STUDY GUIDE

Theory of Energy and Sustainability Engineering (ENG 571)

Fall 2025

Prof. Leon Liebenberg

During the Industrial Revolution, there was a rapid expansion of railways, train transport, the telegraph, and steam-powered ships, fundamentally transforming economies and societies. More recently, the Information Revolution brought about the widespread adoption of the internet, smartphones, artificial intelligence, and social media on a global scale. Today, we are witnessing a comparable transformation in the energy and transportation sectors, driven by the rapid development and deployment of technologies such as solar power, electric vehicles, battery storage, heat pumps, hydrogen energy, and emerging forms of small-scale nuclear power.

Jack's Solar Garden in Colorado grows about 20 types of fruits, vegetables and herbs underneath its solar panels. Image credit: WSJ

COURSE ORGANIZATION

Instructor: Prof. Leon Liebenberg, Energy and Sustainability Engineering, Department of Nuclear, Plasma & Radiological Engineering, 121 Talbot Laboratory, 104 S. Wright St., Urbana 61801

E-mail: leonl@illinois.edu Tel: (217) 300-5496

Lectures: The Fall 2025 course will be delivered fully online in an asynchronous format. This means there will be no live (in-person or synchronous) lectures. You are expected to complete coursework independently and submit all deliverables by the specified deadlines.

All lectures have been pre-recorded and are available on the course's Canvas site. Each week, you should watch approximately 3 hours of assigned video content and review the corresponding lecture notes and/or the relevant sections of the prescribed textbook.

Please note that the video recordings and lecture notes partially overlap, so you do not need to watch or read every single resource in full. Instead, develop a study approach that works for you. That said, it is essential to use the lecture videos and notes as a guide through the textbook, which contains the core material for the course.

If you are enrolled in the 3-credit-hour version, plan to spend approximately 12 hours per week (in addition to watching the videos) on studying and completing assignments.
If you are a graduate student enrolled in the 4-credit-hour version, expect to spend about 16 hours per week (in addition to watching the videos), as you will be required to complete additional assignment questions.

Course Objective: By the end of this course, students will be expected to demonstrate mastery of the fundamental scientific and engineering principles underpinning energy systems, along with essential concepts in energy economics. This knowledge will enable students to design and evaluate energy systems and infrastructure that are sustainable with respect to resource availability, energy security, and environmental impact.

Course webpage (Canvas): https://canvas.illinois.edu/courses/60099

If you have difficulties accessing Canvas, then please contact consult@illinois.edu, *not* the instructor, *nor* the teaching assistant.

Course Organization: Students are expected to follow the syllabus closely, complete all assigned readings, watch the required video lectures, and submit assignments by the stated deadlines. Reminders for deliverables will generally not be provided—it is your responsibility to manage your time and stay on schedule.

As a 500-level course, this class emphasizes independent learning and requires you to demonstrate a high level of self-direction and mastery of the material. Support with instructor and teaching assistant will be available as needed, but active guidance will be minimal. You are expected to take initiative in engaging with the course content and completing your work.

Instructor's office hours: Professor Liebenberg's office hours will be held online-only via Zoom on Thursdays from 3:00 p.m. to 3:50 p.m. (excluding holidays):

Join Zoom Meeting:
https://illinois.zoom.us/j/84776638551?pwd=4E6uBrLgaDZr5k1SHqTAaFFDSjZGLa.1

Meeting ID: 847 7663 8551

Password: 217479

If these office hours are inconvenient for you, please email Professor Liebenberg detailing your difficulty and attaching any relevant information, such as calculations.

Your queries: You may submit queries or questions anytime via *Piazza*. Students are encouraged to view their classmates' questions and to participate in course discussions on *Piazza*.

Sign up at: https://piazza.com/illinois/fall2025/eng571

Private questions should be directed using the "Private" option on *Piazza*, else the whole class will see your query / request. The course assistant or the instructor will respond to your questions as soon as they can. The instructor and the teaching assistant will attempt to address your queries promptly from Mondays to Fridays (9 a.m. – 5 p.m.) and less promptly after these hours or over weekends. No questions will be taken during holidays.

Teaching Assistant: Your teaching assistant is *Ms. Apurva Malpure.* She will grade all your assignments. Apurva will also maintain an office hour which you may find helpful, especially when engaging with simulation tools such as HOMER Pro. Apurva will further assist Professor Liebenberg with some course administration functions.

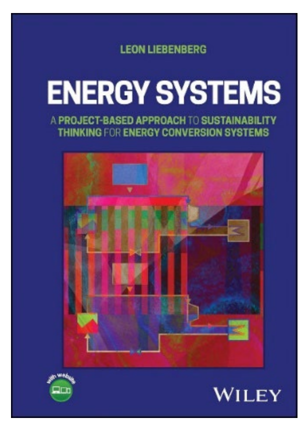
Ms. Apurva Malpure, amalpu2@illinois.edu
Apurva's office hour: Fridays, 9 a.m. – 10 a.m.

Zoom link for Apurva's office hour:
https://illinois.zoom.us/j/86958835376?pwd=VWZiC2kOEV48sPGjPW1mttwoWORPgb.1
Meeting ID: 869 5883 5376
Passcode: 305783

Course assistant: *Mr. Raj Mohite* will assist Apurva with grading your assignments. Raj will not maintain office hours.

