# High Speed Aero Dynamics - Video course

## COURSE OUTLINE

The course is designed as a core course for the undergraduate students of Aerospace engineering and contains the basic material essential for a foundation of compressible flow aerodynamics. The course introduces the fundamental concepts and principles of compressible flow and intends to provide the necessary background for advanced studies on the subject. A number of application problems are incorporated to illustrate the concepts. The course covers the general principles and essentials of compressible flow, the flow equations, one-dimensional gas dynamics, wave motion and waves in supersonic flow, flow in ducts, small-perturbation theory, method of characteristics and similarity rules. The exercises included in the course are intended to demonstrate the use of the course material and to outline additional equations and results. Even though the course is prepared mainly for the use of undergraduate students in aerospace engineering, it will also be useful to graduate students, teachers and practicing engineers and scientists.

**Contents:** Basic concepts of compressible flow, Governing equations of compressible flow, One-dimensional gas dynamics, Normal shock, Linear and nonlinear wave motion, Flow in ducts, Oblique shock and expansion, Interaction of waves, Shock-expansion theory, Small-disturbance theory, Linearized subsonic and supersonic flow, Method of characteristics, The similarity rules of high-speed flow and determination of critical Mach number of transonic flow.

## COURSE DETAIL

| Sl. No | Topic | No. of Hours |
|---|---|---|
| 1 | Basic concepts of compressible flow - continuity, energy and momentum equations; One-dimensional inviscid flow; Stagnation quantities; Isentropic conditions; Speed of sound and Mach number; Isentropic relations; Area-velocity relation | 06 |
| 2 | Flow through constant area duct; Normal shock; Propagating Normal Shock | 02 |
| 3 | One-dimensional linear and nonlinear wave motion; Linear and Nonlinear Shock tube | 05 |
| 4 | Oblique shock and supersonic compression by turning; Weak shocks and Mach waves; Supersonic expansion by turning; Prandtl-Meyer expansion fan; Reflection and intersection of shocks; Shock detachment and bow shock; Shock-Expansion theory with application to thin airfoils | 06 |
| 5 | Flow through converging and converging-diverging ducts; Flow through constant area duct with friction (Fanno flow) and Flow through constant area duct with hear addition (Rayleigh flow) | 07 |

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Aerospace Engineering

**Pre-requisites:**

Fluid Mechanics/Introduction to Aerodynamics, Engineering Thermodynamics, Low-Speed Aerodynamics

**Coordinators:**

**Dr. K.P. Sinhamahapatra**
Department of Aerospace EngineeringIIT Kharagpur

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| 6 | Relation between vorticity and entropy – Crocco's equation; Compressible potential flow; Potential and Stream functions; Linearized subsonic and supersonic flow theory; Small Perturbation Equation – Subsonic, Supersonic and Transonic flows; Ackeret's problem; Supersonic thin airfoil theory | 06 |
| 7 | Slender body theory; Singularity solutions; Affine transformation | 02 |
| 8 | Method of characteristics; Compatibility equations and method of solutions for isentropic and non-isentropic flows; Method of finite waves | 03 |
| 9 | Similarity rules for subsonic, supersonic and transonic flows; Critical Mach number of an airfoil | 03 |
| | **Total** | **40** |

**References:**


1. A H Shapiro, Dynamics and Thermodynamics of Compressible Fluid Flow-Volume I & II, Ronald Press
2. H W Liepmann and A Roshko, Elements of Gas Dynamics, John Wiley & Sons
3. J D Anderson, Jr., Modern Compressible Aerodynamics, McGraw-Hill International