SEMESTER 4

LOW SPEED AERODYNAMICS

Course Code	PBAOT404	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Student should be able to explain and use basic theorems in fluid mechanics, Sketch the stream line and equipotential lines of effective body under the different elementary flow combinations.
2. Student should be able to transform the flow past a body of definite shape , flow past the other related bodies by using complex variables and able to apply theory to predict air foil performance characteristics.

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Concept of control volume and system - Reynold's transportation theorem - Continuity equation, energy equation and momentum equation (Conservation and Non-Conservation forms). Path line, Streamline, Streakline, Irrotational flows, Barotropic flow, Stream function, Potential function, Equipotential line, Circulation and Vorticity, Green's lemma, Elementary flows and their combinations, Stoke's theorem, (Problems)	11
2	Ideal Flow over a circular cylinder, D'Alembert's paradox, Magnus effect, Real flow over smooth and rough cylinders, Kutta Joukowski's theorem, Kutta condition, Kelvin's theorem, Cauchy-Riemann relations, Complex potential, Methodology of conformal transformation, Kutta Joukowski's transformation and its applications, Blasius theorem. (Problems)	11

3	Starting vortex, Thin airfoil theory and its applications. Vortex filament, Biot and Savart law, Bound vortex and Trailing vortex, Horse shoe vortex, Lifting line theory and its limitations. (Problems)	**11**
4	Panel methods-Source and Vortex Panel, Turbulence on spheres, Shape parameter, Boundary layer growth over a flat plate, Propeller Theories- Ideal Momentum and Blade element theory Numerical problems on the performance of propellers using propeller charts.	**11**

Suggestion for Project topics

- Identify shapes which are more aerodynamic by observing the flow patterns in wind tunnel -Need of streamline body.
- Drag force estimation for different Shapes-Dependency of frontal area on drag force.
- Demonstrate flow over a cricket ball, Golf ball, Tennis ball in rotating and non-rotating conditions- Magnus effect
- Test propeller with and without twist- importance of blade twist.

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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x2 =16 marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

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	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand governing equations of incompressible fluid.	**K2**
CO2	Apply transformation techniques to convert physical problem to mathematical models.	**K3**
CO3	Understand the theories to quantify lift produced in airfoil, wing and propeller.	**K2**
CO4	Evaluate the relation of parameters that govern the aerodynamic forces produced on arbitrary bodies due to flow over it.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-					2	2		2
CO2	3	3	-	-					2	2		2
CO3	2	2	-	-					2	2		2
CO4	3	3	3	3					2	2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Aerodynamics	John D Anderson,	McGraw Hill	5th Edition
2	Aerodynamics for Engineering students, 2016	E.L. Houghton P.W. Carpenter & Steven H. Collicott, ,	McGraw Hill	6th Edition
3	Fluid Mechanics,	Frank M. White	McGraw Hill	8th edition
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Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechanics of Flight, 2011	A C Kermode,	Pearson India,	11th edition
2	Aerodynamics for Engineers,	J Bertin,	Pearson Education	7th edition

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PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation / Video Presentation: Students present their results in a 2 to 5 minutes video

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Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	**5**
2	Contribution in Progress Presentations and Question Answer Sessions	**4**
3	Involvement in the project work and Team Work	**3**
4	Execution and Implementation	**10**
5	Final Presentations	**5**
6	Project Quality, Innovation and Creativity	**3**
Total		**30**

Project Assessment and Evaluation criteria (30 Marks)

1. **Project Planning and Proposal (5 Marks)**

   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

   - Active participation and individual contribution
   - Teamwork and collaboration

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4. **Execution and Implementation (10 Marks)**

   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**

   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation
   - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

   - Overall quality and technical excellence of the project
   - Innovation and originality in the project
   - Creativity in solutions and approache