INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**COMPUTATIONAL AERODYNAMICS LABORATORY**				
Course Code	AAE109				
Programme	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. G Satya Dileep, Assistant Professor				
Course Faculty	Mr. G Satya Dileep, Assistant Professor Ms. D.Anitha, Assistant Professor				

I. COURSE OVERVIEW:

The aim of this lab complements the computational Aerodynamics course. Students will gain experience in computing aerodynamic problems and understanding flow physics over flat plate, pipe, cylinder, over a wedge and flow over an airfoil. They can gain knowledge in estimating flow analysis for different mach numbers in determining the pressure coefficients over different structural objects and can find lift and drag counters.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AAE003	III	Fluid Mechanics and Hydraulics	4
UG	AAE004	IV	Low Speed Aerodynamics	4
UG	AAE008	V	High Speed Aerodynamics	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Computational Aerodynamics Laboratory	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:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS.

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

20 %	To test the preparedness for the experiment.
20 %	To test the performance in the laboratory.
20 %	To test the calculations and graphs related to the concern experiment.
20 %	To test the results and the error analysis of the experiment.
20 %	To test the subject knowledge through viva – voce.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Table 1: Assessment pattern for CIA

Component	**Laboratory**		**Total Marks**
Type of Assessment	Day to day performance	Final internal lab assessment	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):
One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Preparation	**Performance**	**Calculations and Graph**	**Results and Error Analysis**	**Viva**	**Total**
2	2	2	2	2	10

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.	2	Calculations of the observations
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.	3	Calculations of the observations
PO 3	**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	Lab Practices
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.	2	Term observations
PO 5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Presentation on real-world problems

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:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	2	Lab Practices
PSO2	**Problem-solving Skills:** Imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles.	2	Guest Lectures
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	1	Presentation on real-world problems
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aeronautical/aerospace allied systems to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Experience in computing aerodynamic problems and understanding flow physics over the objects.
II	Knowledge in estimating flow analysis for different mach numbers.
III	Determining the aerodynamic forces like mainly lift and drag.
IV	Analyze the errors and cause of errors in computational analysis.

IX. 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
AAE109.01	CLO 1	Understand the behavior of flows around different structured objects.	PO 1	3
AAE109.02	CLO 2	Implement the computational fluid dynamic and computational aerodynamic fundamentals by using advanced solvers.	PO 1, PO 3, PO 4	3
AAE109.03	CLO 3	Explain the usage of modern tools like ICEM-CFD& FLUENT	PO 3, PO 4, PO 5	3
AAE109.04	CLO 4	Understand the flow properties of flat plate to demonstrate Reynolds number.	PO 1, PO 2	2
AAE109.05	CLO 5	Understand the aerodynamic properties for flow through circular pipe.	PO 1, PO 2	3
AAE109.06	CLO 6	Understand the aerodynamic properties for flow through cylinder.	PO 1, PO 2	2
AAE109.07	CLO 7	Observe the properties at separation region and wake region of circular cylinder at different Reynolds numbers	PO 2, PO 3	1
AAE109.08	CLO 8	Understand the aerodynamic properties of supersonic flow over a wedge	PO 2, PO 3	1
AAE109.09	CLO 9	Understand the aerodynamic properties of flow over an airfoil.	PO 1, PO 2, PO 3	2
AAE109.10	CLO 10	Differentiate the flow properties around symmetrical and cambered airfoil	PO 1, PO 2	2
AAE109.11	CLO 11	Analyze the errors and cause of errors in the computational analysis.	PO 2, PO 3	3
AAE109.12	CLO 12	Analyze the coefficient of pressure, lift, drag and moment for different bodies for different flow conditions.	PO 1, PO 2	3
AAE109.13	CLO 13	Determine the shock wave around cone and wedges for supersonic flow conditions..	PO 2, PO 3	3
AAE109.14	CLO 14	Observe flow properties and compare the computation results with experimental results	PO 2, PO 3, PO 4	2
AAE109.15	CLO 15	Observe the shock waves and 3D relieving effect around the cone at supersonic mach number;	PO 2, PO 3	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAE109.16	CLO 16	Solve the One dimensional wave equation using explicit method of lax equations using finite difference method	PO 2, PO 3, PO 4	2
AAE109.17	CLO 17	Solve the One dimensional heat conduction equation using explicit method	PO 2, PO 3, PO4	3
AAE109.18	CLO 18	Generate the Algebraic and Elliptic grids for computational domains.	PO 1, PO 2, PO 3, PO 4	2

