ME 300: Engineering Thermodynamics

The Pennsylvania State University
Department of Mechanical Engineering
Dr. Catherine Berdanier

Class Location: Willard 260
Time: MWF 1:25-2:15 pm
Learning Management System: canvas.psu.edu

Office: 206 Reber Building
Contact information: cgb9@psu.edu (The easiest way to reach me is via email, placing "ME 300" before your subject in the email)

Graduate Teaching Assistant: Gaby Sallai, gms5516@psu.edu

Office Hours:
Dr Berdanier: Tuesdays and Fridays, 9-10 am in the Reber e-Knowledge commons
TA Office Hours: Wednesdays 11 am-12 pm; Thursdays 1:30-2:30 pm in the Reber e-Knowledge commons

If these times do not work for you, please email Dr. Berdanier to set up a time for a meeting.

> **Office hours policy:** If you are requesting homework help, you need to have attempted the problem before asking for help. If you have not done this step on your own, we will ask you to do so, such that you are working to make sense of the problem before asking for help.

Textbook: Cengel, Boles, & Kanoglu: Thermodynamics: An Engineering Approach (9th Ed.)

Poll Everywhere: We will be using Poll Everywhere as an in-class response system. This system uses your cell phone or computer to register responses rather than a clicker. Separate instructions for registering for and using the system will be posted on Canvas.

COURSE DESCRIPTION and OBJECTIVES:
Overview of topics covered: Basic thermodynamics concepts, properties of pure substances, first and second law analysis of systems and control volumes.

The objective of this course is to prepare engineering students to effectively solve theoretical and applied thermodynamics problems. Multiple forms of assessment will be used throughout the course in order to evaluate student learning. Many of the competency-based assessments can be tailored to be useful to your long-term learning goals. In addition, multiple professional skills will be practiced and demonstrated throughout the course, such as engineering communication and teamwork, since these skills are important in all engineering professions.

By the end of this course, students will be able to:

1. Obtain thermodynamic data necessary to solve thermodynamic problems and when necessary use appropriate approximations. These skills include the use of equations of state and/or tabulated property tables.
2. Write the First Law of Thermodynamics in their appropriate forms for both closed system and control volume problem.
3. Solve problems requiring First Law analysis that produce a simple single answer.
4. Make appropriate assumptions when applying the First Law to a "real-world" problem.
5. Write the Second Law of Thermodynamics in their appropriate forms for both closed system and control volume problem.
6. Apply the Second Law to determine the performance limitations of a given thermodynamic system.
7. Apply thermodynamic concepts to describe the performance of the individual components of an engineering system, e.g. a power plant, a jet engine, etc., and then relate that information to the overall performance of the entire system.
8. Physically interpret and apply integrals and derivatives to solve thermodynamic problems.
9. Translate complex word problems into an orderly and logical problem solving approach.
10. Use software to solve thermodynamics problems.

There are also learning objectives for each specific week, as outlined within the Canvas modules. These learning objectives are intended to help students "benchmark" their progress and evaluate their mastery of the course material.

Dr. Berdanier reserves the right to alter or change this syllabus at any point in the syllabus should modification of the semester (for weather, travel, etc.) such that the syllabus may be affected. If this should occur, Dr. Berdanier will post an updated syllabus on Canvas and email it to the entire class. It is each student's responsibility to check their email and Canvas frequently, as well as to pay attention in class to stay up to date on any changes.

COURSE REQUIREMENTS:

This is a 15-week course on engineering thermodynamics meeting three times per week. The course will require active participation throughout the course both in class and outside of class. A variety of assessment mechanisms will be used to encourage students to fully engage in the class, including those that may not be considered traditional for engineering courses. I expect all learners in the experience to invest the time in the course required to complete deliverables at a level expected by engineering scholars. I have explicitly placed deliverables throughout the semester in order to facilitate the "deliberate and distributed practice" of the concepts in this course, which has been proven to increase transfer and memory of learning.

Study groups are strongly encouraged, and while most of the assessments will be personal, a collegial environment is most representative of the working situations in which modern engineers will find themselves.

