

# MEMS 0051 - Introduction to Thermodynamics

Department of Mechanical Engineering and Materials Science  
University of Pittsburgh

Spring 2020

## Contact Information

Matthew M. Barry, Ph.D.

email: matthew.michael.barry@pitt.edu

phone: 412-624-9031

office hours: M/W/F, 1:00 to 3:00 pm

office: 204 Benedum Hall

class time: M/W/F, 9:00-9:50 am, 157 Benedum Hall

## Class Information

- Pre-reqs: PHYS 0150, 0174, 0201 or 0475 and CHEM 0101, 0110, 0111, 0410, 0710, 0760 or 0960.
- Text: Sonntag, Borgnakke, Van Wylen, **Fundamentals of Thermodynamics**, 8<sup>th</sup> Edition, Wiley, 2013.

## Course Description

- To introduce students to the First and Second Laws of Thermodynamics for open and closed systems (i.e. energy, work, heat and entropy).
- To build upon the fundamentals and introduce calculus-based thermodynamics.

The chapters from the text will be covered in the following manner:

- Chapter 1: Introduction
- Chapter 2: Properties of Pure Substance
- Chapter 3: First Law of Thermodynamics and Energy
- Chapter 4: Energy Analysis for a Control Volume
- Chapter 5: Second Law of Thermodynamics
- Chapter 6: Entropy
- Chapter 7: Second Law Analysis for a Control Volume

## Grading Policy

- The grading scheme is as follows<sup>0</sup>:
- The grading scale is as follows:

1. Homework: 15%
2. Quizzes: 15%
3. Midterm 1: 20%
4. Midterm 2: 20%
5. Final: 30%

Numeric Score	Letter Grade	Numeric Score	Letter Grade
98-100	A+	78-79.9	C+
92-97.9	A	72-77.9	C
90-91.9	A-	70-71.9	C-
88-89.9	B+	68-69.9	D+
82-87.9	B	62-67.9	D
80-81.9	B-	60-61.9	D-
		0-59.9	F

<sup>0</sup>No assignment (homework/quiz/project) or in-class evaluation (quiz/exam) will be curved.

## Class Schedule<sup>1</sup>

Week	Date	Lecture	Topic	Homework	Quiz	Section(s)
1	6-Jan		Syllabus			
	8-Jan	1	Introductory Material, Conservation of Mass			1.1-1.6, 3.13
	10-Jan	2	Introductory Material Continued	#0		1.7-1.11
2	13-Jan	3	Substances and P-v-T			2.1-2.3
	15-Jan	4	Thermodynamic Tables		#0	2.4, 2.6-2.7
	17-Jan <sup>2</sup>	5	Two-Phase Systems	#1		2.5
3	20-Jan		Dr. Martin Luther King's birthday			
	22-Jan	6	Ideal Gas and Compressibility		#1	2.8-2.9
	24-Jan <sup>3</sup>	7	Energy and the 1 <sup>st</sup> Law of Thermodynamics	#2		3.1-3.2
4	27-Jan	8	Energy, Work and Heat			3.1, 3.3, 3.5
	29-Jan	9	Evaluation of Work, Conservation of Mass		#2	3.4, 3.13
	31-Jan	10	Internal Energy and C <sub>v</sub> Specific Heat	#3		3.7, 3.10
5	3-Feb	11	Enthalpy and C <sub>p</sub> Specific Heat			3.9, 3.10
	5-Feb	12	U, H and C of Ideal Gases		#3	3.11
	7-Feb		Review for Midterm #1	#4		
6	10-Feb	13	HE, Refrigerators and the 2 <sup>nd</sup> Law			5.1, 5.2
	12-Feb	14	Reversibility and Irreversibility		#4	5.3, 5.4
	14-Feb		<b>Midterm #1</b>			
7	17-Feb	15	The Carnot Cycle and it's Propositions			5.5, 5.6
	19-Feb	16	Thermodynamic & Ideal Gas Temp. Scales			5.7, 5.8
	21-Feb	17	Ideal vs. Real Machines	#5		5.9
8	24-Feb	18	The Clausius Inequality			6.1
	26-Feb	19	Entropy as a Property and of a Substance		#5	6.2, 6.3
	28-Feb	20	Entropy of Reversible Processes	#6		6.4
9	2-Mar	21	Entropy Change of Solids, Liquids and Gases			6.5-6.8
	4-Mar	22	Entropy Change, Generation and Increase		#6	6.9-6.12
	6-Mar <sup>4</sup>		Review for Midterm #2	#7		
10	9-Mar		Spring Break			
	11-Mar					
	13-Mar					
11	16-Mar	23	C.O.M. and Energy for a C.V.,			4.1, 4.2
	18-Mar	24	C.O.E. for Steady State, Nozzles/Diffusers		#7	4.3, 4.4
	20-Mar		<b>Midterm #2</b>			
12	23-Mar	25	Pumps and Turbines			4.4
	25-Mar	26	Heat Transfer Devices			4.4, 4.5
	27-Mar	27	Cycles	#8		4.4
13	30-Mar	28	Second Law for C.V.			7.1
	1-Apr	29	2 <sup>nd</sup> Law: Nozzles/Diffusers		#8	7.2
	3-Apr	30	2 <sup>nd</sup> Law: Pumps and Turbines	#9		7.2
14	6-Apr	31	2 <sup>nd</sup> Law: Heat Transfer Devices			7.2
	8-Apr	32	Increase of Entropy Principle		#9	7.4
	10-Apr	33	Efficiency	#10		7.5
15	13-Apr	34	Special Topics			
	15-Apr	35	Special Topics		#10	
	17-Apr		Review for Final Exam			
16	20-Apr		Final Exam Week			
	22-Apr					
	24-Apr					

