Course Category:
Programme core

a. Preamble:
The primary objective of this course is to teach students how to determine aerodynamic lift and drag over an airfoil and wing at incompressible flow regime by analytical methods.

b. Prerequisite Courses:
- Fluid Mechanics

c. Related Courses:
- Airplane Performance
- Compressible flow Aerodynamics
- Aero elasticity
- Flapping wing dynamics
- Industrial aerodynamics
- Transonic Aerodynamics

d. Course Educational Objectives:
- To introduce the concepts of mass, momentum and energy conservation relating to aerodynamics.
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing sections.
- To introduce the basics of viscous flow.

e. Course Outcomes:
Upon the successful completion of the course, students will be able to:

<table>
<thead>
<tr>
<th>CO Nos.</th>
<th>Course Outcomes</th>
<th>Knowledge Level (Based on revised Bloom’s Taxonomy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Apply the physical principles to formulate the governing aerodynamics equations</td>
<td>K3</td>
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<tr>
<td>CO2</td>
<td>Find the solution for two dimensional incompressible inviscid flows</td>
<td>K3</td>
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<tr>
<td>CO3</td>
<td>Apply conformal transformation to find the solution for flow over airfoils and also find the solutions using classical thin airfoil theory</td>
<td>K3</td>
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<tr>
<td>CO4</td>
<td>Apply Prandtl’s lifting-line theory to find the aerodynamic characteristics of finite wing</td>
<td>K3</td>
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<tr>
<td>CO5</td>
<td>Find the solution for incompressible flow over a flat plate using viscous flow concepts</td>
<td>K3</td>
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f. Correlation of COs with POs:

<table>
<thead>
<tr>
<th>COs</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
<th>PO4</th>
<th>PO5</th>
<th>PO6</th>
<th>PO7</th>
<th>PO8</th>
<th>PO9</th>
<th>PO10</th>
<th>PO11</th>
<th>PO12</th>
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<tbody>
<tr>
<td>CO1</td>
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</tbody>
</table>
H- High; M-Medium; L-Low

g. Course Contents:

UNIT-I INTRODUCTION TO LOW SPEED FLOW
Models of the fluid: control volumes and fluid elements. Continuity, Momentum and energy equations. Substantial derivative, Vorticity and circulation, stream function, irrotational flow, velocity potential, Euler equation, incompressible Bernoulli’s equation.

UNIT-II TWO DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW
Laplace Equation, Elementary flows and their combinations, Ideal Flow over a circular cylinder, Alembert’s paradox, Magnus effect, Kutta joukowski’s theorem, real flow over smooth and rough cylinder

UNIT-III AIRFOIL THEORY
Cauchy-Riemann relations, complex potential, methodology of conformal transformation, Kutta-Joukowski transformation and its applications, Kutta condition, kelvin’s circulation theorem, starting vortex, thin airfoil theory and its applications.

UNIT-IV WING THEORY
Vortex filament, Biot-savart law, Helmholtz Theorems bound vortex and trailing vortex, horse shoe vortex, lifting line theory and its limitations.

UNIT-V VISCOUS FLOW
Newton’s law of viscosity, Boundary Layer, Navier-Stokes equation, displacement, Momentum thickness, Flow over a flat plate, Blasius solution.

Total Periods: 45

h. Learning Resources

i. Text Books:

ii. References: