INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**FLUID DYNAMICS**				
Course Code	AAEB03				
Programme	B.Tech				
Semester	III	AE			
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. Shiva Prasad U, Assistant Professor.				
Course Faculty	Dr. Govardhan D, Professor and Head Mr. Shiva Prasad U, Assistant Professor				

I. COURSE OVERVIEW:

The aim of this course is to introduce basic principles of fluid dynamics and it is furtherextended to cover the application of aeronautical engineering.Thiscourse also deals with the large variety of fluids such as air, water, steam, etc; however, themajor emphasis is given for the study of water.Topics covered in the course include pressure, hydrostatics, and buoyancy; open systems and control volume analysis; mass conservation and momentum conservation for moving fluids; viscous fluid flows, flow through pipes; dimensional analysis; boundary layers, and lift and drag on objects. Students will work to formulate the models necessary to study, analyze, and design fluid systems through the application of these concepts, and to develop the problem-solving skills essential to good engineering practice of fluid mechanics in practical applications.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS002	I	Linear Algebra and Differential Equations	4
UG	AME002	II	Engineering Mechanics	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Fluid Dynamics	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, engineeringfundamentals, 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 complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Assignments
PO 3	**Design/development of solutions**: Design solutions for complex engineering problems anddesign 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.	2	Assignments
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	--	--

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	**Professional skills:**Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	1	Seminar

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
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.	-	-
PSO3	**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	-	-
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Illustrate about the basic properties of a fluid, hydrostatic forces on submerged bodies and different manometers.
II	Derive the basic principles of a fluid-continuity, momentum, Euler and Bernoulli‘s equations.
III	Explain the concept of boundary layer theory and importance of Prandtl‘s boundary layer theory.
IV	Understand the flow behavior through different fluidpumps, fans and turbine systems.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the basic fluid properties and fluid dynamic concepts with its applications of fluid statics to determine forces of buoyancy and stability; and to fluids in rigid-body motion.	CLO 1	Define the properties of fluids and its characteristics, which will be used in aerodynamics, gas dynamics, marine engineering etc.
		CLO 2	Explain the hydrostatic forces on submerged bodies, variation with temperature and height with respect to different types of surfaces.
		CLO 3	Define different types of manometers and explain buoyancy force, stability of floating bodies by determining its metacentre height.
CO 2	Use of conservation laws in differential forms and Understand the dimensional methods and kinematics of fluid particles.	CLO 4	Dimensional similarity and prediction of flow behaviour using dimensionless numbers.
		CLO 5	Classification of fluid flows and governing equations of inviscid fluid flows.
		CLO 6	Conceptual analysis of fluid flow and exact solutions of navier stokes equations for coquette flow and poiseuille flow.
CO 3	Use Euler’s and Bernoulli’s equations and the conservation of mass to determine velocities, pressures, and accelerations for incompressible and inviscid fluids.	CLO 7	Define Fluid forces and describe the motion of a fluid particle with fluid deformation.
		CLO 8	Determine the Euler's and Bernoulli's equation and obtain its phenomenological basis of Naviers-stokes equation.
		CLO 9	Describe about the flow measurements using different equipment’s of fluid flows.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 4	Understand the concepts of viscous boundary layers, mechanics of viscous flow effects on immersed bodies and its forces.	CLO 10	Understand the Concept of boundary layer flows and control of flow separation.
		CLO 11	Determine the flows over streamlined and bluff bodies to predict the drag and lift forces.
		CLO 12	Understand the thickness factor with respect to Displacement, momentum and energy thickness.
CO 5	Apply principles of fluid mechanics to the operation, design, and selection of fluid machinery and to understand the ethical issues associated with decision making.	CLO 13	Explain about the turbo machinery systems and working.
		CLO 14	Describe the concepts of turbo machinery in the field of aerospace engineering and concepts of internal flows through engines.
		CLO 15	Demonstrate the knowledge gained from the working of compressors, fans and pumps.