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X. 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	PSO4
CLO 1	3															
CLO 2	3		3	2										1		
CLO 3			3	3	2								2	2	1	
CLO 4	2	3														
CLO 5	3	3														
CLO 6	3	3														
CLO 7		3	2													
CLO 8		3	2													
CLO 9	2	2	3													
CLO 10	2	2											1	2		
CLO 11		2	3													
CLO 12	2	3											2	1		
CLO 13		3	3													
CLO 14		2	3	3									1	2	1	
CLO 15		3	3													
CLO 16		2	3	2												
CLO 17		3	3	2												
CLO 18	1	3	3	2									2	2		

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO 1, PO 2 PO 3, PO 4, PO 5	SEE Exams	PO 1, PO 2 PO 3, PO 4, PO 5	Assignments	-	Seminars	-
Laboratory Practices	PO 1, PO 2 PO 3, PO 4, PO 5	Student Viva	-	Mini Project	-	Certification	-

XII. ASSESSMENT METHODOLOGIES - INDIRECT

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

XIII. SYLLABUS

LIST OF EXPERIMENTS	
Week-1	**INTRODUCTION**
Introduction to computational aerodynamics, the major theories, approaches and methodologies used in computational aerodynamics. Applications of computational aerodynamics for classical aerodynamic's problems.	
Week-2	**INTRODUCTION TO GAMBIT**
Introduction to gambit, geometry creation, suitable meshing types and boundary conditions.	
Week-3	**INTRODUCTION TO FLUENT**
Introduction to fluent, boundary conditions, solver conditions and post processing results.	
Week-4	**FLOW OVER A FLAT PLATE**
Flow over a flat plate at low Reynolds numbers, observe the boundary layer phenomena, no slip condition and velocity profile inside the boundary layer.	
Week-5	**FLOW THROUGH PIPE**
Flow through pipe at different Reynolds numbers; observe the velocity changes for laminar and turbulent flows.	
Week-6	**FLOW OVER A CIRCULAR CYLINDER**
Flow over a circular cylinder at different Reynolds numbers, observe the properties at separation region and wake region.	
Week-7	**FLOW OVER A CAMBERED AEROFOIL**
Flow over a cambered aerofoil at different velocities, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).	
Week-8	**FLOW OVER A SYMMETRIC AEROFOIL**
Flow over a symmetric aerofoil at different velocities, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).	

Week-9	FLOW OVER WEDGE
Flow over wedge body at supersonic mach number; observe the shock wave phenomena and change of properties across the shock wave.	
Week-10	**FLOW OVER A CONE**
Flow over a cone at supersonic mach number; observe the shock waves and 3D relieving effect.	
WeeK-11	**CODE DEVELOPEMENT**
Solution for the following equations using finite difference method I. One dimensional wave equation using explicit method of lax. II. One dimensional heat conduction equation using explicit method.	
Week-12	**CODE DEVELOPEMENT**
Generation of the following grids I. Algebraic grids. II. Elliptic grids.	
Reference Books:	
1. Hirsch, C., "Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics", Vol. I, Butter worth-Heinemann, 2nd edition, 2007. 2. Hoffmann, K. A. and Chiang, S. T., "Computational Fluid Dynamics for Engineers", Engineering Education Systems, 4th edition, 2000. 3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Pub. Corporation, 1st edition, 1980. 4. H K Varsteeg, W Malalasekera, " An Introduction to Computational Fluid Dynamics – The Finite Volume MEthod", Longman Scientific and Technical, 1st edition, 1995.	

XIV. COURSE PLAN:

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

Week No.	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Introduction to computational aerodynamics	CLO 2	R1: 1.2
2	Introduction to ICEM CFD	CLO 3	R4: 3.5
3	Introduction to fluent, boundary conditions, solver conditions and post processing results	CLO 3	R1: 3.4
4	Flow over a flat plate at low Reynolds numbers	CLO 4	R1: 2.2
5	Flow through pipe at different Reynolds numbers	CLO 5	R1: 2.4
6	Flow over a circular cylinder at different Reynolds numbers	CLO6, CLO 7	R1: 4.5
7	Flow over a cambered airfoil at different velocities	CLO 10, CLO 12	R2: 2.6
8	Flow over a symmetric airfoil at different velocities	CLO 10, CLO 12	R2: 2.6
9	Flow over wedge body at supersonic Mach number	CLO 8, CLO 13, CLO 15	R1: 5.2

Week No.	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
10	Flow over a cone at supersonic Mach number	CLO 9, CLO 13, CLO 15	R1: 5.2
11	Solve One dimensional wave equation using explicit method of lax. One dimensional heat conduction equation using explicit method.	CLO 16, CLO 17	R1:7.2
12	Generation of the Algebraic and Elliptic grids.	CLO 18	R1:7.3

XV. 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.	Guest Lectures	PO 1, PO 2, PO 4	PSO 1, PSO 2
2	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2, PO 3	PSO 1, PSO 2

Prepared by:
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