
Goals and Objectives: Fluid Mechanics is a fundamental course in mechanical engineering. The goal of this course is to give you an understanding of the physical mechanisms involved in fluid flows including predictions of flows and resulting forces. This course covers fundamental concepts of fluid mechanics with a broad range of engineering and technological applications. An understanding of fluid mechanics is necessary since fluid dynamical processes are an important part of the design processes of vehicles, power plants, chemical processing units, buildings, bridges and among other things.

Knowledge, Skills, and Abilities gained: Knowledge of physical quantities important to fluid flow, Ability to apply fundamental laws in control volume form to engineering situations, Knowledge of fluid flows in pipes and around objects, and Ability to apply basic laws of fluid mechanics to compute various quantities.

Impact on subsequent courses in curriculum: Knowledge needed to understand heat transfer, thermal-design and other thermal fluid system courses

Prerequisites: All students taking the course must have a basic knowledge of engineering (Thermodynamics laws, Newtonian Mechanics/Laws) and differential and integral calculus.

MATERIALS COVERED:

- Review of BASIC Concepts: Properties, Kinematics, Statics [Ch 1-5]
- MASS, BERNOULLI, AND ENERGY EQUATIONS [Ch 5]
- MOMENTUM ANALYSIS OF FLOW SYSTEMS [Ch 6]
- DIMENSIONAL ANALYSIS AND MODELING [Ch 7]
- INTERNAL FLOW [Ch 8]
- DIFFERENTIAL ANALYSIS OF FLUID FLOW [Ch 9]
GRADING: There will be several assignments at regular intervals during the semester. You are required to submit the assigned work on or before the deadline. Late submission of the assigned work will not be allowed unless medical and emergency reasons exist. The following percentages of the assignments, exams, and project will constitute the basis for the assigning of the final grade in the course:

Class performance & Quizzes: 10%, Homework: 10%
Exam 1: 20%, Exam 2: 20%, Exam 3: 20%, Exam 4 (final): 20%
Grading criterion: A (≥ 90%); B(<90% & ≥ 80%); C(<80% & ≥ 70); D(<70% & ≥ 60%); F(<60%)

Note: Any outstanding issues related to grading of assigned work (quizzes, exams, homework or projects) must be resolved within two weeks from the day the graded work is returned. There will be no makeup exams or quizzes.

Academic Misconduct: Students are encouraged to work together to discuss the subject, however, all graded materials must represent the student's individual work. Scholastic dishonesty is the attempt of any student to present as his or her own work of another, or any work which he/she has not honestly performed, or attempting to pass any examination by improper means. Scholastic dishonesty is a serious offense and will not be accepted. Academic misconduct will be handled according to the current university policy.

Reasonable Accommodation Policy: Any student in this course who has disability that may prevent him or her from demonstrating his or her abilities should contact me personally as soon as possible so we can discuss accommodation necessary to ensure full participation and facilitate your educational opportunities.
COURSE PLAN

REVIEW OF BASIC CONCEPTS (Ch 1-5) [1 Week]

Week 1:
- Properties,
- Statics,
- Kinematics: Lagrangian and Eulerian Descriptions, The Reynolds Transport Theorem

Homework

5 MASS, BERNAULLI, AND ENERGY EQUATIONS [4 Weeks]

Week 2:
5–1 Introduction 172
- Conservation of Mass 172
- Conservation of Momentum 172
- Conservation of Energy 172

Homework

Week 3:
5–2 Conservation of Mass 173
- Mass and Volume Flow Rates 173
- Conservation of Mass Principle 175
- Moving or Deforming Control Volumes 177
- Mass Balance for Steady-Flow Processes 177
- Special Case: Incompressible Flow 178

Homework

Week 4:
5–3 Mechanical Energy and Efficiency 180 5–4
- The Bernoulli Equation 185
- Acceleration of a Fluid Particle 186
- Derivation of the Bernoulli Equation 186
- Force Balance across Streamlines 188
- Unsteady, Compressible Flow 189
- Static, Dynamic, and Stagnation Pressures 189
- Limitations on the Use of the Bernoulli Equation 190
- Hydraulic Grade Line (HGL) and Energy Grade Line (EGL) 192
Homework

Week 5:

5–5 Applications of the Bernoulli Equation 194

5–6 General Energy Equation 201
   Energy Transfer by Heat, Q 202
   Energy Transfer by Work, W 202

5–7 Energy Analysis of Steady Flows 206
   Special Case: Incompressible Flow with No Mechanical Work Devices and Negligible Friction 208
   Kinetic Energy Correction Factor, a 208