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
AAEB03.01	CLO 1	Define the properties of fluids and its characteristics, which will be used in aerodynamics, gas dynamics, marine engineering etc.	PO 1	3
AAEB03.02	CLO 2	Explain the hydrostatic forces on submerged bodies, variation with temperature and height with respect to different types of surfaces.	PO 1	3
AAEB03.03	CLO 3	Define different types of manometers and explain buoyancy force, stability of floating bodies by determining its metacentre height.	PO 1	3
AAEB03.04	CLO 4	Dimensional similarity and prediction of flow behaviour using dimensionless numbers.	PO 2	2
AAEB03.05	CLO 5	Classification of fluid flows and governing equations of inviscid fluid flows.	PO 3 PO 4	2
AAEB03.06	CLO 6	Conceptual analysis of fluid flow and exact solutions of navier stokes equations for coquette flow and poiseuille flow.	PO 2	1
AAEB03.07	CLO 7	Define Fluid forces and describe the motion of a fluid particle with fluid deformation.	PO 2	2
AAEB03.08	CLO 8	Determine the Euler's and Bernoulli's equation and obtain its phenomenological basis of Naviers-stokes equation.	PO 3 PO 4	2
AAEB03.09	CLO 9	Describe about the flow measurements using different equipment's of fluid flows.	PO 3	2
AAEB03.10	CLO 10	Understand the Concept of boundary layer flows and control of flow separation.	PO 2	2
AAEB03.11	CLO 11	Determine the flows over streamlined and bluff bodies to predict the drag and lift forces.	PO 1	3
AAEB03.12	CLO 12	Understand the thickness factor with respect to Displacement, momentum and energy thickness.	PO 1	3
AAEB03.13	CLO 13	Explain about the turbo machinery systems and working.	PO 3	3
AAEB03.14	CLO 14	Describe the concepts of turbo machinery in the field of aerospace engineering and concepts of internal flows through engines.	PO 4	3
AAEB03.15	CLO 15	Demonstrate the knowledge gained from the working of compressors, fans and pumps	PO 4	3

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

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

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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	PSO4
CLO 1	3												1			
CLO 2	3												1			
CLO 3	3												1			
CLO 4		2														
CLO 5			2	2									1			
CLO 6		1														
CLO 7		2														
CLO 8			2	2									1			
CLO 9			2													
CLO 10		2														
CLO 11	3												1			
CLO 12	3												1			
CLO 13			3													
CLO 14				3												
CLO 15				3									1			

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2 PO 3, PO 4	SEE Exams	PO 1, PO 2 PO 3, PO 4	Assignments	PO 1,PO 2	Seminars	PO 2 PO3
Laboratory Practices	PO 2, PO 3	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

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

XV. SYLLABUS

MODULE-I	**FLUID PROPERTIES AND FLUID STATICS**
Density, specific weight, specific gravity, surface tension and capillarity, Newton's law of viscosity, incompressible and compressible fluid, numerical problems; Hydrostatic forces on submerged bodies - Pressure at a point, Pascal's law, pressure variation with temperature and height, center of pressure plane, vertical and inclined surfaces; Manometers - simple and differential Manometers, inverted manometers, micro manometers, pressure gauges and numerical problems. Buoyancy - Archimedes principle, metacenter, Meta centric height calculations; Stability.	
MODULE-II	**FLUID KINEMATICS AND BASIC EQUATIONS OF FLUID FLOW ANALYSIS**
Statement of Buckingham's π- theorem, similarity parameters - Reynolds number, Froude number,concepts of geometric, kinematic and dynamic similarity, Reynolds number as a very approximate measureof ratio of inertia force and viscous force.Types of fluid flows, differential equations of mass and momentum for incompressible flows, inviscideulers equation and viscous flows- navier stokes equations, concept of fluid rotation, vorticity and streamfunction, exact solutions of navier stokes equations for coquette flow and poiseuille flow, numericals.	
MODULE-III	**FLUID DYNAMICS**
Fluid forces and Motion of a fluid particle; Fluid deformation; Euler's and Bernoulli's equation, phenomenological basis of Naviers- stokes equation, flow measurements : pressure, velocity and massflow rate, viscosity, pitot-static tube, venturi meter, orifice meter and V-Notch, numericals.	
MODULE-IV	**BOUNDARY LAYER THEORY**
Concept and assumptions, qualitative idea of boundary layer and separation, streamlined and bluff bodies, drag and lift forces. Displacement, momentum and energy thickness, numericals.	
MODULE-V	**TURBO MACHINERY**
Introduction and classification of fluid machines: Turbo machinery analysis; The angular momentumprinciple; Euler turbo machine equation; Application to fluid systems, working principle overview ofturbines, fans, pumps and compressors.	

