Code No: RR322104

**Set No. 1**

**III B.Tech II Semester Supplementary Examinations, November/December 2005**

**COMPUTATIONAL AERODYNAMICS-II**

**(Aeronautical Engineering)**

**Time: 3 hours** **Max Marks: 80**

**Answer any FIVE Questions**

**All Questions carry equal marks**

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1. (a) Show with one example that Computational aerodynamics is also termed numerical experiments in the language of Aerospace Engineering. Justify the statement with at least one example. What are the specific advantages?

   (b) Show the impact of CFD on the problems of aerodynamics of road vehicles with one example. [16]

2. The partial differential equation representing equation of continuity is $\frac{\partial \rho}{\partial t} + \nabla.(\rho\nu)$ =0.Derive it from the first principle. Put this equation in other forms known in the dynamics of fluid. Present your work. [16]

3. Put the Governing equations for unsteady, three dimensional, compressible, inviscid flows in conservation form .Recast the equations suitable for computational work. How can a time marching problem be formulated? [16]

4. Consider the irrotational, two dimensional inviscid, steady flow of a compressible gas. If the perturbation components of u and v are $u'$ and $v'$ and $M_\infty$ is the free stream Mach number, then the governing continuity , momentum and energy equations can be reduced to the system $(1 - M_\infty^2)\frac{\partial u'}{\partial x} + \frac{\partial v'}{\partial y} = o, \frac{\partial u'}{\partial y} - \frac{\partial v'}{\partial x} = 0.$ Establish the condition for which the above system of equations represents elliptic partial differential equations. [16]

5. Find the characteristics of p.d.e. given by $\frac{\partial^2 u}{\partial x^2} + 3\frac{\partial^2 u}{\partial x \partial y} + 2\frac{\partial^2 u}{\partial y^2} = 0$ [16]

6. Consider the function $\phi(x, y) = e^x + e^y$ .Consider the point (x,y) =(1,1).Use first order central differences, with $\Delta x$=$\Delta y$=0.02, to calculate approximate values of $\frac{\partial \phi}{\partial x}$and $\frac{\partial \phi}{\partial y}$ at (1,1).Calculate the percentage difference when compared with the exact solution at (1,1). [16]

7. $U_m^{n+1} = (1 - 2r)U_m^n + r(U_{m+1}^n + U_{m-1}^n)$gives finite difference approximation of $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$over a rectangular mesh (x=mh ,t=nk, m,n are integers,r= $\frac{k}{h^2}$).Prove that this scheme is stable for r $\leq \frac{1}{2}$. [16]

8. What are the principles, capabilities and utilities of structured grid .Consider the domain ABCD bounded by the lines $x$=0.5; $y$=0; $x$=-0.5 and the circular arc $y = (1 - x^2)^{\frac{1}{2}}$ and the transformation $\xi = \frac{y}{(1-x^2)}$ , $\eta = x + 0.5$ .Obtain the body conforming grid. [16]

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**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. (a) Comment with one example on the statement that Computational aerodynamics is also termed numerical experiments in the language of Aerospace Engineering. What are the specific advantages?

   (b) Comment with one example on the impact of CFD on the problems of aerodynamics of road vehicles. [16]

2. The p.d.e. depicting equation of continuity is $\frac{\partial \rho}{\partial t} + \nabla.(\rho\nu)$ =0. Derive it from the first principle. Put this equation in other forms known in the dynamics of fluid. Present your work. [16]

3. Consider the non-conservation form of equations of motion in fluid mechanics for applications in Computational Fluid Dynamics? How do these equations differ from the conservation form of such equations? Hence explain differences between integral and differential forms of equations. [16]

4. Given is a system of quasi-linear partial differential equations as below, $a_1\frac{\partial u}{\partial x} + b_1\frac{\partial u}{\partial y} + c_1\frac{\partial v}{\partial x} + d_1\frac{\partial v}{\partial y} = \int_1, a_2\frac{\partial u}{\partial x} + b_2\frac{\partial u}{\partial y} + c_2\frac{\partial v}{\partial x} + d_2\frac{\partial v}{\partial y} = \int_{2_1}$, where u and v are the dependent variables, continuous functions of x and y and the coefficients a,b,c,d and f can be functions of x, y, u, and v. Work out to show the conditions under which the above system of equations represents parabolic partial differential equations. [16]

5. Find the characteristics of p.d.e. given by $\frac{\partial^2 u}{\partial x^2} + 4\frac{\partial^2 u}{\partial x \partial y} + 3\frac{\partial^2 u}{\partial y^2} = 0$ [16]

6. Consider the function $\phi(x, y) = e^x + e^y$ .Consider the point (x,y) =(1,1).Use first order backward differences, with $\Delta x$=$\Delta y$=0.05, to calculate approximate values of $\frac{\partial \phi}{\partial x}$and $\frac{\partial \phi}{\partial y}$ at (1,1).Calculate the percentage difference when compared with the exact solution at (1,1). [16]

7. $U_m^{n+1} = (1 - 2r)U_m^n + r(U_{m+1}^n + U_{m-1}^n)$ gives finite difference approximation of $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$ over a rectangular mesh (x=mh ,t=nk, m,n are integers,r= $\frac{k}{h^2}$) .Using Taylor series expansion, obtain the principal part of the local truncation error. [16]

8. Describe the necessity of the grid generation in the area of Computational Fluid Dynamics. Explain with an appropriate illustration that 'A problem having simple equations but complex boundary conditions gets transformed in to a problem now having complex equations and simple boundary conditions' with the application of the technique of Grid Generation. [16]

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Code No: RR322104

**Set No. 3**

**III B.Tech II Semester Supplementary Examinations,**
**November/December 2005**
**COMPUTATIONAL AERODYNAMICS-II**
**(Aeronautical Engineering)**

**Time: 3 hours** **Max Marks: 80**

**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. (a) Justify with one example that computational aerodynamics is also called numerical experiments. What are the specific advantages of numerical experiments?

