INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**HYDRAULICS AND HYDRAULIC MACHINERY**				
Course Code	ACE011				
Programme	B. Tech				
Semester	V	CE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. Ch. V. S. S. Sudheer, Assistant Professor				
Course Faculty	Dr. P. Ram Mohan Rao, Professor Mr. Ch. V. S. S. Sudheer, Assistant Professor				

I. COURSE OVERVIEW:

This course is intended to introduce basic principles of fluid mechanics. It is further extended to cover the application of fluid mechanics by the inclusion of fluid machinery especially water turbine and water pumps. Now a day the principles of fluid mechanics find wide applications in many situations directly or indirectly. The use of fluid machinery, turbines pumps in general and in power stations in getting as accelerated fill up. Thus there is a great relevance for this course for mechanical technicians. The Mechanical technicians have to deal with large variety of fluids like water, air, steam, ammonia and even plastics. The major emphasis is given for the study of water. However, the principle dealt with in this course will be applicable to all incompressible fluids.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACE005	IV	Fluid Mechanics	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Hydraulics and Hydraulic Machinery	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 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz / Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	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 25 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.	2	Presentation on real-world application
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	Seminar
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	Assignment

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.	2	Presentation on real-world application

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	2	Seminar
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	Strengthen the knowledge of theoretical and technological aspects of hydrodynamic forces on jets.
II	Correlate the principles with applications in hydraulic turbines.
III	Apply the practical applications on Francis and Kaplan turbine.
IV	Analysis the similarities between prototype and model types of hydraulic similitude.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the concept of different types of flows, designing of most economical sections of the Open Channel and to understand the concept of specific energy.	CLO 1	Explain the concept for types of flows, type of channels, Non uniform flow - Dynamic equation for G.V.F., Mild, Critical, and Steep channels
		CLO 2	Understand concept of velocity distribution, energy and momentum correction factors for different flows.
		CLO 3	Understand Chezy's, Manning's and Basin formulae for uniform flow.
		CLO 4	Explain the concepts based on Specific energy, critical depth, critical, subcritical and super critical flows.
		CLO 5	Understand and designing for the computation of economical sections based on flow parameters and channel characteristics.
CO 2	Describe the concept of dimensional quantities and application of similitude concept in designing model and prototype.	CLO 6	Understand the Dimensional quantities and analysis for various parameters.
		CLO 7	Derive the problems based on Rayleigh's method and Buckingham's pi theorem with applications.
		CLO 8	Explain the concept of similitude with examples and different types of similitude concepts.
		CLO 9	Remember the concepts of dimensionless numbers to solve numerical problems
		CLO 10	Explain the practical problems associated with model and prototypes based on concept of similitude
CO 3	Understand the concept, working applications of impact of jets with the importance of constructing velocity triangles.	CLO 11	Explain the different types of jets used in construction of turbines and machinery and their importance.
		CLO 12	Demonstrate the formulation of velocity triangles at inlet and out let of vanes with different combinations of jet.

COs	Course Outcome	CLOs	Course Learning Outcome
		CLO 13	Derive the expressions based on Angular momentum principle, work done and efficiency for various types of vanes.
		CLO 14	Explaining the concepts of hydro power plant with various components and their functioning.
		CLO 15	Deriving numerical problems based on power developed in Hydro power plant, efficiency of jet, stationary and moving vanes.
CO 4	Explore the design concept of Pelton, Francis and Kaplan turbines, Centrifugal pumps along with the design of most economical designs.	CLO 16	Demonstrating different types of turbines with their principles and practical applications
		CLO 17	Remember the concept of work done, efficiency for different vanes and application to the concept of turbines.
		CLO 18	Deriving the expressions for most economical design of turbines to withstand for the designed discharge.
		CLO 19	Understand the working principles for various and working of different components of Kaplan, Francis and Pelton turbines.
		CLO 20	Understand the working mechanism of different types of pumps, importance and functioning of various components.
CO 5	Understand the working mechanism of different types of the pumps with their important characteristic curves.	CLO 21	Explain characteristic curves for pumps with their practical applications
		CLO 22	Understand the concept of NPSH, performance of pumps and working efficiency.
		CLO 23	Explain the designing of reciprocating pump and centrifugal pump.
		CLO 24	Understand the practical problems associated during the installation of pumps
		CLO 25	Understand the concept ANOVA to the real world problems to measure the atmospheric tides.

