Code No: RR322105 **RR** **Set No. 2**

III B.Tech II Semester Examinations,December 2010
HIGH SPEED AERODYNAMICS
Aeronautical Engineering

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

Answer any FIVE Questions
All Questions carry equal marks

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1. Air at $M_1 = 2.3$ and at a pressure of 70 kPa flows along a wall which bends away at an angle of 12^0 from the direction of flow. Determine the Mach number and pressure after the bend. If in another case the flow experiences a compression over the concave wall which actually bends through the same angle, determine the Mach number and pressure with the same free stream conditions. Sketch the flow fields in both the cases. [16]

2. A gas is expanded isentropically from p = 10 bar and t = 525^0 C in a nozzle to a pressure of 7.6 bar. If the rate of flow of the gas is 1.5 kg/s, determine
   (a) Pressure, temperature and Velocity at the throat and exit of the nozzle,
   (b) Maximum velocity at exit
   (c) Type of nozzle and its throat area. Take $C_p/C_v = 1.3$ and R = 0.464 kJ/ kg K. [16]

3. (a) Illustrate with theory the phenomenon of Normal shock waves and that the Mach number behind a Normal Shock wave is always subsonic.
   (b) Develop the equation $M_1^* M_2^* = 1$ along with
   (c) The physics involved. [8+4+4]

4. $\beta\frac{\partial^2 \hat{\phi}}{\partial x^2} + \frac{\partial^2 \hat{\phi}}{\partial y^2} = 0$ gives small perturbation potential equation where $\beta = (1 - M_\infty^2)$ .Prove that this equation becomes Laplace equation with the independent variables getting transformed into a new space by ξ = x and $\eta = \beta$y. Hence show that the shape of the airfoil after transformation into the new space remains unchanged.[16]

5. Define the term Impulse function in regard to the thrust exerted by isentropic flow of a fluid. Show that the non-dimensional impulse function is given in terms of the Mach number of the fluid stream as $\frac{F}{F^*} = \frac{1+\gamma M^2}{M\sqrt{2(1+\gamma)\left(1+\frac{\gamma-1}{2}M^2\right)}}$. [16]

6. A thin wedge of semi vertex angle θ is placed in a supersonic flow of free stream Mach number M_1 and the shock angle referenced from the axis of the wedge is β . Show that the θ - β - M relation is given by $\tan\theta = 2\cot\beta\frac{M_1^2\sin^2\beta-1}{M_1^2(\gamma+\cos 2\beta)+2}$ [16]

7. (a) Define the term coefficient of Compressibility K of a fluid and
   $d\rho = \left(\frac{\partial\rho}{\partial T}\right) dT + \left(\frac{\partial\rho}{\partial p}\right) dp$
   (b) Now demonstrate that $E = \frac{1}{K-\beta\frac{dT}{dp}}$, where E = Bulk modulus of elasticity and β = coefficient of volume expansion. [8+8]

8. The partial differential equation in terms of one unknown is given below;
$\left[1 - \frac{1}{a^2}\left(\frac{\partial \phi}{\partial x}\right)^2\right]\frac{\partial^2 \phi}{\partial x^2} + \left[1 - \frac{1}{a^2}\left(\frac{\partial \phi}{\partial y}\right)^2\right]\frac{\partial^2 \phi}{\partial y^2} - \frac{2}{a^2}\left(\frac{\partial \phi}{\partial x}\right)\left(\frac{\partial \phi}{\partial y}\right)\frac{\partial^2 \phi}{\partial x \partial y} = 0$, where $\phi = \phi$(x,y).
State the application of this equation in compressible aerodynamics with one example. [16]

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Code No: RR322105 **RR** **Set No. 4**

III B.Tech II Semester Examinations,December 2010
HIGH SPEED AERODYNAMICS
Aeronautical Engineering

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

Answer any FIVE Questions
All Questions carry equal marks

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1. A gas is expanded isentropically from p = 10 bar and t = 525^0 C in a nozzle to a pressure of 7.6 bar. If the rate of flow of the gas is 1.5 kg/s, determine
   (a) Pressure, temperature and Velocity at the throat and exit of the nozzle,
   (b) Maximum velocity at exit
   (c) Type of nozzle and its throat area. Take $C_p/C_v = 1.3$ and R = 0.464 kJ/ kg K. [16]

2. The partial differential equation in terms of one unknown is given below;
   $\left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial x}\right)^2\right]\frac{\partial^2\phi}{\partial x^2} + \left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial y}\right)^2\right]\frac{\partial^2\phi}{\partial y^2} - \frac{2}{a^2}\left(\frac{\partial\phi}{\partial x}\right)\left(\frac{\partial\phi}{\partial y}\right)\frac{\partial^2\phi}{\partial x\partial y} = 0$, where $\phi = \phi$(x,y). State the application of this equation in compressible aerodynamics with one example. [16]

3. $\beta\frac{\partial^2\hat{\phi}}{\partial x^2} + \frac{\partial^2\hat{\phi}}{\partial y^2} = 0$ gives small perturbation potential equation where $\beta = (1 - M_\infty^2)$ .Prove that this equation becomes Laplace equation with the independent variables getting transformed into a new space by ξ = x and $\eta = \beta$y. Hence show that the shape of the airfoil after transformation into the new space remains unchanged.[16]

4. (a) Define the term coefficient of Compressibility K of a fluid and
   $d\rho = \left(\frac{\partial\rho}{\partial T}\right)dT + \left(\frac{\partial\rho}{\partial p}\right)dp$
   (b) Now demonstrate that $E = \frac{1}{K - \beta\frac{dT}{dp}}$, where E = Bulk modulus of elasticity and β = coefficient of volume expansion. [8+8]

