Sample Syllabus

ME 320.1: Fluid Flow, Spring 2021
Penn State, Department of Mechanical Engineering

Instructor: Prof. Tak-Sing Wong
Office: N330 Millennium Science Complex
Email: tswong@psu.edu
Office hours: M: 9:00 am – 10:00 am (or by appointment)

TAs:

Mr. Leo He
Zoom: https://psu.zoom.us/j/91613898780
Email: sxh1182@psu.edu
Office hours: Thurs 6:00 PM – 9:00 PM

Mr. Md Moinuddin Shuvo
Zoom: https://psu.zoom.us/j/91613898780
Email: mqs6647@psu.edu
Office hours: Wed 5:30 PM – 8:30 PM

Meeting Times and Location:

Lectures: online, Zoom meeting link:
https://psu.zoom.us/j/91483016789?pwd=aFRraUZZRTZJSU1iTjVEcktvYmZEUT09

Lecture Time: M, W, F: 10:10 – 11:00 am

Course Prerequisites: E MCH 212, ME 201 or ME 300; MATH 230 Or MATH 231; MATH 251 (dynamics, thermodynamics, calculus and vector analysis; ordinary and partial differential equations)

Textbooks:

Required: **McGraw Hill Connect:** *Fluid Mechanics: Fundamentals and Applications* by Yunus A. Çengel and John M. Cimbala, 3rd or 4th Edition, McGraw-Hill Publishing Company
Please purchase McGraw Hill Connect through ME320 Canvas

Suggested: *Schaum's Outlines: Mathematical Handbook of Formulas and Tables*, by M.R. Spiegel, S. Lipschutz, and J. Liu, 4th Edition McGraw-Hill, Inc.

Grading Policy and Examination Schedules:

- Homework: 40% Due Friday at the beginning of class
- Quiz 1 – 5 60% During lecture time

Typical Letter Grade Construction

A	90	B	80	C	70	D	60	F	< 60

I reserve the right to make changes to the grading breakdown and construction. For marginal case where students are at the major grade boundary, a 1-point increase may be considered depending on the students efforts on their homework assignments.

Course Policy:

- Please do not hesitate to consult with me or the TA when you have questions on any course-related materials.
- You are expected to attend all classes. In case of emergency that prohibits you from attending a class, you are responsible to collect all study notes from a classmate and learn about any announcements made in the class.
- All electronic devices, including mobile phones and computers, must be turned into silent mode during the lectures.
- In addition to the lectures, reading assignments will be provided on a regular basis to further enhance your learning experience.
- Homework assignment will be posted approximately 1 week before the due date.
- Homework is due on *every Friday at the beginning of class*. Homework solutions will be posted immediately after the class. *Late homework will not be accepted*.
- Discussion on homework with classmates is allowed and encouraged, **but the work must be your own**. *Plagiarism or copying of assignments/exams will be penalized, and no credit will be given on that particular assignment or quiz.*
- Quizzes have to be taken during the lecture time. No exception unless under extremely unusual circumstances.
- Grade Appeal: Any appeals should be made within one week after the grade has been given.
- Partial credits will be given to each problem set in your homework assignments and exams for your efforts, even though the final answers may not be ideal. It is important that *you have done your best* to attempt for these problems.
- Late Drop: You may drop a course up until the late drop deadline. However, a WP (passing), WF (failing), WN (no grade) symbol will be entered on your academic record. The grading will be assigned based on the student's performance on homework assignments and/or mid-term examination.
- Additional course materials and homework solutions will be made available, and can be downloaded from the CANVAS system.

ME 320 Course Objectives (formally adopted April 2007)

A. Develop appreciation for the beauty of fluid phenomena and understanding of the relationship between the mathematics, the physics and the modeling of fluid mechanics.
B. Develop proficiency in the analysis of fluids systems with mathematical modeling, measurement tools, and computer technologies.
C. Understand the application of fluid mechanics to engineering, technology, biology, the environment, and other fluid phenomena.
D. Advance proficiency in professional communications and interactions.