Mr. Raj Mohite, mohite2@illinois.edu

Prescribed (mandatory) textbook: Leon Liebenberg. *Energy Systems. A Project-Based Approach to Sustainability Thinking for Energy Conversion Systems.* New York: John Wiley and Sons, 2024.



This book (or e-book) is available from the Illini Union Bookstore or amazon.com, or from other reputable booksellers. You can also purchase the book or an e-book subscription from the publisher.

Reading material: The prescribed textbook is comprehensive, covering everything from fundamental physics to the crucial details of real-world energy systems. Lecture slides, which are linked to the chapters of the textbook, will be provided.

All Assignments: All assignments and reading materials will be posted on Canvas. All completed assignments should be uploaded as a single PDF document (not multiple sheets). Please make sure that your work is neat and legible. Graded homework assignments and feedback on mini project deliverables will also be posted on Canvas. Your graded assignments will comprise the following:

- Seven (7) homework assignments, to be completed alone, i.e., independently. Submission due on Wednesdays by 10 p.m.
- A series of three mini projects, to be completed in teams of 3 over a period of several weeks. Submissions due on Mondays by 10 p.m.
- Weekly, small, class participation exercises. Submissions due on Fridays by 10 p.m.

Homework assignments: Homework assignments will typically be posted toward the end of every second lecture week, usually by Thursday evening. Completed assignments must be submitted via Canvas by the following Wednesday, giving students approximately six days to complete each assignment.

Assignments will be comprehensive, covering material from the previous two weeks, and may include both quantitative and qualitative questions. Full details and due dates can be found in the "Assignments" folder on Canvas.

Important: Graduate students enrolled in the 4-credit-hour version of the course are required to complete additional questions on each assignment. Please read the instructions for each homework assignment carefully to ensure you complete all required components.

Mini projects: You will be assigned to a team (ideally, 3 members per team). Each team will complete a series of three mini projects based on quantitative and qualitative analyses. Teams will be provided with a project topic. Mini-project deliverables will usually be due on a Monday evening, as indicated in the "Assignments" folder on Canvas.

Peer-grading of Other Teams' Mini Projects: Teams could be asked to peer-grade another team's project deliverables. Teams will then peer-grade a different team's project for each of the three mini-projects. The intention is to promote peer-learning. Teams will be penalized for being overly lenient or overly harsh in peer-grading. It is crucial to adhere strictly to the grading rubric and key. When grading open-ended questions, provide detailed comments. The teaching assistants and the instructor will assign the final grades for each assignment, *independent* of peer grading.

Peer-evaluations of Team Performance: Your team's success depends on everyone doing their part. While your team will receive one shared grade for each assignment, you can highlight teammates who worked especially hard—or raise concerns about unequal participation—through peer evaluations. This helps keep things fair and ensures accountability.

Each team member will *anonymously* rate the contributions of the others. If there are n team members, each team member will have a total of $(n-1)\times 100$ points to assign to the other team members. You will be able to assign a maximum of 130 points and a minimum of 70 points per person. So, if your team comprises three members $(n=3)$, you must allocate a *total* of $(3-1)\times 100 = 200$ points to the other two members of your team.

This system helps reward those who go above and beyond, and fairly reflect if someone didn't do their share.

To prevent surprises at the end of the semester, teams will complete peer evaluations after each of the three mini-projects. You'll also be given a *team agreement* template to fill out before starting your first project. In it, you'll outline how you plan to work together and how you'll evaluate each other's contributions.

Peer evaluation scores will be used to adjust your individual score. Here's how it works:

- Your average peer score will be divided by 100 to get a *multiplier.*
- Your final score = *team score* × your *multiplier*.

Examples:

- If your teammates give you an average score of 100, your multiplier is 1.0, and you'll get the full team score.
  → Team score = say, 94% → Your score = 94%
- If your average score is 80, your multiplier is 0.8.
  → Team score = say, 94% → Your score = 75.2%
- If your average score is 120, your multiplier is 1.2.
  → Team score = say, 94% → Your score = 112.8%

Assessment

- **Homework Assignments (40%) – Individual**
  Seven homework assignments will be given throughout the semester, each based on material from the previous two weeks of lectures. These assignments will assess your understanding of core concepts and may include both qualitative and quantitative questions.
- **Mini-Projects (40%) – Team-Based**
  Students will complete a series of three collaborative mini-projects:
  - Mini Project 1: 10%
  - Mini Project 2: 15%
  - Mini Project 3: 15%

  These projects will apply course concepts to real-world scenarios and promote collaborative problem-solving and communication skills.
- **Class Participation Exercises (20%) – Individual and/or Team-Based**
  Several participation exercises will be administered during randomly selected weeks. These may include in-class activities, online discussions, or short reflections. Some exercises may involve peer grading. Participation tasks are designed to reinforce learning and encourage active engagement with the course content.

