MECHANICAL

DEPARTMENT

2022-23

FM

PREPARED BY

Mr. Harish B.

Techno India NJR Institute of Technology

Session 2022-23

Course File

4ME4-05: FLUID MECHANICS AND FLUID MACHINES

Harish B.
Assistant Professor
Department of Mechanical Engineering

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

2nd Year - IV Semester: B.Tech. : Mechanical Engineering

4ME4-05: FLUID MECHANICS AND FLUID MACHINES

Credit: 4 **Max. Marks: 200 (IA:40, ETE:160)**

3L+1T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Fluid Properties:** Units and dimensions- Properties of fluids- mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapor pressure, surface tension and capillarity.	2
	Fluid Statics and Flow Characteristics: Basic equation of fluid statics, Manometers, Force on plane areas and curved surfaces, center of pressure, Buoyant force, Stability of floating and submerged bodies. Flow characteristics – concept of control volume - application of continuity equation, energy equation and momentum equation.	5
3	**Flow Through Circular Conduits:** Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli-Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation –friction factor- Moody diagram-minor losses – Flow through pipes in series and parallel.	8
4	**Dimensional Analysis:** Need for dimensional analysis – methods of dimensional analysis – Similitude –types of similitude - Dimensionless parameters- application of dimensionless parameters – Model analysis.	8
5	**Pumps:** Impact of jets - Euler's equation - Theory of roto-dynamic machines – various efficiencies– velocity components at entry and exit of the rotor- velocity triangles - Centrifugal pumps– working principle - work done by the impeller - performance curves - Reciprocating pump- working principle – Rotary pumps –classification.	8
6	**Turbines:** Classification of turbines – heads and efficiencies – velocity triangles. Axial, radial and mixed flow turbines. Pelton wheel, Francis turbine and Kaplan turbines- working principles - work done by water on the runner – draft tube. Specific speed - unit quantities – performance curves for turbines – governing of turbines.	7
	TOTAL	39

Course Overview:

This is an introductory course in Fluid Machines. The subject Fluid Machines has a wide scope and is of prime importance in almost all fields of engineering. The course emphasizes the basic underlying fluid mechanical principles governing energy transfer in a fluid machine and also description of the different kinds of hydraulic and air machines along with their performances. There is a well-balanced coverage of physical concepts, mathematical operations along with examples and exercise problems of practical importance. After completion of the course, the students will have a strong foundation on Fluid Machines and will be able to apply the basic principles, the laws, and the pertinent equations to engineering design of the machines for required applications.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Students will summarize the fundamental concepts of fluid mechanics including continuum, velocity field, surface tension, flow visualization etc.
2	Synthesis	Students can create the basic equation of fluid statics to determine forces on planer and curved surfaces that are submerged in a static fluid.
3	Synthesis	Students will be able to formulate the forces and moments on surfaces of various shapes and simple machines
4	Synthesis	Students will able to combine Euler̓s and Bernoulli̓s equations and the conservation of mass to determine velocities, pressures, and accelerations for incompressible and in viscid fluids
5	Synthesis	Students will be able to arrange pipe fittings arrangement as per the requirements.

Prerequisites:

