

# FLUID MECHANICS WITH ENGINEERING APPLICATION

ENME 254

Lecture : 3

Year : II

Tutorial : 1

Part : II

Practical : 3/2

## Course Objectives:

The objective of this course is to provide students with basic concepts of fluid mechanics with different practical applications. After completing the course, they can apply this knowledge to their daily lives and solve basic engineering problems related to fluids.

### 1 Introduction (2 hours)

- 1.1 Comparison of solid and fluid
- 1.2 Fluid Mechanics: Definition, basic concepts, and area of application
- 1.3 Unit and dimension
- 1.4 Properties of fluid: Density, specific weight, specific volume, specific gravity
- 1.5 Viscosity, surface tension, capillarity, compressibility, bulk modulus, vapor pressure
- 1.6 Classification of fluid based on Newton's law of viscosity

### 2 Fluid Statics (8 hours)

- 2.1 Pascal's law of hydrostatic (Pressure intensity at a point)
- 2.2 Equation of fluid statics
- 2.3 Pressure: Definition and types
- 2.4 Classification of pressure measurement devices
- 2.5 Manometer types and application
- 2.6 Forces and center of pressure on submerged surfaces: Horizontal, vertical, inclined, and curved
- 2.7 Principle of floatation: Metacenter, metacentric height, and its determination
- 2.8 Conditions of equilibrium for submerged and floating body

### 3 Kinematics of Fluid Flow (4 hours)

- 3.1 Method of fluid flow analysis: Lagrangian and Eulerian
  - 3.1.1 System and control volume
  - 3.1.2 Differential and integral approach,
  - 3.1.3 Description – Lagrangian and Eulerian: Advantages and disadvantages

- 3.2 Types of fluid flow: One/two/three dimensional flows, steady/unsteady flow, uniform/non-uniform flow, laminar/turbulent flow, compressible /incompressible flow, rotational/irrotational flow
- 3.3 Acceleration of a fluid particle: Local, convective, and material derivative
- 3.4 Rotation and vorticity: Related equations and application
- 3.5 Flow visualization: Lines of flow pattern, application (Particle image velocimetry, Schlieren technique)
- 3.6 Stream function and velocity potential function: Characteristics, equation and relation
- 3.7 Types of fluid particle distortion: Linear strain, translation, rotation, shear strain

#### **4 Fluid Dynamics (8 hours)**

- 4.1 Reynold's transport theorem (RTT)
- 4.2 Basic laws of fluid dynamics: Conservation of mass, conservation of linear momentum, conservation of energy
- 4.3 Continuity equations and applications: One-dimensional steady flow, rectangular coordinate systems
- 4.4 Euler's equation of motion
- 4.5 Bernoulli's equation and applications: Pipe flow, flow from a tank, and siphon flow
- 4.6 Momentum equation and applications: Elbow reactions, jet propulsions, fixed and moving blades, hydraulic jump
- 4.7 Navier-stokes equation: Introduction and application
- 4.8 Introduction to computational fluid dynamics (CFD)

#### **5 Viscous Flow (6 hours)**

- 5.1 Reynold's experiment
- 5.2 Boundary layer: The concept of development and zones on it
- 5.3 Separation of boundary layer and methods of controlling
- 5.4 Viscous flow in horizontal: Between Parallel Plates, and circular Tubes
- 5.5 Drag force on the flat plate due to boundary layer
- 5.6 Flow past submerged bodies: Drag and lift forces, types of drag
- 5.7 Development of lift force on an airfoil

#### **6 Pipe Flows (6 hours)**

- 6.1 Frictional resistance to flow in pipes: Darcy-Weisbach equation, friction factor, use of moody diagram, head loss
- 6.2 Local head losses: Inlet, bends, expansion and contraction joints, valve
- 6.3 Hydraulic and energy grade lines: Reservoirs and pipe flow, pumps, and turbines
- 6.4 Series and parallel combination of pipes
- 6.5 Equivalent pipes

