

**CAE 208 / MMAE 320: Thermodynamics**

Illinois Institute of Technology

Department of Civil, Architectural and Environmental Engineering

**Fall 2023**

3 credit hours

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**Course Unique Number(s)**

CAE 208 Section 01: 10116 – In Person

CAE 208 Section 02: 15456 – Online (Only for remote graduate students with a permit)

MMAE 320: Section 02: 11208 – In Person

**Classroom and Meeting Time**

Wishnick Hall (WS) 116, Tuesdays and Thursdays, 8:35 AM – 9:50 AM

**Course Website**

All content will be provided on Blackboard

Previous lecture notes are available online: <http://built-envi.com/courses/cae-208-thermodynamics-fall-2022/>

**Prerequisites**

CAE 208: ((CHEM 122 and CHEM 123) or CHEM 124) and (MATH 152 and PHYS 123)

MMAE 320: CHEM 124 or CHEM 122

**Instructor**

Mohammad Heidarinejad, Ph.D., P.E. Assistant Professor, Architectural Engineering

Office: Alumni Memorial Hall Room 204, Phone: (312) 567-3426

Email: [muh182@iit.edu](mailto:muh182@iit.edu)

**Teaching Assistant**

Saman Haratian, PhD student in Architectural Engineering

Office: Alumni Memorial Hall Room 217

Email: [sharatian@hawk.iit.edu](mailto:sharatian@hawk.iit.edu)

**Office Hours**

Instructor: Stop by when you see my office door open to see if I'm free. I have an open-door policy. Or you can email me to schedule an appointment or if you have any questions.

Teaching Assistant: Mondays 13-14:30 and Fridays 11:30-13. Or, please email to schedule a time to meet.

**Course Catalog Description**

Basic principles of thermodynamics applied to engineering systems using pure substances and mixtures as working fluids. Direct application of the laws of thermodynamics to analysis of closed and open systems, mass and energy flow. Extensive analysis of isentropic processes in cycles, analysis of gas mixtures and psychometrics in heating and cooling systems. Introduction to fluid mechanics and analysis of fluid statics problems.

## **Instructor's Course Objectives and Learning Outcomes**

To introduce students to fundamentals and theory of thermodynamics. By taking this course students will be able to:

1. Learn properties of pure substances and their implications for building science
2. Understand fundamentals of fluid and energy flows both for open and closed systems
3. Acquire a knowledge of first and second laws of thermodynamics
4. Become proficient in understanding and applications of power cycles and vapor compression cycles

## **Textbook**

Cengel, Y.A., Cimbala, J.M., Ghajar, A.J., *Fundamentals of Thermal-Fluid Sciences*, 6th Edition, 2022. 126059758X 9781260597585

The 5th and 4th edition or any older editions are also accepted. The same authors also have another book with the title Thermodynamics. The recent editions of that book should work. Overall, the concepts in Thermodynamics are similar in all books. You need a Thermodynamics book to use for the Thermodynamics Properties Tables and Charts. You do not need the book to see the problems of the assignments. The problems in assignments will be posted on Blackboard.

## **References (optional; will be given handouts when necessary)**

In addition to the textbook, I may also rely on several other materials in this course. These materials are entirely optional for the student; handouts will be given when necessary, so that no one is required to purchase these items.

Borgnakke, C. and Sonntag, R.E., *Fundamentals of Thermodynamics*, 10<sup>th</sup> Edition, Wiley, 20

Sonntag, R.E., Borgnakke, C., Van Wylen, G.J., *Fundamentals of Thermodynamics*, 6<sup>th</sup> Edition, Wiley, 2002, ISBN 0471152323, 9780471152323

## **Homework Assignments**

There will be a total of 10 homework assignments. Out of 10 assignments, the best of 8 will be used in the final grade. Homework sets will be assigned based on lecture coverage. The homework will involve hand calculations, development of spreadsheets, modeling, and/or learning the fundamentals and data analysis. Each homework will be assigned at least a week before the homework due date. You must work on the homework assignments individually.

## **Exams**

There will be three exams focused on the fundamental concepts learned in the course. Each exam has two parts: (1) a closed book/notes section and (2) an open book/notes section. During the closed book/notes section, students are only allowed to have a one-page cheat sheet that they prepared. During the open book/notes section of each exam, students can use the hard copy of the book only.

Two exams will be during the semester and the third exam will be the final exam. The first exam will cover materials till the last week before the exam. The second exam will only cover materials that are not covered in Exam 1. Exam 3 will cover all the materials in the course. Out of the three exams, the best of two exams will be used for the grade. Missing any exam will lead to zero grade for the exam as the best of two will be used. If the final exam grade is greater than the best of two exams, the entire final exam grade will be counted as 70.

## Quizzes

Students will take random in-class pop quizzes. The quizzes are short and usually they can be solved within 5 minutes. The instructor will randomly assign quizzes in class. There might be two quizzes in a given week. Online student should take the exam on Blackboard.

## Attendance

All students are expected to attend classes regularly. Excessive absences may be grounds for a failing grade. Quizzes and random attendance checks will serve as the only means to assess the student attendance. Students who attend all the quizzes will receive 4% bonus points. Students who attend 90% of the quizzes will receive 2.5% bonus points. Students should familiar themselves with the attendance Illinois Tech's attendance policy here:

<http://bulletin.iit.edu/undergraduate/academic-policies-procedures/registration/>

## Late Homework Assignment and Report Policy

Homework assignments and the course project are due at the midnight on the day that it is due. Homework assignments and the course project will receive a 5-point deduction for every day that it is late before the solution is posted on Blackboard. After the solution is posted or the assignments are graded, the blackboard submission page is closed for that particular homework.

## Grading

For all students, course grades will be determined by the total number of points accumulated through assignments, exams, and course project. The percentage of total points required for various letter grades is also given.

Grading	Quantity	% of Total for Each	% of Total
Homework	10	2	16 (Best of eight)
Exams	3	37	74 (Best of two)*
Quizzes	Vary	Depends on the number of quizzes	10
Attendance	-	-	Max 4

  

Grading Scale	A	B	C	D	F
UG and G	90% and up	80.0 – 89.9%	70.0 – 79.9%	60.0 – 69.9%	< 60.0%

\* If the final exam grade is greater than the best of two exams, the entire final exam grade will be counted as 74.

## Bonus Activity

Each semester some students usually ask for bonus points. This course offers two options which require students to start early if they are interested in receiving these extra points towards their final grade and also engaging further with the concepts presented in the class. (1) Given the importance of data science and coding for all disciplines, especially engineers, some assignments and mini project(s) will be provided with some training how to use a software program for deploying Thermodynamics concepts; (2) A hands on activity to build a small mock-up vapor compression cycle that can be used in this course and future students; (3) creating animations or schematic related to the topics that we cover in the course; and, (4) any relevant activities that could support learning thermodynamics and the materials covered in this course is also accepted with prior communications with the instructor. Resources and directions will be provided. Bonus points can account for up to an extra 10 points. More details will be provided throughout the semester.

### **Personal Problems**

If you have illness or personal problems that will affect your performance during the course of the semester, please let me know as soon as possible. “**After the fact**” provides little protection unless there are extreme circumstances. Contact the instructors by phone or e-mail at any time.

### **Students with Disabilities**

Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources. The Center for Disability Resources (CDR) is located in Life Sciences Room 218, telephone (312) 567-5744 or email: [disabilities@iit.edu](mailto:disabilities@iit.edu).

### **Academic Honesty**

It is your responsibility to be familiar with IIT's Code of Academic Honesty. The Code of Academic Honesty can be found online: <https://www.iit.edu/student-affairs/student-handbook/fine-print/code-academic-honesty>

You must submit your own work for homework. You are encouraged to discuss and even work with other students on homework (unless explicitly told otherwise), but material that is submitted must be your own work. For group project assignments, each group is to submit their own work. For a first violation of the IIT Code of Academic Honesty for a homework or project, the homework will receive a grade of zero for all involved students and the students will be reported to the Designated Dean for Academic Discipline (DDAD). For a first violation of the Code of Academic Honesty for a major project or an examination, the student will receive a failing grade for the course and the student will be reported to the DDAD. For a second violation, the student will receive also failing grade for the course and be reported to the DDAD.

### **COVID-19 Update, July 10, 2023**

Information for the university's COVID related policy is accessible here: <https://www.iit.edu/reopening>. Please make sure to review the policy.

### **Illinois Tech's Sexual Harassment and Discrimination Information**

Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community. This includes harassment among students, staff, or faculty. Sexual harassment of a student by a faculty member or sexual harassment of an employee by a supervisor is particularly serious. Such conduct may easily create an intimidating, hostile, or offensive environment.

Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Office of Title IX Compliance for information on support options and the resolution process.

You can report sexual harassment electronically at [iit.edu/incidentreport](https://www.iit.edu/incidentreport), which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at [foster@iit.edu](mailto:foster@iit.edu) or the Deputy Title IX Coordinator at [eespeland@iit.edu](mailto:eespeland@iit.edu). For confidential support, you may reach Illinois Tech's Confidential Advisor at (773) 907-1062. You can also contact a licensed practitioner in Illinois Tech's Student Health and Wellness Center at [student.health@iit.edu](mailto:student.health@iit.edu) or (312)567-7550.

For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Office of Title IX Compliance website at <https://www.iit.edu/title-ix/resources>.

### **FE Exam**

This is an important course for your Fundamental of Engineering (FE) exam. For students in Architectural Engineering, there are 9 to 14 questions in Section “14. Thermodynamics and Heat Transfer”:

- A. Thermodynamic laws (e.g., first law, second law)
- B. Thermodynamic equilibrium
- C. Thermodynamic properties (e.g., entropy, enthalpy, heat capacity)
- D. Thermodynamic processes (e.g., isothermal, adiabatic, reversible, irreversible)
- E. Heat transfer (e.g., conduction, convection, radiation)
- F. Mass and energy balances
- G. Property and phase diagrams (e.g., T-s, P-h, P-v)
- H. Combustion and combustion products (e.g., CO, CO<sub>2</sub>, NO<sub>x</sub>, ash, particulates)
- I. Psychrometrics (e.g., relative humidity, wet bulb)

Most of the topics will be covered in this course and the heat transfer and fluids topics will be covered in CAE 302 and CAE 331. Architectural engineering students are encouraged to visit this page: <https://ncees.org/wp-content/uploads/FE-Other-Disciplines-CBT-specs.pdf>

Similarly, FE exam for mechanical engineering students includes 10 to 15 questions. Mechanical engineering students are encouraged to visit the Mechanical Engineering Exam requirements here: <https://ncees.org/wp-content/uploads/FE-Mechanical-CBT-specs.pdf>

**Course Topics and Tentative Schedule**

Week	Date	Topics	Reading	Assignment Due
1	08/22/23	Course overview and introduction to the units	Ch. 1	
	08/24/23	Basic concepts of thermodynamics (1)	Ch. 2	
2	08/29/23	Basic concepts of thermodynamics (2)	Ch. 2	
	08/31/23	Basic concepts of thermodynamics (3)	Ch. 2	Assignment 1
3	09/05/23	Energy, energy transfer, and general energy analysis (1)	Ch. 3	
	09/07/23	Energy, energy transfer, and general energy analysis (2)	Ch. 3	Assignment 2
4	09/12/23	Problem solving session	Ch. 3	
	09/14/23	Energy, energy transfer, and general energy analysis (3)	Ch. 3	
5	09/19/23	Properties of pure substances (1)	Ch. 4	
	09/21/23	Properties of pure substances (2)	Ch. 4	Assignment 3
6	09/26/23	Properties of pure substances (3)	Ch. 4	
	09/28/23	Properties of pure substances (4)	Ch. 4	Assignment 4
7	10/03/23	Energy analysis of closed systems (1)	Ch. 5	
	10/05/23	Energy analysis of closed systems (2)	Ch. 5	
8	10/10/23	<b>Exam 1</b>		
	10/12/23	Energy analysis of closed systems (3)	Ch. 5	
9	10/17/23	Mass and energy analysis of control volumes (1)	Ch. 6	
	10/19/23	Mass and energy analysis of control volumes (2)	Ch. 6	Assignment 5
10	10/24/23	Mass and energy analysis of control volumes (3)	Ch. 6	
	10/26/23	Mass and energy analysis of control volumes (4)	Ch. 6	Assignment 6
11	10/31/23	Mass and energy analysis of control volumes (5)	Ch. 7	
	11/02/23	The second law of thermodynamics (1)	Ch. 7	Assignment 7
12	11/07/23	The second law of thermodynamics (2)	Ch. 7	
	11/09/23	<b>Exam 2</b>		
13	11/14/23	Entropy (1)	Ch. 8	Assignment 8
	11/16/23	Entropy (2)	Ch. 8	
14	11/21/23	Entropy (3)	Ch. 8	Assignment 9
	11/23/23	<b>Thanksgiving – No Class</b>	Ch. 8	
15	11/28/23	Power and refrigeration cycles (1)	Ch. 9	Bonus Activity Idea
	11/30/23	Power and refrigeration cycles (2)	Ch. 9	Assignment 10
16	12/06/23	<b>Exam 3 (8 am to 10 am)</b>		
17	12/11/23	<b>Final Bonus Activity Submission (Optional)</b>		