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R07

SET No - 1

IV B.TECH - II SEMESTER EXAMINATIONS, APRIL/MAY, 2011
BOUNDARY LAYER THEORY
(AERONAUTICAL ENGINEERING)

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

Answer any FIVE questions
All Questions Carry Equal Marks
- - -

1. (a) Explain the significance of substantial derivative with a sketch and obtain suitable expression for it.
   (b) Derive the total energy equation in the non-conservative form, assuming the flow model of an infinitesimally small fluid element moving along the flow with a neat sketches along x, y, and z directions. [6+10]

2. (a) Define Viscosity, classify the fluids based on it and enumerate its significance. Explain the general stress system across a solid body.
   (b) Define the following terms and explain their significance with suitable correlations
   (i) Nominal thickness
   (ii) Displacement thickness
   (iii) Momentum Thickness and
   (iv) Energy Thickness. [5+11]

3. (a) Write short notes on the following (i) Stokes Law (ii) General Viscosity Law applied for flow of fluids with suitable correlations.
   (b) What are Navier-Stokes equations? Explain its significance and deduce a suitable expression for a 3D unsteady, viscous, incompressible, irrotational fluid (only the x component) in the differential form. [5+11]

4. (a) Explain the significance of critical Reynolds number in complex fluid flows.
   (b) Consider a 2D steady flow between two parallel plates separated by a distance b vertically, where one plate is at rest and the other is moving with a velocity U (Couette flow). Using exact solution for Navier-Stokes equation, obtain relations for maximum (U_{max}) and minimum (U_{min}) velocities, average velocity (U_{AV}), shearing stress (τ_{yx}) at the wall and local friction coefficient (C_f). [4+12]

5. Derive momentum-integral equations for boundary layer suggested by Karman-Pohlhausen for 2D steady, laminar, incompressible flows. [16]

6. From the integral equation of boundary layer derive Falkner-Skan equation for wedge flows. [16]

7. Discuss and compare the characteristics of turbulent flow and laminar flow with respect to (a) Variation of 'u' components of velocity (b) Velocity profiles in a pipe using appropriate sketches. [16]

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8. Considering a 2D steady, compressible, viscous, irrotational flow and using Crocco-Busemann relations undermining thermodynamic relations of perfect gases obtain expression for heat flux (q_w) and skin friction (C_h) across turbulent boundary layers. [16]

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SET No - 2

IV B.TECH - II SEMESTER EXAMINATIONS, APRIL/MAY, 2011
BOUNDARY LAYER THEORY
(AERONAUTICAL ENGINEERING)

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

Answer any FIVE questions
All Questions Carry Equal Marks
- - -

1. (a) What are the different forces acting on a fluid particle? Explain the significance of body forces and surface forces with appropriate sketches.
   (b) Derive the continuity equation for model of finite control volume fixed in space with fluid flowing through it. [6+10]

2. (a) Define a fluid and explain the No-slip condition along with the primitive observations made by Prandtl in the conceptual development of boundary layer with suitable sketches.
   (b) Define the following terms (i) Nominal thickness (ii) Displacement thickness (iii) Momentum Thickness & (iv) Energy Thickness. Derive the expression to compute energy thickness with a suitable sketch. [5+11]

3. (a) State Hooke's law. Explain the general stress system across a finite control volume of fluid comparatively that observed for a solid body.
   (b) What are governing equations for fluid flows? Explain their significance and deduce a suitable expression for 3D unsteady, viscous, incompressible, irrotational fluid in the differential form (only the y and z components). [5+11]

4. Consider a 2D steady, rotational flow (essentially fully developed laminar flow) through a straight tube of circular cross-section of radius (r_0) and of straight length (L) (Hagen-Poiseuille flow). Using the exact solution for Navier-Stokes equation, obtain relations for average velocity (V_{max}), discharge (Q) through pipe, shearing stress (τ_r) across cross-section, maximum shearing stress (τ_{max}) at the wall, Total shear force (F_s), Head loss (h_f) and skin friction coefficient (C_f). [16]

5. Derive Prandtl's boundary-layer equations for 2D steady, incompressible laminar flows over a flat plate. [16]

6. (a) Discuss in detail about different zones/layers of turbulent flow past a wall with a neat sketch.
   (b) Obtain heat transfer rate equation across Falkner-Skan flows. [6+10]

7. (a) What do you understand by mean motion and fluctuations experienced during turbulence? Explain in detail steady and unsteady mean motions in a turbulent flow with neat sketches.
   (b) Derive the governing equations for an incompressible viscous turbulent flow. [6+10]

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8. (a) Discuss the significance of pressure field due to a moving source with suitable diagrams.
(b) Write short notes on the following using appropriate sketches (i) Flow separation (ii) Law of the wake and (iii) Boundary layers with pressure gradients. [6+10]

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SET No - 3

IV B.TECH - II SEMESTER EXAMINATIONS, APRIL/MAY, 2011
BOUNDARY LAYER THEORY
(AERONAUTICAL ENGINEERING)

