MAE 241 Introduction to Thermodynamics, Spring 2023

(Class # 22907)

Course Description	Introduction to Thermodynamics: Concepts of equilibrium, properties, states, systems, energy and entropy; 1st and 2nd thermodynamic laws, analysis of open and closed systems, power and refrigeration cycles.
Lecture	T and Th: 10:30 AM to 11:45 AM, LIB C14
Instructor	Prof. Luis Bocanegra, ERC 461, Luis.Bocanegra@asu.edu
Instructor for Other Sections	Prof. Joshua Wilbur, ERC 459, Joshua.Wilbur@asu.edu
Recitations	Friday (18879, 7:30 AM; 22929, 4:30 PM; 22930, 6:00 PM
TAs	Nathan Coll (Lead TA), ncoll@asu.edu Sophia Pedersen, smpeders@asu.edu Jay Tangella, jtangell@asu.edu Harsha Kotta, hkotta@asu.edu
Graders	Manikandan Raghuraman, mraghur4@asu.edu Isabel Schinella, ischinel@asu.edu John Wadlund, jwadlund@asu.edu
Office Hours	Office hours for the entire MAE 241 teaching staff will be posted on Canvas. You may attend office hours for any of the instructors, TAs, or graders above.
Textbook	Çengel Y., Boles M., Kanaglu M. *Thermodynamics: An Engineering Approach, 9th Ed.* & Connect Card. Inclusive Access ISBN: 9781264199181
Other Helpful Resources	Moran M., Shapiro H., Boettner D., Bailey M. *Fundamentals of Engineering Thermodynamics*. Any version will do; most current is 9th. Sometimes more mathematical/technical than the Çengel text, but generally at the same level. Claire Yu Yan. *Introduction to Engineering Thermodynamics.* This is an open educational resource (OER) that can be accessed freely and read in many different formats (e.g., PDF or ePub). The ePub version has interactive questions at the end of many sections. Ron Hugo. Mechanical Engineering Thermodynamics. A YouTube channel run by a long-time professor of mechanical engineering (i.e., you can trust that the content is legit, which isn't true for all YouTube channels).
Prerequisites	Prerequisite(s) with C or better: AE or ME major: CHM 114; MAT 267 or 272; PHY 121 Non-AE or Non-ME major: MAT 267 or 272; PHY 121;
Websites	Basic course info and announcements and solutions: https://myasucourses.asu.edu (ASU Canvas) Submission, grading, and return of homework: https://gradescope.com (accessed from Canvas)
Units	3 units. Expect to spend 12 hours of study time outside of class each week.
Free Tutors	http://tutoring.engineering.asu.edu/

ASU's COVID-19 Policy

ASU's official source of information about COVID-19 can be found at this website. In brief, this policy aligns with that of the Center for Disease Control and Prevention (CDC). CDC guidance notes that vaccination and boosters greatly reduce the risk of severe illness or death from COVID-19. COVID-19 vaccinations and boosters are readily available through ASU Health Services. ASU also offers COVID-19 tests for free of charge via Devils' drop-off

As of July 5, 2022, the CDC recommends face coverings indoors in public in those counties that have a high level of COVID-19 transmission. Check any county's status at the CDC's county check website.

Course Structure

This course is being taught in coordination with the other MAE 241 sections offered this semester. This will help ensure uniform course content, grading, and preparation for future courses in your degree program. Some outcomes of this coordination are:

- Office hours for all instructors and TAs are open to any student in any MAE 241 section. See the schedule in Canvas.
- The homework assignments for all sections will be identical. The assignments for all sections will be posted at the same time and have the same due date.
- Midterms across all sections will happen at approximately equal times and cover approximately equal material. Note that midterms will not be identical due to scheduling differences between the different sections.
- The final exam for all sections will be identical and will occur simultaneously.
- Exams will be graded by instructors and homework will be graded by TAs/graders across all sections.

