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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, April 2017

Program/course: B. Tech. (ASE), B. Tech. (ASE+ AVE) | **Semester – VIII**
Subject: Computational Fluid Dynamics | **Max. Marks : 100**
Code : GNEG 403 | **Duration : 3 Hrs**
No. of page/s: 03

Section A

Section A has ten (10) questions of 2 marks each. All the questions in this section are compulsory.

1. List down the four model of fluid flow for derivation of governing equations of fluid flows.
2. Name the various forces acting on an infinitesimally small fluid element moving in space.
3. Define the round off error for numerical solution of fluid flow equations.
4. Discuss the effect of successive under- and over-relaxation for the solution of a boundary value problem using Gauss Seidel relaxation scheme.
5. What is the physical meaning of the divergence of velocity for a moving fluid element?
6. What are the face centered and node centered grids? Draw to illustrate.
7. What do you mean by a time marching solution of a steady state flow?
8. Why is grid transformation required for the solution partial differential equations using finite difference methods on a non-rectangular domain?
9. Why are unstructured grids preferred over structured grids for solution of fluid dynamic equations over arbitrary bodies?
10. Discretize the following equation using the explicit Forward in Time and Central in Space scheme.

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

Section B

Section B has or Four (4) Questions of 10 marks each. All the questions in this section are compulsory.

11. Consider the 2-dimensional transient heat conduction equation given below. The Crank-Nicolson discretization of the equation results in a pentadiagonal system of equations. Describe the Alternating Direction Implicit (ADI) technique to solve the system of equations iteratively.

$$\frac{\partial T}{\partial t} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right)$$

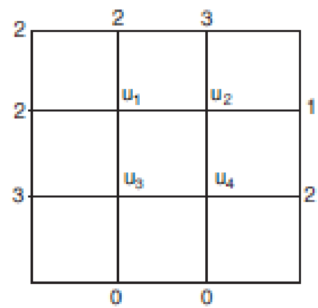
12. What is *artificial diffusion*? How does the diffusive and dispersive errors affect a solution? Discuss in context to the solution of the one-dimensional scalar wave equation using the explicit Forward in Time and Backward in Space (FTBS) scheme. Suggest methods to alleviate the diffusive error.
13. Explicate the explicit McCormack time marching algorithm for the solution of transient Euler equations in 2-dimensions.
14. Explain the following methods for the approximation of surface integrals over a two-dimensional control volume.
    a. Mid-point Rule
    b. Trapezoidal Rule
    c. Simpson's Rule

Section C

Section C has two (2) Questions of 20 marks each. Both the questions in this section are compulsory; however one of the questions has an internal choice.

15. 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.



OR

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.

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

16. Elaborate the following interpolation schemes for the evaluation of flux values at the center of a control volume face using the flux values at computational nodes for a structured finite volume grid.

    a. UDS
    b. CDS
    c. QUICK
    d. Hybrid Scheme

    Discuss the advantages, disadvantages and the order of accuracy of each of these schemes.