HIGH SPEED AERODYNAMICS

V Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAEB15	Core	3	1	-	4	30	70	100
Contact Classes: 33	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 48		

OBJECTIVES:

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 ofsolutions for isentropic and non-isentropic flows

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

COURSE OUTCOMES:

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

CO 1 **Recall** the basic concepts in aero-thermodynamic and fluid mechanicsfor describing various flow phenomenon

CO 2 **Explain** the basic concepts of gas dynamicsfor determining how compressibility affects the global and local nature of flow

CO 3 **Demonstrate**the wave formation in the supersonic flow fieldfor determining the nature of shock and expansion wave

CO 4 **Construct the equations of change in pressure, density and temperature**for determining the nature of compression and expansion waves.

CO 5 **Illustrate**the wave formation on wedge shaped and concave cornersfor solving complex problems in supersonic vehicles.

CO 6 **Develop**the fundamental equation for one-dimensional and quasi one-dimensional flowof compressible ideal gas.

CO 7 **Analyze** the steady isentropic flow, flow with friction and flow with heat transferfor solving problems in flow through one-dimensional passage.

CO 8 **Build** the small perturbation equationsfor subsonic, transonic, supersonic and hypersonic flow

CO 9 **Apply** the concept of method of characteristicsfor the design of supersonic nozzle.

CO 10 **Illustrate** the different wind tunnel configurations utilizedfor subsonic and supersonic applications

CO11 **Demonstrate**the various optical flow visualization techniques usedfor capturing compressible flow fields.

CO 12 **Analyze**a supersonic intake for real world application for determining their performance characteristics.

Module-I	INTRODUCTION TO COMPRESSIBLE FLOWS
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**
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	**DIMENSIONAL AND QUASI ONE DIMENSINAL FLOW**
Quasi one-dimensional flow: Isentropic 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**
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**
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	

Textbooks:

1. John D. Anderson, ―Modern Compressible flow with historical perspective‖, McGraw-Hill Education, 3rd Edition, 2002.
2. John D. Anderson, ―Fundamentals of Aerodynamics‖, McGraw-Hill Education, 6th Edition, 2016.

Reference Books:

1. Ascher H. Shapiro, ―The Dynamics and Thermodynamics of Compressible Fluid Flow‖ John Wiley & Sons; Volume 1 ed. Edition, 1977.
2. RadhakrishnanEthirajan, ―Gas Dynamics‖, John Wiley & Sons, 2nd edition 2010.

E-Text Books:

1. https://bookboon.com/en/engineering-fluid-mechanics-ebook
2. https://www.slideshare.net/asifzhcet/fluid-mechanics-and-hydraulic-machines-dr-r-k-bansal
3. https://eprints.staffs.ac.uk/222/1/engineering-fluid-mechanics%5B1%5D.pdf
4. https://www.engr.uky.edu/~acfd/me330-lctrs.pdf