Even though the content and pace of lectures and recitations will be approximately equivalent across all sections, *you are required to attend the lecture and recitation for which you are enrolled.*

Prerequisite Competencies

- Properties of solids, liquids, and gases
- Ideal gas law
- Concepts of work and energy
- Multivariable Calculus

Course Objectives and Learning Outcomes

Course Outcome	ABET (1-7)	Level of Mastery
Students will define and evaluate thermodynamic properties.	1	Comprehension
Students will apply the 1st law of thermodynamics to open and closed systems	1, 2	Comprehension
Students will apply the 2nd law of thermodynamics to open and closed systems	1, 2	Comprehension
Students will analyze power and refrigeration cycles	1, 2, 4, 6	Comprehension

Course Topics

- Systems, States, and Properties
  - Temperature, pressure, specific volume
  - Internal energy and enthalpy
  - Specific heat
  - Pure substances and phases
  - Ideal gases
  - Equations of state
  - Open and closed systems
  - Processes and cycles
  - Thermodynamic property tables
- First Law of Thermodynamics
  - Work and heat
  - 1^{st} law analysis of closed systems (e.g. piston-cylinder)
  - 1^{st} law analysis of open systems (e.g. nozzles, diffusers, turbines, compressors, pumps, and heat exchangers)
- Second Law of Thermodynamics
  - Entropy
  - Reversibility
  - Carnot cycle
  - Reversible steady-flow work
  - Second-law analysis of turbines, pumps and compressors
- Power and Refrigeration Cycles
  - Gas power systems
  - Vapor power systems
  - Refrigeration and heat pump systems

Grading Policies

Course grades will be based upon the following breakdown (%):

Task		**Value**
Recitation	Submission to *GradeScope* - Two Lowest Scores Dropped	8
Homework	Practice problems *(Connect)*	6
	Written problems (*GradeScope*) - Lowest Score Dropped	18
Exam 1	Practice exam *(Connect)*	4
	Written exam (in-class)	11
Exam 2	Practice exam *(Connect)*	4
	Written exam (in-class)	12
Exam 3	Practice exam *(Connect)*	4
	Written exam (in-class)	13
Final Exam	Practice exam *(Connect)*	4
	Written exam (in-class)	16
Total		**100**

The course grades in this class will be assigned using an ***absolute scale***. No grading curves/distributions will be used. The absolute scale that will be used is as follows:

Grade	Minus	Nominal	Plus
A	89.0 – < 92.0	92.0 – < 96.0	> 96.0
B	79.0 - < 82.0	82.0 – < 85.0	85.0 – < 89.0
C	-	69.0 - < 75.0	75.0 - < 79.0
D	-	57.0 - < 69.0	-
E	-	< 57.0	-

Regrading:

- You have **5 calendar days to request a regrade** for homework and exams. After this period, no regrading inquiry will be accepted.
- Regrades for homework shall be submitted using GradeScope and require having an explanatory justification for your request; please do not submit unfounded regrade requests as these will be tracked.
- Regrade requests for exams must be submitted in writing with the adequate justification in a pdf file sent to the course instructor using your asu.edu email.
- Please check Canvas frequently to ensure all your grades are listed correctly.

Recitation (8%):

- In-person attendance to recitations is required; you must be in the designated classroom for the recitation session that you enrolled in at the time the recitation starts to be counted as present. No Zoom live streaming or recordings will be available. Recitations will be administered by TAs each week.
- Recitation will be a "workshop-style" problem solving session in which students will work through example problems. Note that recitation problems will not be available on Canvas or GradeScope but will be projected by the TA at the beginning of the recitation.
- A typical recitation session schedule looks like the following:
    - ~5 mins: students get ready and TA projects the problems with computer in the classroom.
    - ~10 mins: students attempt to solve problem 1 (group discussion is encouraged).
    - ~5 mins: TA goes through the solution of problem 1.
    - ~10 mins: students attempt to solve problem 2 (group discussion is encouraged).
    - ~5 mins: TA goes through the solution of problem 2.
    - ~5 mins: students use phones to scan their work and upload to GradeScope before leaving.
    - ~10 mins: Q&A and conclude
- There will be no sign-up sheet to pass around for recording the attendance, while the submission of your work to GradeScope accounts for the attendance record.
- There will be no hard-copy handout for the recitation problems. Please either bring your own scratch paper or use tablets for writing down your work.
- Please submit your work on both recitation problems to GradeScope and confirm with TA before leaving the classroom. The recitation scores are based on:

    - 50% attendance by submitting the work to GradeScope (25% off if late for 10 mins or more)
    - 50% participation and work done (25% off if work is not detailed enough)
- Recitation absences due to emergency, health conditions, self-isolation can be possibly approved by emailing the lecture instructor and recitation TA with sufficient evidence before recitation starts. If approved, students who are absent from in-person recitation can earn the credit by submitting their work of the recitation problems to GradeScope before it closes at 6PM Fridays.
- Solutions to recitation problems will be posted on Canvas site around 6PM on Fridays.
- Two unexcused recitation absences or the two lowest recitation scores will be dropped in computing the total recitation score.
- Collaboration with peer groups is allowed. The recitation TA will provide the answers to the workshop problems. In most cases, it will be up to you to attempt the solution of the recitation problems again. Note that in this course you will "*learn by doing, and not learn by watching!*"

Homework - Connect practice problems (6%):

- Practice problems from your textbook's Connect Platform to accompany each HW will be assigned and graded; the grade will be part of the course grade (6%).
- These problems are there for you to practice and receive real-time feedback on your progress. Take advantage of the feedback and solution hints offered by your textbook. These problems are assigned to develop your proficiency.
- For each practice problem assigned you will have more than one attempt available to solve it. The scoring will help you in assessing your performance and identify which areas of the content you need to review again.
- These problems have a due date, and grades will be posted directly to Canvas. No late submissions will be accepted.

Homework – Written problems (18%):

- Homework assignments will be assigned a week in advance of the due date and posted in ***Canvas***.
- Your lowest Written HW score will be dropped at the end of the semester.
- Homework will be submitted via ***GradeScope*** prior to 11:59 PM (Arizona Time) on the due date.
- Access GradeScope through Canvas to set up your account for the first time. Please do not enter a different email, different name, or student ID number; this information will be there for you.
- The main purpose of the homework is that you develop knowledge, confidence and mastery by practicing the application of concepts presented in class such that you can demonstrate it during course evaluations.
- You are allowed to study together, but you cannot copy each other's work and you must understand what you have written down. Copying each other and/or not understanding what you have written is considered academic dishonesty with severe consequences (see Academic Integrity section).
- Start the solution to each problem with the problem statement. For the solution, follow the 7-Step format used in your textbook (Section 1-11): Problem Statement; Schematic; Assumptions and Approximations; Physical Laws; Properties; Calculations; Reasoning, Verification and Discussion.

- Show all your partial work including governing equations and calculations along with an explanation of your procedure and decision criteria when applicable.
- Underline your partial answers and box your final answers.
- Illegible and/or poorly organized homework problems may adversely affect your grade and may result in a score of zero for the question.
- The 18% portion of your grade derived from homework will be divided evenly between all of the homework assignments (i.e., all homework assignments are worth the same regardless of length).
- *Late homework will not be accepted.*

Exams (68% overall):

