HIGH SPEED AERODYNAMICS

V Semester: AE									
Course Code	Category	Hours / Week			Credits	Maximum Marks			
AAEC16	Core	L	T	P	C	CIA	SEE	Total	
		3	1	-	4	30	70	100	
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60			
Prerequisite: Aerodynamics									

I. COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of high-speed aerodynamics (Compressible aerodynamics). The high-speed aerodynamics is the first course for graduate and undergraduate students in Aerospace Engineering. The precise algorithm, mathematical derivation, numerical solutions is also the primary objective of this subject. The experimental techniques and its applications are taught to meet the requirements of industry need. The course consists of a strong mathematical component in addition to the design of various concepts. A number of problems/examples will be cited to enhance the understanding of the subject matter and besides, many unsolved problems willbe provided with answers to further learning.

II. COURSE OBJECTIVES:

The student will try to learn:

I. Basic concepts of compressible flow, governing equations of compressible flow, compressibility effect at high speeds and their importance on the design of high-speed vehicles

II. The wave formations, propagation in supersonic flow field and their resultant effect on flow properties variations.

III. The Method of characteristics, compatibility equations and method of solutions for isentropic and non-isentropic flows

IV. The various experimental methods and measurement techniques utilized in compressible flow regimes.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Utilize** the basic concepts of gas dynamics for determining how compressibility affects the global and local nature of flow.	Apply
CO 2	**Construct** the equations of change in pressure, density and temperature for determining the nature of compression and expansionwaves.	Apply
CO 3	**Develop** the fundamental equation for one-dimensional and quasi one-dimensional flow of compressible ideal gas.	Apply
CO 4	**Examine** the steady isentropic flow, flow with friction and flow withheat transfer for solving problems in flow through one-dimensional passage..	Analyze
CO 5	**Analyze** the airfoils at subsonic, transonic and supersonic flight conditions using the perturbed flow theory assumption for solvingcompressible flow over finite wing.	Analyze
CO 6	**Apply** the various optical flow visualization techniques used for capturing compressible flow fields.	Apply

IV. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO COMPRESSIBLE FLOWS (10)

Basic concepts: Introduction to compressible flow, 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.

MODULE –II: SHOCK AND EXPANSION WAVES (12)

Shocks and expansion waves: Development of governing equations for normal shock, stationery and moving normal shock waves, applications to aircrafts, supersonic wind tunnel, shock tubes, shock polars, supersonic pitot-probes; oblique shocks, governing equations, reflection of shock, Prandtl-Meyer expansion flow, shock expansion method for flow over airfoil, introduction to shock wave boundary layer interaction.

MODULE –III: ONE DIMENSIONAL AND QUASI ONE DIMENSINAL FLOW (9)

Quasi one-dimensional flow: sentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slip streamline. One dimensional flow: Flow in constant area duct with friction and heat transfer, Fanno flow and Rayleigh flow, flow tables and charts for Fanno flow and Rayleigh flow.

MODULE –IV: APPLICATIONS OF COMPRESSIBLE FLOWS AND NUMERICAL TECHNIQUES (9)

Small perturbation equations for subsonic, transonic, supersonic and hypersonic flow; Experimental characteristics of airfoils in compressible flow, supercritical airfoils, area rule; Theory of characteristics, determination of the characteristic lines and compatibility equations, supersonic nozzle design using method of characteristics.

MODULE –V: EXPERIMENTAL METHODS IN COMPRESSIBLE FLOWS (08)

Experimental methods: Subsonic wind tunnels, supersonic wind tunnels, shock tunnels, free-piston shock tunnel, detonation-driven shock tunnels, and expansion tubes and characteristic features, their operation and performance, flow visualization techniques for compressible flows.

V. TEXT BOOKS:

1. Radhakrishnan Ethirajan, “Gas Dynamics”, John Wiley & Sons, 7th Edition, 2020.
2. John D. Anderson, “Modern Compressible flow with historical perspective”, McGraw-Hill Education, 3rd Edition, 2002.

VI. REFERENCE BOOKS:

1. Ascher H. Shapiro, “The Dynamics and Thermodynamics of Compressible Fluid Flow”, John Wiley & Sons; Volume 1, 4th Edition, 1977.
2. John D. Anderson, “Fundamentals of Aerodynamics”, McGraw-Hill Education, 6th Edition, 2016.

VII. WEB REFERENCES:

1. https://www.slideshare.net/lccmechanics/high-speed-aerodynamics
2. https://en.wikipedia.org/wiki/High-speed_flight

VIII. E-TEXT BOOKS:

1. https://www.ebooksdirectory.com/details.php?ebook=8565