

## SEMESTER 4

### LOW SPEED AERODYNAMICS

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

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Contact Hours</b> |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>1</b>          | 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) | <b>11</b>            |
| <b>2</b>          | 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)                                                                     | <b>11</b>            |

|          |                                                                                                                                                                                                                                                                 |           |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>3</b> | 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)                                                       | <b>11</b> |
| <b>4</b> | 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. | <b>11</b> |

### **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.

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

### **Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Project</b> | <b>Internal Examination-1<br/>(Written)</b> | <b>Internal Examination- 2<br/>(Written )</b> | <b>Total</b> |
|-------------------|----------------|---------------------------------------------|-----------------------------------------------|--------------|
| <b>5</b>          | <b>30</b>      | <b>12.5</b>                                 | <b>12.5</b>                                   | <b>60</b>    |

## 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     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <ul style="list-style-type: none"><li>• 2 Questions from each module.</li><li>• Total of 8 Questions, each carrying 3 marks</li></ul> <p><b>(8x2 =16 marks)</b></p> | <ul style="list-style-type: none"><li>• Each question carries 9 marks.</li><li>• Two questions will be given from each module, out of which 1 question should be answered.</li><li>• Each question can have a maximum of 3 sub divisions.</li></ul> <p><b>(4x6 = 24 marks)</b></p> | <b>40</b> |

## Course Outcomes (COs)

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

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

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 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 2   | 2   | -   | -   |     |     |     |     | 2   | 2    |      | 2    |
| <b>CO2</b> | 3   | 3   | -   | -   |     |     |     |     | 2   | 2    |      | 2    |
| <b>CO3</b> | 2   | 2   | -   | -   |     |     |     |     | 2   | 2    |      | 2    |
| <b>CO4</b> | 3   | 3   | 3   | 3   |     |     |     |     | 2   | 2    |      | 2    |

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

| <b>Text Books</b> |                                             |                                                       |                              |                         |
|-------------------|---------------------------------------------|-------------------------------------------------------|------------------------------|-------------------------|
| <b>Sl. No</b>     | <b>Title of the Book</b>                    | <b>Name of the Author/s</b>                           | <b>Name of the Publisher</b> | <b>Edition and Year</b> |
| 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             |
| 4                 | Fluid Mechanics,                            | Frank M. White                                        | McGraw Hill                  | 8th edition             |

| <b>Reference Books</b> |                             |                             |                              |                         |
|------------------------|-----------------------------|-----------------------------|------------------------------|-------------------------|
| <b>Sl. No</b>          | <b>Title of the Book</b>    | <b>Name of the Author/s</b> | <b>Name of the Publisher</b> | <b>Edition and Year</b> |
| 1                      | Mechanics of Flight, 2011   | A C Kermode,                | Pearson India,               | 11th edition            |
| 2                      | Aerodynamics for Engineers, | J Bertin,                   | Pearson Education            | 7th edition             |

## PBL Course Elements

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

## Assessment and Evaluation for Project Activity

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

## **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

### **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 approaches