ME 320 COURSE OUTCOMES (formally adopted April 2007)

1. **Articulate** the properties that distinguish **fluids** from other forms of matter, and the broad range of engineering applications and natural phenomena that involve fluid mechanics.
2. **Apply** concepts of **vector fields** (velocity and streamlines, force and acceleration), scalar fields (pressure, density, temperature), and vector differential and integral calculus to engineering analysis of fluids systems, and to the interpretation of flow physics through the conservation laws and flow visualization.
3. **Apply Newton's second law** to analysis and design involving fluids at rest using integral and differential calculus, including pressure variation, forces and moments on plane surfaces, and buoyancy.
4. **Apply systems and control volume methods** based on mass, momentum, and energy conservation, as appropriate, to the analysis and design of engineering fluid systems.
5. Interpret and **apply the various differential forms of the conservation laws**, particularly Newton's second law and its various approximate forms, to engineering analysis and design.
6. Apply mass, momentum, and energy conservation to **steady internal (pipe and duct) flows**, correctly interpret and apply laminar and turbulent flow models, and estimate head loss and power requirements in piping systems.
7. **Develop mathematical models** through **justifiable approximations**; for example, correctly interpret and apply the boundary layer approximation, the "inviscid" approximation and the Bernoulli relationships to analysis of fluid systems, and estimate levels of approximation in engineering models.
8. **Apply basic principles of dimensional homogeneity** to engineering analysis, and apply dimensional analysis and similitude to the design of experiments, and to the representation and interpretation of data. Properly interpret the Reynolds number and other fundamental non-dimensional parameters, and their roles in defining regimes of fluid flows.
9. **Apply** integral methods, and basic empirical and theoretical models, to the **analysis of boundary layer flows**, and to the estimation of lift and drag on bodies.
10. Apply fundamental knowledge of fluid mechanics to the analysis of specific **sensors and instruments** used in fluid-flow experiments.
11. Apply **basic software tools** (e.g., spreadsheets and mathematical solving software) to the analysis of experimental data and mathematical models.
12. Demonstrate the **ability to solve problems in a clear step-by-step manner** and follow policies and instruction as outlined in the syllabus and other course materials.
13. Demonstrate professionalism in oral and written communications with course instructors and fellow students.

ME 320.1 COURSE OUTLINE (Tentative, subject to change depending on the progress)

Week 1: Introduction and Basic Concepts of Fluids (Chapter 1, 2)
- Application Areas of Fluid Mechanics
- Classification of Fluid Flows and Properties
- System and Control Volume, and Problem Solving Technique
- Others (Density, Energy, Compressibility, Viscosity, Surface Tension etc.)
- Quiz 1 (Chapter 1 - 2)

Week 2 – 3: Pressure and Fluid Statics (Chapter 3)
- Pressure and Pressure Measurements, Fluid Statics and Hydrostatic Forces
- Buoyancy and Stability, Fluid in Rigid-Body Motion

Week 4: Fluid Kinematics (Chapter 4)
- Lagrangian vs Eulerian
- Flow Patterns and Visualization, Plots of Fluid Flow Data
- The Reynolds Transport Theorem
- Quiz 2 (Chapter 3, 4)

Week 5 – 6: Mass, Bernoulli, and Energy Equations (Chapter 5)
- Conversation of Mass, Energy Efficiency
- The Bernoulli Equation
- General Energy Equation
- Energy Analysis of Steady Flows

Week 7: Momentum Analysis of Flow Systems (Chapter 6)
- Newton's Laws
- Control Volume Analysis
- The Linear Momentum Equation, Rotational Motion and Angular Momentum
- Quiz 3 (Chapter 5, 6)

Week 8: Dimensional Analysis and Modeling (Chapter 7)
- Dimensional Homogeneity
- Dimensional Analysis and Similarity
- The Buckingham Pi Theorem

Week 9 – 10: Internal Flow (Chapter 8)
- Laminar and Turbulent Flows
- Laminar and Turbulent Flows in Pipes
- Minor Losses, Piping Network and Pump Selections
- Flow Rate and Velocity Measurements

Week 11: External Flow: Drag and Lift (Chapter 11)
- Drag and Lift
- Friction and Pressure Drag, Drag Coefficients
- Flow over Plates, Cylinders and Spheres
- Quiz 4 (Chapter 8, 11)

Week 12: Differential Analysis of Fluid Flow (Chapter 9)
- Conservation of Mass – The Continuity Equation
- The Stream Function
- The Differential Linear Momentum Equation
- The Navier-Stokes Equation
- Differential Analysis of Fluid Flow

Week 13: Approximate Solutions of the Navier-Stokes Equation (Chapter 10)
- Approximation for Inviscid Regions
- The Irrotational Flow Approximation
- The Boundary Layer Approximation
- Quiz 5 (Chapter 9, 10)