GRADING:

Practice Problem Sets (11):	10%
In-class work (drop lowest 8):	5%
Quizzes (6):	15%
Thermo Charrettes (2):	10%
Exam 1:	15%
Exam 2:	15%
Exam 3:	15%
Final Exam:	15%
Late drops prior to first exam	-WN
Late drops after first exam:	
With a score ≥ 60%	-WP
With a score < 60%	-WF

GRADING SCALE

A	93
A-	90
B+	87
B	83
B-	80
C+	77
C	70
D	60

ATTENDANCE and IN-CLASS PARTICIPATION POLICIES:

Attendance in class will be required. All students are responsible for the material given during class as well as all material from the readings that accompany the content. If you need to miss class for a legitimate reason, please let me know ahead of class, preferably by the day before. For extenuating circumstances such as extended illness, bereavement, or other formally-excused absence validated by university regulations, please be in contact with me so I can work with you to achieve your curricular goals. Attendance exceptions that are made for religious purposes must be submitted to me in writing by the end of the second week of class. If you have health issues (visible or invisible) and may need special accommodations, I am best able to work with you if I am aware of these issues in advance. In addition, if you have a family emergency, please inform me as soon as possible.

I **do not** post "filled in" notes, as it tempts students to not pay as much attention. Cognitive science also tells us that "multimodal learning" (e.g. writing something in addition to listening to it) is stored in different parts of the brain, and the more times and ways our brain accesses material, the more likely we are to remember it and be able to apply it. If you miss something during class, you can come to office hours to fill in some details.

Attendance will be taken starting the second week of class, after the add/drop period. Attendance points will be measured through a variety of methods, including but not limited to sign-in sheets, quizzes, or Poll Everywhere. You are allowed eight missed participation points. These points will factor into your attendance/participation score. Attendance/Participation points will be awarded during class. If you are not in the classroom at the time the points are awarded, then you will not have the opportunity to make them up. This means you'll likely want to be in class and ready to go when class starts! In the extent of a long-term extenuating absence (bereavement, etc.) we will work out a suitable alternative for attendance and deliverables.

Quiz and Exam Attendance: No make-up exams or quizzes will be given except as required by University policy. See me prior to any anticipated absence, preferably at the beginning of the semester. Any approved make-up exams will be administered via verbal exam with Dr. Berdanier.

Classroom Rules: We have a lot to learn this semester and the following classroom rules are in place to ensure respect for the learning experience of each member of the classroom:

-Please remember to turn your phone ringer off before class starts. You may use your phone for Poll Everywhere questions, but the sounds should not disrupt the class. Cell phone rings will result in a letter-grade deduction on the final exam or the requirement to bring donuts for the entire class during the next class. Note: this class can have up to 75 students.

-Tardiness is disruptive – please make every attempt to be in class on time. If you are late, be considerate of your classmates as you enter the classroom and find a seat. There will be a Poll Everywhere question in the first five minutes of almost every class – participation in these questions is part of your grade. You will not be given extra time on a quiz or test if you are late for class.

OFFICE HOURS:

Walk-in office hours are available on a first-come, first-served basis in the e-Knowledge commons in Reber at the time indicated on page 1. The Graduate Teaching Assistant for this course will also hold office hours. To best facilitate your learning, you must have attempted any homework problems on which you are requesting help prior to asking about those questions.

COMMUNICATION POLICIES:

Because part of becoming a professional in engineering is learning to effectively communicate, I expect that all elements of communication between students and with me as an instructor be conducted with respect. All emails sent to me must subscribe to professional expectations for communication, including a salutation, clear emails in full sentences that are grammatically correct and have been spell-checked, communicate clearly how you would like me to assist you, and end with a respectful closing followed by your name. I request that you call me Dr. Berdanier or Dr. B, and address me as such in emails and in person. If your emails with me do not subscribe to these requirements, I will kindly request that you revise your emails and re-send it to me before I will respond to your email.

You are welcome to email me at any time, however, I will be most responsive to emails during business hours. Although you may receive emails from me on weekends/holidays/evenings, I reserve the right to not be "on call" outside of working hours. All emails should include ME 300 in the subject line, as well as the subject of the email in order so I can quickly scan my emails. I will respond within one full business day to emails. You can also send "emails" through the messages feature in Canvas—this comes both to my Canvas account and also to my Penn State email address.

DELIVERABLES and WEEKLY ASSIGNMENTS:

The following list is an overview of the types of assessments that will be used in the course. Assignments will be submitted in class at the beginning of the class period. All assignments must be legible. If we can't read it or follow your line of thought, we cannot award you points.