5. (a) Illustrate with theory the phenomenon of Normal shock waves and that the Mach number behind a Normal Shock wave is always subsonic.
   (b) Develop the equation $M_1^* M_2^* = 1$ along with
   (c) The physics involved. [8+4+4]

6. Air at $M_1 = 2.3$ and at a pressure of 70 kPa flows along a wall which bends away at an angle of 12^0 from the direction of flow. Determine the Mach number and pressure after the bend. If in another case the flow experiences a compression over the concave wall which actually bends through the same angle, determine the Mach number and pressure with the same free stream conditions. Sketch the flow fields in both the cases. [16]

7. A thin wedge of semi vertex angle θ is placed in a supersonic flow of free stream Mach number M_1 and the shock angle referenced from the axis of the wedge is β . Show that the θ - β - M relation is given by $\tan\theta = 2\cot\beta\frac{M_1^2\sin^2\beta-1}{M_1^2(\gamma+\cos 2\beta)+2}$ [16]

8. Define the term Impulse function in regard to the thrust exerted by isentropic flow of a fluid. Show that the non-dimensional impulse function is given in terms of the Mach number of the fluid stream as $\frac{F}{F^*} = \frac{1+\gamma M^2}{M\sqrt{2(1+\gamma)\left(1+\frac{\gamma-1}{2}M^2\right)}}$. [16]

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Code No: RR322105 **RR** **Set No. 1**

III B.Tech II Semester Examinations,December 2010
HIGH SPEED AERODYNAMICS
Aeronautical Engineering

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

Answer any FIVE Questions
All Questions carry equal marks
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1. Define the term Impulse function in regard to the thrust exerted by isentropic flow of a fluid. Show that the non-dimensional impulse function is given in terms of the Mach number of the fluid stream as $\frac{F}{F^*} = \frac{1+\gamma M^2}{M\sqrt{2(1+\gamma)\left(1+\frac{\gamma-1}{2}M^2\right)}}$. [16]

2. $\beta\frac{\partial^2 \hat{\phi}}{\partial x^2} + \frac{\partial^2 \hat{\phi}}{\partial y^2} = 0$ gives small perturbation potential equation where $\beta = (1 - M_\infty^2)$ .Prove that this equation becomes Laplace equation with the independent variables getting transformed into a new space by ξ = x and $\eta = \beta$y. Hence show that the shape of the airfoil after transformation into the new space remains unchanged.[16]

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4. (a) Illustrate with theory the phenomenon of Normal shock waves and that the Mach number behind a Normal Shock wave is always subsonic.
   (b) Develop the equation $M_1^* M_2^* = 1$ along with
   (c) The physics involved. [8+4+4]

5. Air at $M_1 = 2.3$ and at a pressure of 70 kPa flows along a wall which bends away at an angle of 12^0 from the direction of flow. Determine the Mach number and pressure after the bend. If in another case the flow experiences a compression over the concave wall which actually bends through the same angle, determine the Mach number and pressure with the same free stream conditions. Sketch the flow fields in both the cases. [16]

6. The partial differential equation in terms of one unknown is given below;
$\left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial x}\right)^2\right]\frac{\partial^2\phi}{\partial x^2} + \left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial y}\right)^2\right]\frac{\partial^2\phi}{\partial y^2} - \frac{2}{a^2}\left(\frac{\partial\phi}{\partial x}\right)\left(\frac{\partial\phi}{\partial y}\right)\frac{\partial^2\phi}{\partial x\partial y} = 0$, where $\phi = \phi$(x,y). State the application of this equation in compressible aerodynamics with one example. [16]

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   $d\rho = \left(\frac{\partial\rho}{\partial T}\right)dT + \left(\frac{\partial\rho}{\partial p}\right)dp$
   (b) Now demonstrate that $E = \frac{1}{K-\beta\frac{dT}{dp}}$, where E = Bulk modulus of elasticity and β = coefficient of volume expansion. [8+8]

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   (a) Pressure, temperature and Velocity at the throat and exit of the nozzle,

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   (c) Type of nozzle and its throat area. Take $C_p/C_v = 1.3$ and R = 0.464 kJ/ kg K. [16]

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Code No: RR322105 **RR** **Set No. 3**

III B.Tech II Semester Examinations,December 2010
HIGH SPEED AERODYNAMICS
Aeronautical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Illustrate with theory the phenomenon of Normal shock waves and that the Mach number behind a Normal Shock wave is always subsonic.
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   (c) The physics involved. [8+4+4]

2. The partial differential equation in terms of one unknown is given below;
$\left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial x}\right)^2\right]\frac{\partial^2\phi}{\partial x^2} + \left[1 - \frac{1}{a^2}\left(\frac{\partial\phi}{\partial y}\right)^2\right]\frac{\partial^2\phi}{\partial y^2} - \frac{2}{a^2}\left(\frac{\partial\phi}{\partial x}\right)\left(\frac{\partial\phi}{\partial y}\right)\frac{\partial^2\phi}{\partial x\partial y} = 0$, where $\phi = \phi$(x,y).
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4. (a) Define the term coefficient of Compressibility K of a fluid and
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   (b) Now demonstrate that $E = \frac{1}{K - \beta\frac{dT}{dp}}$, where E = Bulk modulus of elasticity and β = coefficient of volume expansion. [8+8]

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