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
ACE011.01	CLO 1	Explain the concept for types of flows, type of channels, Non uniform flow - Dynamic equation for G.V.F., Mild, Critical, and Steep channels	PO 1, PO4	2
ACE011.02	CLO 2	Understand concept of velocity distribution, energy and momentum correction factors for different flows.	PO 1, PO4	2
ACE011.03	CLO 3	Understand Chezy's, Manning's and Basin formulae for uniform flow.	PO 4	3
ACE011.04	CLO 4	Explain the concepts based on Specific energy, critical depth, critical, subcritical and super critical flows.	PO 1, PO4	2
ACE011.05	CLO 5	Understand and designing for the computation of economical sections based on flow parameters and channel characteristics.	PO 1, PO 2, PO4	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE011.06	CLO 6	Understand the Dimensional quantities and analysis for various parameters.	PO 1, PO 2, PO 4	2
ACE011.07	CLO 7	Derive the problems based on Rayleigh's method and Buckingham's pi theorem with applications.	PO 2	3
ACE011.08	CLO 8	Explain the concept of similitude with examples and different types of similitude concepts.	PO 1	2
ACE011.09	CLO 9	Remember the concepts of dimensionless numbers to solve numerical problems.	PO 1	3
ACE011.10	CLO 10	Explain the practical problems associated with model and prototypes based on concept of similitude.	PO 2, PO 4	2
ACE011.11	CLO 11	Explain the different types of jets used in construction of turbines and machinery and their importance.	PO 1, PO 4	3
ACE011.12	CLO 12	Demonstrate the formulation of velocity triangles at inlet and out let of vanes with different combinations of jet.	PO 1, PO 2, PO 4	2
ACE011.13	CLO 13	Derive the expressions based on Angular momentum principle, work done and efficiency for various types of vanes.	PO 2	3
ACE011.14	CLO 14	Explaining the concepts of hydro power plant with various components and their functioning.	PO 2, PO 4	2
ACE011.15	CLO 15	Deriving numerical problems based on power developed in Hydro power plant, efficiency of jet, stationary and moving vanes.	PO 1, PO 2, PO 4	2
ACE011.16	CLO 16	Demonstrating different types of turbines with their principles and practical applications	PO 1, PO 4	2
ACE011.17	CLO 17	Remember the concept of work done, efficiency for different vanes and application to the concept of turbines.	PO 1	3
ACE011.18	CLO 18	Deriving the expressions for most economical design of turbines to withstand for the designed discharge.	PO 1, PO 4	3
ACE011.19	CLO 19	Understand the working principles for various and working of different components of Kaplan, Francis and Pelton turbines.	PO 1	3
ACE011.20	CLO 20	Understand the working mechanism of different types of pumps, importance and functioning of various components.	PO 1, PO 2	2
ACE011.21	CLO 21	Explain characteristic curves for pumps with their practical applications	PO 1, PO 4	2
ACE011.22	CLO 22	Understand the concept of NPSH, performance of pumps and working efficiency.	PO 1	3
ACE011.23	CLO 23	Explain the designing of reciprocating pump and centrifugal pump.	PO 1, PO 2	3
ACE011.24	CLO 24	Understand the practical problems associated during the installation of pumps	PO 1, PO 2, PO 4	2
ACE011.25	CLO 25	Understand the concept ANOVA to the real world Problems to measure the atmospheric tides.	PO 1, PO 2, PO 4	2

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 4	PSO1	PSO2
CO 1	3	1	3	3	2
CO 2	2	2	2	3	1
CO 3	2	3	2	2	2
CO 4	2	1	2	2	
CO 5	3	3	2	2	

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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
CLO 1	3			2									3		
CLO 2	2			3									2	3	
CLO 3				3										2	
CLO 4	3			3									3	2	
CLO 5	2	3		3									2	1	
CLO 6	2	2		2									3		
CLO 7		3													
CLO 8	2												2		
CLO 9	3												3		
CLO 10		2		2										2	
CLO 11	3			3									3		
CLO 12	2	3		2									2	2	
CLO 13		3													
CLO 14		3		2										2	
CLO 15	2	2		2									2	2	
CLO 16	2			2									2		