1. Basic knowledge of Fluid Mechanics
2. Concepts of Engineering mechanics, basic physics, Newton’s Laws

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	-	-	-	-	1	-	-	-
CO2	3	2	3	2	2	-	-	-	-	1	-	1
CO3	3	2	3	2	2	-	-	-	-	1	-	1
CO4	2	1	-	2	2	1	-	-	-	-	-	1
CO5	2	2	2	2	1	1	1	1	1	2	-	1
1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	**INTRODUCTION**
2	**2**	**FLUID PROPERTIES:** Students will able to know the basic concepts related to units and dimensions- Properties of fluids- mass density, specific weight, specific volume
3	2	Students will able to know the basic concepts related to fluid properties: Units and dimensions- Properties of fluids- specific gravity, viscosity, compressibility, vapor pressure
4	2	Students will able to know the basic concepts related to fluid properties: Units and dimensions- Properties of fluids- surface tension and capillarity.
5	2	Students will able to know the basic concepts related to fluid statics and flow characteristics: Basic equation of fluid statics, Manometers (Simple Manometer).
6	2	Students will able to know the basic concepts related to Manometers- Piezometer, U-tube manometer (Numerical Problem)
7	2	Students will able to know the basic concepts related to Manometers- Single column Manometer, Differential Manometer
8	2	Students will able to know the basic concepts related to Hydrostatic Law - Vertical Plane Surface, Horizontal Plane Surface.
9	2	Students will able to know the basic concepts related to Inclined plane surface Sub-merged in Liquid and curved Surface Sub-merged in liquid.
10	2	Students will able to know the basic concepts related to Buoyancy- Meta-Centre, Meta-Centre Height.

11	2	Students will able to know the basic concepts related to stability of floating and submerged bodies.
12	2	Students will able to know the basic concepts related to flow characteristics – concept of control volume - application of continuity equation.
13	2	Students will able to know the basic concepts related to energy equation and momentum equation.
14	**3**	**FLOW THROUGH CIRCULAR CONDUITS:** Students will able to know the basic concepts related to Hydraulic and energy gradient line
15	3	Students will able to know the basic concepts related to Laminar flow through circular pipe and Parallel plate.
16	3	Students will able to know the Darcy Weisbach equation –friction factor, Moody diagram-minor losses
17	3	Students will able to know the flow through pipes in series and parallel.
18	**4**	**DIMENSIONAL ANALYSIS**
19	4	Students will able to apply the Rayleigh's method to existing problems (Numerical)
20	4	Students will able to apply the Buckingham's Pi theorem (Numerical Problem)
21	4	Students will able to apply the Buckingham's Pi theorem (Numerical Problem)
22	4	Students will able to apply the Model Analysis, Similitude- Types of Similarities.
23	4	Students will able to apply the Dimensionless Numbers- Reynolds's Number, Froude's Number, Euler's Number.
24	4	Students will able to apply the Dimensionless Numbers- Weber's Number, Mach's Number.
25	4	Students will able to apply the Model Laws or similarities Laws.
26	4	Numerical Problem (Dimensionless Numbers, Model Laws or similarities Laws.)
27	**5**	**IMPACT OF JET**
28	5	Students will able to know the Impact of jet (curved plate, movable flat plate, movable inclined plate, movable curved plate.)
29	5	Students will able to know the basic concepts related to Pump- Euler’s equation - Theory of Roto-dynamic Machines, various efficiency.
30	5	Numerical Discussion
31	5	Students will able to know the basic concepts related to Velocity components at entry and exit of the rotor, velocity triangles (Blade Diagram.)
32	5	Students will able to know the basic concepts related to Centrifugal pumps– working principle - work done by the impeller
33	5	Students will able to know the basic concepts related to Centrifugal pumps– performance curves

34	5	Students will able to know the basic concepts related to Reciprocating pump-working principle Rotary pumps –classification.
35	**6**	**TURBINES:** Students will able to know the basic concepts related to Classification of turbines, heads and efficiencies
36	6	Students will able to know the basic concepts related to Pelton wheel, Francis turbine and Kaplan turbine - Velocity components at entry and exit of the rotor, velocity triangles (Blade Diagram.), work done by water on the runner
37	6	Students will able to know the basic concepts related to Kaplan turbines-Velocity components at entry and exit of the rotor, velocity triangles (Blade Diagram.), work done by water on the runner
38	6	Students will able to know the basic concepts related to draft tube. Specific speed and unit quantities
39	6	Students will able to know the basic concepts related to performance curves for turbines – governing of turbines.

Text Books

1. Fluid Mechanics and Fluid Machinery by R. K. Bansal, Laxmi Publications.
2. Hydraulics & Fluid Mechanics by Dr. P. N. Modi and Dr. S. M. Seth, Standard Book House.

