STUDY GUIDE

Theory of Energy and Sustainability Engineering – ES 571

(Designing Sustainable Energy Futures)

Fall 2026

Prof. Leon Liebenberg

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

ES 571 explores one of the defining engineering challenges of the twenty-first century: How should engineers help design and navigate the transition to a more sustainable energy future?

Traditional energy courses often focus on individual technologies and their technical performance. ES 571 instead approaches energy through a systems perspective, recognizing that every engineering decision influences not only technical outcomes, but also economies, communities, ecosystems, public health, and future generations.

Throughout the semester, you will investigate how technologies such as nuclear power, solar energy, wind energy, hydrogen systems, geothermal energy, energy storage, and conventional energy systems interact within complex environmental, economic, and societal contexts. Through engineering analysis, systems thinking, and professional communication, you will learn to evaluate competing alternatives, recognize uncertainty, balance trade-offs, and make evidence-based engineering recommendations.

The course is organized around a simple professional decision-making framework:

> *Think:* Develop a rigorous understanding of energy systems, engineering principles, evidence, uncertainty, and trade-offs.
>
> *Feel:* Recognize that engineering decisions influence the lives of people, the resilience of communities, the health of ecosystems, and the opportunities available to future generations.
>
> *Do:* Apply engineering knowledge to investigate complex problems, evaluate realistic interventions, communicate professional recommendations, and support informed decision making.

Rather than studying technologies in isolation, you will repeatedly investigate authentic engineering problems through Engineering Investigations and System Interventions. These activities will challenge you to analyze technical systems, interpret their broader consequences, communicate your findings to diverse audiences, and justify engineering decisions using evidence and sound professional judgment.

By the end of the semester, you will have developed far more than a knowledge of energy technologies. You will have strengthened the analytical, communication, and leadership skills required to evaluate complex engineering decisions and contribute thoughtfully and responsibly to the design of more sustainable energy futures.

The goal of ES 571 is not simply to help you understand energy systems, but to help you become the kind of engineer who can improve them.

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

Course webpage (Canvas): https://canvas.illinois.edu/courses/71819/

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

Lectures: The Fall 2026 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: The purpose of ES 571 is to prepare students to analyze, evaluate, communicate, and help shape engineering decisions that support a more sustainable energy future.

Students will develop a strong foundation in the scientific, engineering, economic, environmental, and societal principles governing modern energy systems. Through quantitative analysis, systems thinking, engineering investigations, professional communication, and the use of state-of-the-art decision-support tools, students will learn to evaluate how energy technologies influence technical performance, economies, communities, ecosystems, public health, and future generations.

The course emphasizes human-centered systems engineering through a Think–Feel–Do framework. Rather than serving merely as a teaching strategy, Think–Feel–Do provides a practical model for professional engineering decision-making.

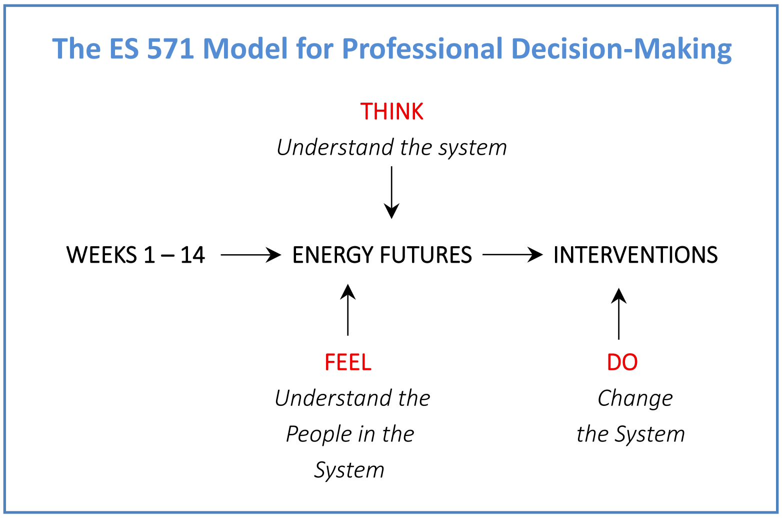
Think: Develop a rigorous understanding of engineering principles, energy systems, evidence, uncertainty, and competing alternatives.