An enhanced geothermal plant near Winnemucca, Nevada, generates power for Google data centers. Image credit: Google

SYLLABUS (subject to change)

Week #	For the class in the week of …	… you should first study the following lecture notes at home (Project deliverables stated in brackets)	… which is in the text-book, chapter #
1.	25 Aug.	• **Lectures:** Watch Videos #0 (Welcome) and 1 (Introduction to Energy). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview of course; introduction to energy. • **Assignments:** Read the course Study Guide very carefully! Complete online survey by due date. Complete Class Participation Exercise 1.	Study Guide Textbook: Chapter 1
2.	1 Sept.	• **Lectures:** Watch Videos #2 (Conservation of Quantity of Energy) and 3 (Destruction of Quality of Energy). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Introduction to the and the First Law of Thermodynamics, Second Law of Thermodynamics, entropy, and exergy. **Assignment:** Complete Class Participation Exercise 2. Homework 1 posted, due in Week 3.	2, 3
3.	8 Sept.	• **Lectures:** Watch Videos #4 (Energy & Society) and 5 (Energy Usage and the Environment). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Investigation of energy and society, energy usage and the environment. • **Assignment:** Complete Class Participation Exercise 3.	4, 5
4.	15 Sept.	• **Lectures:** Watch Videos #6 (Energy Economics) and 6.1 (Extensive Example: Energy Economics). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview the important topic of energy economics, focusing on a salient economic metrics. • **Assignment:** Complete Class Participation Exercise 4. Homework 2 posted, due in Week 5.	6
5.	22 Sept.	• **Lectures:** Watch Videos #7 (Fuels), 8 (Coal), and 9 (Oil, Natural Gas, Hydrogen, and Biofuel). Study the accompanying lecture slides and sections in the textbook. • **Activity:** The combustion of chemical fuels, including coal, oil, natural gas, hydrogen, and biofuel. • **Assignment:** Complete Class Participation Exercise 5. Mini Project 1 is due this week.	7, 8, 9
6.	29 Sept	• **Lectures:** Watch Videos #10 (Internal Combustion Engines) and 11 (External Combustion Engines). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview of ubiquitous internal- and external combustion engines, and controlling their emissions. • **Assignment:** Complete Class Participation Exercise 6. Homework 3 posted, due in Week 7.	10, 11, 12
7.	6 Oct.	• **Lectures:** Watch Video #12 (Steam Power Plants). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview of steam power plants, found in fossil-fired, nuclear-powered, and geothermal power plants. • **Assignment:** Complete Class Participation Exercise 7.	13, 15
8.	13 Oct.	• **Lectures:** Watch Video #13 (Refrigeration and Air-conditioning). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Vapor power plants and vapor refrigeration cycles and controlling their emissions. • **Assignment:** Complete Class Participation Exercise 8. Homework 4 posted, due in Week 9.	14, 15

Week #	For the class in the week of …	… you should first study the following lecture notes at home (Project deliverables stated in brackets)	… which is in the text-book, chapter #
9.	20 Oct.	• **Lectures:** Watch Videos #14 (Nuclear Physics), 15 (Nuclear Fission and Fusion), and 16 (Controlling Radioactive Waste and Emissions). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview of nuclear physics and fission, and overviewing fusion. Strategies to control emissions and radioactive wastes. • **Assignment:** Complete Class Participation Exercise 9. Mini Project 2 is due this week.	16, 17, 18
10.	27 Oct.	• **Lectures:** Watch Videos #14 (Nuclear Physics), 15 (Nuclear Fission and Fusion), and 16 (Controlling Radioactive Waste and Emissions), again. Study the accompanying lecture slides and sections in the textbook. • **Activity:** Overview of nuclear physics and fission, and overviewing fusion. Strategies to control emissions and radioactive waste. • **Assignment:** Complete Class Participation Exercise 10. Homework 5 posted, due in Week 11.	16, 17, 18
11.	3 Nov.	• **Lectures:** Watch Videos # 17 (Direct Energy Conversion) and 18 (Solar Electricity). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Direct conversion of solar energy to either electricity or heat. • **Assignment:** Complete Class Participation Exercise 11.	19, 20
12.	10 Nov.	• **Lectures:** Watch Videos #19 (Fuel Cells and Electrolyzers), 20 (Solar heating), and 21 (Solar-thermal Electric Power Plants). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Hydrogen-power fuel cells; electrolyzers; solar heating, and solar-thermal electric power plants. • **Assignment:** Complete Class Participation Exercise 12. Homework 6 posted, due in Week 13.	21, 22, 23
13.	17 Nov.	• **Lectures:** Watch Videos #22 (Wind Power), 23 (Waterpower), 24 (Geothermal Power). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Wind power; waterpower and pumped hydro storage, tidal and wave power; geothermal power. • **Assignment:** Complete Class Participation Exercise 13. Mini Project 3 is due this week	24, 25, 26
	22 Nov. – 30 Nov.	**Thanksgiving Break**	
14.	1 Dec.	• **Lectures:** Watch Video #25 (Storage of electricity and heat). Study the accompanying lecture slides and sections in the textbook. • **Activity:** Long-duration storage of electricity and heat. • **Assignment:** Complete Class Participation Exercise 14. Homework 7 posted, due in Week 15.	27
15.	8 Dec.	• **Activity:** Summary of semester's work. Project Winners' Day (via Zoom). • **Assignment:** Complete Class Participation Exercise 15.	

