Gas Dynamics - Web course

COURSE OUTLINE

This course essentially deals with the very high speed fluid flows, mainly the flows in the regime of supersonic speed. Hence understanding of this flow regime and its characteristic signatures is the objective of this course.

Theoretical understanding of this subject along with the experimental introduction is very useful for advanced studies like missile and reentry aerodynamics and hypersonic aerothermodynamics. Hence, inorder to build the basic platform, this course starts with basic governing equations of the fluid flows.

Modifications of these equations for simplified studies of one dimensional flow and certain special cases like Rayleigh flow and Fanno flow are introduced afterwards. One more example of one dimensional flow as normal shock wave follows the same chapter.

Concept of oblique shock as a consequence of two dimensional flows along with various conditions is the part of next chapter. Expansion of the supersonic flow and basic governing equations are also part of the two dimensional flows.

Quasi-one dimensional flow and understanding of supersonic nozzle and diffuser follows this. Unsteady flows and method of characteristics with itsapplication ends the theoretical understanding in the course. However this course ends with the introduction to various experimental facilities of this flow regime.

Contents: Basic concepts of thermodynamics, governing equations in various forms, concept of Mach number, one dimensional flows and normal shock wave, Reylaigh and Fanno flows, Two dimensional flows and oblique shock waves, θ-B-M relations, understanding of shock interaction and shock reflection with various graphs, Prandtl- Mayer expansion, shock-expansion theory, quasi one dimensional flows, method of characteristics and, unsteady wave motion and introduction to various experimental facilities for these speed ranges.

COURSE DETAIL

Sl.No	Topics	Hours
1.	**Basic concepts :** Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Integral forms of conservation equations, Differential conservation equations, Continuum Postulates, Acoustic speed and Mach number, Governing equations for compressible flows.	4
2.	**One-dimensional compressible flow:** One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine-Hugonoit equations, Rayleigh flow, Fanno flow, Crocco's theorem.	5
3.	**Two-dimensional flows:** Oblique shock wave and its governing equations, θ-B-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and	5

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Mechanical Engineering

Pre-requisites:

- Fluid Dynamcis and Thermodynamics.

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	cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.	
4.	**Quasi-one dimensional flows:** Governing equations, Areavelocity relations, Isentropic flow through variable-area ducts, Convergent-divergent (or De Laval) nozzles, Over-expanded and under-expanded nozzles, Diffusers.	3
5.	**Unsteady wave motions:** Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic theory, Incident and reflected waves, Shock tube relations, Piston analogy, Incident and reflected expansion waves, Finite compression waves, Shock tube relations.	3
6.	**Introduction to experimental facilities:** Subsonic wind tunnels, Supersonic wind tunnels, Shock tunnels, Free-piston shock tunnel, Detonation-driven shock tunnels, and Expansion tubes.	2

References:

1. John D. Anderson Jr (1990),**Modern Compressible Flow with Historical Perspective**, McGraw-Hill, Singapore.
2. Liepmann HW and Roshko A (1957), **Elements of Gas Dynamics,** John Wiley & Sons, Inc., New York.
3. Shapiro A (1954) **The Dynamics and Thermodynamics of Compressible Flow**, Ronald Press, London.