INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AEROSPACE ENGINEERING

COURSE DESCRIPTOR

Course Title	**ADVANCED COMPUTATIONAL AERODYNAMICS LABORATORY**				
Course Code	BAEB09				
Programme	M.Tech				
Semester	I	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	-	-	-	4	2
Chief Coordinator	Ms. D. Anitha, Assistant Professor				
Course Faculty	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, nozzle, 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
-	-	-	-	-

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Advanced 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 12th 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	Identify, formulate, and solve complex aerospace engineering problems by applying advanced principles of engineering	2	Discussion
PO 2	Apply aerospace engineering design to produce solutions that meet specified needs with frontier technologies.	2	Laboratory Practices
PO 5	Independently carry out research / investigation and development work to solve practical problems	2	Projects

3 = High; 2 = Medium; 1 = Low

VII. COURSE OBJECTIVES (COs):

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.

VIII. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Implement the computational fluid dynamic and computational aerodynamic fundamentals by using advanced solvers.	CLO 1	Understand the behavior of flows around different structured objects.
		CLO 2	Implement computational aerodynamic fundamentals by using advanced solvers.
		CLO 3	Explain the usage of modern tools like ICEM-CFD& FLUENT
CO 2	Understand the flow properties of flat plate, nozzle and cylinder to demonstrate Reynolds number.	CLO 4	Understand the flow properties of flat plate to demonstrate Reynolds number.
		CLO 5	Understand the aerodynamic properties for flow through nozzle.
		CLO 6	Observe the properties at separation region and wake region of circular cylinder at different Reynolds numbers
CO 3	Differentiate the flow properties around symmetrical and cambered airfoil.	CLO 7	Determine the shock wave around the wedge under supersonic conditions
		CLO 8	Understand the aerodynamic properties of flow over an airfoil.
		CLO 9	Differentiate the flow properties around symmetrical and cambered airfoil
CO 4	Analyse the coefficient of pressure, lift, drag and moment for different bodies for different flow conditions.	CLO 10	Observe the shock waves and 3D relieving effect around the cone at supersonic Mach number.
		CLO 11	Analyze the errors and cause of errors in the computational analysis.
		CLO 12	Analyze the contours for different bodies for different flow conditions.
CO 5	Visualize the flow around the different bodies under supersonic conditions.	CLO 13	Understand the aerodynamic properties of flow through diffuser.
		CLO 14	Visualize the aerodynamic properties though the supersonic intake.

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
BAEB09.01	CLO 1	Understand the behavior of flows around different structured objects.	PO1	2
BAEB09.02	CLO 2	Implement computational aerodynamic fundamentals by using advanced solvers.	PO1, PO2	2
BAEB09.03	CLO 3	Explain the usage of modern tools like ICEM-CFD& FLUENT	PO1, PO2, PO5	2
BAEB09.04	CLO 4	Understand the flow properties of flat plate to demonstrate Reynolds number.	PO2, PO5	2
BAEB09.05	CLO 5	Understand the aerodynamic properties for flow through nozzle.	PO2, PO5	2
BAEB09.06	CLO 6	Observe the properties at separation region and wake region of circular cylinder at different Reynolds numbers	PO2, PO5	2
BAEB09.07	CLO 7	Determine the shock wave around the wedge under supersonic conditions	PO2, PO5	3
BAEB09.08	CLO 8	Understand the aerodynamic properties of flow over an airfoil.	PO1, PO5	2
BAEB09.09	CLO 9	Differentiate the flow properties around symmetrical and cambered airfoil	PO2, PO5	2
BAEB09.10	CLO 10	Observe the shock waves and 3D relieving effect around the cone at supersonic Mach number;	PO2, PO5	2
BAEB0911	CLO 11	Analyze the errors and cause of errors in the computational analysis.	PO1	3
BAEB09.12	CLO 12	Analyze the contours for different bodies for different flow conditions.	PO1, PO2, PO5	2
BAEB09.13	CLO 13	Understand the aerodynamic properties of flow through diffuser.	PO2, PO5	3
BAEB09.14	CLO 14	Visualize the aerodynamic properties though the supersonic intake.	PO2, PO5	3