- There are two types of exams that will be part of your overall grade: Practice Exams and Written Exams.
- Practice Exams will be posted on Connect Platform 3 calendar days before the exam date. You have two attempts to complete it within the given time limit. The grade will be part of the course grade and represents 16% of the overall grade.
- To ensure fairness across all sections, written midterm exams will be 70 minutes long for all sections.
- You are allowed to bring your own note sheets. The number of sheets (front and back, letter size, no photocopies) will vary between exams and will be announced via Canvas in the days leading up to the exam. Notes sheets should be original handwritten, represent the work of the student using the notes sheet, **and may not contain example problems and solutions**. Notes sheets will be collected at the end of the exam and returned during recitation the following week.
- Please bring a calculator (not network connected).
- Any necessary tables/charts/constants will be supplied with the exam.
- Attendance to the final exam is mandatory even if your computed final grade prior to the final exam is a passing grade.
- Student IDs will be verified during the exam. Please bring your Suncard or driver's license.
- Make-up exams will only be given in cases of medical/family excuses, participation in university-sanctioned events, and religious observance in accordance with ACD 304-04.
- No cell phones, smart phones, smart watches, tablets, laptops, or any other device capable of holding information or of communicating with others are allowed during an exam. Such devices need to be kept in your backpack during the exam. Their use during a midterm or final exam will be considered evidence of academic dishonesty and will result in a failing grade for the course.
- Multiple ASU exams on a single day will be addressed per university policy. Non-ASU exams are not considered a sufficient cause for rescheduling.

Incompletes:

- An "incomplete" may be awarded only in cases when a student, who is otherwise performing satisfactorily, cannot complete final course requirements, such as the final exam or final assignment, due to circumstances beyond the student's control (such as illness or family emergency). Such circumstances must be documented. Incompletes will be approved only within the last one or two weeks of the semester. Incompletes cannot be requested after the time of the scheduled final exam

for the course. To request a grade of incomplete, the student must formally apply to the instructor using the university's "Incomplete Grade Request" form. Requests must be submitted to the student's advisor prior to the final grade due date and are subject to final approval by the program.

Absence and Make-up Policies

- While class attendance is not required, lack of class participation will slow down your learning experience.
- No late homework or makeup exams outside of ASU policy exceptions:
  a. Absences related to religious observances/practices –See ACD 304-04 "Accommodation for Religious Practices," and for official university-recognized religious holidays https://eoss.asu.edu/cora/holidays.
  b. Absences related to university-sanctioned events and activities, such as participating in officially recognized sporting events, representing ASU at student conferences, etc. – See ACD 304-02**,** "Missed Classes Due to University-Sanctioned-Activities."
  c. Excused absences related to missed class due to military line-of-duty activities that are in accord with ACD 304–11, "Missed Class Due to Military Line-of-Duty Activities," and SSM 201–18, "Accommodating Active Duty Military"
  d. Illness, quarantine or self-isolation related to illness as documented by a health professional.
  e. If notification is made in advance due to unforeseen circumstances, e-mailed homework will be provisionally accepted as being "on-time" however; a hard copy is required on the next class.

Note: ASU requests that sick students remain away from campus in order to prevent the spread of infectious disease. Students with documented illness will be given accommodation through an alternative grading basis.

Student Expectations – Classroom Behavior

- Be in the classroom no later than 5 mins before class starts. Because of the large size of this class, please avoid being late and distracting your peers and instructor. Keep in mind this class is only 75 minutes – 15 minutes of lateness represents 20% of the lecture; by being late you will miss important announcements and the class outline.
- No food during the class.
- Turn OFF your electronics during the class; any distraction will affect your learning. The only permissible exceptions are tablet/OneNote users who want to take class notes; other devices, except for phones used as "clickers," are not allowed.
- The use of audio or video recording devices is not permitted during class.
- Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students.
- The learning experience is interactive. The degree of class participation and discussion will help everyone, including the instructor, in accomplishing the goals for the course. Participation requires class attendance and effort from students in remaining current with topics discussed in class and application of class material. Sharing your practical knowledge and asking questions is expected from you; especially if you have work or related internship experience.

