IV B.Tech. I Semester Regular Examinations, November -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. Consider a constant - strength source distribution along the x-axis at $x_{\underline{1}}$ =0.5 and x_2 =0.75 with the source strength σ =0.2 (SI units).Obtain the u and w components of the velocity at a point P(1.5,0.5). What if there were a point source of the same strength at x_1? Derive the formula used. [6,4,6]

2. Consider a constant - strength Vortex distribution along the x-axis at $x_{\underline{1}}$ =0.15 and x_2 =0.65 with the vortex strength Γ =0.35 (SI units).Obtain the u and w components of the velocity at a point P(0.5,0.75). What if there were a point vortex of the same strength at x_2? Derive the formula used. [6,4,6]

3. A supersonic nozzle with a test section Mach number of 1.571 and Test section height of 25 cm is desired to be designed with a single-step of characteristic methods .Make use of gas tables and graph sheets. Start with M=1.0.Show the nozzle boundaries / contour with a neat diagram. Illustrate the procedure adopted.[10,6]

4. Consider full nonlinear equations of motion for a two dimensional, non viscous, irrotational flow as below; $(u^2 - a^2)\frac{\partial u}{\partial x} + uv\left(\frac{\partial u}{\partial y} + \frac{\partial u}{\partial x}\right) + (v^2 - a^2)\frac{\partial v}{\partial y} = 0$ $\frac{\partial u}{\partial y} - \frac{\partial u}{\partial y} = 0$ Develop the compatibility relations , if for the above flow (state the conditions) the characteristics exist? [16]

5. Define the term transonic range of flow of a fluid .Describe all aspects of this flow over a non-symmetrical airfoil at zero angle of attack with sketches and plots. Explain the shock wave-boundary layer interaction and its effect on the lift and drag of the shape and configuration under consideration. [2,6,4,4,]

6. Consider the TSP equation written as $\left[(1 - M_\infty^2) - (\gamma + 1)M_\infty^2\varphi_x\right]\varphi_{xx} + \varphi_{yy} + \varphi_{zz} = 0$ Transform this equation into the Murman and Cole form (after defining scaling factors) given below; $\left[K - (\gamma + 1)\tilde{\varphi}_{\tilde{x}}\right]\tilde{\varphi}_{\tilde{x}\tilde{x}} + \tilde{\varphi}_{\tilde{y}\tilde{y}} + \tilde{\varphi}_{\tilde{z}\tilde{z}} = 0$ Specify the boundary conditions and with compatible expression for $\underset{p}{\widetilde{C}}$, describe a backward difference scheme as the solution method for the problem under consideration. [8,8]

7. Show that Prandtl BL equations for flow over a flat plate aligned with a steady uniform free stream of a viscous fluid can be put in the form given as; $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2}$ $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ From above eqs. obtain the Blasius equation .What are the boundary conditions under these transformed co-ordinates. [6,8,2]

8. 20. One method of obtaining approximations to the wave equation is due to Euler, given below; $\frac{u_j^{n+1} - u_j^n}{\Delta t} + c\frac{u_{j+1}^n}{\Delta x} = 0$. The above scheme is known to be unconditionally

unstable. It is suggested that you replace the forward space differencing by a backward space difference for $c>0$. Work out your scheme , present your result . Is this scheme now stable? [8,8]

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Code No: RR412103 **Set No.2**

IV B.Tech. I Semester Regular Examinations, November -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. Consider a constant strength source panel AB forming a part of an airfoil section located at A(x_1=0.5,y_1=0.11) ,B(x_2= 0.75,y_2 =0.10). Obtain the induced velocity at P(0.67,0.35), in panel coordinates and Global coordinates.Explain the procedure for proceeding further in evaluating flow over this airfoil. [6,4,6]

2. Consider a constant - strength Vortex distribution along the x-axis at $x_{\underline{1}}$ =0.15 and x_2 =0.57 with the vortex strength Γ =0.35 (SI units).Obtain the u and w components of the velocity at a point P(0.5,0.75). What if there were a point vortex of the same strength at x_1? Derive the formula used. [6,4,6]

