Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2019

Programme Name: B. Tech. ASE | **Semester : VI**
Course Name : Computational Fluid Dynamics | **Time : 03 hrs.**
Course Code : GNEG 401 | **Max. Marks: 100**
Nos. of page(s) : 03
Instructions: Assume any missing data appropriately.

SECTION A

S. No.		Marks	CO
Q 1	Sketch the various models of fluid flow used for derivation of governing equations. Write down the forms of equations that emanate from these models on applications conservation laws.	**4**	**CO1**
Q 2	List down any four applications of Computational Fluid Dynamics.	**4**	**CO1**
Q 3	Discuss a mathematical model for the *round off error* for a finite difference discretization on a structured grid.	**4**	**CO1**
Q 4	Consider the function $\phi(x, y) = \sin x + \cos y$ a. Calculate the values of $\frac{\partial \phi}{\partial x}$ at a point (*x*,*y*) = (1,1) using first order forward difference, with $\Delta x = \Delta y = 0.1$. b. Calculate the values of $\frac{\partial \phi}{\partial x}$ at a point (x,y) = (1,1) using second order central difference, with $\Delta x = \Delta y = 0.1$.	**4**	**CO2**
Q 5	Formulate any two approximations for the evaluation surface integral of fluxes over the east face of a two-dimensional control volume.	**4**	**CO2**

SECTION B

Q 6	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**	**CO1**
Q 7	Illustrate the strong and weak forms of the weighted residual formulation for finite element discretization. Justify that a proper choice of *weight function*	**10**	**CO2**

	makes the weighted residual formulation equivalent to Finite difference or Finite Volume Methods. ***OR*** Define shape functions as used in Finite Element Method. Deduce shape functions for a one-dimensional quadratic element for the value of a function at any location in the domain in terms of nodal values.		
Q 8	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**	**CO2**
Q 9	Discuss an explicit time marching algorithm for the solution of transient Euler equations in 2-dimensions.	**10**	**CO3**
SECTION-C			
Q 10	Consider a two-dimensional square plate ABCD with edges AB and CD maintained at temperatures of 200 ^oK and 100 ^oK respectively. The other two edges DA and BC are also maintained at temperatures of 200 ^oK, except at the corners C and D. Find the steady state temperatures of at least 9 locations on the plate. Take *AB=BC=CD=DA*= 4 cm. Use pure *Gauss-Seidel relaxation* scheme for at least 4 iterations. The two-dimensional steady state heat conduction is governed by $$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}=0$$	**20**	**CO4**
Q 11	Derive the *modified equation* that emanates from the first order forward in time and backward in space discretization of the first order wave equation given below. $$\frac{\partial u}{\partial t}+a\frac{\partial u}{\partial x}=0$$ Discuss the nature of dominating error for the above discretization and suggest means to minimize them. ***OR***	**20**	**CO3**

	Deduce the *modified equation* for the solution of the first order wave equation using Lax Method given by $$\frac{u_j^{n+1} - (u_{j+1}^n + u_{j-1}^n)/2}{\Delta t} + c\frac{u_{j+1}^n - u_{j-1}^n}{2\,\Delta x} = 0$$ Hence, discuss the effect of the dominating error on the solution obtained.		