ME 500, Advanced Thermodynamics

Instructor: Dr. Huidan (Whitney) Yu
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Class Meetings:
Monday and Wednesday: 4:30 - 5:45 pm, SL051

Office Hours:
Monday and Wednesday: 3:00-4:00 pm SL 260H

Textbook:
Desmond E. Winterbone and Ali Turan, *Advanced Thermodynamics for Engineers*, 2nd Edition, Elsevier

Reference Book:
M. J. Moran and H. N. Shapiro, Fundamentals of Engineering Thermodynamics, Wiley.

Prerequisite:
ME 200000 or consent of the instructor

Course Description:
The course will teach advanced topics of classical thermodynamics with an emphasis on major concepts, laws, and thermodynamic relationships. Applications topics to engineering thermal systems focus on the analysis of (maximum) thermal efficiencies, thermal properties of ideal/real gases, and pure/mixture fluids. Team projects provide connections between thermodynamic principles and engineering systems.

Course outcomes:
Upon completion of the course, students are expected to be able to do the following.

- Understand energy and entropy from both macroscopic and microscopic points of view.
- Apply the 1st Law for steady and transient systems.
- Use Gauss divergence theorem in obtaining different forms of energy conservation equation and entropy balance equation.
- Understand maximum entropy and minimum energy principles.
- Understand the physical meaning of availability in open and closed systems.
- Understand thermo-mechanical equilibrium, thermo-mechanical-chemical equilibrium, and chemical availability for open and closed systems.
- Understand the (mathematical) approach to thermodynamics.
- Discuss state equations for real gas and fluids in terms of measurable properties.

- Derive thermodynamic relations between the measurable and non-measurable properties.

Grading Scale:

The course grade scale will follow the Latter Grades with +/- on Canvas.

Name:	Range:	
A+	100%	to 97.0%
A	< 97.0%	to 93.0%
A-	< 93.0%	to 90.0%
B+	< 90.0%	to 87.0%
B	< 87.0%	to 83.0%
B-	< 83.0%	to 80.0%
C+	< 80.0%	to 77.0%
C	< 77.0%	to 73.0%
C-	< 73.0%	to 70.0%
D+	< 70.0%	to 67.0%
D	< 67.0%	to 63.0%
D-	< 63.0%	to 60.0%
F	< 60.0%	to 0.0%

The instructor may or may not provide opportunities for students to earn extra credits based on the entire class performance. Grade upgrade requests based on personal expectation/imagination or special needs will not be issued.

Homework (HW) ---------- 25 %
Project ---------- 20 %
Home Video ---------- 5%
Mid-term exam ---------- 25 %
Final exam ---------- 25 %

- **Homework (HW)** consists of 6 sets in a timely order. Each set includes 3-4 problems. HW is required to be submitted electronically and then graded on Canvas.

- The **project** is for the understanding of thermodynamic principles and analysis in real-world systems. The project topics and related instructions, requirements, and grading policy will be announced in Week 11. Example project topics: Rational Efficiency and Related Concerns of Power Plants, Entropy of Electromagnetic Radiation, Exergy Analysis of Heat Engines, Thermal Efficiency of Fuel Cell, etc.
    - The project will be team-based, consisting of 2 students in general. The team formation proposal is accepted immediately via email notice, subject to approval from the instructor. The proposal should include two names and a brief reason about how and why you want to team up. If no team proposal was received one week before the project assignment, the instructor would form the teams.

- Proposal for project topic is welcomed but must from a formed team. The proposal should include a title and a short paragraph about what to study. If no proposal is received one week before the project assignment, the instructor would provide the project topics to those teams.

- **Home Video** will be watched at home. The scope of the video report will be beyond the textbook material and reflect individual understanding of energy and entropy in a big picture.

- **Exams** are closed book and closed notes but a one-page (A4 size) "cheat sheet" for equations, units, concepts, etc. is allowed in each exam. The "cheat sheet" should be turned in with the exam papers. Tables and graphs will be provided when needed. The midterm exam covers Chapters 1-4 and the final exam will cover all lectured chapters in general but focus on Chapters 5-8. Problem types of each exam will be announced in the corresponding review class.

Missing HW/exam/presentation policy:

There will be **NO MAKEUP** exam/presentation. Late HW after the completion of the grading will not be accepted. In case that a student is excused with **valid written documents for an emergency** (e.g. doctor notes or medicine purchase receipts for illness, evidence or witness for vehicle failure, etc.) or a **prior written request and approval for non-emergency** (e.g. travel itinerary, conference registration, etc.), the missed points can be credited. The instructor reserves the right to decide how to credit based on specific cases.