References

1. Fluid Mechanics by Yunus Cengel, Jhon Cimbala, Tata Mcgraw Hill,New Delhi.
2. Introduction to Fluid Mechanics & Fluid Machines by S.K Som, Gautam Biswas & Suman Chakraborty, Tata Mcgraw Hill,New Delhi.

Assessment Methodology:

1. Conducting vica voce examination on weekly basis.
2. Practical exam in lab where students have to apply their theoretical understanding to perform experiments practically and correlate them analytically. (Once in a week)
3. Assignments one from each unit.
4. Midterm subjective paper where they have to solve basic questions with numerical and derivations from each unit. (Twice during the semester)
5. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

Introduction & Fluid Properties

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105171/

Quiz: https://www.sanfoundry.com/1000-fluid-mechanics-questions-answers/

Unit-2

Flow through circular conduits

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105171/

Quiz: https://www.sanfoundry.com/1000-fluid-mechanics-questions-answers/

Unit-3

Dimensional Analysis

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105171/

Quiz: https://www.sanfoundry.com/1000-fluid-mechanics-questions-answers/

Unit-4

Impact of Jet

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105171/

Quiz: https://www.sanfoundry.com/1000-fluid-mechanics-questions-answers/

Unit-5

Turbines

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105171/

Quiz: https://www.sanfoundry.com/1000-fluid-mechanics-questions-answers/

Previous Year Question Papers:

4E414

B.Tech. IV sem.(Main&Back) Examination May - 2018
Mechanical Engg.
4ME2A Fluid Mechanics & Machines
AE, ME

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 26

*Attempt any **five** questions, selecting one question from **each unit**. All questions carry equal marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Use of following supporting material is permitted during examination. (Mentioned in form No. 205).

1. Moady's chart.

Unit - I

1. a) Calculate the Pressure and density of air at a height of 4000m from sea - level where pressure and temperature of the air are 10.143 N/cm^2 and 15°C respectively. The temperature lapse rate is given as 0.0065°C/m. Total density of air at sea - level equal to 1.285 kg/m^3. **(8)**

b) What do you mean by

i) Weight Density

ii) Newtonian Fluid

iii) Bluk modulus of Elasticity

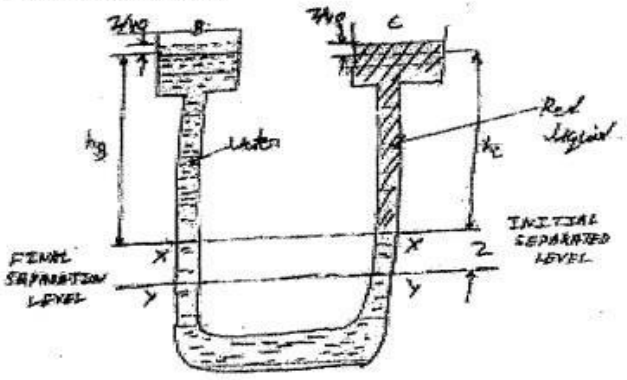
iv) Cavitations. **(4×2=8)**

OR

1. a) With neat sketches, explain the conditions of equilibrium for floating and sub-merged bodies. **(6)**

b) A pressure gauge consists of two cylindrical bulbs B and C each of 10 sq.cm cross - sectional area, which are connected by a U- tube with vertical limbs each of 0.25 sq. cm. cross sectional area. A red liquid of specific gravity 0.9

is filled into C and clear water is filled into B, the surface of separation being in the limb attached to C. Find the displacement of the surface of separation when the pressure on the surface in C is greater than that in B by an amount equal to 1 cm head of water.