Feel: Recognize that engineering decisions have consequences for people, communities, ecosystems, and future generations, and appreciate the ethical responsibility of engineers to consider those broader impacts.

Do: Apply engineering knowledge to investigate complex problems, evaluate realistic interventions, communicate evidence-based recommendations, and support informed decision-making through professional engineering practice.

Throughout the semester, students will complete a series of *Engineering Investigations* and S*ystem Interventions* that progressively develop analytical competence, systems thinking, engineering judgment, and professional communication. These authentic learning experiences require students not only to perform engineering analyses but also to interpret results, evaluate trade-offs, acknowledge uncertainty, communicate with diverse audiences, and justify recommendations using evidence.

By the end of the semester, students will be able to critically evaluate competing energy pathways, integrate technical and societal considerations into engineering decisions, communicate complex ideas clearly to both technical and non-technical audiences, and make professionally justified recommendations that contribute to the design of more sustainable, resilient, and equitable energy systems.



Engineering decisions are never purely technical decisions. They also shape economies, communities, ecosystems, public health, and the opportunities available to future generations.

Course Organization: Students are expected to follow the syllabus closely, complete all assigned readings, and watch the recommended video lectures when additional context is needed for the lecture notes or textbook chapters. All assignments must be submitted by the stated deadlines. Please note that reminders for deliverables will generally not be provided—it is each student's responsibility to manage their time effectively 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.

Educational Philosophy: ES 571 is built upon five complementary educational principles that reflect both the nature of modern engineering practice and the complexity of sustainable energy systems.

Guided Self-Directed Learning
Students are expected to take increasing responsibility for their own learning while receiving structured guidance and support from the instructor and teaching assistants. Rather than simply acquiring information, students are encouraged to investigate questions, evaluate evidence, seek additional sources, and develop the habits of lifelong professional learning.

Systems Thinking
Energy technologies are studied not as isolated devices, but as components of interconnected technical, economic, environmental, societal, and governance systems. Throughout the course, students learn to recognize relationships, feedback loops, trade-offs, uncertainty, and unintended consequences, appreciating that engineering decisions rarely optimize a single objective.

Think–Feel–Do Professional Decision-Making
Think–Feel–Do is used not merely as a learning strategy but as a practical framework for professional engineering decision-making.

- Think: Develop a rigorous understanding of engineering principles, evidence, uncertainty, and competing alternatives.
- Feel: Recognize that engineering decisions affect people, communities, ecosystems, public health, and future generations, and appreciate the ethical responsibility that accompanies those decisions.
- Do: Apply engineering knowledge to investigate complex problems, evaluate realistic interventions, communicate professional recommendations, and support informed decision-making.

Authentic Engineering Practice
Students learn by engaging in activities that closely resemble professional engineering practice. Through Engineering Investigations and System Interventions, they analyze realistic problems, use industry-relevant decision-support tools, communicate with diverse audiences, evaluate trade-offs, and justify recommendations using evidence. These experiences emphasize not only technical competence, but also professional judgment, collaboration, and effective communication.

Human-Centered Systems Engineering

The ultimate purpose of engineering is not merely to develop technologies, but to improve the well-being of people while respecting environmental limits and supporting resilient, equitable, and sustainable societies. Throughout ES 571, students are encouraged to view engineering decisions through both technical and human lenses, recognizing that every significant engineering decision has consequences that extend far beyond the technology itself.

Emerging Energy-System Evaluation Platform: Students will be introduced to a developing energy-system evaluation framework, called EMPATHI (Energy Metrics for Project Assessment of Trade-offs & Human Impacts), that enables project-scale assessment of environmental, health, societal, and economic outcomes associated with energy investments.

The EMPATHI framework will be used to examine how energy-system decisions influence communities and stakeholders beyond traditional engineering metrics such as efficiency, cost, and emissions.

