 7	Apply the law of conservation of momentum for an infinitesimally small element of a viscous fluid moving in space and hence derive the momentum equations for fluids in non- conservation form. Change the momentum equations thus obtained into its conservation form.	**10**	**CO1**

Q 8	Consider the following system of linear equations that governs a 2-dimensional, irrotational, inviscid, steady flow of a compressible gas. $$(1-M_\infty^2)\frac{\partial u'}{\partial x}+\frac{\partial v'}{\partial y}=0$$ $$\frac{\partial u'}{\partial y}-\frac{\partial v'}{\partial x}=0$$ Classify the above system for a supersonic freestream Mach number.	**10**	**CO2**
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.	**10**	**CO2**
Q 10	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 11	Discuss an explicit time marching algorithm for the solution of transient Euler equations in two dimensions.	**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 12	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 the results correct to two decimal places by iterating up to five steps or until convergence with an over-relaxation factor of 1.2.	**20**	**CO4**



OR

Consider the problem of source-free heat conduction in an insulated 6 cm long rod whose ends are maintained at constant temperatures of 200 °C and 800 °C respectively. The one- dimensional transient heat conduction problem is governed by

$$\frac{\partial T}{\partial t} - \alpha \frac{\partial^2 T}{\partial x^2} = 0, \ \alpha = 0.0002\ m^2/s.$$

Calculate the temperatures at a minimum of 5 internal points in the rod after 2 iterations using an implicit scheme. Choose an appropriate time step.