Hydrogen production is seen as a viable fossil-fuel replacement for heavy industry, unlike many other renewable-energy sources. The image shows Monolith's plant in Nebraska runs on renewable power to turn natural gas into clean hydrogen and carbon materials. Image credit: The Wall Street Journal

MINI PROJECTS

<u>Mini Project 1</u>: Energy Scenarios for a Sustainable World

Overview: In this mini project, you will use the En-ROADS simulation model to develop and analyze a global energy and climate scenario that limits global warming to less than 2 °C compared to preindustrial levels. You will consider economic, social, and environmental factors and reflect on the realism and implications of your proposed solutions. This assignment encourages critical thinking, policy analysis, and use of modeling tools.

Team Formation: Teams must consist of three members. In the event of an uneven number of students in the class, or if a student joins the class late, or if a team member drops the course, one team of four members will be permitted. You may form your own team or request the instructor to assign one for you. This collaborative effort will encourage the exchange of diverse ideas and foster the development of well-rounded solutions. Note that the same quality of work is expected from teams regardless their size. However, proportionally more work is expected from a team of three students.

Context: In this climate action simulation, you will learn about the dynamics of the climate-energy system by simulating the climate and energy outcomes of your own decisions with the interactive computer model En-ROADS. You will also engage in the social dynamics of climate and energy decision making in a role-play simulation. Please note that some of the terminology used in the En-ROADS simulation might differ from that used in the UN's SDGs.

In this mini project, you will work with the En-ROADS simulation model to create a scenario that can mitigate global warming to the internationally agreed target of less than 2 °C compared to preindustrial times. In addition, you will consider the economic, political, and social issues relevant to the successful implementation of your policies.

Details: See the "Mini-Project 1" folder in the "Modules" section of Canvas for the detailed mini-project and grading rubric.

<u>Mini Project 2</u>: Hybrid Renewable Energy-Powered Cooling System

Overview: In this mini project, you will use the HOMER Pro simulation tool to model and to optimize an energy system comprising solar-PV, wind, lithium-ion battery storage, and grid electricity, to provide cooling for a medium-sized data center. You will perform techno-economic sensitivity and optimization analyses and make recommendations.

Team Formation: Teams must consist of three members. In the event of an uneven number of students in the class, or if a student joins the class late, or if a team member drops the course, one team of four members will be permitted. You may form your own team or request the instructor to assign one for you. This collaborative effort will encourage the exchange of diverse ideas and foster the development of well-rounded solutions. Note that the same quality of work is expected from teams regardless their size. However, proportionally more work is expected from a team of three students.

Context: The rapid growth of internet and AI services has led to data centers consuming approximately 1% of global electricity, globally. By 2030, this figure is projected to rise to 9%. Currently, data centers use 60% of their energy for computational processes, while the remaining 40% is dedicated to cooling. Traditional cooling methods, which often involve air-cooled systems and liquid (commonly water) for heat dissipation, are inefficient and unsustainable.

While renewable sources such as wind and solar are generally seen as unsuitable for powering data centers due to their intermittency, their viability improves when paired with lithium-ion battery storage and supported by grid connectivity for supplemental electricity. This project explores the techno-economic feasibility of using such hybrid renewable energy systems—solar and wind, combined with battery storage and grid backup—to meet the cooling energy demands of data centers.

Details: See the "Mini-Project 2" folder in the "Modules" section of Canvas for the detailed mini-project and grading rubric.

Mini Project 3: Techno-Economic Analysis of a Solar Power Tower with Molten Salt Storage

Overview: In this mini project, you will use the System Advisor Model (SAM) tool to perform a simulation and financial analysis of a 560-MW_{th} solar power tower near Tucson, Arizona, using molten salt heat transfer and storage.

Team Formation: Teams must consist of three members. In the event of an uneven number of students in the class, or if a student joins the class late, or if a team member drops the course, one team of four members will be permitted. You may form your own team or request the instructor to assign one for you. This collaborative effort will encourage the exchange of diverse ideas and foster the development of well-rounded solutions. Note that the same quality of work is expected from teams regardless their size. However, proportionally more work is expected from a team of three students.

Context: Molten salt power tower systems use direct thermal energy storage, allowing them to generate electricity on demand—particularly during periods of high market prices or peak energy demand. This dispatchability adds significant value: grid operators benefit from enhanced stability, while plant owners can increase profitability. When paired with a well-designed, "smart" operational strategy that manages energy reserves effectively, these systems can reliably deliver power during peak hours. As such, molten salt power towers represent a valuable addition to modern power grids—supporting the urgent goal of decarbonization while helping to maintain energy security.

Details: See the "Mini-Project 3" folder in the "Modules" section of Canvas for the detailed mini-project and grading rubric.

A recently completed 100-MW concentrated solar power plant located in Dunhuang, northwest China's Gansu Province. The plant uses 12,000 mirrors that concentrate the sunlight onto a receiver at the top of a solar tower, which then heats molten salt. The molten salt exchanges heat with water, to produce steam that drives turbines. The plant is designed to generate 390 million kWh of power annually, which can reduce carbon dioxide emissions by 350,000 metric tons per year, compared to a similarly sized natural gas-fired steam power plant. Image credit: www.xinhuanet.com