Students will use the platform to investigate broader system consequences and support evidence-based decision making.

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/89235464944?pwd=eDRVqVcTpLjSeEopnTdgzrMQQjb1Ny.1
Meeting ID: 892 3546 4944
Password: 630840

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 Canvas or *Piazza*.
Students are encouraged to view their classmates' questions and to participate in course discussions on *Piazza*.

Sign up at: https://piazza.com/illinois/fall2026/es571

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 *Mr. Pratik Patil.* He will grade most of your assignments. Pratik will also maintain an office hour which you may find helpful, especially when engaging with simulation tools such as HOMER Pro. Pratik will further assist Professor Liebenberg with some course administration functions.

Mr. Pratik Patil, pvpatil2@illinois.edu

Pratik's office hour: Fridays, 9 a.m. – 10 a.m.

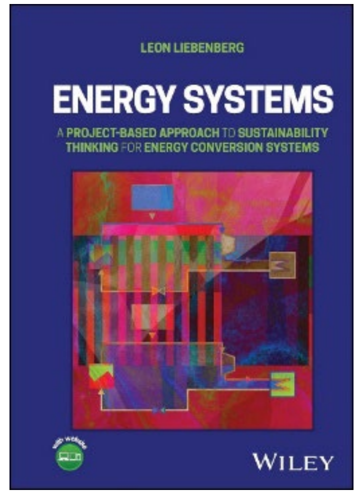
Zoom link for Pratik's office hour:

https://us05web.zoom.us/j/82140585447?pwd=9m65aD2FbEno4sMNKsbsBSRnnkmASj.1

Meeting ID: 821 4058 5447
Passcode: mux9iD

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 Engineering Investigation assignments and feedback on System Intervention deliverables will also be posted on Canvas. Your graded assignments will comprise the following:

- Seven (7) *Engineering Investigations*, to be completed alone, i.e., independently. Submission due on every second Wednesday by 10 p.m.
- A series of three *System Interventions,* to be completed in teams of 3 over a period of several weeks. Submissions due on indicated Mondays by 10 p.m.

***Engineering Investigation* assignments:** Engineering Investigation assignments will typically be posted at the beginning of a two-week study block. Students typically have around two weeks to complete each Engineering Investigation.

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 Engineering Investigation assignment carefully to ensure you complete all required components.

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

Everything you learn in ES 571 ultimately converges in these three System Interventions. The lectures and Engineering Investigation build your understanding; the System Interventions challenge you to apply that understanding to realistic engineering problems.

- In System Intervention 1, you will use the En-ROADS simulation platform which asks "What happens when billions of people, governments, and industries interact over decades?".
- In System Intervention 2, you will use the HOMER Pro simulation platform whish asks "Can we design a technically and economically feasible energy system?"
- In System Intervention 3, you will use the EMPATHI platform, which asks "What do those engineering decisions actually mean for people, communities, and the environment?"

Those are not merely three tools. They are three complementary perspectives on the same engineering problem, moving from the technology to the system, to the human consequences. That progression fits beautifully with our Think–Feel–Do philosophy:

- *Think:* analyze engineering systems and trade-offs.
- *Feel:* appreciate who benefits, who bears the costs, and why those impacts matter.
- *Do:* make and defend better engineering decisions.

SUMMARY: The Lectures and readings build your engineering knowledge. The Engineering Investigations develop your analytical and professional judgment. The System Interventions challenge you to apply that knowledge to authentic engineering decisions using state-of-the-art decision-support tools. Together, these activities develop the systems thinking, communication, and leadership skills needed to design more sustainable energy futures.

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 System Interventions. 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

Component	Weight
Engineering Investigations	40%
System Intervention 1 (En-ROADS)	15%
System Intervention 2 (HOMER)	20%
System Intervention 3 (EMPATHI)	25%

The assessment structure has been designed to encourage continuous engagement throughout the semester. Assignment weights increase in accord with their intellectual sophistication.