   (b) How did the discipline of CFD influence the aerodynamics of road vehicles? Explain. [16]

2. Consider the motion of a viscous fluid and obtain the balance of momentum of an infinitesimal element. Identify the surface forces and body forces. Hence write down the complete equation of motion in vector and long hand. [16]

3. Consider the conservation form of equations of motion in fluid mechanics. How do these equations differ from the non-conservation form of these equations? Hence discuss the differences between integral and differential forms of equations. [16]

4. Establish the type of partial differential equation given by $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$, [16]

5. Find the characteristics of p.d.e. given by $\frac{\partial^2 u}{\partial x^2} + 3\frac{\partial^2 u}{\partial x \partial y} + 2\frac{\partial^2 u}{\partial y^2} = 0$ [16]

6. Prow that an expression for $2^{nd}$ order central difference expression for the mixed derivative,is $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j} = \frac{u_{i+1,j+1} - u_{i+1,j-1} - u_{i-1,j+1} + u_{i-1,,j-1}}{4\partial x \partial y} + O\left[(\Delta x)^2, (\Delta y)^2\right]$ can be obtained. [16]

7. Show that solution of p.d.e. $\frac{\partial u}{\partial t} = \frac{\partial}{\partial x}\left[a(x)\frac{\partial u}{\partial x}\right], a(x) \neq 0$ with finite difference approximation on a rectangular mesh (x=mh ,t=nk, m,n are integers,r= $\frac{k}{h^2}$) is given by $U_m^{n+1} = (1-2ra)U_m^n + ra(U_{m+1}^n + U_{m-1}^n) + \frac{rh}{2}a'(U_{m+1}^n - U_{m-1}^n)$. [16]

8. What are the principles, capabilities and utilities of structured grid? Consider the domain ABCD bounded by the lines $x$=0.5; $y$=0; $x$=-0.5 and the circular arc $y = (1-x^2)^{\frac{1}{2}}$ and the transformation $\xi = \frac{y}{(1-x^2)^{\frac{1}{2}}}$ , $\eta = x + 0.5$ Obtain the body conforming grid. [16]

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1. (a) Show with one example that Computational aerodynamics is also termed numerical experiments in the language of Aerospace Engineering. Justify the statement with at least one example. What are the specific advantages?
   (b) Show the impact of CFD on the problems of aerodynamics of road vehicles with one example. [16]

2. Apply the first law of thermodynamics to an infinitesimally small fluid element moving with the flow to obtain the energy equation in terms of the internal energy. [16]

3. Consider the conservation forms of the governing equations in Computational Fluid Dynamics given by $\frac{\partial U}{\partial t}+\frac{\partial F}{\partial x}+\frac{\partial G}{\partial y}+\frac{\partial H}{\partial z}=J$. If steady flow is considered ,then explain that it is possible to map the flow with such formulation. Take U,F,G ,H and J having usual significance. [16]

4. The boundary layer equations in a compressible flow in 2 -dimensions are given below

$$\begin{array}{ll} Continuity & \frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}=0 \\ x-momentum & \rho u\frac{\partial u}{\partial x}+\rho v\frac{\partial u}{\partial y}=-\frac{dp_e}{dx}+\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right) \\ y-moment & \frac{\partial p}{\partial y}=0 \\ Energy & \rho u\frac{\partial h}{\partial x}+\rho v\frac{\partial h}{\partial y}=\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)+u\frac{dp_e}{dx}+\mu\left(\frac{\partial u}{\partial y}\right)^2 \end{array}$$

   Establish the type of partial differential equations for boundary layer flow. [16]

5. Consider the equation $y\frac{\partial U}{\partial x}+\frac{\partial U}{\partial y}=2$,where U is known along the initial segment defined by y = 0,0 $\leq x \leq$1.Determine the equation of the characteristic curve.[16]

6. Show how can you derive difference approximation for mixed partial derivatives

$$\left(\frac{\partial^2 u}{\partial x\partial y}\right)_{i,j}=\frac{1}{2\Delta x}\left(\frac{u_{i+1,j+1}-u_{i+1,j}}{\Delta y}-\frac{u_{i-1,j+1}-u_{i-1,j}}{\Delta y}\right)+O\left[(\Delta x)^2,\Delta y\right]$$ [16]

7. Consider the finite difference approximation of $\frac{\partial u}{\partial t}=\frac{\partial^2 u}{\partial x^2}$ over a rectangular mesh (x=mh ,t=nk, m,n are integers,r= $\frac{k}{h^2}$).where the Taylor series expansion is taken about (mh ,k(n+1/2) . Obtain the approximation and suggest a solution method . [16]

8. Describe the necessity of the grid generation in the area of Computational Fluid Dynamics. Explain with an appropriate illustration that ‘A problem having simple

equations but complex boundary conditions gets transformed in to a problem now having complex equations and simple boundary conditions' with the application of the technique of Grid Generation. [16]

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