E41 Thermo-Fluid Mechanics

Fall 2024

CRN 10098

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Instructor	Emad Masroor `emasroo1@swarthmore.edu`	
Lectures	MWF 9:30 — 10:20	033 Singer Hall
Office hours	W 1:15 — 2:45 PM & by appt.	112 Singer Hall
Wizards	Angela Gil, Chisom Obiora-Egbuziem, Jacob Sherman	
Graders	Lindsey Turner, Omar Ebied, Georgi Matthews	
Textbook	Munson, Young and Okiishi's Fundamentals of Fluid Mechanics 9th edition, Gerhart, Hochstein & Gerhart	
Prerequisites	ENGR 006, ENGR 012, and MATH 033, MATH 034, or MATH 035	
Lab	You must be concurrently enrolled in E41 Lab;	
Lab Instructor	Carr Everbach `ceverba1@swarthmore.edu`	
Website	`moodle.swarthmore.edu`	
Final Exam	TBD	

Course description This is a first course in fluid mechanics and thermodynamics. Building on your knowledge of mechanics, and using the techniques of single- and multi- variable calculus, this course will develop the governing equations of fluid mechanics and show you how to use these equations to model physical phenomena. The emphasis will be on both theory — i.e., physics and mathematics — and its applications to real-world engineering problems. The course will also equip you with a fundamental understanding of the Laws of Thermodynamics, which is an essential part of a scientific education for practicing engineers as well as laypeople.

Course evaluation Your grade in this course will be made up of the following five components.

Homework	25%
Quizzes	5%
Labs	20%
Mid-term exams	15% ×2
Final exam	20%

The assignment of letter grades will be at the discretion of the Instructor, but will generally adhere to the following schematic: A- 90+, B- 80+, C- 70+, D- 60+, NC <60. The class will not be 'curved'.

Class Meetings This course will be conducted in the form of (in-person) lectures during the regularly scheduled meeting times (i.e., Monday, Wednesday and Friday at 9:30 AM for 50 minutes per class meeting). Students are expected to attend every class meeting and take notes. The instructor will make available the lecture slides/notes developed in class, but these do not replace the need for students to actively engage with the material, ideally by taking their own notes. Please be respectful of everyone else's time by being punctual. You must not use cell phones or laptop computers during class (except during quizzes, as explained below), but you are permitted to take notes on a tablet or tablet-like device (**not** by typing on a laptop computer). If you must use your cell phone during class, you may excuse yourself from the classroom.

Laboratory This course has an accompanying lab section. You must be enrolled in one of the lab sections. The lab is run independently, and all questions regarding lab should be directed to the lab instructor.

Quizzes At the beginning of each class, there may be a short quiz, conducted via Moodle, to test your knowledge of the material most recently covered in the course. These questions will be conceptual, and won't require detailed calculations; instead, they are intended to test how well you are following the subject material over the course of the semester. Your score on the quizzes should be a barometer for you to gauge how well you are doing in this course. You will need to use a phone or computer to complete the quiz.

Exams There will be two mid-term exams and one final exam; all three exams will contribute equally to your grade. The material covered in each mid-term will be specified in advance, and will generally include the material covered up to and including the week prior to the mid-term. The final exam will largely focus on the material after the second midterm, but may also include questions from topics covered in the first two exams. All exams will be closed-book and closed-notes; you are permitted to bring one $8\frac{1}{2} \times 11$ sheet of paper with equations and other information (but no practice problems or homework solutions). Fluid/thermal properties and necessary constants will be provided with the exams. The mid-term exams will be conducted during class time on the dates noted in the syllabus, whereas the final exam will be conducted at a date and time to be determined later. Once you have received your grades for a midterm exam, you will have one week to submit requests for a regrade.

Evening Review Sessions Prior to each exam, the Instructor will hold an evening review session from 6:00 to 8:00 PM on the dates listed on the syllabus. Attendance at these review sessions is *optional*.

Textbook This course has an assigned textbook: *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics*, 9th edition, by Andrew Gerhart, John Hochstein, and Philip Gerhart. Readings are assigned in the course schedule for each day of lecture, which you are encouraged to consult *before* the corresponding lecture. Additional reading assignments will be provided by the Instructor for the thermodynamics section of this course. Textbooks are expensive, and you may find an older edition for a better price than the campus store. There should be no disadvantage to using an older edition.

Policy on Artificial Intelligence With the widespread availability of Large Language Models (LLMs), such as OpenAI's ChatGPT, Google's Bard, or Microsoft's Bing AI, this semester you will have unprecedented access to a new, powerful piece of technology that has the potential to drastically change the way we obtain information.

Please note that:

- You are not prohibited from using these tools — the same way you would use a search engine or an online forum — to help you answer questions when you are studying for this class.
- You are encouraged to use these tools creatively to aid in your understanding. For example, you might ask one of these models: "Explain why the pressure at the nose of an airplane is higher than the nearby air pressure, and give me a sample calculation for this".
- Everything you turn in for this class — homework solutions, answers to quizzes, exams, and labs — must be your own work, and therefore copying answers from a Large Language Model is unacceptable, just as copying answers from Chegg or from your fellow students is unacceptable.
- Consulting an AI tool during a 'closed-book' exam will be treated as academic misconduct.

Homework assignments

Purpose One of the objectives of this course is to enhance your ability to solve technical problems and to communicate the *results* as well as the *process* you used to arrive at the result. The purpose of homework assignments is therefore to evaluate not just your ability to arrive at the correct solution to an engineering problem, but also your process for working through it.