Homework

MOMENTUM ANALYSIS OF FLOW SYSTEMS [Ch 6] [2 Weeks]

Week 6

6–1 Newton’s Laws and Conservation of Momentum 228

6–2 Choosing a Control Volume 229

6–3 Forces Acting on a Control Volume 230

6–4 The Linear Momentum Equation 233
   Special Cases 235
   Momentum-Flux Correction Factor, b 235
   Steady Flow 238
   Steady Flow with One Inlet and One Outlet 238
   Flow with No External Forces 238

Homework

Week 7

6–5 Review of Rotational Motion and Angular Momentum 248

6–6 The Angular Momentum Equation 250
   Special Cases 252
   Flow with No External Moments 253
   Radial-Flow Devices 254
DIMENSIONAL ANALYSIS AND MODELING [Ch 7] [2 Weeks]

Week 8

7–1 Dimensions and Units 270
7–2 Dimensional Homogeneity 271
Nondimensionalization of Equations 272
7–3 Dimensional Analysis and Similarity 277

Homework

Week 9

7–4 The Method of Repeating Variables and the Buckingham Pi Theorem 281
   Historical Spotlight: Persons Honored by Nondimensional Parameters 289
7–5 Experimental Testing and Incomplete Similarity 297
   Setup of an Experiment and Correlation of Experimental Data 297
   Incomplete Similarity 298
   Wind Tunnel Testing 298
   Flows with Free Surfaces 301

Homework

INTERNAL FLOW [Ch 8] [2 Weeks]

Week 10

8–1 Introduction 322
8–2 Laminar and Turbulent Flows 323
   Reynolds Number 324
8–3 The Entrance Region 325
   Entry Lengths 326
8–4 Laminar Flow in Pipes 327
   Pressure Drop and Head Loss 329
   Inclined Pipes 331
Laminar Flow in Noncircular Pipes 332

8–5 Turbulent Flow in Pipes 335
   Turbulent Shear Stress 336
   Turbulent Velocity Profile 338
   The Moody Chart 340
   Types of Fluid Flow Problems 343

Homework

Week 11

8–6 Minor Losses 347

8–7 Piping Networks and Pump Selection 354
   Piping Systems with Pumps and Turbines 356

8–8 Flow Rate and Velocity Measurement 364
   Pitot and Pitot-Static Probes 365
   Obstruction Flowmeters: Orifice, Venturi, and Nozzle Meters 366
   Positive Displacement Flowmeters 369
   Turbine Flowmeters 370
   Variable-Area Flowmeters (Rotameters) 372
   Ultrasonic Flowmeters 373
   Electromagnetic Flowmeters 375
   Vortex Flowmeters 376
   Thermal (Hot-Wire and Hot-Film) Anemometers 377
   Laser Doppler Velocimetry 378
   Particle Image Velocimetry 380

Homework

DIFFERENTIAL ANALYSIS OF FLUID FLOW [Ch 9] [1 Week]

Week 12

9–1 Introduction 400

9–2 Conservation of Mass—The Continuity Equation 400

9–4 Conservation of Linear Momentum 421

9–5 The Navier–Stokes Equation 426

Homework
EXTERNAL FLOW: DRAG AND LIFT [Ch 11] [1 Week]

Week 13

11–1 Introduction 562

11–2 Drag and Lift 563

11–3 Friction and Pressure Drag 567
   Reducing Drag by Streamlining 568
   Flow Separation 569

11–4 Drag Coefficients of Common Geometries 571
   Biological Systems and Drag 572
   Drag Coefficients of Vehicles 574
   Superposition 577

11–5 Parallel Flow over Flat Plates 579
   Friction Coefficient 580

11–6 Flow over Cylinders and Spheres 583
   Effect of Surface Roughness 586

11–7 Lift 587

Homework

TURBOMACHINERY [Ch 14] [1 Week]

Week 14

14–1 Classifications and Terminology 736

14–2 Pumps 738
   Pump Performance Curves and Matching a Pump to a Piping System 739
   Pump Cavitation and Net Positive Suction Head 745
   Pumps in Series and Parallel 748
   Positive-Displacement Pumps 751
   Dynamic Pumps 754
   Centrifugal Pumps 754
   Axial Pumps 764

14–4 Turbines 781
   Positive-Displacement Turbines 782
   Dynamic Turbines 782
   Impulse Turbines 783
   Reaction Turbines 785
Homework