THERMODYNAMICS (MENG S211)
SPRING 2022

YALE UNIVERSITY
DEPARTMENT OF ENGINEERING

Course Description: Fundamental principles of classical equilibrium thermodynamics. Modeling of gas and fluid properties and thermodynamic processes. Development and application of the first and second laws of thermodynamics to steady flow, transient flow and non-flow processes. Applications of thermodynamics to power and refrigeration cycles, psychrometrics, and to the design of thermal processes. The course begins with the basic properties of ideal gases followed by the use of control volume analysis to introduce conservation of mass and energy with the first law of thermodynamics. Subtleties' of the first law are elaborated on with examples. Control volume analysis is then used to introduce entropy and its application to the second law of thermodynamics. This is followed by analysis of other fluids, including steam and refrigerants. These fluids are analyzed in a wide variety of applications such as HVAC, steam power plants, nuclear power plants, combustion engines, etc.

Course Objectives: Thermodynamics is one of the fundamental engineering sciences. Energy conversion, storage and transportation are fundamental to modern technology. If one is going to be successful as an engineer, and also understand the environmental impact of energy systems, one needs to have a good understanding of the basic principles underlying the function of such systems as power plants, refrigerators and air conditioning systems, gas turbines, internal combustion engines and fresh-water-producing evaporators. In this course, the student will extend his/her ability to apply basic principles in the analysis and design of a variety of engineering systems as well as evaluating their environmental impact.

Text: *Thermodynamics, an Engineering Approach,* 9th ed., Yunus A. Cengel and Michael A. Boles, McGraw-Hill, 2010 (students may use older editions)

Instructors:

Professor Andy Foley P.E

Grading:	Homework	40 %	Exams (1)	15 %
			Final Exam	45 %

Grades: Grades will be based on an A, B, C scale (plus/minus at ends of scale as appropriate):

Course Structure: Lectures, reading, and homework will be integrated to promote effective use of time and development of analysis and problem solving skills. You need to be proactive, think critically, and use time effectively. Your learning and motivation are your responsibility. If expectations for any instruction are unclear it is your responsibility to seek clarification from the instructor. Lack of understanding of the instructions or citing of alternate standards used by others are not valid reasons for unacceptable submittals.

Lecture: It is assumed students have reviewed assigned reading and will ask questions. Lecture time will generally be devoted to definitions, key concepts, and solution of example problems. Students are expected to bring a writing instrument to class.

Homework: The homework problems on the schedule are subject to change and may not be weighted equally for grading. Homework shall be submitted via ONENOTE by the due date and time specified in the assignment. Late homework will be graded at the instructors' discretion **but is generally not accepted**.

Your presentation of homework should focus on communicating effectively what you have done, why you have done it, and how you have done it. Clear well labeled sketches and clearly stated assumptions are essential, particularly if partial credit for incorrect solutions is to be obtained.

You are responsible for the failures of technology, so plan ahead, save early, and save often. Neatness counts. Excessive messiness or spelling and grammatical errors are unacceptable and will result in work not

being graded.
*** Note : To be successful in the exams it is imperative that all homework assignments are undertaken and fully understood.

Exams and Quizzes: Formal exam dates are specified on the course schedule. The final exam is mandatory. All exams will be open-book, open-note.

Collaboration, Assistance, and Documentation**:** Group collaboration with other students on homework **concepts and methodology** is encouraged and permitted unless specifically instructed otherwise. Simply copying solutions will be **considered cheating** and dealt with accordingly. All assistance or guidance, written or otherwise, from someone or something other than the student submitting it for credit must be documented on each submittal with a brief statement specifying source and type of collaboration.

Achieving Program Outcomes: ABET specified the following for undergraduate engineering majors. Objectives in italics are those for which some knowledge development should occur as a result of completing this course. Those in bold indicate significant knowledge development should occur.

1. ***An ability to apply knowledge of mathematics, science and engineering***
2. An ability to design and conduct experiments as well as to analyze data
3. *An ability to design a system, component or process to meet desired needs*
4. An ability to function on multi-disciplinary teams
5. ***An ability to identify, formulate and solve engineering problems***
6. An understanding of professional and ethical responsibility
7. **An ability to communicate effectively**
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context
9. *A recognition of the need for and an ability to engage in life-long learning*
10. A knowledge of contemporary issues
11. *An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*

Additional ABET requirements for graduates of Mechanical Engineering programs include:

1. *Knowledge of chemistry and calculus based physics with depth in at least one;*
2. ***Ability to apply advanced mathematics through multivariate calculus and differential equations;***
3. Familiarity with statistics and linear algebra;
4. The ability to work professionally in both thermal and mechanical systems areas including their design and realization.

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Tentative Schedule updated April 2022

Week	Week of	LECTURE TITLE
1		**1.** Course Introduction. **2.** Ideal Gas Law. **3.** Reynolds Equation and Control Volumes.
2		**4.** Energy / Work **5.** Otto Cycle / Diesel Cycle **6.** Exam 1
3		**7.** Entropy I **8.** Entropy II **9.** Gas Turbines
4		**10.** Steam **11.** Pumps & Heat Exchangers **12.** Steam Cycle
5		**13.** Carnot Engines. Heat Pumps **14.** Refrigeration **15.** Review