<sup>1</sup> Subject to change

<sup>2</sup> Spring term add/drop period ends

<sup>3</sup> Spring term extended drop period ends

<sup>4</sup> Spring term monitored withdrawal deadline & final exam conflict submission form deadline

## Student Expectations

- A 3-credit engineering course requires 6-9 hours per week of outside classroom work. This is in the form of reading your book, reading the corresponding sections ahead of lecture, and completing the practice problems in the provided text.
- Evaluation tools (homework, quizzes, exams) are designed to test your understanding and mastery of, and ability to critically think about, course content. Your exams will not test your ability to regurgitate material or simply solve an equation, rather, how you can *apply* your knowledge of course concepts and mathematics to *analyze* and solve unfamiliar problems. See Bloom's taxonomy.
- Homework deadlines will be found on the top of assignment and on the course schedule. Homework is due at the beginning of class on the day due. Late homework will not be accepted.
- Homework is to be done on the assigned class homework submission sheet. Your name, the date, class and assignment number, and page numbers, should appear in the proper fields. Homework assignments are to be stapled in the top left hand corner; paper-clips, folded edges or paper-tears will result in only the first page of the homework being graded. Each problem is to be clearly numbered, with the solution boxed. Units must be included, otherwise the problem will be marked incorrect. Work should be clear and coherent, starting from problem givens, working through the methodology and arriving at a clear solution. Homework is a representation of your work - it should be neat, clean and clear. Your work should follow a logical flow and provide substantiation for your results.
- Only 3 questions from the homework assignments will be selected at random and graded; the entire assignment will not be graded, thus it is important to completely answer each question.
- Graded homework, quizzes and exams will be redistributed the following week. Uncollected homework will be placed in the hanging folder outside room 204 and will remain there for one week. If the assignment is still uncollected, it will be discarded.
- Statute of limitations - upon redistributing graded assignments, you have two weeks to bring up any potential grading issues. After the two week period, your assignment will not be re-evaluated. If an obvious, objective error is made (i.e. incorrect totaling of your score) is made, contact myself or the course grader. If a subjective error arises (i.e. you think more credit is deserved), you must submit a written appeal, which includes the original assignment, a cover page describing the problem and the perceived injustice, and how many points you believe should be awarded. The appeal must be submitted in person within the statute of limitations.
- Quizzes will be issued the Wednesday following homework submission, giving sufficient time to review the posted homework solutions. Quizzes will be issued during the last 10 minutes of class.