- The course syllabus has the planned topics that will be covered during the lecture, please read the material before coming to class.
- Mastering this course requires dedication and does not happen overnight; this course relates to deeper study of thermal physical principles and its applications. You should plan to spend time reviewing thermodynamic concepts discussed in class and applying them to the solution of suggested problems and homework – typically, at least 12-14 hours per week during a regular semester, in addition to class time.
- Presentation and organization of your work is taken into consideration in grading homework and exams. Treat the quality of your work as your letter of presentation.
- You are expected and required to use professional language in your oral and written communications. This applies but not limited to the following: class discussions, Zoom chats, vocabulary used during class time, essays, homework and exams. Any violation of this expectation will be reported to the Program Chair.
- When contacting your instructor or TA via email please include in the Subject line MAE 241 followed by a summary of your inquiry. Please use your ***asu.edu*** email to ensure your email is delivered.

Academic Integrity

Students in this class must adhere to ASU's academic integrity policy, which can be found at https://provost.asu.edu/academic-integrity/policy). Students must review this policy and become familiar with each of the areas in which academic dishonesty can occur. All academic integrity violations will be reported to the Fulton Schools of Engineering Academic Integrity Office. The Academic Integrity Office (AIO) maintains a record of all violations and has access to academic integrity violations committed in all other ASU college/schools. Course content, including lectures, are copyrighted materials. In addition to ASU's academic integrity policy, students may not share outside the class, upload, sell, or distribute course content or notes taken during the conduct of the course (see ACD 304–06, "Commercial Note Taking Services" for more information). Students must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the student first complies with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

Typical recommended sanctions for academic integrity violations in this class may include:

- Zero on the assignment or test
- Zero on the assignment or test and course grade lowered by one letter grade
- Receiving an "E" in the course
- Receiving an "XE" in the course

Note that in cases of copying, both the copyist and the person who allowed their work to be copied are considered guilty. Consequently, engaging in this type of activity places both you and your friend/colleague at risk.

Unless otherwise specified in writing, collaboration on homework, projects or take-home exams are NOT allowed; you are expected to turn in your own work. Keep in mind that even if collaboration is allowed, the resulting work products would never be identical or nearly so.

Use of solution manuals for solution to homework or take-home or online exam questions is not allowed and will be considered plagiarism. Similarly access to services that provide free or paid consultation or solutions to problems is not allowed (i.e., chegg.com, coursehero.com, or similar). Likewise, use of homework or project materials from prior semesters is prohibited.

Policy against Threatening Behavior

Students are expected to act with maturity and civility to the other students, faculty and staff. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off campus) must be reported to the ASU Police Department and the Office of the Dean of Students.

Disability Accommodations

Suitable accommodations will be made for students having disabilities. Students needing accommodations must register with the ASU *Student Accessibility and Inclusive Learning Services* (SAILS, https://eoss.asu.edu/drc) and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in sufficient time for it to be properly arranged. See ACD 304-08 Classroom and Testing Accommodations for Students with Disabilities.

Sexual Discrimination

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at https://sexualviolenceprevention.asu.edu/faqs.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling, is available if you wish to discuss any concerns confidentially and privately.

Notes that will facilitate your learning

- Form study groups; ideally, three students can work efficiently to make learning an interactive experience.
- Relate each new concept that you learn to your daily surroundings (environment, climate, air conditioning, car engine, transportation, pollution, human body temperature control, etc.).
- If at any point during the semester you feel lost in the course, please talk to your course instructor immediately so that you can receive proper personalized guidance. **Do not wait until it is too late!** The instructors and TAs are available to facilitate a successful learning process.

Miscellaneous Notices

- Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.
- All contents of these lectures, including written materials distributed to the class, are under copyright protection. Notes based on these materials may not be sold or commercialized without the express permission of the instructor. [Based on ACD 304-06.]