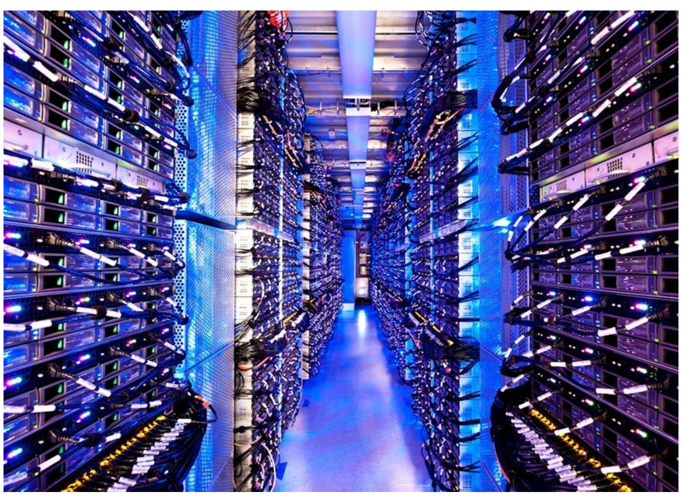
CLASS PARTICIPATION EXERCISES

In asynchronous online engineering courses such as this one—especially those with bi-weekly homework and a series of mini-projects—weekly participation activities can powerfully deepen engagement, reinforce learning, and build community even without real-time interaction.

You will therefore complete a set of asynchronous-friendly participation activities tailored for your context. These will usually be due by Friday evenings. These are designed to be lightweight but meaningful, and easily assessable. They will contribute 20% to your final course grade.

Week	Participation Activity	Description	Tool	Credit Weight
1	Real-World Connection	Post a brief example of how a course concept (from Chapter 1 in your textbook) shows up in everyday life.	Canvas	1%
2	AI-Supported Learning Reflection	Use ChatGPT to explain the concepts of entropy and exergy. Reflect on what was helpful/misleading.	Canvas	1%
3	Peer Feedback Forum	Related to Chapter 5 in your textbook, share a diagram or part of a problem approach with your teammate. Each teammate must give 1–2 constructive comments.	Canvas	1%
4	Explain Your Thinking	Submit a short (1-minute) reflection on Mini-Project 1 progress, challenges, and how you intend tackling them. Produce this video with your teammates.	Short (1-minute) video posted on Canvas	1%
5	Enrichment Puzzle	Solve an optional estimation or open-ended challenge pertaining to combustion of chemical fuels	Canvas	1%
6	Teach-Back Micro-Lesson	Record a 2-minute explanation of how energy is released from the combustion of methane gas. If you use a narrated PowerPoint presentation, do not use more than four slides.	Short (2-minute) video posted on Canvas	2%
7	Homework Check-In	Choose a solution step from a Homework 3-problem and explain your reasoning.	Canvas	1%
8	Real-World Application (Article)	Share a news article that connects to advanced refrigeration and air-conditioning; explain clearly how this innovation will benefit society and/or the environment	Canvas	1%
9	AI Feedback Critique	Ask AI to critique a sample solution from Mini Project 2; reflect on quality of feedback.	Canvas	1%
10	Peer Hackboard Showcase	Share a short (2-minute) narrated video of your modeling work in HOMER Pro.	Canvas	2%
11	Explain Your Thinking	Reflect on a difficult or insightful step in Homework 5. Provide a one-page written account.	Canvas	1%
12	Puzzle Challenge	Try a mini-scenario with an engineering twist (e.g., optimize cooling setup).	Canvas	1%
13	Teach-Back Micro-Lesson 2	Present a fresh concept learned during your work on Mini Project 3. Present your thoughts in a short (1 to 2-minute video recording with no more than 4 PowerPoint slides.)	Canvas	2%
14	Final Project Reflection	Share what you learned from Mini-Project 3; what you'd do differently.	Canvas	1%
15	Exit Ticket	Summarize key takeaways and unresolved questions from the course. On a one-page fact sheet.	Canvas	1%


In this aerial view, the shuttered Three Mile Island nuclear power plant stands in the middle of the Susquehanna River near Middletown, Pennsylvania. The plant owners stated that they plan to restart the reactor so tech giant Microsoft can buy the power to supply its data centers. Image credit: Image is in the public domain


A few of the 2,500 servers at a new Microsoft data center in Chicago. Image credit: Microsoft

COURSE & UNIVERSITY POLICIES / RULES

Grade appeal policy: If you wish to appeal your grade on a homework assignment, mini project, or class participation exercise, you must submit to the instructor a written grade appeal request within *one week* (7 days) of when the assignment score was posted on Canvas. After this period, all grades are considered final.

Grade appeals for any assignment should be directed to the instructor via email at leonl@illinois.edu. The appeal must include:

- A *clear statement* of your grade concern.
- A *justification* of how many points you believe you deserve for the specific question(s) in question.

In the event of appeal of a mini project grade, the appeal process must be followed by the entire team. So, when sending your appeal to the instructor, be sure to *copy all your teammates* and ensure that your teammates are in accord with the appeal. Incomplete, incorrectly addressed, or vague appeals will not be considered.