3. A supersonic nozzle with a test section Mach number of 1.571 and Test section height of 31 cm is desired to be designed with a single-step of characteristic methods .Make use of gas tables and graph sheets. Start with M=1.0.Show the nozzle boundaries / contour with a neat diagram. Illustrate the procedure adopted.[10,6]

4. $\left(1-\frac{u^2}{a^2}\right)\frac{\partial^2\phi}{\partial x^2}-2\frac{uv}{a^2}\frac{\partial^2\phi}{\partial x\partial y}+\left(1-\frac{v^2}{a^2}\right)\frac{\partial^2\phi}{\partial y^2}=0$ represents differential equation for flow in two dimensions , where a and ϕ are speed of sound and velocity potential function respectively. Examine, the condition which makes this equation hyperbolic. Hence define characteristics and develop the compatibility relations. Make use of sketches and illustrations. [4,6,6]

5. Define the term 'Transonic Parameter'. As an example consider that an airfoil with 12% thickness ratio has critical C_p of 0.62 at about 25% of the chord at M∞ = 0.80.If now an airfoil with the same camber and thickness distribution having a thickness ratio of 14% is kept in the flow with same Mach number, what could be the status ofC_p at the same location of the chord. Support your answer with sketches. What if the earlier airfoil were kept at a higher Mach number .Comment on the flow field thus resulting, supported with sketches [8,8]

6. Develop the transonic small perturbation equation $(1-M_\infty^2)\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=M_\infty^2(\gamma+1)\frac{u}{U}\frac{\partial u}{\partial x}$. Explain the process for getting this equation. [12,4]

7. Show that the BL equations for flow over a flat plate aligned with a steady uniform free stream of a viscous fluid can be put in the form given as; $u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2}$, $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$ Hence obtain the Blasius equation .What are the boundary conditions under these transformed co-ordinates. [6,8,2]

8. One method of obtaining approximations to the wave equation is due to Euler, given below; $\frac{u_j^{n+1}-u_j^n}{\Delta t}+c\frac{u_{j+1}^n}{\Delta x}=0$. The above scheme is unconditionally unstable.

It is now suggested that you replace the forward space differencing by a backward space difference for $c>0$. Work out your scheme , present your result . Is this scheme now stable? [8,8]

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Code No: RR412103 **Set No.3**

IV B.Tech. I Semester Regular Examinations, November -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. Consider a constant - strength source distribution along the x-axis at x_1=0.5 and x_2 =0.32 with the source strength σ =0.2 (SI units).Obtain the u and w components of the velocity at a point P(1.5,0.5). What if there were a point source of the same strength at x_2? Derive the formula used. [6,4,6]

2. Consider a constant - strength Vortex distribution along the x-axis at x_1 =0.15 and x_2 =0.70 with the vortex strength Γ =0.35 (SI units).Obtain the u and w components of the velocity at a point P(0.5,0.75). What if there were a point vortex of the same strength at x_1? Derive the formula used. [6,4,6]

3. A supersonic nozzle with a test section Mach number of 1.571 and Test section height of 26 cm is desired to be designed with a single-step of characteristic methods .Make use of gas tables and graph sheets. Start with M=1.0.Show the nozzle boundaries / contour with a neat diagram. Illustrate the procedure adopted.[10,6]

4. Present your work in deriving the compatibility relations
$(\nu - \theta) = R$,
$(\nu + \theta) = Q$
from the full nonlinear equations of motion for a two dimensional, non viscous, irrotational flow as below;
$(u^2 - a^2)\frac{\partial u}{\partial x} + uv(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}) + (v^2 - a^2)\frac{\partial v}{\partial y} = 0, \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = 0$ [16]

5. Define the term transonic range of flow of a fluid .Describe all aspects of this flow over a symmetrical airfoil at non zero angle of attack with sketches and plots. Hence explain the terms Critical Mach number, sub-Critical Mach Number and super-Critical Mach number. [2,8,6]

