

# CAE 208 Thermal-Fluids Engineering I

## MMAE 320: Thermodynamics

Fall 2022

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**August 23, 2022**  
Course Overview and Units

Built  
Environment  
Research

@ IIT



*Advancing energy, environmental, and  
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Illinois Institute of Technology

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# **INTRODUCTION**

# About Me

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- B.S.E., Mechanical Engineering
  - ❑ Sharif University of Technology Tehran, Iran, 2006
- M.S.E., Architectural Engineering
  - ❑ The Pennsylvania State University, 2011
- Ph.D., Mechanical Engineering
  - ❑ The Pennsylvania State University, 2014
- Experience relevant to this course
  - ❑ ASHRAE, DOE, EPA, HUD, NSF, and industry projects
  - ❑ University of Maryland College Park
  - ❑ Licensed Professional Engineer
  - ❑ ASHRAE New Investigator
  - ❑ Developed and taught several courses at Illinois Tech
  - ❑ Recipient of the Michael J. Graff Award for Innovation in Teaching



# Introduce Yourself

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- Please introduce yourself
- What concentration or major are interested in?
- What do you expect from the course?
- Do you do have any relevant internship/work experience?

# Course

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## Classroom and Meeting Time:

- 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:

- Location: PS 152
- Tuesdays and Thursdays, 10 AM – 11:15 AM

## Course Website:

- All content will be provided on Blackboard

# Course Catalog Description

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- 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 & Learning Outcomes

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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

# Office Hours

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## Instructor:

- Office hours are by appointment only. Please email me to schedule an appointment. Or stop by when you see my office door open to see if I'm free. I have an open door policy.

❑ Office: Alumni Memorial Hall Room 204

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

❑ Phone: (312) 567-3426



# Office Hours

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## Teaching Assistant:

- TBD
  - Name: Jongki Lee, Ph.D. Student, Architectural Engineering
  - Email: [jlee310@hawk.iit.edu](mailto:jlee310@hawk.iit.edu)

# Office Hours

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## ARC SI:

- ❑ Name: Rachel Naomi Tjakra
- ❑ Email: [rnaomi@hawk.iit.edu](mailto:rnaomi@hawk.iit.edu)

# Textbook

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- 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 older editions are also accepted.  
Assignments will be posted on Blackboard.*

# **GRADING AND COURSE POLICIES**

# Course Grading

Grading	Quantity	% of Total for Each		% of Total
Homework	11	1.5		15 (Best of ten)
Exams	3	35		70 (Best of two)
Quizzes	Vary	Depends on the number of quizzes		15
Attendance	-	-		Max 5

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%

# Exams

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- There will be three exams focused on the fundamental concepts learned in the course:
  - ❑ Two exams will be during the semester
  - ❑ 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
- The **best of two exams** will be used for the grade
- **Missing** the exam will lead to **zero grade** for the exam

# Homework Assignments

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- There will be a total of **11 homework** assignments
- The best of **10 assignments** will be used in the final grade
- Homework sets will be assigned based on lecture coverage
- Each homework will be assigned at **least a week before** the homework due date
- You must work on the homework assignments **individually**
- Each assignment accounts for 1.5% of the total grade

# Quizzes

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- There will be random in-class pop quizzes
- The quizzes are short and usually they can be solved within 10 minutes
- The instructor will randomly assign quizzes in class (i.e., there might be two quizzes in a given week)



# Attendance

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- All students are expected to attend classes regularly
- Excessive absences may be grounds for a failing grade
- Quizzes will serve as the only means to assess the student attendance
- Students who attend the quizzes will receive bonus point:
  - ❑ Attending all the quizzes: 5% bonus points
  - ❑ Attending 90% of the quizzes: 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

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- Homework assignments are due at the ***midnight on the day that it is due***
- Homework assignments 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***, the blackboard submission page ***is closed for that particular homework***

# Course Topics

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Week	Date	Topics	Reading	Assignment Due
1	08/23/22	Introduction and Overview (I)	Ch. 1	
	08/25/22	Basic Concepts of Thermodynamics (I)	Ch. 2	
2	08/30/22	Basic Concepts of Thermodynamics (II)	Ch. 2	
	09/01/22	Basic Concepts of Thermodynamics (III)	Ch. 2	
3	09/06/22	Energy, Energy Transfer, and General Energy Analysis (I)	Ch. 3	Assignment 1
	09/08/22	Energy, Energy Transfer, and General Energy Analysis (II)	Ch. 3	
4	09/13/22	Properties of Pure Substances (I)	Ch. 4	Assignment 2
	09/15/22	Properties of Pure Substances (II)	Ch. 4	
5	09/20/22	Properties of Pure Substances (III)	Ch. 4	Assignment 3
	09/22/22	Energy Analysis of Closed Systems (I)	Ch. 5	