(10)

Unit - II

2. a) What is a 'flownet'? Enumerate the methods of drawing flownets. **(8)**

   b) State the Euler's equation of motion and also establish the Bernoulli's equation. **(8)**

OR

2. a) Explain the following :

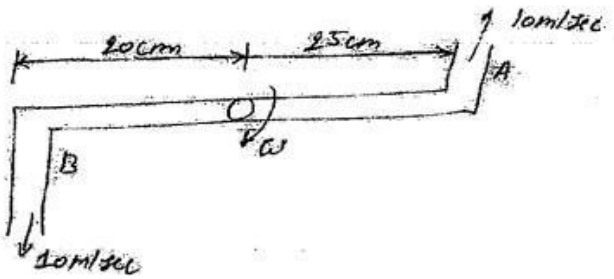
   i) Laminar and Turbulent flow

   ii) Stream line and streak line

   iii) Uniform and Non - uniform flow

   iv) Steady and Unsteady flow. **(4×2=8)**

   b) A lawn sprinkler shown in fig has 0.8 cm diameter nozzle at the end of a rotating arm and discharges water at the rate of 10 m/s velocity. Determine the torque required to hold the rotating arm stationary. Also determine the constant speed of ratation of the arm, at free to rotate.



(8)

Unit - III

3. a) Determine the fall velocity of 0.06 mm sand particle (specific gravity = 2.65) in water at 20°C, take $\mu = 10^{-3} kg/ms$. **(8)**

b) Prove that for laminar flow in a round pipe, the drop of pressure AP over a finite length L is given by :

$\Delta P = (8\mu VL / R^2)$

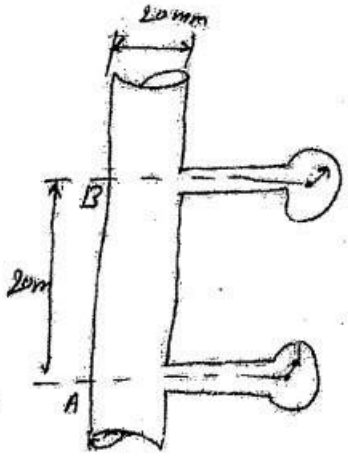
Where, V = Average velocity of flow in the pipe.

R = Radius of pipe. **(8)**

OR

3. a) A smooth pipe line of 100 mm diameter carries 2.27 m^3 per minute of water at 20°C with kinematic viscosity of 0.0098 stokes. Calculate The friction factor, maximum velocity as well as shear stress at the boundary. **(8)**

b) Crude oil of $\mu = 1.5$ poise and relative density 0.9 flows through a 20 mm diameter vertical pipe. The pressure gauges fixed 20 m apart read 58.86 N/cm^2 and 19.62 N/Cm^2 and shown in fig. Find the direction and rate of flow through the pipe.



(8)

Unit - IV

4. a) Derive an expression for the power transmission through the pipes. Find also the condition for maximum transmission of power. **(8)**

b) Three pipes of 400 mm, 200mm, and 300 mm diameters have lengths of 400 m, 200 m & 300 m respectively. They are connected in series to make a compound pipe. The ends of this compound pipe are connected with two tanks whose difference of water levels is 16m. If co - efficient of friction for. these pipes is same and equal to 0.005, determine the dischrage through the compound pipe reglecting first the minor losses and then including them. **(8)**

OR

4. a) Define an arifice meter. Prove that the discharge through an orifice meter is given by the relation :

$$Q = C_d \frac{a_0 a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

Where : a_1 = Area of pipe in which orific meter in fitted. a_2 = Area of orifice.**(8)**

b) A 150 mm diameter pipe reduces in diameter abruptly to 100 mm diameter. If the pipe carries water at 30 litres per second, calculate the pressure loss across. the contraction. Take the co-efficient of contraction as 0.6. **(8)**

Unit - V

5. a) A water turbine has a velocity of 6 mts at the entrance to the draft - tube and a velocity of 1.2 mts at the exit. For friction losses of 0.1m and a fail water 5 m below the entrance to the draft - tube, find the pressure head at the entrance. **(8)**

b) Describe the following hydraulic system in details describing their working; Hydraulic Accumulator, Hydraulic Intensities, Hydraulic coupling and hydraulic torque converter. **(2×4=8)**

