Elementary Fluid Mechanics CEE 357

Course Outline- Fall 2019

Instructor: C.D. Guzman, Assistant Professor
21 Marston Hall, Civil and Environmental Engineering Department
545-1510, cdguzman@umass.edu
Class Hours: Lecture: MWF 8:00-8:50; Engineering Laboratory Rm 306,
Office Hours: 11 am-12:00 pm, Tuesday & Wednesday

Computer: We will write simple MATLAB programs. Please utilize University resources to download a University-licensed copy.

Objectives (Catalog Description): A basic understanding of fluid mechanics through the study of the properties, stationary behavior, and flow characteristics of incompressible fluids. The fundamental constitutive relations and conservation equations governing the pressure, velocity, and free surface elevation of the fluid. Hydrostatic forces, pipe flow, open channel flow, and storm surge as examples of environmental fluid mechanics. *Prerequisite*: CEE 240, MATH 331, CEE 250.

ABET Outcomes for CEE 357

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

ABET Course Performance Indicators

1. I understand how a shear stress defines the difference between a fluid and a solid.
2. I know how to compute the resultant fluid pressure on a planar surface, and how to determine the center of pressure.
3. I understand how the conservation of mass and energy determine the rate at which the water level in my kitchen sink drops, and why calculus is essential to this understanding.
4. I know what the three reversible forms of energy are in the Bernoulli principle, and why they are important.
5. I know how to compute a regime-based Darcy Weisbach friction factor for pipe flow.
6. I know how to compare operating and capital costs of a pump and piping system.
7. I know how to compute an operating point, and how to compute an energy grade line for a pump and piping system.
8. I know how to estimate the storm surge from a hurricane.

Coursework (Outcome Measures and Assessment): The Instructor will assess the student performance by grading the following coursework:

- 7 Problem Sets @ 3% Each (21% total)
- 1 Problem Set+Matlab @ 4% Total (4% total
- 2 Exams @ 25% Each (50% total)
- 1 Final @ 25% Total (25% total)

- 1 Evening Exam.Ch10 @ 15% Total *
- 34 Paired Reflections @ 10% Total *

You must accumulate at least 60% to pass the course.
*[Conditional Combined Use for make-up]

Students will evaluate the course design and materials as well as the instructor at the end of the semester to provide feedback to the department on the perceived quality of the learning resources and the effectiveness of the instructor's content delivery. 34 paired reflections (submitted to website, posted to blogsite, code via course number) plus an exam on Ch 10 provides options for making up an anticipated missed-exam.

Exams and Finals: Exams and the final will be proctored, open book, timed, tests of your individual knowledge. Calculators should be brought to exams, but no other electronic devices are permitted (e.g. no cell phones, iPads, tablets, etc., no electronic access to pdfs). Problem set (and, after the fact, exam) solutions will be sent as pdfs, however if you'd like to access them during exams, they must be personal printed out hardcopies.

Homework Problem Sets: The problem set questions will be listed at the start of each lesson. Your solutions must be turned in as hardcopy form on engineering grid paper. Multiple pages must be stapled and have your last name at the top-right. *These will be collected from you in class only, and on the due date. No late homework, and no handing in of assignments by someone else. Your corrected problem sets and exams will be available in class following three class sessions, to be picked up by you, and only you.*

Announcement about Disability Services (DS): The University of Massachusetts Amherst is committed to making reasonable, effective, and appropriate accommodations to meet the needs of students with disabilities and help create a barrier-free campus. If you have a documented disability on file with Disability Services (www.umass.edu/disability), you may be eligible for reasonable accommodations in this course. If your disability requires an accommodation, please notify your instructors as early as possible in the course so that we may make arrangements in a timely manner.

Cell Phones: Please ensure that you turn off mobile devices or set them to airplane mode before lectures.

Required Text: White, F.M., Fluid Mechanics, McGraw-Hill, New York, NY. (readings are 8th edition). There will be course notes for the environmental fluid mechanics (last third) part of the course.

Outline:
Fluid Properties and Variables (Chapter 1; ps 1)
• Definitions and history

• Basic dimensions and units of measure
• Density, pressure, and compressibility
• Viscosity and shear stress

Fluid Statics (Chapter 2; ps 2)
• Conservation of vertical momentum
• Hydrostatic pressure
• Manometry
• Forces on submerged surfaces

Conservation Equations and Control Volumes (Chapter 3; ps 3)
• Reynolds transport theorem
• Conservation of mass and Venturi meter
• Conservation of energy and the Bernoulli Principle
• Conservation of momentum and pipe bends

Exam #1 (In Class, 50-75 minutes)

Pipe Flow (Chapters 6 and 11; ps 4-6)
- Laminar and turbulent flow
- Flow resistance and friction factors
- Minor losses
- Energy and hydraulic grade lines
- Pump curves and operating points

Exam #2 (In Class, 50-75 minutes)

Environmental Fluid Mechanics (Chapter 10 and Course Notes; ps 7 and 8)
- Steady, uniform open channel flow
- Logarithmic wind and the air/ocean interface
- Storm surge
- Flow through porous media