# Course Topics

Week	Date	Topics	Reading	Assignment Due
6	09/27/22	Energy Analysis of Closed Systems (II)	Ch. 5	Assignment 4
	09/29/22	Energy Analysis of Closed Systems (III)	Ch. 5	
7	10/04/22	Mass and Energy Analysis of Control Volumes (I)	Ch. 6	Assignment 5
	10/06/22	Mass and Energy Analysis of Control Volumes (II)	Ch. 6	
8	10/11/22	Mass and Energy Analysis of Control Volumes (II)	Ch. 6	Assignment 6
	10/13/22	<b>Exam 1</b>		
9	10/18/22	The Second Law of Thermodynamics (I)	Ch. 7	
	10/20/22	The Second Law of Thermodynamics (II)	Ch. 7	
10	10/25/22	The Second Law of Thermodynamics (III)	Ch. 7	Assignment 7
	10/27/22	Entropy (I)	Ch. 8	

# Course Topics

Week	Date	Topics	Reading	Assignment Due
6	11/01/22	Entropy (II)	Ch. 8	Assignment 8
	11/03/22	Entropy (III)	Ch. 8	
7	11/08/22	Power and Refrigeration Cycles (I)	Ch. 9	Assignment 9
	11/10/22	<b>Exam 2</b>		
8	11/15/22	Power and Refrigeration Cycles (II)	Ch. 9	
	11/17/22	Power and Refrigeration Cycles (III)	Ch. 9	Assignment 10
9	11/22/22	Power and Refrigeration Cycles (IV)	Ch. 9	
	11/24/22	Gas Mixtures (I)	Notes	Assignment 11
10	11/29/22	Gas Mixtures (II)	Notes	
	12/01/22	Combustion (I)	Notes	
	TBD	<b>Exam 3 (Final Exam Scheduled by IIT)</b>		21

# Academic Honesty

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- 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***

# Academic Honesty

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- 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

# Personal Problems

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- 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



# Personal Problems

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- Academic Regulations: <https://web.iit.edu/student-affairs/handbook/fine-print/academic-and-department-regulations>

*“All students are **expected to attend classes regularly**. Excessive absences may be grounds for a failing grade. Non-attendance does not constitute an official withdrawal. When illness or emergency requires a student to miss an exam and/or more than two days of class, the student must notify the course instructor. It is also recommended that the student **contact the office of the Dean of Students ([dos@iit.edu](mailto:dos@iit.edu)) to request an excused absence**. It will be necessary to provide written documentation of the reason for the absence(s). The Office of Student Affairs manages the process for requesting and documenting excused absences but the decision to excuse an absence is generally made by the Professor. Faculty members determine their own policies for attendance and make-up work.”*

# Students with Disabilities

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- 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)

# Sexual Harassment and Discrimination Information

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- 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.

# Sexual Harassment and Discrimination Information

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- 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

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- 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)

# FE Exam

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- Most of the topics will be covered in this course and the heat transfer topics will be covered in CAE 209 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>

# **INTRO TO THERMODYNAMICS**

# Intro to Thermodynamics

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- Thermodynamics can be defined as the science of energy “ability to cause changes”:
  - First law of thermodynamics “Conservation of Energy”
  - Second law of thermodynamics “define quality and quantity of energy” as well as “direction of decreasing quality of energy”



# Intro to Thermodynamics

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- There are two main approaches to look at Thermodynamics
  - Macroscopic approach rather than individual particles or known as “classical thermodynamics”
  - Microscopic approach meaning average of individual particles or known as “statistical thermodynamics”

# Intro to Thermodynamics

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- Another concept to consider is heat transfer:
  - Primarily interested in heat and its rate
  - Heat is defined as the form of energy that can be transferred from one system to another as a result of temperature difference
  - Rates of such energy “heat” transfer is heat transfer
  - What’s the driving force?

# Intro to Thermodynamics

- Applications



# **UNITS AND DIMENSIONS**

# Units and Dimensions

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- Dimensions defines any physical quantity
  
- The magnitude of dimensions is expressed in units

# Units and Dimensions

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- Relevant primary or fundamental units are:
  - Temperature (T)
  - Length (L)
  - Time (t)
  - Mass (m)
- Others are secondary or derived:
  - 
  - 
  -

# Units and Dimensions

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- Two systems of units are
  - SI
  
  
  
  
  
  
  
  
  
  
  - IP or English

# Units and Dimensions

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- Common units are:

<b>Dimension</b>	<b>SI Unit</b>	<b>IP Unit</b>
Length		
Mass		
Time		
Temperature		

*See Table 1-1 and 1-2*



# Units and Dimensions

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- Examples:

- $1 \text{ lbm} = 0.45359 \text{ kg}$

- $1 \text{ ft} = 0.3048 \text{ m}$



# Units and Dimensions

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- Some important SI and IP units
  - Force = (Mass)(Acceleration)

# Units and Dimensions

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- Some important SI and IP units
  - Weight = (Mass)(Gravitational Acceleration)

# Units and Dimensions

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- Some important SI and IP units
  - Work = (Force)(Distance)

# Units and Dimensions

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- Some important SI and IP units
  - Power = Rate of Energy