SYLLABUS (subject to change)

Week #	For the class in the week of …	… you should do the following …	… which is in the text-book, chapter #
1.	24 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.	Study Guide Textbook: Chapter 1
2.	31 Aug.	• **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:** Engineering Investigation 1 is due in Week 3.	2, 3
3.	7 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:**	4, 5
4.	14 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 of the important topic of energy economics, focusing on a salient economic metrics. • **Assignment:** Engineering Investigation 2 is due in Week 5.	6
5.	21 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:** System Intervention 1 is due this week.	7, 8, 9
6.	28 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:** Engineering Investigation 3 is due in Week 7.	10, 11, 12
7.	5 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:**	13, 15
8.	12 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:** Engineering Investigation 4 is due in Week 9.	14, 15

Week #	For the class in the week of …	… you should do the following …	… which is in the text-book, chapter #
9.	19 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:** System Intervention 2 is due this week.	16, 17, 18
10.	26 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:** Engineering Investigation 5 is due in Week 11.	16, 17, 18
11.	2 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:**	19, 20
12.	9 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:** Engineering Investigation 6 posted is due in Week 13.	21, 22, 23
13.	16 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:** System Intervention 3 is due this week	24, 25, 26
	23 Nov. – 29 Nov.	**Fall Break**	
14.	30 Nov.	• **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:** Engineering Investigation 7 is due in Week 15.	27
15.	7 Dec.	• **Activity:** Summary of semester's work. Project Winners' Day (via Zoom). • **Assignment:**	

China added 62 gigawatts of solar and wind power capacity in the first four months of 2023. In comparison, the country added "only" around 26 gigawatts during the same period in 2022. That brings non-fossil fuel electricity generating capacity above half of the nation's total power mix for the first time.

Workers install solar panels in Wuhan, China. Buoyed by massive domestic demand, Chinese manufacturing of polysilicon and its processing results in a product that is two-thirds the price of a European-made product. Image credit: Financial Times.

Workers are seen at a project with an annual output of 10 gigawatt-hours of high-efficiency solar cells in Huai'an, East China's Jiangsu Province on March 18, 2024. China's installed solar power generation capacity rose by 55.2 percent in 2023, data released by the National Energy Agency showed. Photo: cnsphoto

COURSE & UNIVERSITY POLICIES / RULES

Grade appeal policy: If you wish to appeal your grade on an Engineering Investigation assignment or a System Intervention assignment, 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 System Intervention 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.

Course Policies

Late Work Policy:

a. Project deliverables (i.e., "System Interventions") 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 Engineering Investigations or non-completion of those assignments will receive a 0% grade. Students will have around two weeks to complete each Engineering Investigation, and solutions will be posted after the submission deadline passes.

c. Extensions for Engineering Investigation or System Intervention 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 academic 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 nonsubmissions 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 direct family (e.g., father, mother, sibling), 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.

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 University of Illinois NetID email; *do not use any alternate such as gmail as such mail will be ignored.*

Use of Generative AI Technology

AI tools such as ChatGPT, Claude, Microsoft Copilot/Bing Chat, Google Gemini, and others may help you learn. However, 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, <u>but only</u> 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 adhere to the following requirements:

- **Do not use AI tools during graded work**.
  AI tools may *not* be used to complete graded assessments, including Engineering Investigations and System Investigations, unless their use is explicitly authorized in the assignment instructions or Honor Code. You are welcome to use AI to help you understand course materials, prepare for teamwork, or support your general learning, but you may not use AI to generate answers or complete graded assignments.

- **Submit only your own original work.**
  All submitted work must represent your own thinking and effort. You must not submit AI-generated text, analyses, solutions, or other content as your own, even if you have edited or paraphrased it. If you wish to include an AI-generated image, you must first obtain your instructor's permission.

- **Be prepared to explain your work**.
  Your instructor may ask you to explain any part of your submission, either orally or in writing. If you are unable to demonstrate a clear understanding of the work you submitted, you may receive a score of zero on the assignment and may be referred for investigation under the University's academic integrity procedures.