OR

5. a) Prove that for hydraulic efficiency can be expressed by :

$$y_n = \frac{2}{2 + \tan^2 \frac{}{a}}$$ **(8)**

b) A pelton wheel is to be designed for a head of 60 m when running at 200 rpm. The pelton wheel develops 95.6475 KW shaft power. The velocity of the buckets = 0.45 times the velocity of the jet, overall efficiency = 0.85 and co-efficient of the velocity is equal to 0.98. **(8)**

4E4141

Roll No. _____ Total No. of Pages : 4

4E4141

B. Tech. IV-Sem. (Back) Exam; April-May 2017

Mechanical Engg.

4ME2A(O) Fluid Mechanics

Time : 3 Hours **Maximum Marks : 80**

Min. Passing Marks : 26

Instructions to Candidates :-

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*
Units of quantities used / calculated must be stated clearly.
Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

UNIT - I

1 A - U-tube Manometer is used to measure the pressure of water in a pipeline, which is in excess of atmospheric pressure. The right limb of the manometer contain mercury and is open to atmosphere. The contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs of U-tube is 10 cm and free surface of mercury is in level with the centre of the pipe. If the pressure of water in pipeline is reduced to 9810 N/m^2, calculate the new difference in the level of mercury. Sketch the arrangements in both cases. **16**

OR

1 (a) Determine the viscosity of a liquid having kinematic viscosity 6 stokes and specific gravity 1.9.

6

(b) A caisson for closing the entrance to a dry clock is of trapezoidal form 16 m wide at top and 10 m wide at bottom and 6 m deep. Find total pressure and centre of pressure on the caisson if the water on outside is just level with the top and clock is empty.

10

UNIT - II

2 A fluid flow field is given by

$$V = x^2yi + y^2zj - \left(2xyz + yz^2\right) K$$

Prove that it is a case of possible steady incompressible fluidflow. Calculate velocity and acceleration at point [2, 1, 3].

16

OR

2 (a) Derive the Bernoull's Equation.

8

(b) A nozzle of diameter 20 mm is fitted to a pipe of diameter 40 mm. Find the force exerted by nozzle on the water which is flowing through the pipe at the rate of 1.2 m^3/min.

8

UNIT - III

3 (a) Derive the Hagen Poiseuille formula.

8

(b) An oil of viscosity 10 poise flows between two parallel fixed plates which are kept at a distance of 50 mm apart. Find the rate of flow of oil between the plates if the drop of pressure in a length of 1.2 m be 0.3 N/cm^3. The width of plate is 200 mm.

8

OR

3 (a) A rough pipe is of diameter 8.0 cm. The velocity at a point 3.0 cm from wall is 30% more than velocity at a point 1.0 cm from pipe wall. Determine the average height of roughness.

8

(b) Explain hydrodynamically smooth and rough boundaries.

8

UNIT - IV

4 (a) Derive the discharge formula for venturimeter.

8

(b) Derive the experssion for discharge over a triangular notch.

8

OR

4 (a) Derive the Darcy-Weisbach equation.

8

(b) A horizontal pipe line 40 m long is connected to a water tank at one end and discharge freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipe is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of pipe. Consider all losses of head which occur, determine the rate of flow.

Take f = .01 for both secitons of the pipel

8

UNIT - V

5 (a) A Pelton wheel has a mean bucket speed of 10 meter per second with a jet of water flowing at the rate of 700 litres/sec. Under a head of 30 meter. The buckets deflect the jet through an angle of 160°. Calculate the power given by water to the runner and hydraulic efficiency of turbine take C_v = .98.

8

(b) Explain the draft-tube.

8

OR

5 Explain any four in following :

(i) Hydraulic press

(ii) Hydraulic ram

(iii) Hydraulic lift

(iv) Hydraulic accumulator

(v) Hydraulic coupling

(vi) Hydraulic torque converter gear pump.

4×4