Late Work Policy:

a. Mini-project deliverables must be submitted on time to ensure the effectiveness of the peer feedback process. Late submissions will not be accepted, and no make-up assignments will be provided. Any late or missing submission will receive a grade of 0%—applied to all members of the team.
   Teams have several weeks to plan and execute their work, so it's important not to leave tasks until the last moment. Teams should plan thoroughly and have contingencies in place to handle situations where a team member may be unable to contribute due to extenuating circumstances, such as illness.
b. Late homework assignments or non-completion of class participation exercises will receive a 0% grade. Students will have around 6 days to complete each quiz, and solutions will be posted after the submission deadline passes.
c. Extensions for homework assignments or class participation deadlines may be granted at the instructor's discretion, provided the student gives advance notice by email—except in cases of emergency. Valid reasons for requesting an extension include, but are not limited to:
   i. serious illness, serious injury, or death in the student's *direct* family (not grandparents, uncles, or cousins, for instance);
   ii. birth of a child for which the student is identified as a parent on the birth certificate;
   iii. required duty in the U.S. military (active-duty, reserve, or in a National Guard unit activated by the President or a governor), required service in a foreign military organization acting in concert with the United States, or service under provisions of the Volunteer Emergency Worker Job Protection Act;
   iv. participation in, or travel to, an obligatory AFROTC, NROTC, or ROTC event;
   v. participation in, or travel to, varsity or DRES-sanctioned athletic events (excluding fencing, bowling, and other club sports);
   vi. participation in, or travel to, an organized extracurricular activity sanctioned by the College of Engineering or one of its departments, for which a full-time or emeritus faculty member of the College of Engineering attests that the student's participation is essential;
   vii. observance of a religious holiday;
   viii. any excuse allowed by the UIUC for students participating in online learning.

If the student was so seriously ill or injured as to be unable to communicate their intentions to the instructor prior to the beginning submission deadline, the advance notification requirement will be waived if the student subsequently provides satisfactory documentation of such incapacitation. The student will do well to also reach out to an emergency dean in the Office of the Dean of Students to enquire the available care resources to help you navigate your challenge. In these circumstances, students should also contact their advisor.

In those cases where advance notification of lateness or non-submission has been provided, or where such notice has been waived according to the provisions of the second sentence of the above paragraph, late submissions of non-submissions will be classified as unexcused unless the student provides satisfactory after-the-fact documentation, as indicated below.

For illness or injury of the student, a satisfactory letter stating that the student was medically unfit to complete the quiz by the submission deadline must be provided by an appropriate medical practitioner (C.N.P., D.D.S., D.M.D., D.O., D.P.M., M.D., O.D., or P.A.) after the quiz submission deadline. *Medical bills, prescriptions, e-mail or letters from friends or relatives, letters from naturopaths, chiropractors, psychologists, and mental health counselors, "visit slips" from McKinley Health Center, and records of calls to McKinley Health Center's Dial-a-Nurse program (with or without endorsement by an "emergency dean" in the Office of the Dean of Students) are among the types of documentation that will not be accepted.*

For serious illness, serious injury, or death in the student's family, the student's relationship to the ill, injured, or deceased party must be established, along with documentation of the illness, injury, or death.

For birth of a student's child, a photocopy of an original birth certificate, showing the student as a parent, is required.

For military duty, copies of valid military orders are required.

For participation in or travel to varsity or DRES-sanctioned athletic events or AFROTC/NROTC/ROTC events, a satisfactory letter from the Division of Intercollegiate Athletics, DRES, or the commanding officer of the detachment is required.

For participation in, or travel to, an organized extracurricular activity sanctioned by the College of Engineering or one of its departments, a satisfactory letter from the faculty sponsor is required.

Independent work: The work you submit in this course, in individual or team assignments, must reflect exclusively the effort of those listed in the submitted materials and must not come significantly from the work of others. You are encouraged to study and discuss the course materials and assignments with your peers. But you are responsible for ensuring that you follow the rules laid out in this study guide and in the University of Illinois' Academic Integrity Policy. Also see *Academic Integrity* on page 17 of this study guide.

Communication etiquette: We welcome communications concerning possible errors, or constructive suggestions about the materials. Please do not contact us to request increases in your assigned grade, outside of errors in grading.

All class communications will use your UI NetID email; do not use any alternate such as gmail as such mail will be ignored.

Use of Generative AI Technology

You are allowed to use generative AI tools such as ChatGPT (OpenAI), Microsoft Copilot/Bing Chat, Google Gemini, and others to help you learn. These tools can explain concepts, give you extra practice, and help clarify things you're unsure about. However, you must use them carefully and responsibly.

These AI tools often give incomplete, incorrect, or misleading answers, especially when it comes to advanced reasoning or technical calculations—which are common in this course. To spot these mistakes, you need to already understand the topic well, like a qualified instructor or experienced engineer would. Since students are still learning, it's easy to accept wrong answers as correct, which can seriously harm your learning or even teach you false information.

You may use AI tools to support your learning, but only if you follow the rules below and the honor code on each assignment.

Permitted Uses of AI (for Learning, Not Grading)

You may use AI tools in these two ways:

1. **As a personal tutor**
   You can ask the AI to explain concepts, break down techniques step by step, list key ideas, give extra examples, or create self-test questions for you.
2. **As a feedback tool**
   You can ask the AI to review your work, point out possible mistakes, or suggest how to improve your explanations or calculations.

AI Use That Is Not Allowed

To maintain academic integrity, you must follow these rules:

- **Do not use AI tools during graded work**, including homework, mini-projects, or participation exercises. You may use AI tools to help you understand readings, prepare for team work, or study in general.
  But you cannot use AI to generate answers or solve graded questions—unless your instructor explicitly allows it in the assignment instructions or honor code.
- **Do not submit any work created by AI**.
  Everything you turn in must be your own original thinking and effort. You must not include AI-generated solutions or text, even if you edited them.
- **Be prepared to explain your work**.
  Your instructor may ask you to explain your submission in person or in writing. If you can't explain it clearly, you may receive a score of zero and could be reported for academic misconduct.

