INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**AERODYNAMIC**				
Course Code	AAEB10				
Programme	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. P K Mohanta, Professor				
Course Faculty	Dr. Maruthupandyan K, Professor				

I. COURSE OVERVIEW:

Aerodynamics extends fluid mechanic concepts to the aerodynamic performance of wings and bodies in sub/supersonic regimes. The course has four components: (i) subsonic potential flows, including source/vortex panel methods; (ii) viscous flows, including laminar and turbulent boundary layers; (iii) aerodynamics of airfoils and wings, including thin airfoil theory, lifting line theory, and panel method/interacting boundary layer methods; (iv) introduction to propeller. Aerodynamics is the study of the flow of air about a body. In this case, the body will be an airplane, but much of the aerodynamics in this course is relevant to a wide variety of applications from sail boats to automobiles to birds. The course should help students to: formulate and apply appropriate aerodynamic models to predict the forces on and performance of realistic three-dimensional configurations; assess the applicability of aerodynamic models to predict the forces on and performance of realistic three-dimensional configurations and estimate the errors resulting from their application; perform a computational and experimental aerodynamic analysis and design.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	Nil

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aerodynamics	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with “either” or “choice” will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Design

PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Analysis

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO 3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Understand the basics of aerodynamics, aerofoil and wing characteristics
II	Calculate forces and moments acting on aero foils and wings under ideal flow conditions.
III	Design a propeller and determine aerodynamic interaction effects between different components of aircraft.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Potential flow, velocity potential, stream function, Laplace equation, flow singularities-Uniform flow, source, sink, doublet, Vortex, Non lifting and lifting flow over a cylinder Kutta-Joukowski theorem.	CLO 1	Describe the basic concepts of Potential flow and its properties.
		CLO 2	Properties of Laplace and Flow Singularities.
		CLO 3	Various potential flow properties and their combination.
		CLO 4	Basic concept of lifting theory due to flow over objects and Kutta-Joukowski theorem.
CO 2	Aerofoil nomenclature, aerodynamic characteristics, centre of pressure and aerodynamic centre; Wing of infinite aspect ratio, C_L-α-diagram for a wing of infinite aspect ratio,	CLO 5	Geometry of Airfoil and nomenclature.
		CLO 6	Impact of angle of attack on Lift coefficient
		CLO 7	Lift generation in infinite and finite wings and various vortex generation conditions

	generation of lift, starting Vortex, Kutta's trailing edge condition; Thin aerofoil theory; Elements of panel method; High lift airfoils, High lift devices. .	CLO 8	Thin airfoil theory of symmetric and nonsymmetric conditions. High lift devices and panel methods.
CO 3	Vortex motions, vortex line, vortex tube, vortex sheet; Circulation; Kelvin and Helmhotz theorem; Biot-Savart's law, applications, Rankine's vortex; Flow past finite wings, vortex model of the wing and bound vortices; Induced drag; Prandtl's lifting line theory; Elliptic wing. Influence of taper and twist applied to wings, effect of sweep back wings; Delta wings, primary and secondary vortex; Elements of lifting surface theory. Source Panel Vortex panel and Vortex lattice methods.	CLO 9	Various Vortex properties and their applications
		CLO 10	Various wing geometry and its impact on aerodynamics properties
		CLO 11	Methods to augment the lift and various methods are used.
		CLO 12	Various Panel methods used
CO 4	Flow past non lifting bodies, method of singularities; Wing-body interference; Effect of propeller on wings and bodies and tail unit; Flow over airplane as a whole.	CLO 13	Flow over the lifting bodies and understand of various properties conditions
		CLO 14	Wing interfaces and its impact
		CLO 15	Propeller location and its impact on various aircraft parts.
		CLO 16	Net flow over the aeroplane body.
CO 5	Introduction to boundary layer, laminar and turbulent boundary layer, transition, boundary layer on flat plate, displacement thickness, momentum thickness, energy thickness, effect of curvature, temperature boundary layer.	CLO 17	Impact of viscosity and development of boundary layer
		CLO 18	Various types of boundary layers and their properties.
		CLO 19	Various thickness properties of boundary layer
		CLO 20	Impact of boundary layer due to geometry and flow properties like temperature.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAEB10.01	CLO 1	Describe the basic concepts of Potential flow and its properties.	PO 1	3
AAEB10.02	CLO 2	Properties of Laplace and Flow Singularities.	PO 2	2

