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)
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