MECH 3314: Fluid Mechanics
https://sites.google.com/view/fluid-mechanics-utep/

Class time and location: TR 1030 - 1150, LART 319
Instructor: Dr. Piyush Kumar, pkumar2@utep.edu
Teaching Assistant: Aaron A Rodriguez (aarodriguez29@miners.utep.edu),
Office hours: MW 1200-1330 or by appointment (MS Team)
Textbook: "*Cengel, Y. A. and Cimbala, J. M., Fluid Mechanics Fundamental and Applications, 2006, Second Edition, McGraw-Hill Inc. NY, ISBN 0-07-247236-7*". Instructors may provide additional reading materials.
Class delivery: The class will be delivered in in-person mode or as informed by the instructor.
Participation requirements: You must attend at least 75% of all the classes in person.

Goals and Objectives: Fluid Mechanics is a fundamental course in mechanical engineering. The purpose 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 essential part of the design processes of vehicles, power plants, chemical processing units, buildings, bridges, and among others.

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]
- EXTERNAL FLOW: DRAG AND LIFT [Ch 11]
- TURBOMACHINERY [Ch 14]

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 projects will constitute the basis for the assigning of the final grade in the course:

Class performance & Quizzes: 15%, Homework: 15%, attendance: 10%
Exam 1: 20%, Exam 2: 20%, Exam 3: 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 a 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 the 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
Homework

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

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