AAEB10.03	CLO 3	Various potential flow properties and their combination.	PO 1	3
AAEB10.04	CLO 4	Basic concept of lifting theory due to flow over objects and Kutta-Joukowski theorem.	PO 1	3
AAEB10.05	CLO 5	Various Vortex properties and their applications	PO 2	2
AAEB10.06	CLO 6	Various wing geometry and its impact on aerodynamics properties	PO 2	2
AAEB10.07	CLO 7	Methods to augment the lift and various methods are used.	PO 2	2
AAEB10.08	CLO 8	Various Panel methods used	PO 2	2
AAEB10.09	CLO 9	Various Vortex properties and their applications	PO 4	2
AAEB10.10	CLO 10	Various wing geometry and its impact on aerodynamics properties	PO 4	1
AAEB10.11	CLO 11	Methods to augment the lift and various methods are used.	PO 2	2
AAEB10.12	CLO 12	Various Panel methods used	PO 2	2
AAEB10.13	CLO 13	Flow over the lifting bodies and understand of various properties conditions	PO 1	3
AAEB10.14	CLO 14	Wing interfaces and its impact	PO 1	3
AAEB10.15	CLO 15	Propeller location and its impact on various aircraft parts.	PO 1	3
AAEB10.16	CLO 16	Net flow over the aeroplane body.	PO 1, PO 2	3
AAEB10.17	CLO 17	Impact of viscosity and development of boundary layer	PO 1, PO 2	3
AAEB10.18	CLO 18	Various types of boundary layers and their properties.	PO 1, PO 2	3
AAEB10.19	CLO 19	Various thickness properties of boundary layer	PO 1, PO 2	3
AAEB10.20	CLO 20	Impact of boundary layer due to geometry and flow properties like temperature.	PO 1, PO 2	3

3= High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 3	PSO1
CO 1	3	2		1
CO 2		2	1	
CO 3	3	2		1
CO 4	3	2		1
CO 5	3	2		

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2		2													
CLO 3	3												1		
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7		2													
CLO 8		2													
CLO 9				1											
CLO 10				1											
CLO 11		2											1		
CLO 12		2											1		
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3	2											1		
CLO 17	3	2											1		
CLO 18	3	2											1		
CLO 19	3	2											1		
CLO 20	3	2											1		

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4,PSO1	SEE Exams	PO1, PO2, PO4,PSO1	Assignments	-	Seminars	PO1, PO2, PO4,PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4,PSO1						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Module-I	**INTRODUCTORY TOPICS FOR AERODYNAMICS**
Potential flow, velocity potential, stream function, Laplace equation, flow singularities-Uniform flow, source, sink, doublet, Vortex, Non lifting and lifting flow over a cylinder Kutta-Joukowski theorem.	
Module-II	**THIN AEROFOIL THEORY**
Aerofoil nomenclature, aerodynamic characteristics, centre of pressure and aerodynamic centre; Wing of infinite aspect ratio, CL-α- diagram for a wing of infinite aspect ratio, generation of lift, starting Vortex, Kutta's trailing edge condition; Thin aerofoil theory; Elements of panel method; High lift airfoils, High lift devices.	
Module-III	**FINITE WING THEORY**
Vortex motions, vortex line, vortex tube, vortex sheet; Circulation; Kelvin and Helmhotz theorem; Biot-Savart's law, applications, Rankine's vortex; Flow past finite wings, vortex model of the wing and bound vortices; Induced drag; Prandtl's lifting line theory; Elliptic wing. Influence of taper and twist applied to wings, effect of sweep back wings; Delta wings, primary and secondary vortex; Elements of lifting surface theory. Source Panel Vortex panel and Vortex lattice methods.	
Module-IV	**FLOW PAST NON-LIFTING BODIES AND INTERFERENCE EFFECTS**
Flow past non lifting bodies, method of singularities; Wing-body interference; Effect of propeller on wings and bodies and tail unit; Flow over airplane as a whole.	
Module-V	**BOUNDARY LAYERTHEORY**
Introduction to boundary layer, laminar and turbulent boundary layer, transition, boundary layer on flat plate, displacement thickness, momentum thickness, energy thicknSess, effect of curvature, temperature boundary layer.	
Text Books:	
1. E. L. Houghton and P. W. Carpenter, "Aerodynamics for Engineering Students", Edward Arnold Publishers Ltd., London, 5th Edition, 1982, 2. J. D. Anderson, "Fundamentals of Aerodynamics", Mc Graw Hill Book Co., New York, 5th Edition, 1985. 3. John J. Bertin and Russell M. Cummings, "Aerodynamics for Engineering Students", Pearson, 5th Edition, 2009.	
Reference Books:	
1. L. J. Clancy, "Aerodynamics", Pitman, 1st Edition, 1986. 2. L. H. Milne, S. Thomson, "Theoretical Aerodynamics", Dover, 2nd Edition, 1985. 3. K. Karamcheti, "Principles of Ideal-Fluid Aerodynamics", Krieger Pub Co; 2nd edition, 1980.	