Documentation and Citation of AI Use

If you use AI tools in your learning:

- **Keep a record**: Save or log the prompts you used, the AI's responses, and how you used them.
- **Be ready to share this record** if your instructor asks.

If an assignment *does* allow AI use, you must:

- Cite your AI use properly, using APA style. This includes the text of your prompt and a reference to the tool used (e.g., ChatGPT).
- Do not cite AI as a source of facts. AI can invent information. Always verify facts and cite the original sources they come from.

Final Notes on AI and Academic Integrity: Misusing AI tools—by submitting AI-generated work or using AI when it's not allowed—is a violation of academic integrity. Any suspected misuse will be investigated and may result in penalties under the Illinois Student Code. Please read the University of Illinois System's Generative AI Guidance for Students to learn more about your responsibilities.

Most Valuable Players (MVPs): As mentioned, you should state all your queries via Piazza, not via email. Piazza is configured to allow any student to post anonymously to their classmates whenever they prefer. In each discussion thread, different anonymous posters are automatically differentiated with pseudonyms to avoid confusion. The instructor invites you all to help answer your classmate's Piazza questions. The course assistant and the instructor will keep track of each time a student suitably answers a fellow student's Piazza question. At the end of the semester, we will tally all the results to see which students *consistently* and *significantly* helped their fellow classmates the most. Those winning students will each receive a bump of 1% in their final grade! Those winning students will also win the "Most Valuable Player" certificates that will be awarded at the end of the semester. We encourage the students in our class to make the most of this opportunity. This helps you to learn from each other's understanding of the course and increase your grades! And, as you answer the questions posted by your fellow classmates, you will realize that it also betters your own understanding of any concept.

The instructor reserves the right not to issue any MVPs in the event of non-performance by class members.

Note: When the course assistant or instructor award "good post" awards on Piazza, which will eventually be tallied to give us the MVPs, they will use the following criteria:

- Does the question or the answer clarify a technical (not class-administrative) issue which was vague or confusing in the class instructional materials (lecture announcements and syllabus)?
- Does the question or the answer demonstrate unique and thoughtful engagement with the course material?
- Is one student going out of their way to clarify something from the lecture to another student?
- Does reading what the student wrote make you excited to learn more about the energy systems?
- Other: (New justification which we can apply retroactively).

Final grade

At the end of the semester, letter grades are determined based on composite numerical scores, weighted as previously described. The instructor does not have a predetermined "target" grade distribution, and it may vary significantly from semester to semester. Additionally, there is no "curving" of grades in this class. Grades will be rounded to the nearest whole number. For example, a final grade of 93.2% will be rounded down to 93%, while a final grade of 93.6% will be rounded up to 94%.

Letter grades at semester's end

Grade meaning	Refined letter scale	Numerical scale of marks
Excellent	A+	97 to 100
	A	94 to <97
	A-	90 to <94
Good	B+	87 to <90
	B	84 to <87
	B-	80 to <84
Adequate	C+	77 to <80
	C	74 to <77
	C-	70 to <74
Marginal	D+	67 to <70
	D	64 to <67
	D-	60 to <64
Inadequate	F	<60

> Skeptics argue that abatement technologies such as carbon capture and storage, or CCS, are expensive boondoggles that aren't nearly as effective in reducing emissions as proponents say and give energy giants an excuse to continue producing fossil fuels. Overreliance on CCS to counteract fossil-fuel emissions is dangerous, the Paris-based International Energy Agency warned in a November report, potentially requiring an "inconceivable" 32 billion metric tons of carbon captured at a cost of more than $3.5 trillion a year until 2050 if current oil and gas consumption trends continue.

BKV compressor units process carbon dioxide in Bridgeport, Texas, before it is injected into a well. Denver-based BKV says that by the 2030s it will store millions of tons of climate-warming carbon dioxide in wells deep underground to eliminate or offset all the emissions generated from manufacturing and using its gas. Image credit: The Wall Street Journal.

The Energy and Sustainability Engineering (EaSE) graduate certificate

ENG 471 and ENG 571 are the core courses in the EaSE graduate certificate (or "microcredential"). If you are enrolled in any M.S. or Ph.D. degree program, consider adding the certificate to your credentials: EaSE.Illinois.edu. Enquiries may be directed to Ms. Amy McCullough: amccul2@illinois.edu

OTHER COURSE & UNIVERSITY RULES / POLICIES & ADVICE

Teamwork: Effective teamwork requires empathy and respect. You should be willing and able to 'bend' your minds to recognize where others are coming from and what is important to them, and then to 'blend' with them, moving in a unified direction. You will learn techniques to be more receptive and connected, and to have greater influence whilst accommodating others. Rather than opposing or agreeing with other people, you will learn how to accept and acknowledge the other's position until you can understand what is important about it. This requires a willingness to flex, bend, and search to understand someone else's perspective. Once you understand their perspective, you can pivot and create an opening for that person to understand what is important to you.