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 17	3														
CLO 18	1			2									2		
CLO 19	3												3		
CLO 20	3	3											3		
CLO 21	2			2									2		
CLO 22	3														
CLO 23	3	3													
CLO 24	2	3		2									2		
CLO 25	3	3		2									3		

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4, PSO 1, PSO 2	SEE Exams	PO1, PO2, PO4, PSO 1, PSO 2	Assignments	PO 4	Seminars	PSO 2
Laboratory Practices	PO1	Student Viva	PO 2	Mini Project	-	Certification	-
Term Paper	-	Guest lectures	PSO 1				

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

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

XV. SYLLABUS

Unit – I	OPEN CHANNEL FLOW
Types of flows, types of channels, channel characteristics, velocity distribution, energy and momentum correction factors, Chezy's, Manning's, Basin's formulae for uniform flow, economical sections, critical flow, critical depth, specific energy, channel transitions	
Unit – II	**DIMENSIONAL ANALYSIS AND SIMILITUDE**
Dimensional analysis, Rayleigh's method, Buckingham's pi theorem, hydraulic models, similarity laws, geometric, kinematic and dynamic similarities, dimensionless numbers, model and prototype relations.	
Unit – III	**HYDRODYNAMIC FORCE ON JETS**
Hydrodynamic force of jets on stationary and moving flat inclined and curved vanes, jet striking centrally and at tip. Velocity triangles at inlet and outlet, work done, efficiency, angular momentum principle, layout of hydropower plant, heads and efficiencies.	

Unit – IV	HYDRAULICS TURBINES
Classification of hydraulic machine, Euler's equation of turbo machines, selection of hydraulic machines, design of Pelton turbines, design of Francis turbine, design of Kaplan/ axial flow turbine, draft tube, theory and function efficiency.	
Unit – V	**CENTRAIFUGAL PUMPS**
Pump installations, classification of pumps, work done, Manometric head, minimum starting speed, losses and efficiency, specific speed, multistage pump, pumps in parallel, performance of pumps, design of centrifugal pumps, design of reciprocating pumps, NPSH, cavitation.	
Text Books:	
1. Subramanya K, "Open Channel Flow", Tata McGraw Hill Publications, New Delhi, 2008. 2. Modi, Seth, "Fluid Mechanics. Hydraulic and Hydraulic Machines", Standard Book House, 2011. 3. Madan Mohan Das, Mimi Das Saikia, Bhargab Mohan Das, "Hydraulics and Hydraulic Machines Textbook", PHI Learning, 1st edition, 2013.	
Reference Books:	
1. Ojha CSP, Chandramouli P. N., Berndtsson R., "Fluid Mechanics and Machinery", Oxford University Press, 2010. 2. Chow V.T., "Open Channel Hydraulics", Blackburn Press, 2009. 3. Rajput R.K., "A text book of Fluid Mechanics", S. Chand Publications, 1998. 4. Franck N. White, "Fluid Mechanics", Tata Mc Grawhill Publications, 8 th Edition, 2015. 5. Dr .R.K Bansal A text book of Fluid mechanics & Hydraulics machines in SI units Laxmi publications 2015.	

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 – 2	To understand the Basics of Open Channel Flow.	CLO 1	T1:22.5 R1:2.3
3 – 4	To know the types of flows, Type of channels, Velocity distribution.	CLO 2	T1:22.5 R1:2.4
5 – 6	To derive the derivation of Energy and momentum correction factors, Chezy's, Manning's and Bazin's formulae for uniform flow.	CLO 3	T1:22.6 R1:2.6
7 – 8	Ability to solve the problems on Energy and momentum correction factors, Chezy's, Manning's and Bazin's formulae for uniform flow.	CLO 4	T1:22.7 R1:4.4
9 – 11	Ability to know the Most Economical sections.	CLO 5	T1:22.7 R1:4.10
12 – 13	To understand the Basics of Critical Flow	CLO 6	T1:22.8
14 – 15	To know the Specific energy, critical depth, computation of critical depth	CLO 7	T1:22.9 R1:5.4
16 – 18	To know the critical sub-critical and super critical flows	CLO 8	T1:22.9 R1:5.8
19 – 20	Ability to solve the problems on Specific energy, critical depth, computation of critical depth	CLO 9	T1:23.10 R1:6.8
21 – 23	Ability to understand Non uniform flow-Dynamic equation for G.V.F., Mild, Critical, Steep	CLO 10	T1:23.10 R1:6.13
24 – 26	Ability to understand Non uniform flow-Dynamic equation for horizontal and adverse slopes, surface profiles, direct step method	CLO 11	T1:23.9 R1:7.5

