

UNIVERSITY OF NOTRE DAME
DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

Professor H. M. Atassi
113 Hessert Aerospace Center
Tel: 631-5736
Email:atassi@nd.edu

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Advanced Aerodynamics

TOPICAL OUTLINE

Introductory Concepts

- History and Objectives.
- Aerodynamic Variables.
- Forces and Moments
- Dimensional Analysis.
- Real and Ideal Flows.
- The Mach Number: Subsonic, Transonic, and Supersonic Flows
- Bluff and Streamlined Bodies.
- Aerodynamic Coefficients.

Fundamental Equations

- Eulerian and Lagrangian Representations.
- The Material Derivative.
- The Continuity equation.
- The Momentum Equations
- The Energy Equation.
- Navier-Stokes Equations.
- Euler Equations for Inviscid Flows.
- Boundary Conditions.
- Circulation (Kelvin Theorem), Vorticity, Bernoulli's Equation.

Irrotational Incompressible Flows

- Fundamental Solutions: Source, Dipole, Point Vortex, Vortex Filament.
- Law of Biot and Savart.
- Method of Images.
- Two-Dimensional Flows: Analytic Functions Representation.
- Vortex Flow.
- Flow Around a Cylinder.
- Conformal Mapping.

Two-Dimensional Airfoil Theory

Airfoil Characteristics: Camber, Thickness.
The Kutta Condition.
The Kutta-Joukowski Theorem.
Flow Around an Airfoil.
Thin Airfoil Approximation: The Vortex Sheet
The Source Panel Method.
The Vortex Panels Method.
Cambered and Flapped Airfoils.
Modern Low-Speed Airfoils.
Cascade Flow.

Finite Wings

Downwash and the Induced Drag.
Fundamental Equations of Finite wing Theory.
Comparison with Experiments.

Three-Dimensional Incompressible Flow

Three-Dimensional Source and Doublet.
Flow over a Sphere.
Comparison with Experiments.

Compressible Flows

Thermodynamic and Energy Relations.
Normal Shock Waves
Oblique Shock and Expansion Waves.

Airfoils in Subsonic Flows

Potential Flows.
Linearized Theory.
Prandtl-Glauert Transformation.
Critical Mach Number.
Goethert Rule.
Swept Wings.

Airfoils in Transonic and Supersonic Flows

The Method of Characteristics.

Linearized Supersonic Flows.
Drag and Lift in Supersonic Flow.
Transonic Similarity Law.
Drag and Lift in Transonic Flow.

Equations of Motion of Unsteady Flows

Continuity, Momentum and Energy Equations.
Boundary conditions on a Solid Surface in Motion.
Kinetic Energy - Virtual Mass.
Cylinder Moving in Unbounded Fluid.
Irrotational Motion
Sources and Vortices - Vortex Sheet - Vortex Street.
Large Structure Rotational Motion.

Application to Aeroacoustics and Aeroelasticity

Aerodynamic Noise.
Flutter and Forced Vibrations.