CFD-QUE BANK

2 MARKS

1) Define control volume?

   A closed volume drawn within a *finite* region of the flow. This volume is defines as *control volume, V*.

2) Define Well-Posed Problems?

   Therefore, we define a well-posed problem as follows: If the solution to a partial differential equation exists and is unique, and if the solution depends continuously upon the initial and boundary conditions, then the problem is *well-posed*. In CFD, it is important that you establish that your problem is well-posed before you attempt to carry out a numerical solution.

3) Define grid point?

   Analytical solutions of partial differential equations involve closed-form expressions which give the variation of the dependent variables *continuously* throughout the domain. In contrast, numerical solutions can give answers at only *discrete points* in the domain, called *grid points*.

4) What are error influence numerical solutions the PDE?
   a. Discretization error
   b. Round-off error

5) Define Discretization error?

   The difference between the exact analytical solution of the partial differential equation and the exact solution of the corresponding difference equation. Discretization error for the difference is simply the truncation error for the difference equation plus any errors introduced by the numerical trement of the boundary condition.

6) Define Round-off error?

   The numerical error introduced after a repetitive number of calculation in which the computer is constantly rounding the number to some significant figure.

7) Type of grid generation?
structured,
unstructured

8) Write the Disadvantage of the explicit approach.
Given *x*, *t* must be less than some limit imposed by stability constraints. In many cases, *t* must be very small to maintain stability; this can result in long computer running times to make calculations over a given interval of *t*.

9) Write the advantage of implicit *approach*.
Stability can be maintained over much larger values of *t*, hence using considerably fewer time steps to make calculations over a given interval of *t*. This results in less computer time.

10) Write the advantage of implicit *approach*.
1. More complicated to set up and program.
2. Since massive matrix manipulations are usually required at each time step, the computer time per time step is much larger than in the explicit approach.

3.Since large *t* can be taken, the truncation error is larger, and the use of implicit methods to follow the exact transients (time variations of the independent variable) may not be as accurate as an explicit approach. However, for a time-dependent solution in which the steady state is the desired result, this relative time-wise inaccuracy is not important.

11) What is Lax method?

$$\frac{\partial u}{\partial t} = \frac{u_i^{n-1} - \frac{1}{2}(u_{i+1}^n + u_{i+1}^n)}{\Delta t}$$

……..(a)

The differencing used in the above equation, where Eq. (a) is used to represent the time derivative, is called the *Lax method.*

12) Define Courant number? (or)

What is the important stability criterion for hyperbolic equation?

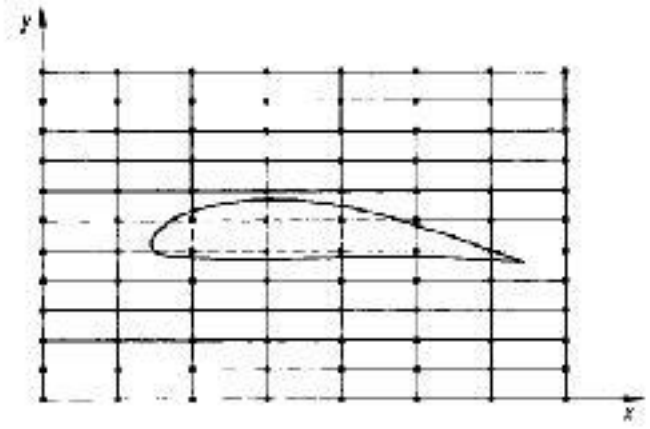
$$C = c\frac{\Delta t}{\Delta x} \leq 1$$

C is called the *Courant number*. This equation says that $t \leq x/c$ for the numerical solution of Eq. (5.45) to be stable. Moreover, Eq. (5.47) is called the *Courant–number*

13) Explain the problems with rectangular grid?

(1) Some grid points fall inside the airfoil, where they are completely out of the flow. What values of the flow properties do we ascribe to these points?