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
27 – 28	Ability to understand Rapidly varied flow, hydraulic jump, energy dissipation	CLO 12	T1:23.10 R1:7.5
29 – 30	Ability to solve the problems on Non uniform flow-Dynamic equation for G.V.F., Mild, Critical, Steep.	CLO 13	T1:23.10 R1:8.1
31 – 32	Ability to solve the problems on Rapidly varied flow, hydraulic jump, energy dissipation	CLO 14	T1:23.1 R1:9.2
33 – 34	To understand the Dimensional analysis, Rayleigh's method and Buckingham's pi theorem	CLO 15	T1:23.1 R1:9.4
35 – 36	To study of Hydraulic models, Geometric, kinematic and dynamic similarities. To know dimensionless numbers, model and prototype relations.	CLO 16	T1:23.1 R1:9.9
37 – 38	To solve the problems Rayleigh's method and Buckingham's pi theorem	CLO 16	T1:23.1 R1:9.9
39 – 41	Ability to solve the problems on kinematic and dynamic similarities. Ability to solve dimension less numbers, model and prototype relations.	CLO 17	T1:23.1 R1:9.10
41 – 43	To understand the Basics of Basics of Turbo Machinery, to know the Hydrodynamic force of jets on stationary and moving flat inclined and curved vanes.	CLO 18	T2:27.5 R1:10.2
44 – 46	Ability to solve the problems on Hydrodynamic force of jets on stationary and moving flat inclined and curved vanes, to know the jet striking centrally and at tip, velocity triangles at inlet and outlet.	CLO 19	T2:27.7 R1:11.3
47 – 50	Ability to solve the problems jet striking centrally and at tip, velocity triangles at inlet and outlet.	CLO 20	T2:27.8 R1:11.6
51 - 52	To know the concept of the Angular momentum principle, applications to radial flow turbines.	CLO 20	T2:27.8 R1:11.6
52 – 53	Ability to solve the problems on Angular momentum principle, To know Layout of a typical Hydropower installation, Heads and efficiencies.	CLO 21	T2:27.12 R1:11.7
54 – 55	To know about the Hydraulic Turbines, To know classification of turbines- Pelton wheel, Francis turbine and Kaplan turbine working, working Proportions	CLO 21	T2:27.12 R1:11.7
56 – 57	To know velocity diagram, hydraulic design, draft tube, theory and function efficiency.	CLO 22	T2:27.12 R1:11.8
58 – 59	To know Governing of turbines, surge tanks, unit and specific turbines, unit speed, unit quantity, unit power and specific speed, performance characteristics	CLO 22	T2:27.12 R1:11.8
60 – 61	To know the centrifugal pumps, To study the Pump installation details, classification, Manometric head, minimum starting speed.	CLO 23	T2:27.12 R1:11.9
62 – 63	Ability to solve problems on specific speed , multi stage pumps, speed.	CLO 24	T2:27.12 R1:11.10
64 – 65	Ability to solve problems on multi stage pumps, pumps in pumps in parallel. Ability to solve the problems on performance of pumps characteristic curves –NSPH cavitation.	CLO 25	T2:27.14 R1:12.3
66 – 68	Classification of hydro power plants – definition of terms: load factor, utilization factor, capacity factor, estimation of hydro power potential.	CLO 25	T2:27.14 R1:12.3

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	Practical applications of dimensional analysis and design of pumps.	Seminars / NPTEL	PO 4	PSO 2
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

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