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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, January-February 2020

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 06 questions and all questions are compulsory. Select all the correct answer(s).

S. No.		**Marks**	**CO**
Q 1	The 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 Navier-Stokes equations can be used to solve the following problem i. Dispersion of pollutant in atmosphere ii. Free Molecular flow over an spacecraft iii. Flow of plasma in a magnetic field iv. Circulation of blood in arteries v. Bombardment of neutrons on a thin foil	**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 v. The value of primitive variable is computed as a part of solution	**05**	**CO1**

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 x-momentum equation for fluids in non- conservation form. Change the x-momentum equation 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 as hyperbolic or elliptic for a supersonic freestream Mach number.	**10**	**CO2**
Q 9	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 = 3 mm. **y (mm)** — **u (m/s)** 0 — 0 3 — 45.75 6 — 80.45 9 — 135.0 Imagine that the values of $\boldsymbol{u}$ listed above are discrete values at discrete grid points located at $\boldsymbol{y}$ = 0, 3, 6 and 9 mm as obtained from a numerical finite difference solution of the flowfield. 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 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**

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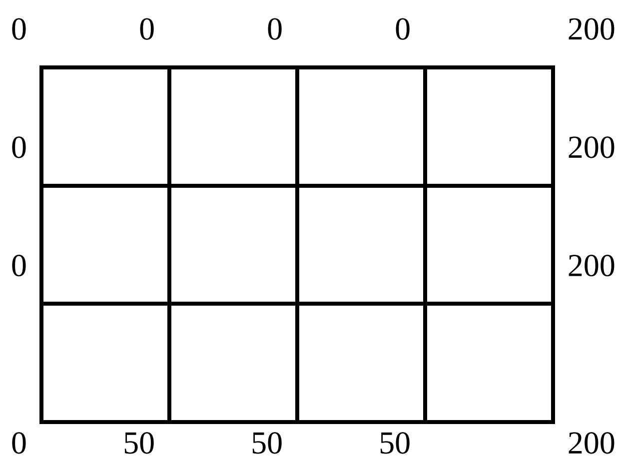
<tr><td>Q 11</td><td>Consider the 2-dimensional transient heat conduction equation given below. The Crank-Nicolson discretization of the equation results in a penta-diagonal system of equations. Demonstrate an algorithm to solve the system of equations iteratively.
$$\frac{\partial T}{\partial t} = \alpha \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right)$$</td><td>10</td><td>CO3</td></tr>
<tr><td colspan="4">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).</td></tr>
<tr><td>Q 12</td><td>Solve the Laplace equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ numerically, using the successive over relaxation in conjunction 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, for a relaxation factor of 1.2.


OR</td><td>20</td><td>CO4</td></tr>
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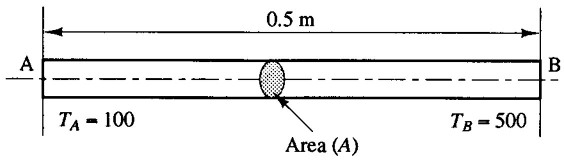
Consider the problem of source-free transient heat conduction in an insulated rod whose ends are maintained at constant temperatures of 100 °C and 500 °C respectively. The one- dimensional problem sketched in figure below,



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.
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