6. Consider the 2D TSP equation $\left[(1 - M_\infty^2) - (\gamma + 1)M_\infty^2\varphi_x\right]\varphi_{xx} + \varphi_{yy} = 0$
. Develop the boundary conditions satisfying the condition of NO NORMAL flow on the surface of the thin airfoil like object along with the expression for Cp. [10,6]

7. Consider Navier-Stokes equations in Cartesian co-ordinates. How will you obtain Prandtls BL equations$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\frac{\partial^2 u}{\partial y^2}$ $\frac{\partial p}{\partial y} = 0$ $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ State the boundary conditions . [14,2]

8. Consider the simple Euler scheme for approximating the solution of the wave equation $u_{tt} = c^2 u_{xx}$. It is well known that the above scheme is unconditionally unstable. It is proposed that you replace the forward space differencing by a backward

space difference for $c>0$. Work out your scheme , present your result . Is this scheme now stable? [8,8]

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Answer any FIVE Questions
All Questions carry equal marks
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1. Consider a constant - strength source distribution along the x-axis at x_1 =0.5 and x_2 =0.75 with the source strength σ =0.25 (SI units).Obtain the u and w components of the velocity at a point P(1.5,0.5). What if there were a point source of the same strength at x_1? Derive the formula used. [6,4,6]

2. Consider a constant - strength Vortex distribution along the x-axis at x_1 =0.35 and x_2 =0.55 with the vortex strength Γ =0.35 (SI units).Obtain the u and w components of the velocity at a point P(0.5,0.75). What if there were a point vortex of the same strength at x_1? Derive the formula used. [6,4,6]

3. A supersonic nozzle with a test section Mach number of 1.503 and Test section height of 24 cm is desired to be designed with a single-step of characteristic methods .Make use of gas tables and graph sheets. Start with M=1.0.Show the nozzle boundaries / contour with a neat diagram. Illustrate the procedure adopted. [10,6]

4. Present your work in deriving the compatibility relations $$\frac{\partial}{\partial \eta}(\nu - \theta) = 0, \quad \frac{\partial}{\partial \xi}(\nu + \theta) = 0$$
from the full nonlinear equations of motion for a two dimensional, non viscous, irrotational flow as below;
$(u^2 - a^2)\frac{\partial u}{\partial x} + uv(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}) + (v^2 - a^2)\frac{\partial v}{\partial y} = 0, \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = 0$ [16]

5. Define the term transonic range of flow of a fluid .Describe all aspects of this flow over a cambered airfoil at zero angle of attack with sketches and plots. Hence explain the terms Critical Mach number, sub-Critical Mach Number and super-Critical Mach number. [2,8,6]

6. Consider the 2D TSP equation $[(1 - M_\infty^2) - (\gamma + 1)M_\infty^2 \varphi_x]\,\varphi_{xx} + \varphi_{yy} = 0$
. Develop the boundary conditions satisfying the condition of NO NORMAL flow on the surface of the thin airfoil like object along with the expression for Cp. [10,6]

7. Show that Prandtl BL equations can be derived from the NS equations and can be put in the form $\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \frac{\partial U}{\partial t} + U\frac{\partial U}{\partial x} + \nu\frac{\partial^2 u}{\partial y^2}$ $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$, if the pressure distribution within the boundary layer is a function of the stream wise co-ordinate x alone. Write down the boundary conditions as well. Under what conditions these equations hold for curved flows? [13,2,1]

8. One method of obtaining approximations to the wave equation is due to Euler, given below; $\frac{u_j^{n+1}-u_j^n}{\Delta t}+c\frac{u_{j+1}^n}{\Delta x}=0$. The above scheme is unconditionally unstable. It is now suggested that you replace the forward space differencing by a backward space difference for c>0. Work out your scheme , present your result . Is this scheme now stable? [8,8]

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