FLUID MECHANICS FOR CHEMICAL ENGINEERING

ENCH 202

Lecture : 4
Tutorial : 1
Practical : 1.5

Year : II
Part : I

Course Objectives:

The objective of this course is to provide understanding of fluid properties, focusing on fluid flow and its measurement techniques. It covers the flow governing principles with practical applications in pipe flow, pump and compressor.

1 Introduction (8 hours)

1.1 Basic Concepts; Units and dimensions; Dimensional analysis, Dimensionless numbers
1.2 Concept of fluids and fluid properties; Pressure concept, principles and techniques
1.3 Fluid statics; Buoyancy; Manometers
1.4 Surface tension and surface energy; The measurement of surface tension
1.5 Wetting and contact angle; Forces due to curved surfaces

2 Basic Equations of Fluid Flow (8 hours)

2.1 The general balance equation; The mass balance; Steady-state balances
2.2 One-dimensional mass balance; Unsteady-state mass balance; Mass balance for mixtures
2.3 The momentum balance; Some steady-state flow applications of the momentum balance
2.4 Relative velocities; Starting and stopping flows
2.5 The angular-momentum balance; Rotating systems

3 The Boundary Layer (6 hours)

3.1 Prandtl's boundary layer equations; Boundary layers on a flat plate parallel to the flow
3.2 Turbulent boundary layers; Separations
3.3 Turbulent flow in pipes

4 **Bernoulli's Equation** (8 hours)

4.1 The energy balance for a steady, incompressible flow
4.2 The friction-heating term
4.3 Zero flow
4.4 The head form of Bernoulli's equation
4.5 Bernoulli's equation for gases; Bernoulli's equation for unsteady flows; Limitation of Bernoulli's theorem
4.6 Torricelli's equation and its variants
4.7 Diffusers and sudden expansions; Fluid-flow measuring devices

5 **Fluid Friction in Steady (One-dimensional Flow)** (8 hours)

5.1 The history of potential flow and boundary layer
5.2 Laminar flow; Turbulent flow; Streamlines
5.3 Stream function and losses
5.4 Fluid friction in 1-D flow in non-circular channels
5.5 Economic pipe diameter, economic velocity
5.6 Flow around a cylinder and submerged objects

6 **Pumps and Compressors** (12 hours)

6.1 General relations for all pumps, and compressors
6.2 Positive-displacement pumps and compressors
6.3 Centrifugal pumps and compressors
6.4 Axial flow pumps and compressors
6.5 Pump and compressor efficiencies and stability
6.6 Regenerative pumps; Selection of pumps; Cavitation

7 **Flow Through Porous Media** (4 hours)

7.1 Fluidization
7.2 Fluid friction in porous media
7.3 Two-fluid co-current flow in porous media
7.4 Countercurrent flow in porous media

8 **Two-dimensional and Three-dimensional fluid mechanics** (4 hours)

8.1 Mass balances for multidimensional flows
8.2 Momentum balances for multidimensional flows
8.3 Navier-Stokes equations

9 **Mixing** (2 hours)

9.1 Types of mixing problems
9.2 The role of turbulence and molecular diffusion
9.3 Mixing in stirred tanks and pipe flow

Tutorial **(15 hours)**

1. Fluid mechanics basic calculations
2. The balance equation and the mass and momentum balance, solving mass and momentum balance equation
3. The boundary layer, calculations on boundary layer equations such as solving thickness
4. Bernoulli's equation, solving Bernoulli's equation to calculate different parameters
5. Fluid friction in steady, 1-D Flow, economic pipe diameter and velocity
6. Pumps and compressors, pumps and compressors sizing
7. Flow through porous media, and 2-D and 3-D fluid mechanics, flow though porous media and 2-D and 3-D

Practical **(22.5 hours)**

1. To find pressure drop through valves, determine head loss for pipes.
2. To investigate the validity of the Bernoulli equation when applied to the steady flow of water in a converging or a diverging duct
3. Fluid visualization through different arrangements
4. Determine the co-efficient of discharge with outflow under constant and varying discharge
5. Study characteristics of pumps

Evaluation Scheme:

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as follows:

Chapter	Hours	Marks distribution*
1	8	6
2	8	6
3	6	6
4	8	10
5	8	8
6	12	14
7	4	4
8	4	4
9	2	2
Total	**60**	**60**

* There may be minor deviation in marks distribution.

References

1. Nevers, N. (2020). Fluid Mechanics for Chemical Engineers. McGraw Hill.
2. McCabe, W.L., Smith, J.C., Harriott, P. (2017). Unit Operations of Chemical Engineering. McGraw Hill Inc.
3. Wilkes, J.O. (2017). Fluid Mechanics for Chemical Engineers. Pearson.

4. Fox, R.W., McDonald, A.T., Pritchard, P.J. (2020). Introduction to Fluid Mechanics. John Wiley & Sons.
5. Gerhart, A.L., Hochstein, J.I., Gerhart, P.M. (2020). Fundamentals of Fluid Mechanics. Wiley.
6. Holland, F.A., Bragg, R. (1995). Fluid flow for Chemical Engineers. Butterworth & Heinemann.
7. White, F.M., Xue, H. (2022). Fluid Mechanics. McGraw Hill.
8. Çengel, Y.A., Cimbala, J.M. (2017). Fluid Mechanics: Fundamentals and Applications. McGraw Hill.
9. Coulson, J.M., Richardson, J.F., Backhurst, J.R., Harker, J.H. (2017). Fluid Flow: Fundamentals and Applications. Butterworth Heinemann, Elsevier.