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

Answer any FIVE questions
All Questions Carry Equal Marks
- - -

1. (a) What do you understand by an infinitesimally small fluid element and a finite control volume? Explain with neat sketches each of them for (i) fixed in space (ii) moving along with flow.
(b) Derive the continuity equation for a model of infinitesimally small fluid element fixed in space using a sketch. [6+10]

2. (a) Explain the significance of viscosity for flow of real fluids in terms of boundary layer growth over different surfaces (i) Flat plate (ii) Cylinder (iii) Sphere with suitable sketches.
(b) Define the following terms (a) Displacement thickness (b) Momentum Thickness & (c) Energy Thickness and derive the expression to compute displacement thickness with a suitable sketch. [5+11]

3. (a) State and explain (i) Hooke's law (ii) Stokes law and (iii) General viscosity law applied with suitable correlations.
(b) What are Navier-Stokes equations? Explain its significance and deduce suitable expression for a 3D unsteady, viscous, incompressible, irrotational fluid in differential form (only the x and z components). [5+11]

4. (a) Discuss the need to obtain exact solution for the Navier-Stokes equations.
(b) For a 2D steady, rotational flow (essentially fully developed laminar flow) between two concentric cylinders of radii (r_1 & r_2) rotating at uniform angular speeds (ω_1 & ω_2) in cylindrical co-ordinates (r,Θ,z) using the exact solution for Navier-Stokes equation, obtain relations for the velocity distribution (V_Θ), shearing stress ($\tau_{r\Theta}$) and torque exerted on the outer cylinder due to viscous shear (T). [4+12]

5. (a) Discuss and analyze with basic correlations flow past a flat plate and a cylinder at zero angle of attack using neat sketch.
(b) Derive thermal-energy integral boundary layer equations (Frankl equations) for 2D unsteady, incompressible laminar flows over a flat plate. [6+10]

6. (a) Derive the solution for momentum-integral equation of boundary layer over a flat plate using Pohlhausen approximate method.
(b) Discuss the Reynolds analogy as a function of pressure gradient with suitable relations. [10+6]

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7. (a) What is turbulence? Discuss in detail the characteristics of turbulent flows using suitable sketches.
   (b) Define and discuss in detail about Isotropic turbulence. Compare velocity profiles in a pipe for laminar and turbulent flows with a neat sketch. [6+10]

8. (a) Discuss about the turbulent flow in pipes and channels with suitable sketches.
   (b) Derive energy equation for a 2D unsteady, viscous, compressible, irrotational fluid in the differential form (for x and y components). [4+12]

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SET No - 4

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BOUNDARY LAYER THEORY
(AERONAUTICAL ENGINEERING)

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

Answer any FIVE questions
All Questions Carry Equal Marks
- - -

1. (a) What do you understand by conservative form and non-conservative form of governing fluid flow equations? Explain them by taking examples.
   (b) Derive the momentum equation assuming the flow model of an infinitesimally small fluid element fixed in space with a neat sketch along x, y, and z directions. [6+10]

2. (a) Define boundary layer? Explain the development of boundary layer over a flat plate in a completely viscous flow with a neat sketch.
   (b) Define the following terms (a) Displacement thickness (b) Momentum Thickness & (c) Energy Thickness and derive the expression to compute momentum thickness with a suitable sketch. [5+11]

3. (a) State and explain (i) Hooke's law and (ii) General viscosity law applied for solids and fluids with suitable correlations.
   (b) What are Navier-Stokes equations? Explain its significance and deduce suitable expression for a 3D unsteady, viscous, incompressible, irrotational fluid in differential form (only the x and y components). [5+11]

4. (a) Consider 2D steady flow past/around a sphere with a very low velocity velocity (U) in cylindrical co-ordinates (r,Θ,z). Using the exact solution for Navier-Stokes equation, obtain relations for corresponding velocity components (V_r & V_Θ), vorticity (ω), pressure/surface forces (P), viscous stressess ($\tau_{r\Theta}$, $\tau_{r\Psi}$ & τ_{rr}), drag force (D or F), and drag coefficient (C_D).
   (b) What is the significance of Reynolds number? Discuss briefly about low and high speed Reynolds numbers in various fluid flows. [12+4]

5. (a) Explain the development of boundary layer over a flat plate in a complete viscous flow with a neat sketch.
   (b) What do you understand by laminar flows? Derive mechanical-energy integral boundary layer equations (Leibenson equations) for 2D unsteady, incompressible laminar flows over a flat plate. [4+12]

6. (a) Discuss in detail about the three basic approaches adopted in thermal boundary layer calculations.
   (b) Using the integral energy equation obtain the exact analytical solution for it. [6+10]

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7. (a) Discuss in detail about mean motion and fluctuations encountered in turbulence using suitable sketches.
   (b) Discuss in detail about the six different events occurring during transition from laminar flow to turbulent flow with suitable sketches. [6+10]

8. (a) Discuss the importance of turbulent boundary layers across compressible flows.
   (b) Derive x and y component momentum equations for a 2D unsteady, viscous, compressible, irrotational fluid in the differential form. [4+12]

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