Documentation and Citation of AI Use

If you use AI tools to support your learning, you should:

- **Keep a record.** Save or document the prompts you entered, the AI-generated responses, and how you used them.
- **Be prepared to share this record.** Your instructor may ask you to provide this documentation.

If an assignment explicitly permits the use of AI, you must:

- **Cite your AI use appropriately.** Follow APA guidelines (or any citation style specified by your instructor). Your citation should identify the AI tool used (e.g., ChatGPT), the date of use, and the prompt(s) that substantially contributed to your work.
- **Cite original sources—not AI—for factual information.** AI tools can generate inaccurate or fabricated information. Always verify factual claims using reliable, original sources and cite those sources rather than the AI tool itself.

Misusing AI tools—including submitting AI-generated work as your own or using AI when it is not permitted—constitutes a violation of academic integrity. Any suspected misuse will be investigated and may result in penalties under the University of Illinois Student Code.

Please familiarize yourself with the University of Illinois System's Generative AI Guidance for Students, which explains your rights and responsibilities when using AI tools in your academic work.

Final grade

At the end of the semester, letter grades will be assigned based on your overall weighted numerical score, as described previously in this study guide.

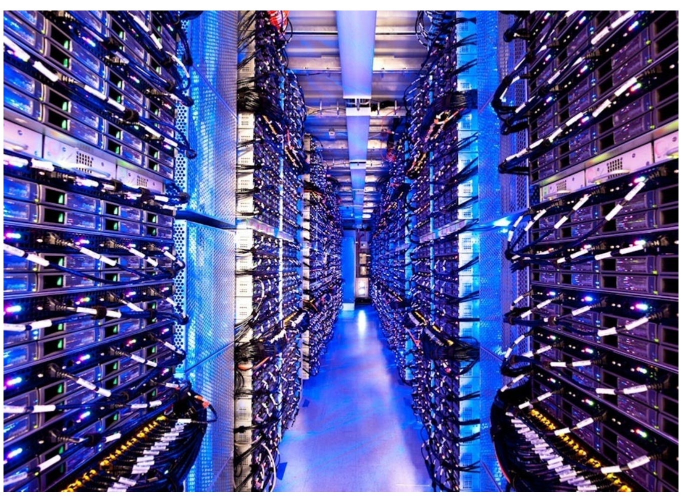
There is no predetermined target grade distribution for this course, and grade distributions may vary considerably from one semester to the next. Likewise, grades will not be curved.

Final numerical grades will be rounded to the nearest whole percentage point before letter grades are assigned. For example, a final score of 93.2% will be rounded down to 93%, while a final score 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

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

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

The Energy and Sustainability Engineering (EaSE) graduate certificate

ENG 471 and ES 571 are the core courses in the EaSE graduate certificate (or “micro-credential”). 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

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

Other Course & University Rules / Policies & Advice

Teamwork in *Engineering Communication Briefs*

The strongest engineering teams are *not* those in which everyone thinks alike, but those in which different perspectives are understood, valued, and integrated into better decisions. *Great engineers learn not only to think together, but also to appreciate what others care about and to act collectively toward a shared purpose.* Throughout your career, you will work with people who think differently, communicate differently, and bring different experiences and expertise to the table. Learning to collaborate effectively is therefore one of the most important outcomes of this course.

Working Effectively with Others

Successful teamwork requires empathy, curiosity, and respect. Be willing to *bend* your thinking to understand where others are coming from and what matters to them and then *blend* your ideas in a shared direction. Rather than immediately agreeing with or opposing another person's viewpoint, first seek to understand it. Ask thoughtful questions. Listen carefully. Acknowledge what is important to the other person before explaining your own perspective.

Once you understand someone else's viewpoint, you are in a much better position to communicate your own ideas and work together toward a stronger solution. Throughout this course, you will practice listening, building consensus, and integrating diverse perspectives. These skills are every bit as important as technical expertise and are essential for professional engineering practice.

Team Communication

Each team should decide early in the semester how it will communicate outside class. Teams are free to choose whichever collaboration platform best suits their needs. Previous classes have successfully used platforms such as Discord, Zoom, Google Docs, WeChat, GroupMe, and Miro.

