JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
II Year B.Tech. AE - II Sem L T/P/D C
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(A42102) AERODYNAMICS - I

Objective:

The student will learn basic principles on how determinate pressure, force and moments acting on airfoils and wings in low speed flights.

UNIT - I

Review of Fluid Mechanics: Importance of Aerodynamics, Fundamental aerodynamics variables and dimensional analysis(statement of buckinghan - π theorem) leading to force & moment coefficient and dimesionless similarity parameters floe, compressible flow and Mach number- Continuity & mementum equations in differential form. Euler equation, viscosity, Navier Stokes equation, Reynolds number as an order - of - magnitude measure of ratio of Inertia force to viscous forces.

UNIT - II

Inviscid Incompressible Flows: Large Reynolds number flows, Prandtl's Boundary Layer Hypothesis, viscous boundary layer flow and inviscid external flow. Justification of inviscid flow analuysis. Angular Velocity, Vorticity and circulatio, Kelvin Theorem and irrotational flow velocity potential, Stream function, Laplace equation, boundary condition at infinity and wall, Elementary flows and their combinations, flow past circular cylinder - non lifting cases, lifting case & Magnus effect, the spinning tennis ball, D'Alembert's Paradox, Kutta - Joukowsky theorem - circular cylinder with vortex, airfoil as an arbitary cylinder with a sharp trailing edge, kutta condition. Kelvin's circulation theorem & starting vortex, concept of small perturbation & thin airfoil theory - linearization of the boundary condition, resolution of thin airfoil problem into lifting & nonlifting cases, their soultions by method of singularity distribution, the aerodynamic center, the center of pressure, load representation.

UNIT - III

Viscous Flow and Boundary Layer: Role of viscosity in fluid flow. Boundary layer growth along a flat plate and nearly flat surface, displacement thickness and patching of inviscid external flow to viscous boundary layer flow, laminar boundary layer, transition and turbulent boundary layer, skin friction drag by integration to tangential stress & pressure dragby integration of normal stress, factors influencing boundary layer separation - adverse pressure gradient and sharp bending / turning of surface. Real (Viscous) flow and variation of drag coefficient with Reynolds number for circular cylinder.

Real (viscous) flow and importance of skin friction drag airfoils. Effect of transition and surface roughness on airfoils, N - S equation, Boundary layer approximation, Blasius solution for the flat plate problem. Definition of momentum thickness & derivation of Von karman's momentum equation.

UNIT - IV

Invicid Flow over Wings & Panel Methods: Vortex filament statement of Helmholtz's vortex theorems, Biot - Savart Law, starting, bound & trailing vortices of wings, Lanchester's experiment, Prandtl's Lifting line theorem - downwash and indiced drag, Elliptic loading & wings of elliptic platforms, expression for induced drag, minimum induced drag for Elliptic platform. Source and vortex panel methods for airfoils. Replacement of an airfoil by a concentrated vortex at quarter - chord point, importance of three - quarter chord point for discretization, use of quarter chord and three - quarter chord points in vortex panel method for wings.

UNIT - V

Applied Aerodynamics & Introduction to Propellers: Critical March number & Drag Divergence, drag reduction & lift augmentation - Sweep, winglets, Flaps, slats and vortex generators. Propellers: Concept of slip stream with only axial velocity, Actuator disk theory due to Ranking & Froude; power & thrust coefficients, why the propeller is twisted by blade element analysis, blade angle, advance ratio and Torque coefficient, efficiency, how to read propeller chart.

TEXT BOOKS

1. Aerodynamics for Engineers, fourth edition, Bertin, J.J., Pearson Education, 2012, ISBN: 81-297-0486-2.
2. Fundamentals of Aerodynamics, Anderson, Jr., J.D., International edition, McGraw Hill, 2001, ISBN: 0-07-118146-6.
3. Kuethe, A.M., and Chow, C., Foundations of Aerodynamics, 5th Edn, Wiley, 1998, ISBN: 0-471-12919-4.
4. Karamcheti, Krishnamurthy, Idea fluid Aerodynamics.

REFERENCES

1. Kuchemann, D., The Aerodynamic Design of Aircraft, Pergamon, 1978.
2. Shevell, R.S., Fundamentals of Flight, Indian reprint, Pearson Education, 2004, ISBN: 81-297-0514-1.
3. McCormick, B.W., Aerodynamics, Aeronautics & Flight Mechanics second edition John Wiley, 1995, ISBN: 0-471-575062.