GASDYNAMICS: FUNDAMENTALS AND APPLICATIONS

PROF. SRISHA RAO M V
Department of Aerospace Engineering
IISc

TYPE OF COURSE: New | Elective | UG/PG
COURSE DURATION: 12 Weeks (18 Jan’ 21 - 09 Apr’ 21)
EXAM DATE: 24 Apr 2021

PRE-REQUISITES: Fluid Dynamics, Thermodynamics, Solution of ODE and PDE, Basic numerical techniques.

INTENDED AUDIENCE: Engineering students of Aerospace, Mechanical, Chemical, Applied Mechanics can take this course. Students of Physical sciences also can take the course.

INDUSTRIES APPLICABLE TO: ISRO, DRDO, HAL, Brahmos Aerospace, Bharath Dynamics, Triveni Turbines, Bellatrix Aerospace

COURSE OUTLINE:
In the previous century, humanity quickly moved from enabling mechanical flight to flying farther, higher, and faster. Now, humanity is endeavoring to explore and colonize other planets. Similarly, engineers are seeking to make compact and efficient systems in the domains of energy and power. All these scenarios and several more, including natural events like explosive volcanic eruptions, involve the high-speed Flow of gases. Speeds at which the compressible nature of gases becomes significant. In this course on the fundamentals and applications of gasdynamics, we shall understand and model the compressible flow phenomena of gases from first principles.

ABOUT INSTRUCTOR:
Srisha Rao M V is currently an Assistant Professor at the Department of Aerospace Engineering, Indian Institute of Science, Bengaluru. He completed his ME and Ph.D. from the Indian Institute of Science and has done post-doctoral research in Muroran Institute of Technology, Japan. His research interests lie in supersonic and hypersonic flows, experimental high-speed aerodynamics, optical flow diagnostics, and data analytic techniques. He has designed and established several unique testing facilities such as the supersonic ejector test facility, high-speed gaseous mixing test facility, and the nozzle-isolator interaction test facility. Recently, he has worked on image analytics for unsteady flow analysis and start-unstart characterization of hypersonic intakes.

COURSE PLAN:
Week 1: Introduction (Why study gasdynamics, Mach number, and flow regimes) Thermodynamics (Review of basics, Calorifically perfect gas, and Thermally perfect gas)
Week 2: Flow Equations (Integral forms and Differential forms) Quasi-1D Flow (The quasi-1D approximation, speed of sound) Isentropic Flow (Stagnation properties and Star properties, Compressible Pitot)
Week 3: Normal Shock Wave (principle and derivation of flow properties across the normal shock, Rayleigh Pitot formula) Moving Shock Wave and its Reflection
Week 4: Unsteady 1D flow and the shock tube Oblique Shock Wave Prandtl Meyer Expansion (Shock-expansion analysis of diamond airfoil)
Week 5: Compressible flow through variable area ducts (choking phenomena, normal shock in supersonic flow) Nozzle flow and Operating points (underexpanded and overexpanded flow)
Week 6: Diffuser flow and flow starting High-speed wind-tunnel operation High-speed air intakes and their characteristics
Week 7: One Dimensional Flow with Friction Fanno flow
Week 8: One Dimensional Flow with Heat Addition Rayleigh flow
Week 9: Generalized Quasi-1D Flow (a typical example of nozzle flow with friction, and heat release in variable area duct) Velocity Potential Equation for compressible flow
Week 10: Small perturbation theory and applications Method of Characteristics (MOC) for Steady Supersonic Flows
Week 11: Design of supersonic nozzle contour using MOC
Week 12: Introduction to Shock-wave boundary layer interaction (Special topic) Introduction to Hypersonic flow (Special topic)