Policies Homework will be assigned approximately once per week, and will be due on **Wednesdays at midnight** unless you are notified otherwise. You must turn in your homework via Moodle in PDF format by taking *clear*, *legible* scans of handwritten work. You may use an application on your phone to make these scans (`Camscanner` is a good option in my experience), but it is recommended that you use a scanner to improve legibility. In general, late homework will not be graded, but each student can request one extension, of one week's duration, with no penalty. However, you **must** specifically request an extension by sending an e-mail to the instructor before the deadline. You are encouraged to discuss solution strategies with other students in the class, but your submissions must be your own work. You are encouraged to note, on the first page of each assignment, which other students you worked with, but this does not permit you to simply copy solutions from another student.

Format Adherence to the following format is expected for all assignments.

- Use A4 or Letter size paper, preferably loose leaf.
- Write/draw clearly and legibly. Always err on the side of using more rather than less space to draw or write. If your handwriting is not legible, your work will not be graded.
- Start each problem on a new page.
- Each solution should be preceded by 'Given:' and 'Find:', with the appropriate information repeated from the problem statement.
- Clearly define all symbols you have used. e.g., 'm: mass, g: acceleration due to gravity', etc, even if these are the same as the problem statement.
- Draw a large, clear diagram or schematic, including a free-body diagram or control-volume diagram, if appropriate.
- If appropriate, you should explicitly state the physical laws or principles (e.g., Newton's second law, conservation of energy, etc.) which you have used in your solution.
- Perform calculations symbolically without substituting values until the last step. This will help the grader follow along with your argument, and will help minimize arithmetic mistakes.
- Box, underline, or otherwise highlight your final answers.
- Unless a quantity is dimensionless, you *must* include units with all of your numerical answers. It is recommended that you also include units in all intermediate steps.
- At this stage in your engineering education, it is assumed that you are familiar with the concept of significant figures. Use sound judgement when deciding how many significant figures you use in your answers; an inordinately high number of significant figures is just as bad as a low one. You *will* be penalized for egregious mistakes of this kind.

Grading You will be graded for correctness and for your approach. In general, to receive a perfect score on a homework problem, you must adhere to the formatting guidelines above. For example, simply writing down one or two lines in your answer to a problem for E41 homework assignments will not get you full credit. You may request a regrade for a homework problem by e-mailing the Instructor within one week of the grade being reported.

Week	No.	Date	Topic	Readings	
1	1	W 9/4	Introduction & course logistics	1.1-1.4	
	2	F 9/6	Fluid & Thermodynamic Properties	1.5-1.10	
2	3	M 9/9	Intro Hydrostatics	2.1-2.3	
	4	W 9/11	Hydrostatics: manometry	2.4-2.6	HW 1 due
	5	F 9/13	Hydrostatics: forces on surfaces	2.8-2.10	
3	6	M 9/16	Hydrostatics: forces on surfaces	2.11	
	7	W 9/18	Fluid kinematics: streamlines etc.	4.1	HW 2 due
	8	F 9/20	Acceleration & material derivative	4.2	
4	9	M 9/23	$F = ma$ along & across a streamline	3.1-3.3	
	10	W 9/25	Bernoulli's Equation	3.4-3.8	HW 3 due
	11	F 9/27	Bernoulli's Equation & Applications	3.4-3.8	
5	12	M 9/30	Systems & Control Volumes	3.4-3.8	
	13	W 10/2	Reynolds Transport Theorem; **Evening review**	skim 5	HW 4 due
		F 10/4	**Midterm 1**		
6	14	M 10/7	R.T.T. for mass	5.1	
	15	W 10/9	R.T.T. for momentum & Newton's 2nd Law for Fluids	5.2	
	16	F 10/11	Newton's 2nd Law for Fluids; changing Control Vols	5.3	
			Fall Break		
7	17	M 10/21	R.T.T. for energy and 1st Law of Thermodynamics	5	
	18	W 10/23	1-D steady energy equation; losses	skim 6	
	19	F 10/25	Differential Equations; Incompr./Irrot. Flow		
8	20	M 10/28	Navier-Stokes and Euler Equations	7.1-7.4	
	21	W 10/30	Dimensional Analysis and Buckingham Π theorem	7.5-7.10	HW 5 due
	22	F 11/1	Fully-developed flow in pipes		HW 6 due
9	23	M 11/4	Internal Flows; friction factor etc.	8.1-8.3	
	24	W 11/6	Internal Flows: Major and minor losses	8.4-8.6	HW 7 due
	25	F 11/8	External Flow: Flow over bodies	8.4-8.6	
10	26	M 11/11	External Flows: Drag and Lift	9.1	
	27	W 11/13	Open Channel Flow	9.2	HW 8 due
	28	F 11/15	Introduction to Thermodynamics	9.3-9.4	
11	29	M 11/18	1^{st} & 2^{nd} Laws;	skim 10	
	30	W 11/20	Processes; heat & work; cycles; **Evening review**		HW 9 due
		F 11/22	**Midterm 2**		
12	31	M 11/25	Swarthmore's Geothermal Heat Exchangers		
	32	W 11/27			
		F 11/29	No class — Thanksgiving Break		
13	33	M 12/2	Efficiency and COP of cycles; the Carnot cycle		
	34	W 12/4	Clausius Inequality, entropy and the 2^{nd} law		HW 10 due
	35	F 12/6	Phase change processes & Rankine Cycle		
14	36	M 12/9	Internal Combustion Engine; The Otto Cycle;		
	37	W 12/11	Philosophical Implications; **Evening Review**		HW 11 due