

## AERODYNAMICS OF FLIGHT VEHICLES

(CORE COURSE- I)

<b>I Semester: AEROSPACE ENGINEERING</b>								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P		C	CIE	SEE
<b>B27601</b>	<b>CC</b>							
		3	-	-	3	30	70	100
<b>Contact Classes: 63</b>		<b>Tutorial Classes: Nil</b>		<b>Practical Classes: Nil</b>		<b>Total Classes: 63</b>		
<p><b>AIM:</b> To impart knowledge in fundamental aspects of aerodynamics of flight vehicles operating at low and high speeds</p> <p><b>OUTCOME:</b> The skills obtained will help students in the aerodynamic design and analysis of flight vehicles for both incompressible and compressible flows</p>								
<b>UNIT-I</b>	<b>AERODYNAMIC CHARACTERISTICS OF AIRFOILS AND FLOW AROUND FINITE WINGS</b>						<b>Classes: 12</b>	
Circulation, irrotational flow, Stokes theorem, velocity potential, point vortex, vortex filament, Biot and Savart law, bound vortex, Kutta condition; Vortex sheet, Vortex sheet in thin-airfoil theory, Planar wing, Properties of symmetrical airfoil, Properties of cambered airfoil, Flapped airfoil, Finite Wing : Flow fields around finite wings, Downwash and induced drag, Fundamental equations of finite-wing theory, Elliptical lift distribution, Arbitrary circulation distribution, Twisted wing: Basic and Additional lift, Approximate calculation of additional lift, Winglets								
<b>UNIT-II</b>	<b>AIRFOILS, WINGS AND WING-BODY COMBINATIONS IN COMPRESSIBLE FLOW</b>						<b>Classes: 13</b>	
Compressible flow field, Mach waves, normal shock wave, oblique shock waves, Prandtl-Meyer flow; Linearized Compressible Flow: Flow equation for small perturbations, steady supersonic flows, pressure coefficient for small perturbations; Airfoils in compressible flows: Boundary conditions, Airfoils in subsonic flow: Prandtl-Glauert transformation, Critical Mach number, Airfoils in transonic flow, Airfoils in supersonic flow; Wings and bodies in compressible flows: Prandtl-Glauert-Goethert transformation, Influence of sweepback, Design rules for wing-fuselage combinations.								
<b>UNIT-III</b>	<b>LAMINAR BOUNDARY LAYER IN COMPRESSIBLE FLOW</b>						<b>Classes: 12</b>	
Viscous boundary layer, boundary layer equation of motion, Conservation of energy in the boundary layer, Rotation and entropy gradient in the boundary layer, Similarity considerations for compressible boundary layers, Solution of energy equation for Prandtl number unity, Temperature recovery factor, Heat transfer versus skin friction, Velocity and temperature profiles and skin friction, Effects of pressure gradient								
<b>UNIT-IV</b>	<b>FLOW INSTABILITIES AND TRANSITION FROM LAMINAR TO TURBULENT FLOW, AND TURBULENT FLOWS</b>						<b>Classes: 13</b>	
Gross effects, Reynolds experiment, Tollmien-Schlichting instability and transition, Natural laminar flow and laminar flow control, Stability of vortex sheets, Stratified flows, Transition phenomenon, Methods for experimentally detecting transition, Flow around spheres and circular cylinders Turbulent Flows: Description of turbulent field, Statistical properties, Conservation equations, Laminar sub-layer, Fully developed flows in tubes and channels, Constant-pressure turbulent boundary layer, Turbulent drag reduction, Effects of pressure gradient, Stratford criterion for turbulent separation, Effects of compressibility on skin friction, Reynolds analogy: Heat transfer and temperature recovery factor, Free turbulent shear flows								

<b>UNIT-V</b>	<b>AIRFOIL DESIGN, MULTIPLE SURFACES, VORTEX LIFT, SECONDARY FLOWS, VISCOUS EFFECTS</b>	<b>Classes: 13</b>
Airfoil design for high $C_{lmax}$ , Multiple lifting surfaces, Circulation control, Stream wise vortices, Secondary flows, Vortex lift: Strakes, Flow about three-dimensional bodies, Unsteady lift		
<b>Text Books:</b>		
1. Foundations of Aerodynamics: Bases of Aerodynamic Design, Arnold M. Kuethe and Chuen-Yen Chow, John Wiley & Sons, Inc., Fifth Edition, 1997		
<b>Reference Books:</b>		
1. Fundamentals of Aerodynamics, Anderson, Jr., J. D. , McGraw-Hill, 2001 2. Aerodynamics for Engineers, fifth edition, Bertin, J.J., Cummings, R. M., Pearson, 2009		