(2) There are few, if any, grid points that fall on the surface of the airfoil. This is not good, because the airfoil surface is a vital boundary condition for the determination of the flow, and hence the airfoil surface must be clearly and strongly seen by the numerical solution.



14) Write the advantages of adaptive grid?

An adaptive grid is expected because the grid points are clustered in regions where the 'action' is occurring.

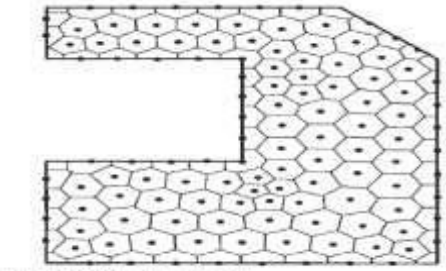
These advantages are:

(1) Increased accuracy for a fixed number of grid points, or

(2) For a given accuracy, fewer grid points are needed.

15) Define Dirichlet tessellatipn or Voronoj diagram?

The Delaunay triangulation is based on a methodology proposed by Dirichlet in 1850 for the unique subdivision of space into a set of packed convex regions. Given a set of points, each region represents the space around the particular point, which is closer to that point than to any other. The regions form polygons (polyhedra in 3D) which are known **as** the ***Dirichlet tessellation*** or the ***Voronoj diagram .***



the Voronoj diagram

16) Define finite element method?

The finite element method (FEM) is a numerical technique for solving partial differential equations (PDE's).

17) What is the basis of FVM?

It is important that the conservation laws in their integral form are represented accurately. The most natural method to accomplish this is to *discretize the integral form of the equations* and not the differential form. This is the basis of a *finite volume method*.

18) Define staggered grid approach?

A typical choice is then *cell-centres* for representation as piecewise constant functions or *cell-vertices* for representation as piecewise linear (or bilinear) functions. choices imply an interpolation structure, the last two do not. In the last example, function values are not defined in all nodes. The grid of nodes on which pressure and density are defined is different from the grid of nodes on which velocity-x components and velocity-y components are defined. This approach commonly is called the *staggered grid approach*.

19) What is the formulation the FVM?

The finite volume method (FVM) tries to combine the best from the *finite element method* (FEM), i.e. the *geometric flexibility*, with the best of the *finite difference method* (FDM), i.e. the flexibility in defining the *discrete flow field* (discrete values of dependent variables and their associated fluxes).

20) What is Lax-Wendroff time-stepping?

Lax-Wendroff time-stepping is a very classic explicit time integration method in the finite difference method the principles of a Lax-Wendroff method with the use of the onedimensional scalar model equation

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

21) What is CFD?

CFD is the simulation of fluids engineering systems using modeling (mathematical physical problem formulation) and numerical methods (discretization methods, solvers, numerical parameters, and grid generations, etc.)

Historically only Analytical Fluid Dynamics (AFD) and Experimental Fluid Dynamics (EFD).CFD made possible by the advent of digital computer and advancing with improvements of computer resources (500 flops, 1947 20 teraflops, 2003)

22) What are the Commercial Software for CFD? The market is currently dominated by four codes:

1) PHOENICS
2) FLUENT
3) FLOW3D
4) STAR-CD

23) What are the Advantages of CFD over EFD?

a. Substantial reduction of lead times and costs of new designs.

b. Ability to study systems where controlled experiments are difficult or impossible to perform (e.g. very large systems).

c. Ability to study systems under hazardous conditions at and beyond their normal performance limits (e.g. safety studies and accident scenarios).

d. Practically unlimited level of detail of results.

16 MARKS

1) Derive Navier-stokes equation in conservation form.
2) Write a note on behavior of PDE's on CFD
3) Write a note on explicit and implicit approaches and stability criteria.
4) Write a note on parabolic and hyperbolic equations
5) Write a note on central and upwind difference schemes for one dimensional steady convection-diffusion equation
6) Explain hybrid law, power law and Quick schemes.
7) Write a note on staggered grid and pressure velocity corrections.
8) Write PISO algorithm and explain it.
9) Write a note on the turbulence flow modeling
10) Explain K-e model and RANS model.