COURSE HANDOUT

KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY (KIIT)
(Deemed to be University)

SCHOOL OF MECHANICAL ENGINEERING

Date:28/01/2025

1. **Course Code: XCT 1005**
2. **Course title: Fluid Mechanics and Machineries**
3. **L-T-P Structure: 3-1-0**
4. **Course Objective(s):**
   - To develop an understanding about the basic laws of fluid mechanics.
   - To apply the laws of fluid mechanics selecting control volume.
   - To develop physical model of the various components used in hydraulic power plant.
   - To apply the fundamental laws of fluid mechanics to various engineering components.
   - To analyse various measuring and instrumentation parts**.**

5. **Course (learning) outcomes:** At the end of the course, the students will be able to:

CO1	Apply conservation laws to fluid flow problems in engineering applications
CO2	Understand various fluid flow concepts and the principle of flow measuring devices
CO3	Design and analyze pipe flows
CO4	Design physical model for experimental studies
CO5	Compute drag and lift coefficients using the theory of boundary layer flows
CO6	Analyze the performance of hydraulic machines

6. **Course Contents**

Introduction:
Definition of fluid, properties of a fluid: density, specific weight, specific volume, specific gravity, viscosity, Newton's law of viscosity, types of fluids.

Fluid at rest:
Variation of pressure in a fluid, Pascal's principle, Manometers, force on submerged surfaces, Buoyancy and flotation, concept of metacentre and metacentric height.

Kinematics of fluid flow:
Lagrangian and Eulerian approach, types of fluid flow, convective and local acceleration, streamline, pathline, streakline, differential form of continuity equation, stream function, velocity potential function. Vortex flows (free vortex and forced vortex flow)

Dynamics of inviscid flow:
Bernoulli's equation along streamline, Venturimeter, Orificemeter.

Dynamics of viscous flow:

Navier-Stokes equations, fully developed laminar flow through pipes.

Dimensional analysis
Buckingham's pi theorem, model study, model laws

Flow past immersed bodies:
Concept of boundary layer, boundary layer thickness, displacement thickness, momentum thickness and energy thickness, Von-karman integral equation, Boundary layer separation, drag and lift, Magnus effect.

Hydraulic turbines:
Types of turbines, velocity triangle diagram for Pelton wheel, efficiency, design parameters, draft tube, cavitation, specific peed, unit quantities, model study.

Hydraulic pumps:
Types of pumps, centrifugal pump, velocity triangle for centrifugal pump, NPSH, specific speed, cavitation, model testing of centrifugal pump, components of a reciprocating pump, slip, indicator diagram, air vessels.

7. Text books

T1: Fluid Mechanics and Hydraulic Machines, Sukumar Pati, McGraw Hill Education (India) Pvt. Ltd, New Delhi

8. Reference books

R1: Hydraulics and Fluid Mechanics Including Hydraulics Machines, P.N. Modi, Standard Publishers Distributors.
R2: A Text Book of Fluid Mechanics, R. K. Rajput, S. Chand Ltd.
R3: Fluid Mechanics, Y. Cengel and J. Cimbala, McGraw Hill Education (India) Pvt. Ltd, New Delhi

9. Lesson plan and active learning activities

Lesson Number	**Learning objectives / activities**	**Topics to be covered**	**Refer to Chapter, (Text Book T1)**
1	Introduction and concepts of various properties	Definition of fluids, concept of continuum, fluid properties, density, specific weight, specific volume, specific gravity, Viscosity, units of viscosity, causes of viscosity, variation of viscosity with temperature.	1.1, 1.2, 1.5, 1.6
2	Newtonian fluids	Newton's law of viscosity, non-Newtonian fluids,	1.6

Lesson Number	Learning objectives / activities	Topics to be covered	Refer to Chapter, (Text Book T1)
		Kinematic viscosity, surface tension. Solving numerical.	
3	**Application of the concepts**	**Tutorial-1**	**Numerical**
4	Pressure	Introduction, fluid pressure at a point, Pascal's principle, Pressure variation in a fluid at rest, absolute, gauge, and vacuum pressure.	2.1, 2.2, 2.4, 2.5
5	Measurement of pressure	Measurement of pressure, manometers, simple manometers (only U-tube), Differential manometers.	2.7, 2.8
6	**Application of the concepts**	**Tutorial-2**	**Numerical**
7	Hydrostatic forces on surfaces	Introduction, total pressure and centre of pressure, hydrostatic force on a plane horizontal submerged surface, hydrostatic force on a plane vertical submerged surface.	3.1, 3.2, 3.3, 3,4
8	Buoyancy and floatation	Introduction, buoyancy, stability of a submerged body, metacentre, stability of floating bodies	4.1,4.2, 4.3, 4.4, 4.5, 4.6
9	Kinematics of fluid, different approaches for analysing the flow, acceleration	Introduction, methods of analyzing fluid motion, types of fluid flow, stream line and stream tubes, path line, streak line	5.1, 5.2, 5.3, 5.4
10	Understand conservation of mass, physical significance of stream function	Continuity equation, continuity equation in Cartesian coordinate system.	5.5, 5.6, 5
11	Acceleration, Stream function and velocity potential function	Acceleration field of a fluid, local and convective acceleration, Stream function, velocity potential, vortex flow	5.7, 5.10, 6.11.1, 6.11.2