Each assessment that is not a traditional problem-solving set through the course has affiliated rubrics in order to help you self-assess your progress and whether or not you have met the objectives of the assessments. **All practice problems will be due on Mondays at 11:59 pm TO CANVAS as a PDF unless otherwise noted on Canvas. Use an app such as CamScanner (or use an actual scanner) to scan your homework.**

For all assignments due online, it is up to you to double check that the document you upload is the correct file, and is uncorrupted, and that the pages are in the right order. If the file cannot be opened or if you upload the wrong document and do not correct it before the deadline, then you will receive a zero on the assignment. It is your responsibility to check these issues. Ensure that the files you upload fully load before submitting, and do not play roulette with the Canvas deadlines!

In extenuating circumstances (bereavement, etc.) I can grant extensions for some deliverables, if requested by the student **at least 48 hours in advance of the deadline**. For most of the deliverables, though, extensions will likely not be granted, because solutions are released automatically after the deadline for the practice problem passes, giving unfair advantages. Situations will be evaluated on a case by case basis, but must be requested at least 48 hours in advance.

REQUIREMENTS OF MAJOR DELIVERABLES:

Quizzes: Quizzes will assess your mastery over the practice problems assigned for homework. These quizzes will be held in class unless directed otherwise on Canvas and per the syllabus.

Practice problems: Practice problem sets will be due most weeks on Mondays at 11:59 pm. I intend that practice problem sets "stretch" students, such that they are more difficult than the example problems we work in class, but are not as difficult as the problems that I will design to assess you on the exams. That being said, you will have to work hard on the homework sets in order to practice and master the materials. Any shortcuts you may be tempted to do will only shortchange your learning, especially because the quizzes will be very closely related to the practice problems assigned in class.

Copying of any solutions from a solutions manual, from other (current or past) students, or from the internet is explicitly cheating, and will not be tolerated. **If you choose to work on problem sets with other students, please note who you worked with at the top of your sheet.** Note, your answers should still represent your individual work (e.g., be in your own hand, showing your own problem solving path). All practice problems must be legible. If we can't read it or follow your line of thought, we can't award you points. Each practice problem set will engage you in a logical problem solving protocol:

1. Start by drawing appropriate diagrams and articulating any assumptions.
2. As you solve the problem, keep your work tidy, show all your work, and **box your final answers.**
3. Comment on your answer and if it seems reasonable or not and why.

Note: For a couple problems, I provide the final numerical answer to guide your problem-solving process [in brackets]. In these cases, if you do not arrive at the final answer, reflect in your comment on how you know your answer is not right, or reflect on where your problem-solving strategy may have been flawed.

Late assignments will not be tolerated. All deliverables will be due on Mondays at 11:59 pm TO CANVAS as a PDF unless otherwise noted on Canvas. The deadline is strict because the solutions will be automatically released at that time so students can begin studying for any upcoming quizzes.

If I cannot read your work, or if I can't tell how you reached the final answer, you will not earn points for the final answer.

For all assignments due online, it is up to you to double check that the document you upload is the correct file, and is uncorrupted. If the file cannot be opened or if you upload the wrong document and do not correct it before the deadline, then you will receive a zero on the assignment. It is your responsibility to check these issues.

If your name is not on your assignment, or if your pages are scanned in the wrong order, you will lose points for the assignment.

Ensure that the files you upload *fully load* before submitting, and do not play roulette with the Canvas deadlines!

Thermo Charrettes: A "charrette" is a term that refers to a period of (typically) design tasks which stretch designers to find solutions to interesting problems. We're taking a thermo spin on the task: The thermo charrettes are opportunities for you to "choose your own adventure" to learn more about thermodynamics. Each charette assignment will have options for open-ended projects to further engage with thermodynamics pertaining to topics that interest you and your future career path.

Exams: Exams will cover the class periods listed in the table below, any associated reading material that corresponds to the class periods, as well as any supplementary materials that are

posted on Canvas (including, but not limited to, example videos, make-up/bonus lectures, extra worked example problems filmed/posted to Canvas, etc.)

For each exam, you may bring one 8.5"x11" equation sheet (single sided) where you can and should write appropriate equations and notes to help you on the test. These will be turned in with your test. Ultimately, the goal of an equation sheet is to help you filter through the course material to aid in your studying.