Tentative Schedule* MAE 241 (Spring 2023)

Week	Day	Date	Chapter	Topic	Sections (read before class)
1	T	1/10	Ch 1	Course introduction and expectations; Introductory Concepts and Definitions	1.1-1.4
	Th	1/12	Ch 1	Introductory Concepts and Definitions	1.5-1.11
2	T	1/17	Ch 2	Energy and Energy Transfer by Heat and Work; Mechanisms of Heat Transfer	2.1-2.5 Special Topic Pages 91-96
	Th	1/19	Ch 2	Energy Transfer by Work; The First Law of Thermodynamics; Energy Conversion and Energy and the Environment	2.5-2.8
3	T	1/24		Pure Substance, Phases, Phase-Change Processes of Pure Substances	3.1-3.4
	Th	1/26	Ch 3	Property Diagrams and P-v-T Surface; Property Tables, applications	3.4-3.5
4	T	1/31	Ch 3	Ideal Gas Equation of State	3.6-3.7
	Th	2/2	Ch 4	Moving Boundary Work, Polytropic Processes, Energy Balance for Closed Systems; Specific Heats	4.1-4.3
5	T	2/7	Ch 4	Internal Energy, Enthalpy and Specific Heats of Ideal Gases; Internal Energy, Enthalpy and Specific Heats of Solids and Liquids	4.4-4.5
	Th	2/9	**Exam 1 (Chapters 1, 2, 3)**		
6	T	2/14	Ch 4 Ch 5	Internal Energy, Enthalpy and Specific Heats of Solids and Liquids; Conservation of Mass Principle for a Control Volume	4.5 5.1-5.2
	Th	2/16	Ch 5	Energy Analysis of Control Volumes: Steady Flow Systems. Steady-Flow Engineering Devices	5.3-5.4
7	T	2/21	Ch 5	Steady-Flow Engineering Devices	5.4
	Th	2/23	Ch 5	Unsteady-Flow Processes in Control Volumes	5.5
8	T	2/28	Ch 6	The Second Law of Thermodynamics; Heat Engines; Kelvin-Planck Statement; Refrigeration and Heat Pumps	6.1-6.4
	Th	3/2	Ch 6	Irreversible Processes; The Perpetual Motion Machines; Carnot Cycle and Carnot Principles; Thermodynamic Temperature Scale	6.5-6.9
9	T	3/7	**Spring Break (no class)**		
	Th	3/9			

Week	Day	Date	Chapter	Topic	Sections (read before class)
10	T	3/14	Ch 6 Ch 7	The Carnot Heat Engine and Carnot Refrigerator and Heat Pump Entropy; Increase of Entropy Principle	6.10-6.11 7.1 – 7.2
	Th	3/16		**Exam 2 (Chapters 3, 4, 5)**	
11	T	13/21	Ch 7	Entropy Change of Pure Substances; Isentropic Processes	7.3-7.4
	Th	3/23	Ch 7	Entropy Property Diagrams; T-ds relations;	7.5-7.7
12	T	3/28	Ch 7	Entropy Change of Liquid, Solids and Ideal Gases	7.8-7.9
	Th	3/30	Ch 7	Reversible Steady-Flow Work; Minimum Compression Work; Isentropic Efficiency	7.10-7.12
13	T	4/4	Ch 7	Entropy Balance, Entropy Transfer and Entropy Generation	7.13
	Th	4/6	Ch 9	Gas Power Cycles: Carnot, Otto and Diesel Cycles	9.1 – 9.6
14	T	4/11	Ch 10	Vapor Power Cycles: The Simple Ideal Rankine Cycle	10.1-10.3
	Th	4/13		Vapor Power Cycles: The Ideal and Actual Rankine Cycle with Superheat and Reheat.	10.4-10.5
15	T	4/18	Ch 10	Refrigeration and Heat Pumps; The Reversible Carnot Cycle;	11.1-11.2
	Th	4/20		**Exam 3 (Chapters 6 and 7)**	
16	T	4/25	Ch 11	Ideal and Actual Vapor Compression Refrigeration Cycle; Refrigerant Selection	11.3-11.4, 11.6
	Th	4/27	Ch 11	Ideal and Actual Vapor Compression Refrigeration Cycle; Refrigerant Selection	11.3-11.4, 11.6
17	W	5/03	**FINAL EXAM (7:10 PM to 9:00 PM) Please check official final exam schedule**		

(*) This lecture schedule is tentative and may be modified at the instructor's discretion.