Lesson Number	Learning objectives / activities	Topics to be covered	Refer to Chapter, (Text Book T1)
12	**Application of the concepts**	**Tutorial-3**	**Numerical**
13	Understand dynamics of flow	Introduction, differential equation of motion, Euler's equation of motion along a stream line	6.1, 6.2, 6.3
14	Bernoulli's equation, Total pressure, stagnation pressure, energy equation for a real fluid.	Bernoulli's equation, Static pressure, total pressure, energy equation for real fluids	6.3, 6.4, 6.5, 6.6
15	Different types of flow meters	Venturi meter (only horizontal and vertical type), orifice meter, Pitot tube	6.7.1, 7.7.2, 6.7.3
16	Vortex flows	Forced vortex flow, free vortex flow,	6.11.1, 6.11.2
17	**Application of the concepts**	**Tutorial-4**	**Numerical**
18	Dynamics of viscous flow	Introduction, Navier-Stokes Equations,	11.1, 11.2
19	Friction factor	loss of energy due to fluid friction- Concept of friction factor, Minor losses in pipe	13.3, 13.4
20	Flow through pipe	Introduction, loss of energy in pipes	13.1, 13.2
21	Fully developed flow	Concept of fully developed flow, Fully developed flow through circular tubes	11.3, 11.6
22	**Application of the concepts**	**Tutorial-5**	**Numerical**
Mid semester examination ( )			
23	Dimensional analysis	Introduction, review of dimensions and dimensional homogenity, dimensional analysis (only Buckingham's pi theorem)	9.1, 9.2, 9.3.2
24	Model study	Model analysis, similude (geometric similarity, kinematic similarity, dynamic similarity)	9.4, 9.5
25	Dimensionless numbers	Forces influencing hydraulic phenomena, dimensionless numbers and their effects	9.6, 9.7

Lesson Number	Learning objectives / activities	Topics to be covered	Refer to Chapter, (Text Book T1)
26	Model laws	Model laws (Reynolds model, Froude model, Euler model law, Mach model law)	9.8.1, 9.8.2, 9.8.3, 9.8.4.
27	**Application of the concepts**	**Tutorial-6**	**Numerical**
28	Boundary layer theory	Introduction, boundary layer concept, concept of displacement thickness, momentum thickness and energy thickness,	14.1, 14.2, 14.3
29	Boundary layer equation and momentum integral equation	Momentum integral equation, solution of the integral equation.	14.5, 14.6
30	Friction coefficient	Boundary layer thickness, wall shear stress, skin friction coefficient	14.6.1, 14.6.2, 14.6.3
31	Separation of boundary layer	Boundary layer separation, control of separation	14.9
32	Drag and lift	Introduction, basic concepts of drag and lift, expression for drag and lift, Dimensional analysis of drag and lift	15.1, 15.2.1, 15.2.2,
33	Types of drag	Pressure drag and skin friction drag, stream lined body and bluff body, Drag on a sphere.	15.2.3, 15.2.4, 15.3
34	Terminal velocity	Terminal velocity of a body, drag on a cylinder	15.4, 15.5
35	Lift	Lift on a circular cylinder, Magnus effect.	15.6
36	**Application of the concepts**	**Tutorial-7**	**Numerical**
37	Hydraulic turbines	Introduction, essential element of a hydraulic power plant.	19.1, 19.2
38	Head and efficiencies, Classification of hydraulic turbines	Head and efficiencies of hydraulic turbine, Classification of turbines	19.3, 19.4
39	Pelton wheel	Pelton wheel, work done and efficiencies of Pelton wheel	19.5
40	Reaction turbine	Working principle of Francis turbine	19.6, 19.7

