AEOE4001 INTRODUCTION TO AERODYNAMICS (3-0-0)

Course Objectives:

1. To introduce the fundamental principles of fluid flow and aerodynamic phenomena.
2. To understand aerodynamic forces and moments acting on bodies moving through air.
3. To study air foil characteristics and wing aerodynamics.
4. To analyze aerodynamic drag, lift generation, and vehicle aerodynamic performance.
5. To familiarize students with modern aerodynamic testing and computational techniques.

Module I: Fundamentals of Fluid Flow and Aerodynamics (9 Hours)

Introduction to aerodynamics and its applications in aerospace and automotive engineering. Properties of fluids. Fluid statics and fluid dynamics. Flow visualization techniques. Types of flow: steady and unsteady, uniform and non-uniform, laminar and turbulent, compressible and incompressible flows. Streamlines, path lines and streak lines. Continuity equation. Bernoulli's equation and its applications. Reynolds number and flow similarity. Introduction to boundary layer theory and flow separation.

Module II: Aerodynamic Forces and Flow Around Bodies (9 Hours)

Pressure distribution around immersed bodies. Aerodynamic forces and moments. Lift, drag and side force. Pressure drag and skin friction drag. Flow over cylinders, spheres and bluff bodies. Wake formation and vortex shedding. Centre of pressure and aerodynamic center. Dimensional analysis and similarity principles. Wind effects on moving vehicles. Aerodynamic stability concepts.

Module III: Air foil and Wing Aerodynamics (9 Hours)

Introduction to air foils and aerofoil nomenclature. Air foil geometry and classification. Lift generation mechanism. Circulation theory and Kutta–Joukowski theorem. Pressure distribution over air foils. Lift and drag coefficients. Angle of attack and stall phenomenon. Finite wing theory. Aspect ratio and wing efficiency. Induced drag. High-lift devices such as flaps and slats. Applications of wing aerodynamics in transportation systems.

Module IV: Automotive Aerodynamics (9 Hours)

Importance of aerodynamics in road vehicles. Aerodynamic drag and fuel economy. Vehicle drag coefficient and its significance. Flow over passenger cars, commercial vehicles, and racing vehicles. Aerodynamic lift and vehicle stability. Underbody aerodynamics. Cooling airflow management. Crosswind effects. Rear spoilers, diffusers, vortex generators, and aerodynamic aids. Noise generation due to airflow. Aerodynamic considerations in electric vehicles and high-speed transportation.

Module V: Aerodynamic Testing and Computational Methods (9 Hours)

Wind tunnel testing and instrumentation. Types of wind tunnels. Measurement of lift, drag and pressure distribution. Flow visualization techniques using smoke, tufts and particle image velocimetry. Data acquisition systems. Introduction to Computational Fluid Dynamics (CFD). Mesh generation and boundary conditions. Applications of CFD in vehicle and aircraft design. Aerodynamic optimization. Emerging trends in active aerodynamics and smart flow control systems.

Course Outcomes (COs): On successful completion of the course, students will be able to:

CO1: Explain the basic principles of fluid mechanics and aerodynamic flow behaviour.
CO2: Analyze aerodynamic forces and pressure distribution on various bodies.
CO3: Evaluate lift and drag characteristics of air foils and wings.
CO4: Assess aerodynamic performance of automobiles and aircraft using experimental methods.
CO5: Apply computational and wind tunnel techniques for aerodynamic analysis and design.

Text Books:

1. John D. Anderson Jr., Fundamentals of Aerodynamics, McGraw-Hill Education.
2. Houghton, E.L. and Carpenter, P.W., Aerodynamics for Engineering Students, Butterworth-Heinemann.
3. Katz, J. and Plotkin, A., Low-Speed Aerodynamics, Cambridge University Press.

Reference Books:

1. Bertin, J.J. and Smith, M.L., Aerodynamics for Engineers, Pearson Education.
2. Cengel, Y.A. and Cimbala, J.M., Fluid Mechanics: Fundamentals and Applications, McGraw-Hill.
3. Hucho, W.H., Aerodynamics of Road Vehicles, SAE International.
4. Pope, A. and Harper, J.J., Low Speed Wind Tunnel Testing, Wiley.
5. White, F.M., Fluid Mechanics, McGraw-Hill Education.
6. Katz, J., Race Car Aerodynamics, Bentley Publishers.