M E 320, *Fluid Flow,* Section 1

Syllabus for Spring Semester 2015

Latest update: 18 February 2015

Lectures: **Room 112 Walker Building** three times per week: **Mon, Wed., and Fri. 8:00 - 8:50 a.m.**

Text: ***Fluid Mechanics: Fundamentals and Applications***, Ed. 3, Y. A. Çengel and J. M. Cimbala, McGraw-Hill, New York, 2014 - ***required***.

Prerequisites: E MCH212, MATH 251; M E 201 or M E 300; MATH 230 or MATH 231 or equivalent.

Instructor:
- **John M. Cimbala**, Professor of Mechanical Engineering. www.mne.psu.edu/cimbala, 234 Reber Building, 814-863-2739, jmc6@psu.edu.
- Office hours: **Thursday 2:00-4:00**. Weekly schedule to be posted on website.

Instructor: **John M. Cimbala**, Professor of Mechanical Engineering. www.mne.psu.edu/cimbala, 234 Reber Building, 814-863-2739, jmc6@psu.edu. Office hours and schedule to be posted.

TA: **Faith Beck**, frb115@psu.edu. See course website for TA contact info and office hours.

Course Description: This course is an introduction to fluid mechanics, and emphasizes fundamental concepts and problem-solving techniques. Topics to be covered include fluid properties, fluid statics, fluid kinematics, control volume analysis, dimensional analysis, internal flows (pipe flows), differential analysis (including approximations such as creeping flow, potential flow, and boundary layers), and external flows (lift and drag). Brief introductions to computational fluid dynamics (CFD), compressible flow, and turbomachinery (pumps and turbines) will also be provided. ***Students are expected to read the assigned portions of the text***! Students are also expected to be proficient in applying mathematics (e.g., integration, differentiation, and application of differential equations), statics and dynamics (e.g., free body diagrams), and thermodynamics (e.g., the first law, systems, and control volumes).

Web Pages: The main URL to all web pages for this course is: **http://www.mne.psu.edu/me320-1**. Students are expected to check the web site regularly for homework assignments, announcements, and other information. Hardcopies (handouts) of homework assignments will *not* be given in class. Some course material will also be placed on Penn State's ANGEL site at **http://www.angel.psu.edu**. There is also a Facebook group that you should join (you do not need to be FB friends with the instructor to join the group). The name of the group is "**M E 320, Spring 2015**", and the website link is **https://www.facebook.com/groups/ME320Spring2015/**.

Grading: All quizzes, exams, and homework assignments are *comprehensive*.

Homework	30%	10 total, throughout the semester, 3% per HW assignment
Quizzes	36%	6 total, approximately one every other week at the Testing Center, 6% per quiz
Class Participation	5%	In-class participation via Poll Everywhere, posting to course Facebook page, etc.
Final Exam	29%	Comprehensive final exam – **Monday, May 4, 8:00-9:50 am, 101 Thomas**.

Class Participation: You are expected to attend all scheduled lectures. Interactive questions will be given in class using Poll Everywhere; your attendance in class as well as your answers will count for a portion of the class participation grade. You may also submit newspaper, magazine, or Internet articles or videos that relate to the topics discussed in class (USA Today, CDT, and NY Times are available free to all students). Submissions may count for additional class participation points *if* you end up "on the border" at the end of the course. For instructions about free print or electronic newspapers, see **www.nytimes.com/passes**.

Grade Disputes: If a student feels that an exam or homework set was graded unfairly, or if there is an error in the grading, it should be brought to the attention of the grader (TA for homework, Professors for quizzes and exams) within one week after the graded material is handed back. Scores will *not* be reconsidered beyond one week after they are handed back.

Cheating Policy: Cheating is not tolerated in this course. You should refer to the College of Engineering's Academic Integrity website at http://www.engr.psu.edu/CurrentStudents/acadinteg.aspx which explains what behaviors are in violation of academic integrity, and the review process for such violations. Specifically for this course:

- First offense: Zero score for the item in question, and infraction reported to the College.
- Second offense: Failure of the course, and infraction reported to the College.

(Continued on next page →)

Lecture Schedule: We will follow the schedule below as closely as possible, subject to change.

Week #	Topics to be Covered	Reading Assignment
1	**Introduction**: fluids and their applications, no-slip condition, classification of fluid flows; **Fluid properties**: density, viscosity, vapor pressure, surface tension	Chapters 1 & 2
2, 3	**Pressure and fluid statics**: manometry and barometry, hydrostatic forces on submerged surfaces, buoyancy and stability, fluids in rigid body motion	Chapter 3
4	**Fluid kinematics**: Lagrangian and Eulerian descriptions, flow visualization, vorticity, Reynolds transport theorem	Chapter 4
5, 6	**Conservation laws**: mass, momentum, and energy equations, control volumes, Bernoulli approximation	Chapters 5 & 6
7	**Dimensional analysis and modeling**: dimensional homogeneity, dimensional analysis, experimental testing, similarity	Chapter 7
8, 9	**Flow in pipes**: laminar and turbulent flow, major and minor losses, piping networks and pump selection, flow rate and velocity measurement instruments; **Turbomachinery**: introduction to pumps and turbines	Chapter 8, plus a quick overview of Chapter 14
10, 11	**Differential analysis**: stream function, continuity, Navier-Stokes equation; **Introduction to CFD**: grids, boundary conditions, residuals, interpretation of results	Chapters 9 & 15 (sections 15.1 – 15.3)
12, 13	**Approximate solutions of the Navier-Stokes equations**: creeping flow, inviscid regions, irrotational regions, boundary layers	Chapter 10
14	**External flows**: drag and lift, friction and pressure drag	Chapter 11
15	**Compressible flow**: isentropic flow through nozzles, shock waves	Chapter 12

Course Objectives: Upon completion of this course, students should be able to:

1. Articulate the properties that distinguish fluids from other forms of matter, and the broad range of engineering applications which involve fluid mechanics.
2. Apply concepts of vector fields (velocity, force, acceleration), scalar fields (pressure, density, temperature), and differential and integral calculus to analysis of fluids systems, and to the interpretation of flow physics through the conservation laws.
3. Properly 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. Properly apply systems and control volume methods based on mass, momentum, and energy conservation, as appropriate, to the analysis and design of engineering fluids systems.
5. Correctly 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. Properly apply mass, momentum, and energy conservation to steady internal (pipe) 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*, correctly interpret and apply 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 representation of data. Properly interpret the Reynolds number and other fundamental nondimensional parameters.
9. Apply integral methods and basic empirical and theoretical models to analysis of boundary layer flows, and to drag on bodies.
10. Apply fundamental knowledge of fluid mechanics to the analysis of sensors and instruments used in fluid-flow experiments.
11. Apply basic software tools (especially spreadsheets) to the analysis of experimental data and mathematical models.
12. Demonstrate professionalism and respectful interaction with faculty and colleagues.