AE 3021 High Speed Aerodynamics

Catalog Description: AE 3021 High Speed Aerodynamics. 3-0-3. Compressibility effects on airfoil and wing aerodynamics; supersonic potential flow; method of characteristics; boundary layer effects on airfoil and wing performance.
Coordinator: L. N. Sankar, Regents' Professor

Text: At the level of: Fundamental of Aerodynamics by Anderson or Bertin and Smith, 2nd Edition. Typed notes.

Learning Objectives

Learn to account for compressibility effects, assuming that the incompressible aerodynamic characteristics of airfoils, wings or bodies of revolution are known. Learn to estimate viscous drag characteristics of airfoils and wings in attached turbulent flow. Learn how to model 2-D supersonic flow including nozzle design.

Prerequisites:
Calculus; computer programming using MATLAB or equivalent; AE 3020, AE 3040.

Lecture Topics

Week 1: Review of Governing Equations (continuity, momentum, energy)
- Crocco's theorem
- Irrotationality
- Derivation of compressible potential flow equation.

Week 2: Supersonic Potential Flow
- Method of characteristics.
- Application of M.O.C. e.g. Flow through diverging ducts; flow over airfoils; underexpanded 2-D jets.

Week 3: Continuation of applications from Week 2;
- Nozzle design.
- Computer project assignment requiring design or analysis of supersonic flow.

Week 4: Exam
- Small disturbance assumptions.
- Derivation of small disturbance form of potential flow equations.

Week 5: Subsonic Flow over Airfoils
- Prandtl-Glauert Rule
- Gothert's Rule
- Corrections for sweep

Week 6: Subsonic Flow over Wings
- Gothert's Rule
- Modifications to lifting line analysis to include compressibility effects.

Week 7:Exam
- Subsonic Potential Flow over Body of Revolution using Gothert's Rule.

Week 8: Supersonic Potential Flow over slender bodies of revolution
- Closed form expressions for Cp, Cd
- Area Rule.

Week 9: Transonic Effects
- Finding Critical Mach Number of airfoils and bodies of revolution
- Drag divergence; elimination of drag rise by sweep, area rule, supercritical airfoils.

Week 10: Exam
- Review of boundary layer equations.
- Approximate methods for solving boundary layer equations.

Week 11: Thwaites' Method (Computer program for use of Thwaites' method given).
- Von Karman's integral equation method.
- Application to flat plate, Howarth flow, Flow over cylinder, etc.
- Compressibility corrections

Week 12: Transition
- Factors affecting transition
- Empirical methods for transition estimate.

Week 13: Turbulent Flows
- Physics of turbulence
- Reynolds averaging of boundary layer equations
- Boussinesq hypothesis
- Eddy viscosity models.

Week 14-15: Approximate methods for computing turbulent boundary layer - Head's entrainment method
- Squire-Young formula for drag. (Computer program for Head's method given).
- Compressibilty corrections
- Construction of drag polar for airfoils