Submission policy:

Students are responsible for high-quality scanning copy of each assignment submission (HW, reports, etc.). If the document must be returned because of the non-readable quality such as $90^o/180^o$ rotated layout, too small/light/noisy to be read, etc., it will be requested for a re-submission within 24 hours after the notice. Late submission/resubmission will cause a penalty, 10% of the assignment points off per late day. **Once the assignment grading is completed, neither late submission/resubmission is accepted.** The grader reserves the right to determine if the document needs to be returned and resubmitted.

Homework Format:

It is strongly recommended that each problem is solved including the following components:

- ***Known:*** A brief summary of the problem, "in your own words".
- ***Find:*** Quantities to be determined.
- ***Sketch:*** Properly labeled and indicated- physical system and property diagrams
- ***Assumptions:*** Modeling assumptions that are used in solving the problem are listed and clearly indicated as a constraint.

- ***Properties:*** Substance identified and needed properties, value (units), and source.
- ***Analysis:*** The problem is solved systematically and logically, showing all steps, starting from the fundamental equation(s) from which the analysis begins [and numerical values (with units) are shown]. Final results clearly indicated.
- ***Discussion:*** Any comments relative to the results.

Canvas:

The entire course-related communication outside of lectures and office hours are through http://canvas.iu.edu.

- All the information and materials will be accessed on this system throughout the semester including messages and announcements, syllabus and course schedule, supplementary handouts, assignments, grades, and so on.
- Students are required to **send course-related messages through Canvas/Inbox.**
- Students are responsible to set up notifications on Canvas and check their emails as well as the course website on Canvas time accordingly for any course information.
- Students are encouraged to discuss course issues on Canvas/Discussion.

~~~~~~~~~~~~~~~~~~~~~~ IMPORTANT POLICY NOTES ~~~~~~~~~~~~~~~~~~

- Each student should complete the pre-requisite questionnaire on Canvas by the assigned due date. Failed to meet the prerequisite requirements will cause an invalid grade at the end of the semester.
- Students are required to sign on a provided sign sheet for each in-person class or sign in through chat function for a zoom class. Written prior/subsequent excuse from a class is highly expected for respect to the instructor.
- Students are required to show appropriate behaviors in the classroom. Electronics such as a laptop, pad, cell phone, etc. are allowed to use per permitted. Food and drinks should not be consumed during class. Any student who is found to be a distraction to the instructor and/or other students will be dismissed immediately.
- Students are highly encouraged to turn the video on whenever it is practical during the Zoom lecturing. Interactive communication is very important for effective teaching and learning.
- Students are aware of the Code of Student Rights, Responsibilities, and Conduct (https://studentcode.iu.edu/index.html). Acts of academic misconduct and personal misconduct will be handled according to the guidelines in the Code. Penalties include lowering a student's grade as well as dismissal from the class.

- If any students need any special accommodations or assistance due to a disability-related issue, please contact **Adaptive Educational Services** (AES, https://diversity.iupui.edu/offices/aes/index.html) at (317)-274-324 or email (aes@iupui.edu). No qualified individual with a disability shall, by reason of such disability, be either excluded from participation in or be denied the benefits of the services, programs, or activities" of Indiana University-Purdue University Indianapolis."

Course Schedule[i]

Week	Topics	Site	Assignment due[ii]
1	Syllabus and Introduction		
	Math Review		
2	Martin Luther King Jr. Day	No class	
	Concepts of Thermodynamics (Ch1)		
3	0^{th} and 1^{st} Law of Thermodynamics (Ch 1)		
	2^{nd} Law of Thermodynamics (Ch 2)		HW 1
4	Entropy and Irreversibility (Ch 2)		
	Equilibrium and Thermal Energy (Ch 2)		
5	Home video time	No class	HW 2
	Recitation of HW1-2		
6	Heat Engines (Ch 3)		
	Air-standard Cycles (Ch 3)		
7	Availability (Ch 4)		HW3
	Irreversibility (Ch 4)		
8	Exergy (Ch 4)		HW4
	Midterm Review		
9	Recitation of HW 3-4		
	In-class exam (Chaps 1-4)		
10	Spring break	No class	
	Spring break	No class	
11	Project Assignment		
	Rational Efficiency (Ch 5)		
12	FTT and Thermal Efficiency (Ch 6)		MS1
	Thermal Efficiency in Reality (Ch 6)		

13	Maxwell Relationships and Uses (Ch 7)		HW5
	Tds Relationships (Ch 7)		
14	Project time	No class	MS2
	Ideal Gas Law (Ch 8)		
15	Equation of State (Ch 8)		HW6
	Final Review		
16	Recitation of HW 5-6		
	Project wrap-up	No class	
17	Oral Presentation		Final report
	Final Exam	SL051	

[i] This schedule is tentative and subject to change with or without prior update. Please be aware of Canvas notices, such as announcement, emails, assignment updates, etc.
[ii] The assignment due dates are tentative, just for a guideline. The real dates will be on the assignment file and Canvas assignment.