Anticipated Class Topic Schedule

Class Period	Date	Topic	Corresponding Textbook Material
Module A: Thermodynamic Properties			
1	M Jan 13	Introduction to course	Chapter 1
2	W Jan 15	Physical frameworks & introduction to conservation principles	
3	F Jan 17	Properties, states, and processes	
	M Jan 20	NO CLASS – MLK DAY **Quiz #1 due on Canvas by 11:59 pm: Covers the Syllabus and Academic Integrity** (Open-Note) **Practice Problem Set 1 Due**	
4	W Jan 22	Equilibrium	Chapter 2
5	F Jan 24	Dimensions and units/problem solving methodology Introduction to Energy, Heat, Work, and the First Law	
6	M Jan 27	Key thermodynamic properties **Practice Problem Set 2 Due**	
Module B: Equations of State for Ideal Gases			
7	W Jan 29	State relationships, Ideal gas law	Chapter 3 (3.1-3.6)
8	F Jan 31	Ideal gas processes **Quiz #2: Covers PP Sets 1 and 2**	
9	M Feb 3	Calorific equation of state; P-v, T-v, u-T, h-T plots for ideal gases **Practice Problem Set 3 Due**	
Module C: Multiphase Substances and Equations of State for Non-Ideal Gases			
10	W Feb 5	Nonideal gases: Van der Waals EOS & generalized compressibility	Chapter 3, cont. (3.7 and 3.8)
11	F Feb 7	Multi-phase substances: phase boundaries, quality, T-v diagrams	

12	M Feb 10	Multi-phase substances: phase boundaries, quality, T-v diagrams **Practice Problem Set 4 Due**	
13	W Feb 12	Compressed liquids and solids	
Module D: The First Law of Thermodynamics			
14	F Feb 14	Energy storage, heat & work interactions at boundaries **Quiz #3: Covers PP Sets 3 and 4**	Chapter 4
15	M Feb 17	Identifying heat & work interactions **Practice Problem Set 5 Due**	
16	W Feb 19	Energy conservation for a system: finite processes	
17	F Feb 21	**EXAM 1 – Covers classes 1-13**	
18	M Feb 24	Energy conservation for a system: at an instant **Practice Problem Set 6 Due**	
19	W Feb 26	Energy conservation for a system: examples & applications	
20	F Feb 28	Energy conservation for a control volume – introduction **Quiz #4: Covers PP Sets 5 and 6**	Chapter 5
21	M Mar 2	Single general 1st law for fixed-mass systems & control volumes **Practice Problem Set 7 Due**	
Module E: Steady-Flow Devices and Processes			
22	W Mar 4	Steady flow processes and devices	Chapter 5 continued
23	F Mar 6	Steady-flow devices: nozzles, diffusers, & throttles **Thermo Charrette #1 Due**	
	Mar 9-13	NO CLASS – SPRING BREAK	
24	M Mar 16	Steady- flow devices: pumps, compressors, fans, & turbines	
25	W Mar 18	Steady-flow devices: heat exchangers	
26	F Mar 20	Steam power plants & jet engines revisited **Quiz #5: Covers PP Set 7**	
Module F: The Second Law of Thermodynamics			
27	M Mar 23	2nd law of thermodynamics: Overview, Kelvin-Planck statement, consequences **Practice Problem Set 8 Due**	Chapter 6
28	W Mar 25	Carnot cycle & Carnot efficiency; definition of entropy	
29	F Mar 27	**Exam 2 – Covers class 14 – 26**	
30	M Mar 30	Entropy-based statement of 2nd law, entropy balances, other 2nd-law statements **ME Counselor Assignment Due IN CLASS**	Chapter 7