## Helpful Hints

- Read the assigned chapters (completely), work through the practice problems and start the homework early! This way, when you encounter a problem with obtaining a solution or understanding a concept, you will have time to seek assistance and resolve the problem.
- Class attendance is strongly recommended (in addition to homework submission and quizzes).
- Working together and discussion amongst yourselves is encouraged - in research and industry you rarely work alone - however, you are expected to do your own work and submit your own assignments.
- I am available for help through office hours, email or phone (worst case scenario). If you are struggling, please seek assistance immediately before things get out of control.

## Course Policies

No makeup quizzes or tests will be given without extenuating circumstances or prior approval. If you are anticipating you will miss a quiz or an exam for a legitimate reason, you must reschedule the exam two weeks prior to the originally scheduled data.

## University and Department Policies

### Disability Resource Services

If you have a disability for which you are or may be requesting and accommodation, please contact both me and Disability Resources Services, 216 William Pitt Union, (412) 648-7890/(412) 383-7355 (TTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course. Their website is <http://www.drs.pitt.edu>.

### Diversity and Inclusion

We ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. No form of harassment (e.g. racist or sexist jokes) will be tolerated in my class, particularly if directed against a student's gender, sexual orientation, race, etc. If you experience or witness harassment or discrimination inside or outside of this class, please contact the Title IX Coordinator by calling 412-648-7860, or e-mailing [titleixcoordinator@pitt.edu](mailto:titleixcoordinator@pitt.edu). You may also choose to report incidents to me; however, I am required to communicate information about harassment to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

### Disciplinary Procedures for Student Transgressions

The MEMS Department takes great pride in both the potential and the accomplishments of our current and graduated students. As professionals in training, we view it as essential that students are instilled with a commitment to upholding the highest standards of honesty and integrity. A fundamental canon within the Code of Ethics published by the National Society of Professional Engineers is that engineers "conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession" (<https://www.nspe.org/resources/ethics/code-ethics>). To that end, the following MEMS Department procedures have been created to foster a sense of professional responsibility and to ensure a highly conducive and nonthreatening learning environment.

### Academic Integrity

Students are expected to comply with the University of Pittsburgh's Policy on Academic Integrity, which is found through the following link: <http://www.as.pitt.edu/fac/policies/academic-integrity>. Adding to this obligation, and to cultivate a culture of ethical conduct, the MEMS Department has established a coordinated and uniform approach to dealing with violations of academic regulations against cheating and plagiarism. This approach involves disciplinary actions that increase in severity with number of instances a student has been found in violation of academic integrity. Specifically, the penalty for the first offense for plagiarism or cheating will be a zero on the assignment(s). The penalty for a second offense will be a zero on the assignment(s) plus the loss of one letter grade from their final grade. A third offense will incur a serious penalty that will be determined on a case-by-case basis, but at a minimum will include a final grade of F. Offenses will be tracked in a student's temporary file in cooperation with other Schools within the University. This file will be destroyed upon graduation. Since classes vary, students are encouraged to seek advice from their professor if there is any question as to what may constitute a violation.

### Student Conduct

Students are also expected to comply with the University of Pittsburgh's Student Code of Conduct, which is found through the following link: <http://www.studentaffairs.pitt.edu/conduct>. In particular, it is a violation of conduct when a student "disrupts or prevents the peaceful and orderly conduct of classes, lectures, quiet study, invited speaker presentations, and/or meetings or deliberately with the freedom of any person to express their views." This includes disrespectful conduct displayed by a student towards his or her professor, TA and/or classmate in or out of class. To foster a professional and collegial learning environment, the MEMS Department has established a three-strike

approach to dealing with student conduct violations. Specifically, a student's first offense will incur a formal warning letter from the Department Chair (strike one). A second offense will impose a temporary ban on attending the MEMS class in which the conduct violation occurred together with a remedial action (strike two). The remedial action will be determined on a case-by-case basis, but will likely include counseling. A third offense will, at the very least, incur a complete ban on attending the class as well as referral of the case to the University's Office of Student Conduct (strike 3). Campus police will be contacted at 412-624-4040 (4-4040 for on-campus telephones) for any offense that is deemed unmanageable.

By signing and dating the syllabus, you agree to the class, departmental and university policies:

Printed Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_