# Fluid Mechanics - Video course

## COURSE OUTLINE

This is intended to be a first course in fluid mechanics for undergraduate students in chemical engineering.

The course will begin by introducing the necessary fundamental concepts of fluid flow, and proceed to cover both macroscopic (i.e. integral balances) and microscopic (i.e. differential balances) approaches to analyze various fluid flow phenomena encountered in chemical engineering applications.

Some specific applications that will be covered in detail are

1. Pipe flows, fittings and friction factor charts,
2. Fow past immersed bodies: drag forces, settling,
3. Flow through packed beds and fluidized beds,
4. Fluid transportation (pumps, compressors and valves),
5. Flow measurement techniques, and
6. Agitation and mixing.

Apart from these applications, the following specialized topics that are relevant to chemical engineers will also be covered:

1. Boundary layer theory,
2. Non-Newtonian and viscoelastic fluids, and
3. Turbulent flows.

A number of problems will be worked out alongside to help illustrate the concepts.

**Contents:**

Introduction to process fluid mechanics; Fluid statics; Macroscopic (integral) balances for mass, energy and momentum with applications; Engineering Bernoulli equation.

Microscopic (differential) balances (Navier-Stokes equations) with simple applications; Dimensional analysis; Inviscid and potential flows; Boundary layer theory.

Pipe flows and friction factor charts; Flow past solid bodies; Flow through packed and fluidized Beds; Agitation and mixing; Flow measurement; Fluid transportation: pumps & compressors; Brief introduction to non-Newtonian fluids; Turbulent flows.

## COURSE DETAIL

| S.No | Topics | No. of Hours |
|---|---|---|
| 1 | Introduction to process fluid mechanics; Dimensions and units; SI units (Fox & Mc-Donald, Chap. 1; Denn, Chap. 1). | 1 |

NP-TEL

# NPTEL

**http://nptel.iitm.ac.in**

## Chemical Engineering

**Pre-requisites:**

Engineering mathematics (differential and integral calculus; ordinary differential equations; elementary ideas in vectors like dot products, surface integrals, volume integrals).

**Coordinators:**

**Dr. V. Shankar**
Department of Chemical EngineeringIIT Kanpur

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| 2 | Fundamental concepts: Definition of a fluid; Continuum hypothesis; Velocity field;Stress field; Newtonian and non-Newtonian fluids (Fox & McDonald Chap. 2; Denn, Chap. 2). | 2 |
| 3 | Fluid statics: pressure variation in a static fluid, hydrostatic forces on submerged surfaces, buoyancy; Illustration by examples (Fox & McDonald Chap. 3). | 3 |
| 4 | Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses. (Fox & McDonald Chap. 4 ; Denn, Chap. 5). | 3 |
| 5 | Application of macroscopic balances: Losses in expansion, Force on a reducing bend, Diameter of a free jet; Jet ejector. (Fox & McDonald, Chap. 4; Denn, Chap. 6). | 2 |
| 6 | Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid.<br><br>Applications to plane Couette, plane Poiseuille and pipe flows. (Fox & McDonald, Chap. 5; Denn, Chap. 7). | 3 |
| 7 | Dimensional analysis and similitude: Buckingham Pi theorem and applications (Fox & McDonald, Chap. 7). | 2 |
| 8 | High-Reynolds number flows: inviscid flows and potential flows (Fox & McDonald,Chap. 6; Denn, Chap. 14). | 2 |
| 9 | Boundary layer theory (Fox & McDonald, Chap. 9, Part A; Denn, Chap. 15). | 3 |
| 10 | Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, flow in manifolds (Wilkes, Chap. 3.4; Denn, Chap. 3 and Chap. 6). | 2 |
| 11 | Flow past immersed bodies: flow past a sphere and other submerged objects (Fox & McDonald, Chap. 9 Part B, McCabe et al., Chap. 7, Wilkes, Chap. 4.3; Denn, Chap. 4). | 2 |
| 12 | Flow through packed beds and fluidized beds (McCabe et al., Chap. 7, Wilkes, Chap. 4.4; Denn, Chap. 4). | 2 |
| 13 | Agitation and mixing: power consumption, mixing times, scale up (McCabe et al., Chap. 9). | 2 |
| 14 | Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rotameters.<br><br>Brief introduction to non-conventional methods: Laser Doppler velocimetry, Particle image velocimetry, ultrasonic flow meters, electromagnetic flow meters. (McCabe et al., | 2 |

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| | Chap. 8, Wilkes, Chap. 2; Denn, Chap. 6). | |
| 15 | Fluid transportation: Valves and Pumps and Compressors (McCabe et. al., Chap. 8, Wilkes, Chap. 4.1). | 2 |
| | Non-Newtonian and viscoelastic fluids; viscometry (Bird et al., Chap. 8; Denn, Chap. 19). | 4 |
| 16 | Introduction to turbulent flows (Bird et al., Chap. 5; Denn, Chap. 16). | 3 |
| | **Total** | 40 |

**References:**


1. R. W. Fox and A. T. McDonald, Introduction to Fluid Mechanics (Fourth Edition) Wiley Singapore (1995).
2. J. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall (1999).
3. W. L. McCabe, W. L. Smith, and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill International Edition (Sixth edition) (2001).
4. R. B. Bird, W. L. Stewart and E. L. Lightfoot, Transport Phenomena (Second edition), Wiley Singapore (2002).
5. M. M. Denn, Process Fluid Mechanics, Prentice Hall (1980).