31	W Apr 1	2nd-law property relationships	
32	F Apr 3	T-s relationships for ideal gases, air tables, & isentropic relationships	
33	M Apr 6	Isentropic & polytropic processes, T-s & P-v diagrams **Practice Problem Set 9 Due**	
34	W Apr 8	Isentropic efficiencies	
Module G: Thermodynamic Cycle Analysis			
35	F Apr 10	Rankine cycle **Quiz #6: Covers PP Sets 8 and 9**	Chapter 10
36	M Apr 13	Vapor-compression refrigeration cycle **Practice Problem Set 10 Due**	
37	W Apr 15	Intro to Air-standard cycles: Otto & Diesel Cycles	
38	F Apr 17	**Exam #3 – Covers classes 27 – 34**	
39	M Apr 20	Cycle analyses	Chapter 9
40	W Apr 22	Gas Turbine Engines: Brayton cycle	
41	F Apr 24	Cycle analyses	
42	M Apr 27	Improving on basic cycles : Real considerations **Practice Problem Set 11 Due**	
43	W Apr 29	"Overflow" day or final exam review	
44	F May 1	Final Review **Thermo Charrette #2 Due**	
	May 4-8	**Final Exam** Location TBD	

GRADE DISPUTES:

If you have an issue with how an assignment was graded, please provide a formal application for grade change, including a copy of the particular question and your original answer, and a paragraph explaining why you believe you deserve a grade change. These applications should be emailed to me and the TA NO EARLIER than 24 HOURS after the assignment was returned; verbal requests for grade change will not be considered. If there was an obvious mistake in grading, the TA and I will immediately correct the issue. If the grade change is more subjective in nature, I will file your request and reconsider at the end of the semester if a change in this grade could change your final grade in the class.

STATEMENT ON ACADEMIC INTEGRITY:

It is a simple matter of personal integrity, but unfortunately there are a few out there that have no personal pride in their own work. Earning a C is far more satisfying than stealing an A. Academic honesty and integrity is of utmost importance. Detailed information on this topic can be found at www.engr.psu.edu/undergrad/acad_int/students. Some examples are given below:

CHEATING: Using crib sheet; pre-programming a calculator; using notes or books during a closed book exam etc.

COPYING ON TEST: Looking at another unsuspecting student's exam and copying; copying in a complicit manner with another student; exchanging color-coded exams for the purpose of copying; passing answers via notes; discussing answers in exam, etc.
PLAGIARISM: The fabrication of information and citations; submitting others work from professional journals, books, articles and papers; submission of other students' papers or lab results or project reports and representing the work as one's own; fabricating in part or total, submissions and citing them falsely, etc.
ACTS OF AIDING OR ABEADING: Facilitating acts by others; unauthorized collaboration of work; permitting another to copy from exam; writing a paper for another; inappropriately collaborating on home assignment or exam without permission or when prohibited, etc.
UNAUTHORIZED POSSESSION: Of examinations, through purchase or supply; stealing exams; failing to return exams on file; selling exams; photocopying exams; buying exams; any possession of an exam without the custodian's permission, etc.
SUBMITTING PREVIOUS WORK: Submitting a paper, case study, lab report or any assignment that had been submitted for credit in a prior class without the knowledge and permission of the instructor.
TAMPERING WITH WORK: Changing own or another student's work product such as lab results, papers, or test answers; tampering with work either as a prank or in order to sabotage another's work, etc.
GHOSTING: Taking a quiz, an exam, performing a laboratory exercise or similar evaluation in place of another; having another take a quiz, an exam, or perform an exercise or similar evaluation in place of the student, etc.
ALTERING EXAMS: When instructor returns graded exams for in class review and subsequently collects them, student changes incorrect answers and seeks favorable grade adjustment asserting that instructor made mistake in grading; other forms may include changing the letter or and/numerical grade on test; obtaining test indiscretely, etc.
COMPUTER THEFT PROGRAM: Electronic theft of computer programs, data, or text belonging to another etc.

STATEMENT ON ACCOMODATIONS FOR STUDENTS WITH DISABILITIES:

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Office for Disability Services (ODS) Web site provides contact information for every Penn State campus: http://equity.psu.edu/ods/dcl. For further information, please visit the Office for Disability Services Web site: http://equity.psu.edu/ods. In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: http://equity.psu.edu/ods/doc-guidelines. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. You must follow this process for every semester that you request accommodations.

COUNSELING AND PSYCHOLOGICAL SERVICES:

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

- Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395
- Counseling and Psychological Services at Commonwealth Campuses (http://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/)
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
  Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

EDUCATIONAL EQUITY AND REPORTING BIAS:

Consistent with University Policy AD29, students who believe they have experienced or observed a hate crime, an act of intolerance, discrimination, or harassment that occurs at Penn State are urged to report these incidents as outlined on the University's Report Bias webpage (http://equity.psu.edu/reportbias/)