Text Books:

1. D.J Tritton, "Physical Fluid Dynamics", Oxford university press, 2nd edition 2016.
2. R. K Bansal, "Fluid mechanics and hydraulic machines", Laxmi publications Ltd, 9th Edition, 2011.
3. Robert W Fox, Alan T McDonald, "Introduction to fluid Mechanics", John Wiley and Sons, 6thEdition, 1995.
4. Streeter V. L, Wylie, E.B., "Fluid Mechanics", McGraw-Hill, 9th Edition, 1983.

Reference Books:

1. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.
2. Milne Thompson L M, "Theoretical Hydrodynamics", MacMillan, 5th Edition, 1968.
3. Rathakrishnan. E, "Fundamentals of Fluid Mechanics", Prentice-Hall, 5th Edition, 2007.
4. Som S. K, Biswas. G, "Introduction to fluid mechanics and fluid machines", Tata McGraw-Hill, 2ndEdition, 2004.

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	Density, Specific weight,Specific gravity.	CLO 1	T2 : 1.2
2	Surface tension and capillarity	CLO 1	T2 : 1.6
3	Newton's law of viscosity	CLO 1	T2 : 1.3
4	Incompressible and compressible fluid, numerical problems.	CLO 1	T2 : 1.3
5-6	Hydrostatic forces on submerged bodies: Pressure at a point	CLO 2	T2 : 3.1
7-8	Pascal's law, pressure variation with temperature and height	CLO 2	T2 : 3.1
9-10	Center of pressure plane, vertical and inclined surfaces.	CLO 2	T2 : 3.2
11-12	Manometers: simple and differential Manometers	CLO 3	T2 : 2.5
13	Inverted manometers,micro manometers	CLO 3	T2 : 2.5
14-15	Pressure gauges and numerical problems.	CLO 3	T2 : 2.5
16	Buoyancy : Archimedes principle		T2 : 2.5
17-18	Metacenter, meta centric height calculations.	CLO 3	T2 : 4.4
19	Statement of Buckingham's π- theorem, similarity parameters - Reynolds number, Froude number	CLO 4	T3 : 5.0
20-21	Concepts of geometric, kinematic and dynamic similarity, Reynolds number as a very approximate measureof ratio of inertia force and viscous force.	CLO 4	T2 : 5.3 R4: 6.6
22	Types of fluid flows, differential equations of mass and momentum for incompressible flows	CLO 5	T1 : 5.1
23-24	InviscidEuler's equation and viscous flows- navier stokes equations	CLO 6	T1 : 5.2
25-26	Concept of fluid rotation, vorticity and streamfunction, Stream line, path line, streak line, stream surface,stream tube.	CLO 6	T2 : 5.3
27-28	Exact solutions of navier stoke equations for coquette flow and poiseuille flow, numerical.	CLO 6	T2 : 5.5 R3: 8.5
29	Equations for coquette flow and poiseuille flow, numerical.	CLO 6	T2 : 5.6
30	Fluid forces and Motion of a fluid particle; Fluid deformation	CLO 7	T2 : 5.9
31	Euler's and Bernoulli's equation	CLO 8	T2 : 6.8
32	Phenomenological basis of Naviers- stokes equation	CLO 8	T2 : 5.9
33-34	flow measurements: pressure, velocity and massflow rate, viscosity, Pitot-static tube, Venturi meter,	CLO 9	T2 : 5.6 R1: 7.7
35	Orifice meter and V-Notch, Numericals.	CLO 9	T2 : 6.8
36	Concept and assumptions of boundary layer, qualitative idea of boundary layer and separation	CLO 10	T2 : 6.8, R2: 4.5
37	Streamlined and bluff bodies,drag and lift forces.	CLO 11	T2 : 6.3
38-39	Displacement, momentum and energy thickness, numericals.	CLO 12	T2 : 6.4
40	Introduction and classification of fluid machines	CLO 13	T3: 10.1
41	Turbo machinery analysis	CLO 14	T3 : 10.3
42	The angular momentumprinciple	CLO 13	T3 : 10.5

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
43	Euler turbo machine equation	CLO 14	T3 : 10.4
44-45	Application to fluid systems	CLO 15	T3: 10.6
46-47	Working principle overview ofturbines, fans	CLO 14	T3 : 10.8
48	Pumps and compressors	CLO 15	T3 : 10.3

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Experimental determination of buoyancy	Seminars	PO 1, PO 2, PO 5	PSO 2
2	Introduction to viscous fluid flows	Seminars / NPTEL	PO 1, PO 2, PO 5	PSO 3
3	Determination of Velocity triangles	NPTEL	PO 2, PO 3, PO 4	PSO 3

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