Lesson Number	Learning objectives / activities	Topics to be covered	Refer to Chapter, (Text Book T1)
41	Draft tube	Kaplan turbine, Draft tube	19.8, 19.9
42	Cavitation in hydraulic machines	Cavitation, dimensional analysis and similarity laws for hydraulic machines	19.10, 19.11
43	Unit quantities of hydraulic turbines	Specific speed Unit quantities, unit speed, unit power,	19.12, 19.13
44	**Application of the concepts**	**Tutorial-8**	**Numerical**
45	Centrifugal pump	Introduction, components of a centrifugal pump.	20(T1)
46	Working principle	Working principle of a centrifugal pump, work done by a CF pump,	20 (T1)
47	Different heads	Different heads in a pumping system, different efficiencies of CF pump.	20(T1)
48	Model testing	Specific speed, model testing.	20 (T1)
49	NPSH	Cavitation , NPSH	20 (T1)
50	**Application of the concepts**	**Tutorial-9**	**Numerical**
51	Reciprocating pump	Introduction, components, Working principle, types, discharge and power requirement	21 (T1)
52	Slip and coefficient of discharge	Slip, coefficient of discharge, variation of velocity and acceleration	21 (T1)
53	Frictional head	Frictional head, effects of velocity and acceleration, Indicator diagram, air vessel	21 (T1)
54	**Application of the concepts**	**Tutorial-10**	**Numerical**
End semester examination			

10. Assessment components:

Type	Process	Marks
Quiz	Objective type test	5

Assignment	Students are required to solve numerical	5
Interactive Focus	Group Activity: Execution of the activity in a group of 4 or 5	5
Critical thinking focus	Group Activity: Issues are to be identified and addressed with suggestions to overcome it by going through different resources	5
Creation	Group Activity: Design model will be developed with design steps and C program may be developed for taking care of all design aspects	5
Reflection	Students are required to evaluate their work (Activity) in terms of quality	5

11. Assessment plan for active learning activities:

Sl. No.	Active learning Assessment Component	Marks	Date of submission	Nature of the Component
1	Assignment -1 Assignment -2	2.5/30 2.5/30		Solving numerical
2	Quiz -1 Quiz -2	2.5/30 2.5/30		Quiz
3	Report writing	5/30		Group activity
4	Summary of research paper	5/30		Critical thinking
5	Mathematical modelling	5/30		Simulation
6	Self assessment	5/30		Self-assessment

Report writing (activity-3)

Presentation by groups consisting of five students in each group
Group-1 : Topic- Different models of non-Newtonian fluids and applications
Group-2: Possible causes of recent accident of Boeing 737 Max 8
Group-3: Prediction of maximum wind speed in a cyclone
Group-4: Estimation of wind load while designing a structure
Group-5: Steps for designing a piping system and selecting a pump
Group-6: Contribution of hydro-electric energy in total energy consumption in India (Plants of NHPC)
Group-7: Merits and demerits of hydro power
Group-8: Methods of harnessing tidal power
Group-9: Wind turbine
Group-10: Methods of measuring blood pressure
Group-11: Ultrasonic flow meter
Group-12: Stability of ships

Summary of research paper (activity-4)

Summary of a research article published in a reputed journal (Journal of Fluid Mechanics, International journal of heat and fluid flow, Journal of fluid Engineering etc)

Mathematical modelling (activity-5)

This activity includes mathematical modeling of physical phenomena. Students, in groups, have to give a report describing the basic assumptions, equations required for analyzing the process.

Group-1: Mathematical modeling of blood flow
Group-2: Mathematical modeling of passing of food items through food pipe
Group-3: Magnetic drug delivery for treatment of cancer
Group-4: Modeling of polymer flows in industry
Group-5: Modeling of chocolate flows in food processing industries
Group-6: Mathematical models of tsunami waves
Group-7: Calculation of drag force over a flying eagle
Group-8: Designing of car fronts to reduce the drag

14. **Attendance:** Every student is expected to be regular (in attendance) in all lecture classes, tutorials, labs, tests, quizzes, seminars etc and in fulfilling all tasks assigned to him / her. Attendance will be recorded and 75% attendance is compulsory.

15. **Makeup:**

1) No make-up examination will be scheduled for the mid semester examination. However, official permission to take a make-up examination will be given under exceptional circumstances such as admission in a hospital due to illness / injury, calamity in the family at the time of examination.

2) A student who misses a mid-semester examination because of extenuating circumstances such as admission in a hospital due to illness / injury, calamity in the family may apply in writing via an application form with supporting document(s) and medical certificate to the Dean of the School for a make-up examination.

3) Applications should be made within five working days after the missed examination.

16. **Discussion of Mid Semester performance:** Performance of the mid semester examination will be discussed in the class room

17. **Chamber consultation hour for doubts clarification:** in virtual mode only.

18. **Notices:** All notices regarding the course will be notified through email only.