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

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

3 = High; 2 = Medium; 1 = Low

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

Course Learning Outcomes (CLOs)	Program Outcome (PO)						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CLO 1	2						
CLO 2	2	**2**					
CLO 3	2	2			2		
CLO 4		2			2		
CLO 5		2			2		
CLO 6		2			2		
CLO 7		3			3		
CLO 8	2				2		
CLO 9		2			2		
CLO 10		2			2		
CLO 11	3						
CLO 12	2	2			2		
CLO 13		3			3		
CLO 14		3			3		

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO5	SEE Exams	PO1, PO2, PO5	Assignments	-	Seminars	-
Laboratory Practices	PO1, PO2, PO5	Student Viva	PO1, PO2, PO5	Mini Project	-	Certification	-

XIII. ASSESSMENT METHODOLOGIES - INDIRECT

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

XIV. 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 ICEM CFD**
Introduction to ICEM CFD, 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	**SHOCK WAVE BOUNDARY LAYER INTERSECTION OVER A FLAT PLATE**
Observe the boundary layer phenomena over a flat plate and velocity profile inside the boundary layer.	
Week-5	**SUBSONIC FLOW IN A CONVERGENT DIVERGENT NOZZLE**
Flow through convergent divergent nozzle at different velocities; observe the velocity changes for laminar and turbulent flows.	
Week-6	**CIRCULATION OF THE LIFT OVER A CIRCULAR CYLINDER**
Observe the properties at separation region and wake region over a circular cylinder at different Reynolds numbers.	
Week-7	**PRESSURE DISTRIBUTION OVER A SYMMETRIC AEROFOIL**
Observe flow properties around the flow over a symmetric aerofoil at different velocities and compare the computation results with experimental results (consider the model from aerodynamics laboratory).	
Week-8	**PRESSURE DISTRIBUTION OVER A CAMBERED AEROFOIL**
Observe flow properties around the flow over a cambered aerofoil at different velocities and compare the computation results with experimental results (consider the model from aerodynamics laboratory).	
Week-9	**SHOCK WAVE SUPERSONIC FLOW OVER WEDGE**
Observe the shock wave phenomena and change of properties around a wedge at supersonic Mach number.	
Week-10	**SHOCK WAVE AROUND A CONE**
Observe the shock wave phenomena and change of properties around a cone at supersonic Mach number.	
WeeK-11	**FLOW THROUGH DIFFUSER**
Flow through diffuser at different velocities; observe the velocity changes for laminar and turbulent flows.	
Week-12	**FLOW THROUGH SUPERSONIC INTAKE**
Flow through Supersonic intake at different velocities; observe the velocity changes for laminar and turbulent flows.	

Reference Books:

1. Anderson, J.D., Jr., Computational Fluid Dynamics the Basics with Applications, McGraw-Hill Inc, 1st Edition 1998.
2. Hoffmann, K. A. and Chiang, S. T., "Computational Fluid Dynamics for Engineers", 4th Edition, Engineering Education Systems (2000).
3. Hirsch, C., "Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics", Vol. I, 2nd Edition, Butterworth-Heinemann (2007).

XV. COURSE PLAN:

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

Week No.	Topics to be covered	Course Learning Outcomes	Reference
1-3	Introduction to computational aerodynamics	CLO 1	T1
4-5	Introduction to ICEM CFD	CLO 3	T1
7-8	Introduction to fluent	CLO 3	T1
9-12	Shock wave boundary layer intersection over a flat plate	CLO 4	T1
13-16	Subsonic flow in a convergent divergent nozzle	CLO 5	T2
17-19	Circulation of the lift over a circular cylinder	CLO 6	T1
20-22	Pressure distribution over a symmetric aerofoil	CLO 8	T1
23-24	Pressure distribution over a cambered aerofoil	CLO 8	T2
25-27	Shock wave supersonic flow over wedge	CLO 7	T2
28-30	Shock wave around a cone	CLO 10	T2
31-33	Flow through diffuser	CLO 13	T2
33-36	Flow through supersonic intake	CLO 14	T2

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

S.NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs
1	To improve standards and analyze the concepts.	Guest Lectures	PO1,PO5
2	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO1, PO3

Prepared by:
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HOD, AE