Team members will communicate with each other using social media platforms of their own choosing. Historically, students enjoy collaborating using the following platforms: Discord, Zoom, Google Docs, WeChat, GroupMe, and Miro. You and your teammates should soon agree on your chosen method of online collaboration and then promptly get into that routine.

It is strongly suggested that teams use roving team leaders. For instance, a student could be team leader for the first mini-project, followed by another student leading the next mini-project, and yet another team member leading the third mini-project. This will help ensure that no single person dominates the team's actions.

Assigned team members will remain unchanged for the duration of the semester. Teams should however note that they must accommodate late-registered students into their teams, as directed by the instructor or TA. Teams may also have to negotiate lost team members as some students might drop the course. So, although ideal team sizes are 3 students, this number might become more (i.e., 4 students) depending on class size. Also, some students might join the class late and asked to merge with an existing team. The instructor and TAs will do their utmost to minimally disrupt existing teams. The full cooperation of every student is expected when forming or changing teams.

Grading the work of large teams and small teams: When grading the mini projects of regularly sized teams (with three team members), we expect the same *quality* (and correctness) of work compared to larger teams (say with four team members); but, for larger teams we expect a greater *quantity* of work than that of a larger team.

Uncooperative team members: In this engineering class, effective teamwork is paramount for successful collaboration and project completion. Students are encouraged to actively engage in open communication, share diverse perspectives, and contribute their unique skills to foster a collaborative and innovative environment. However, should any student fail to cooperate with their team or disrupt the collaborative process, appropriate measures will be taken. These measures include intervention by the instructor, potential reassignment of team roles, and, if necessary, disciplinary actions in accordance with class and University policies. This ensures a fair and conducive learning environment that promotes the development of both technical and interpersonal skills crucial for success in the field of engineering.

Academic integrity: The highest academic integrity is expected. Academic violations will however be dealt with according to the UIUC Student Code, Article 1, Part 4. Violations will be reported to the relevant College and, where relevant, to the FAIR system.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

- All students are responsible to refrain from infractions of academic integrity, conduct that may lead to suspicion of such infractions, and conduct that aids other in such infractions. "I did not know" is not an excuse.
- The following are academic integrity infractions (http://www.provost.illinois.edu/academicintegrity/students):

- ✓ Cheating: using or attempting to use unauthorized materials.
- ✓ Plagiarism: representing the words, work, or ideas of another as your own.
- ✓ Fabrication: falsification or invention of information, including citations.
- ✓ Facilitating infractions of academic integrity, helping, or attempting to help another commit infraction.
- ✓ Bribes, favors, and threats: actions intended to affect a grade or evaluation.
- ✓ Academic interference: tampering, altering, or destroying educational material or depriving someone else of access to that material.
- ✓ Note: All infractions are documented in the campus-wide FAIR database.

- If you have difficulty completing your classwork, you should consult the instructor by showing him evidence of your attempts to solve the specific problem/s. However, most lecture time has been set aside exactly for this type of activity; use it to your full advantage.

- Copying (in whole or in part) another student's (or team's) quiz, project work, or exam is not permitted. Copying solutions from web-based answer keys such as Chegg is an honor code violation.
- If you choose to discuss your work with a fellow student, it should be a discussion in which one teaches the other, or where both work to a mutual understanding. The discussion should however relate to general concepts and not address the specifics of the quiz questions.
- It is not acceptable to give a fellow student your completed project work or quiz or other assignment so that they can copy it. In such a case, both you and your fellow student will have committed an academic violation.
- It is also unacceptable to copy work from a student who completed the course previously.
- You should properly cite references and sources in your written reports. Cases of cheating or plagiarism will be handled severely.

  Also, be wary to correctly use quotation marks for sentences or important data that did not originate with you. Further, paraphrasing should be kept to a minimum. When used, the paraphrased section should be specifically identified by citing the original source. It is not sufficient to simply provide a list of references but not indicate where a specific quotation or paraphrase was employed. In addition, all sources should be fully cited. As is done in scientific and engineering literature, you should briefly acknowledge in writing any significant discussions or interactions you had regarding the work you are reporting on.

- Ignorance of academic integrity or uncertainty regarding the instructor's wishes are not justifiable reasons for academic violations. If you are uncertain of the instructor's wishes or intentions, you should consult with him *before* acting.

Sexual Misconduct Reporting Obligation: The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Community of Care: As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or http://odos.illinois.edu/community-ofcare/referral/). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at the Counseling Center (https://counselingcenter.illinois.edu/) or McKinley Health Center (https://mckinley.illinois.edu/).

Mental Health: Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois Urbana-Champaign offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services and specialized screenings which are covered through the Student Health Fee.

If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

Academic Integrity: The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious Observances*:* The Religious Observance Accommodation Request form is available at http://odos.illinois.edu/community-ofcare/resources/docs/Religious-ObservanceAccommodation-Request-Form.pdf. Submit the form to the instructor and to the Office of the Dean of Students (helpdean@illinois.edu) by the end of the second week of the course; in the case of exams or assignments scheduled after this period, students should submit the form to the instructor and to the Office of the Dean of Students as soon as possible.

Disability-Related Accommodations*:* To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)*:* Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Inclusion: The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment. The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs.

The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable.

You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. You are encouraged to review this website and the campus building floor plans website within the first 10 days of class.
http://police.illinois.edu/emergencypreparedness/building-emergency-action-plans/

Enjoy the course!