GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Aeronautical Engineering
Subject Code: BE05001021
Subject Name: Aerodynamics

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Course

Prerequisite:	Fundamentals of Aeronautical Engineering, Fundamentals of Fluid Mechanics, Engineering Thermodynamics
Rationale:	Aerodynamics is a fundamental discipline within the field of aviation, playing a crucial role in the design and performance of aircraft. A thorough understanding of aerodynamic principles is essential for aeronautical engineers. This course provides foundational knowledge of fluid mechanics and its properties, along with an introduction to various types of airfoils and their aerodynamic characteristics.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Explain the fundamental aerodynamic terms and the effects of aerodynamic properties on wings under incompressible flow conditions.	15
CO-2	Understand the behavior of incompressible flow over finite wings and two-dimensional airfoils.	35
CO-3	Analyze the key aerodynamic parameters and evaluate the influence of compressible flow on wing performance.	15
CO-4	Comprehend the aerodynamic characteristics and flow behavior across shock waves.	35

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Fundamentals of Aerodynamics:** Airfoil, Types of Airfoils, Airfoil Nomenclature and its characteristics, NACA series, Applications of Airfoils.	04	10%

2	**Characteristics of Low Speed Airfoil:** Effect of incidence on pressure distribution, Lift Curve, Airfoil stalling, Flow Separation, Pitching moment, Span-wise flow variation, downwash, Wind Tunnel and Its type.	**07**	15%
3	**Incompressible flow over a Two Dimensional Wing:** Vortex Sheet, The Kutta Condition, Kelvin's Circulation Theorem and starting vortex, Classical Thin Airfoil Theory – 1. Symmetrical Airfoil 2. Cambered Airfoil, Vortex Panel Numerical Method for Lifting flow over Arbitrary bodies, Viscous flow over Airfoil – Estimation of airfoil drag for laminar flow & Turbulent flow, Transition and flow separation, Modern Low Speed airfoils, Flow over airfoil – The real case.	**10**	25%
4	**Incompressible flow over a Finite Wings:** Introduction to Finite Wing, The Vortex system, Laws of Vortex motion – The vortex filament, Biot-Savart Law and Helmholtz's theorem, Prandtl's Classical Lifting Line Theory, A Numerical Nonlinear Lifting Line Method, The Vortex Lattice Numerical Method, The Delta Wing.	**08**	20%
5	**Compressible Flow:** Introduction, Compressibility, Governing equations for inviscid compressible flow, Total conditions, **Flow with Normal shock waves:** Introduction, Development of a Shockwave, Rarefaction wave, Speed of sound with derivation, Prandtl-Meyer relation, Mach number Downstream of the normal shockwave, Static Pressure ratio across the shock, Temperature ratio across the shock , Numerical based on Normal Shockwave density ratio across the shock (Rankine–Hugoniot equation), Stagnation pressure ratio across the shock, change in entropy across the shock, Impossibility of shock in subsonic flow, strength of the shock wave, Determination of mach number of supersonic flows, tables and charts for normal shock wave, Moving normal shockwaves **Flow with Oblique Shock waves:** Introduction, Nature of flows through oblique shock wave, Fundamentals relations of Oblique shock, Prandtl's relation, Rankine–Hugoniot equation.	**16**	30%
		45 Hours	**100%**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**30**	**30**	**10**	**10**	**0**

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
The syllabus of Aerodynamic directly contributes to

No.	SDG	Relevance to Syllabus
SDG 9	Industry, Innovation and Infrastructure	Understanding aircraft performance, stability, and control supports the design of safer and more efficient aerospace systems.
SDG 11	Sustainable Cities and Communities	Knowledge of standard atmosphere, altitude effects, and aircraft performance helps in designing efficient air transport systems, which improves connectivity, reduces fuel consumption and supports sustainable aviation operations impacting urban and regional mobility.
SDG 13	Climate Action	Analysis of aircraft performance and stability contributes to optimizing fuel efficiency and reducing emissions.

Reference Books:

1. Fundamentals of Aerodynamics by John D Anderson, McGraw Hill
2. Fundamentals of Compressible Flow by S M Yahya, New Age International Publishers
3. Aerodynamics by L J Clancy, Sterling Book House
4. Aerodynamics for Engineering Students by E L Houghton and P W Carpenter, Edward Arnold Ltd.
5. Aerodynamics for Engineers by John J Bertin, Pearson Education Inc.

List of Experiments:

1. Introduction to Wind tunnel and its type.
2. To Study different types of airfoil with applications and its characteristics.
3. To determine characteristics of low speed airfoil
4. Numerical based on incompressible flow over a airfoil using software
5. To determine airfoil drag for different flow.
6. To determine effect of aspect ratio on finite wing.
7. Flow with normal shock wave
8. Flow with oblique shock wave
9. To study Delta wing.

Major Equipment: Wind Tunnel

List of Open Source Software/learning website:

- https://nptel.ac.in/courses/101105059
- https://nptel.ac.in/courses/101105660
- https://nptel.ac.in/courses/101106040

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power converters/electronics/drives company)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (SCOPUS Index/any	5 research paper = 20 hrs	Summarize research paper and evaluation critical parameters

		reputed Journal)		
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	Micro Project	Working/non-working model on technical topics	Working = 10hrs Non-working = 10hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10hrs	Based on quiz scores and reflection report after each quiz.
9	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject *Aerodynamics* incorporates;

   - Mini Project – 10 Marks

   These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of Aerodynamics. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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