- 6.6 Pipe flow networks
- 6.7 Phenomenon of water hammer

**7 Flow Measurement (4 hours)**

- 7.1 Measurement of static pressure intensity
- 7.2 Measurement of velocity: Pitot tube, pitot-static tube, particle image velocimetry (PIV)
- 7.3 Restriction flow meters: Orifice plate, flow nozzles, venture, laminar flow elements
- 7.4 Linear flow meters: Rotameter, turbine flow meter, vortex flowmeter, elbow meter, electromagnetic and ultrasonic flow meters
- 7.5 Weir and notches: Classification and flow measurement

**8 Dimensional Analysis and Similitude (5 hours)**

- 8.1 Dimensional analysis: Use, advantages and limitations
- 8.2 Model analysis: Use, advantages and limitations
- 8.3 Forces in fluids and dimensionless numbers
- 8.4 Similitude: Geometric, kinematic, and dynamic
- 8.5 Laws for dynamic similarity and application for submerged and partially submerged body
- 8.6 Scale effect in models
- 8.7 Formation of dimensionless equations by Buckingham's method

**9 Compressible Flow (2 hours)**

- 9.1 Properties, classification and fundamental equations
- 9.2 Nozzle: Purpose, types and equation
- 9.3 Sound wave and Mach number
- 9.4 Mach wave, Mach angle, and Mach cone
- 9.5 Classification of compressible flow
- 9.6 Shock waves: Application and types: Normal, oblique
- 9.7 Basics of measurement of compressible fluid flow (Discharge, velocity, direction)

**Tutorial (15 hours)**

- 1. Calculation related to fluid properties, viscosity, surface tension
- 2. Pressure and Pressure measuring devices: Manometer
- 3. Stream functions, velocity potential
- 4. Continuity equations, Bernoulli's equations, and its application
- 5. Concept of lift and drag, drag force in plate, coefficient of drag
- 6. Major head loss, minor head loss in pipe fittings, pipe flow network
- 7. Notches and weirs, flow measurement devices
- 8. Dimensional analysis using Buckingham's method

**Practical****(22.5 hours)**

1. Measurement of fluid properties
2. Determination of stability of floating objects
3. Determination of the center of pressure of the curved surface
4. Flow visualization through Reynold's experiment
5. Comparison of force due to the impact of a jet on a moving body
6. Determination of loss coefficient of pipe fittings on pipe flow network
7. Plot of hydraulic and energy grade lines: Pipe, venturimeter
8. Measurement of lift and drag forces on objects of different shapes
9. Determination of discharge coefficient: Orifice, venturimeter, notch

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1 and 2	10	12
3 and 5	10	12
4	8	12
6 and 9	8	12
7 and 8	9	12
<b>Total</b>	<b>45</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

**References**

1. Fox, R. W, McDonald, A. T., Pritchard, P. J. (2011). Introduction to Fluid Mechanics. John Wiley & Sons, Inc.
2. Douglas, J. F., Gasoriek, J. M., Swaffield, J., Jack, L. (2006). Fluid Mechanics. Prentice Hall.
3. Daugherty, R. L., Franzini, J. B., Finnemore, J. E. (1977). Fluid Mechanics with Engineering Applications (7th ed.). McGraw Hill Book Company, SI Metric Edition.
4. Massey, B.S. (2006). Fluid mechanics (4th ed.). Taylor & Francis Taylor & Francis Group London and New York.
5. White, F. M. (2011). Fluid Mechanics. McGraw-Hill
6. Streeter, V. L., Benjamin W. E., Bedford, K.W. (2011). Fluid Mechanics. Tata McGraw Hill Publishing Co Ltd., New Delhi, India.
7. Bansal, R.K. (2010). A Textbook of Fluid Mechanics and Hydraulic Machines. Laxmi Publications, New Delhi.
8. Som, S. K., Biswas, G. (2012). Introduction to Fluid Mechanics and Fluid Machines. Tata McGraw Hill, New Delhi
9. Khan, M.K. (2015). Fluid Mechanics and Machinery. Oxford University Press.