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Discuss Importance of Aerodynamics	CLO 1	T1:1.1
2	Define potential flow, velocity potential and stream function	CLO 1	T1:2.4-2.15
3	Derive Laplace equation	CLO 2	T1:2.15
4	Discuss flow singularities	CLO 3	T1:3.9-3.15
5	Discuss uniform flow, source, sink	CLO 5	T1:3.11
6	Discuss doublet, Vortex	CLO 5	T1:3.12-3.14
7	Discuss non-lifting flow over a cylinder	CLO 6	T1:3.13
8	Discuss lifting flow over a cylinder	CLO 6	T1:3.15
9	Derive Kutta-Joukowski theorem	CLO 7	T1:3.16
10	Discuss aerofoil nomenclature	CLO 8	T1:4.2
11	Discuss aerodynamic characteristics	CLO 9	T1:4.3
12	Explain centre of pressure, aerodynamic centre and wing of infinite aspect ratio	CLO 11	T1:1.6-4.9
13	Discuss CL-α- diagram for a wing of infinite aspect ratio, generation of lift	CLO 11	T1:4.7
14	Discuss starting Vortex, Kutta,,s trailing edge condition	CLO 11	T1:4.5-4.6
15	Discuss thin aerofoil theory	CLO 12	T1:4.7- 4.10
16-17	Discuss elements of panel method	CLO 9	T1:4.10
18	Discuss high lift airfoils, High lift devices	CLO 12	T1:4.12
19	Discuss vortex motions, vortex line, vortex tube, vortex sheet	CLO 15	T1:5.2
20	Discuss Circulation; Kelvin and Helmhotz theorem vortices; induced drag	CLO 15	T1:4.6
21	Discuss Biot-Savart,,s law, applications, Rankine,,s vortex	CLO 15	T1:5.2
22	Discuss flow past finite wings, vortex model of the wing and bound vortices; induced drag	CLO 15	T1:5.3
23-24	Discuss Prandtl,,s lifting line theory; Elliptic wing	CLO 11	T1:5.3
25	Discuss influence of taper and twist applied to wings, effect of sweep back wings	CLO 13	T1:5.4
26	Discuss delta wings, primary and secondary vortex	CLO 13	T1:5.6
27	Discuss elements of lifting surface theory	CLO 11	T1:5.5
28	Discuss Source Panel method	CLO 09	T1:5.4

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
29	Discuss Vortex Panel method	CLO 09	T1:5.4
30	Discuss Vortex Lattice method	CLO 09	T1:5.5
31	Describe flow past non lifting bodies	CLO 16	T1:5.4
32-33	Discuss method of singularities	CLO 16	T1:5.3
34	Discuss Wing-body interference	CLO 03	T3:5.2
35-37	Discuss effect of propeller on wings and bodies and tail unit	CLO 10	T2:7.1
38	Discuss flow over airplane as a whole	CLO 03	T3:6.2
39-41	Discuss boundary layer	CLO 04	T1:17.1
42-43	Explain laminar and turbulent boundary layer, transition	CLO 04	T1:18.1- 19.1
44-47	Discuss boundary layer on flat plate	CLO 04	T1:18.2
48-52	Discuss displacement thickness, momentum thickness, energy thickness	CLO 20	T1:17.3
53-56	Discuss effect of curvature	CLO 20	T1:17.5
57-60	Explain temperature boundary layer	CLO 20	T1:19.2

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	To improve standards and analyze the concepts.	Seminars	PO 1	PSO 1
2	Conditional probability, Sampling distribution, correlation, regression analysis and testing of hypothesis	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

Prepared by:
Dr. P K Mohanta, Professor

HOD, AE