Optional Exam #3 (75 minutes)
Final Exam (2 hours): Monday, December 16, 2019, 8:00 am – 10:00 am

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ABET Mapping

CPI	1	2	3	4	5	6	7
1	Yes	Yes	Yes			Yes	
2	Yes	Yes	Yes			Yes	
3	Yes	Yes	Yes			Yes	
4	Yes	Yes	Yes	Yes		Yes	
5	Yes	Yes	Yes			Yes	
6	Yes	Yes	Yes	Yes		Yes	
7	Yes	Yes	Yes	Yes		Yes	
8	Yes	Yes	Yes			Yes	

Tentative Schedule of Topics

Wk	Dates	Topics	Readings
1	Sep 4	Introduction to Fluids (Definitions and History); pp3-14	1) 1.1- 1.6
	Sep 6	Introduction to Fluids (Velocity field, Thermodynamic properties); pp15-25	2) 1.6- 1.8
2	Sep 9	Viscosity and Other Secondary Properties, pp25- 30	3) 1.9
	Sep 11	Viscosity and Other Secondary Properties, pp30-39	4) 1.9
	Sep 13	Viscosity, Flow Patterns, pp39-48	5) 1.9-1.14
		HW1: [1.4 , 1.16, 1.20, 1.38, 1.54, 1.65, 1.73]	
3	Sep 16	Pressure Distribution in a Fluid (Pressure + Gradient, Equilibrium, Hydrostat)	6) 2.1-2.3
	Sep 18	Application to Manometry + Hydrostatic forces, pp69-79	7) 2.4-2.5
	Sep 20	Hydrostatic forces on Curved Surfaces +Layered Fluids+ Buoyancy, pp80-91	8) 2.6-2.8
4	Sep 23	Pressure Distribution in Rigid-Body Motion, pp91-99	9) 2.9
	Sep 25	Pressure Measurement, pp99-103	10) 2.10
		HW2: [2.4, 2.5, 2.9, 2.22, 2.23, 2.24, 2.66, 2.141]	
	Sep 27	Integral Relations for a Control Volume (Basic Laws, Reynolds) pp133- 144	11) 3.1-3.2
5	Sep 30	Conservation of Mass, pp144-149	12) 3.3
	Oct 2	Linear Momentum, pp149-163	13) 3.4
	Oct 4	Frictionless Flow: Bernoulli Equation, pp163-172	14) 3.5
6	Oct 7	The Angular Momentum Theorem, pp172-178	15) 3.6
	Oct 9	The Energy Equation, pp178-188	16) 3.7
		HW3: [ ]	
	Oct 11 (Fri)	EXAM 1	
7	Oct 14 (Mon)	Columbus Day	
	Oct 16	Viscous Flow in Ducts (Reynolds+ Turbulence Modeling), pp338-357	18) 6.1-6.5
	Oct 18	Turbulent Pipe Flow+ Types of Pbs, pp358-371	19) 6.6-6.7
8	Oct 21	Flow in Noncircular Ducts, pp371-380	20) 6.8
	Oct 23	Minor or Local Losses in Pipe, pp 380- 389	21) 6.9
		HW4: [ ]	
	Oct 25	Multiple Pipe systems, pp 389- 395	22) 6.10
9	Oct 28	Experimental Duct Flows +Fluid Meters, pp 395-408	23) 6.11-6.12
	Oct 30	Fluid Meters, pp 408- 421	24) 6.12
		HW5: [ ]	MATLAB DUE
	Nov 1	Turbomachinery: Introduction + Centrifugal Pump, pp741- 750	25) 11.1-11.2

10	Nov 4	Pump Performance Curves, pp 750- 760	26) 11.3
	Nov 6	Mixed- and Axial-Flow Pumps, pp 760- 767	27) 11.4
	Nov 8	Matching Pumps to Systems, pp 767- 775	28) 11.5
	Nov 11 (Mon)	Veteran's Day	
11	Nov 13	Turbines, pp775-783	29) 11.6
	Nov 15	Turbines, pp 783- 789	30) 11.6
		HW6: [ ]	
12	Nov 18 (Mon)	EXAM 2	31)
	Nov 20	Open-Channel Flow: Introduction + Chezy, pp 682-695	32) 10.1-10.2
	Nov 22	Efficient Uniform, pp 695- 697	33) 10.3
13	Nov 25 (Mo-W)	Thanksgiving Break	
14	Dec 2	Specific Energy: Critical Depth, pp 697-708	34) 10.4
	Dec 4	Hydraulic Jump and Gradually Varied Flow, pp 708-716	35) 10.5-10.6
	Dec 6	Flow Measurement and Control by Weirs, pp 716-723	36) 10.7
		HW7: [ ]	
	Dec 6	EXAM 3 (Evening)	
15	Dec 9	Flow through Porous Media/ GW	37) GW
	Dec 11	Flow through Porous Media / GW	38) GW
		HW8: [ ]	
16	Dec 16 (Mon)	FINAL EXAM	