Once your team has selected a platform, establish a regular communication routine and use it consistently throughout the semester.

Team Leadership

Teams are encouraged to rotate leadership responsibilities throughout the semester. For example, one student might coordinate the first Engineering Communication Brief, another the second, and another the third. Rotating leadership gives every team member an opportunity to develop leadership skills while helping to ensure that no single individual dominates the team's work.

Team Membership

Assigned teams will normally remain together for the duration of the semester. However, adjustments may occasionally be necessary. Teams may need to accommodate students who register late or adapt if a team member withdraws from the course.

The preferred team size is *three students*, although some teams may consist of four students depending on class enrollment. The instructor and teaching assistants will make every effort to minimize disruptions, and all students are expected to cooperate fully when teams are formed or adjusted.

Expectations for Larger Teams

The expected quality, technical accuracy, and professionalism of submitted work are the same for all teams, regardless of size. However, teams with four members are expected to produce a correspondingly greater quantity or scope of work than teams with three members.

Professional Conduct

Every team member is expected to contribute constructively, communicate respectfully, and support the success of the team. Differences of opinion are a normal—and valuable—part of engineering, but they should always be handled professionally and respectfully.

If a student consistently fails to contribute, refuses to cooperate, or significantly disrupts the team's ability to function effectively, the instructor may intervene. Depending on the circumstances, this may include coaching, reassignment of responsibilities, adjustments to individual grades where appropriate, modification of team arrangements, or referral under applicable University policies.

These measures are intended not as punishment, but to ensure a fair, respectful, and productive learning environment in which every student can learn, contribute, and succeed.

Academic Integrity

The University of Illinois 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.

Students with Disabilities

The University of Illinois Champaign-Urbana, is committed to ensuring that all students, including students with disabilities, do not experience barriers to learning and participating fully in class. Students who have a letter of accommodation from DRES are advised to share that with instructors as soon as possible to ensure accommodation needs can be discussed and met.

To obtain disability-related academic accommodations, disabled students must contact Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, please visit 1207 S. Oak Street, Champaign, call 217.333.1970, email disability@illinois.edu, or visit the DRES website.

Family Educational Rights and Privacy Act (FERPA)

See http://registrar.illinois.edu/ferpa for more information on Family Educational Rights and Privacy Act (FERPA).

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 offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Health Service 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 (815) 720-4953 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

*This statement is approved by the University of Illinois Counseling Center

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 regarding their well-being or yours, we encourage you to refer this behavior to the Connie Frank CARE Center (formerly the Student Assistance Center) in the Office of the Dean of Students. You may do so by calling 217-333-0050 or by submitting an online referral. Based on your report, staff in the Connie Frank CARE Center will reach out to offer support and assistance.

Further, as a Community of Care, we want to support you in your overall wellness. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, personal emergencies). Should you find that you are managing such a challenge and that it is interfering with your coursework, you are encouraged to contact the Connie Frank CARE Center (formerly the Student Assistance Center) in the Office of the Dean of Students for support and referrals to campus and/or community resources.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (https://go.illinois.edu/ReportMisconduct; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response Recommendations

Emergency response recommendations and campus building floor plans can be found at the following website: https://police.illinois.edu/em/run-hide-fight/. I encourage you to review this website within the first 10 days of class.

Religious Observances

It is the policy of the University of Illinois Urbana-Champaign to reasonably accommodate its students' religious beliefs, observances, and practices that conflict with a student's class attendance or participation in a scheduled examination or work requirement, consistent with state and federal law. Students must make requests for accommodation in advance of the conflict to allow time for both consideration of the request and alternate procedures to be prepared. Requests should be directed to the instructor. The Office of the Dean of Students provides an optional resource on its website to assist students in making such requests.

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 supportive measures, resources, 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.

Veterans and Military Students

As a military-friendly institution, and per federal regulations and Illinois statutes, the University of Illinois Urbana-Champaign has established policies and procedures to accommodate military-connected students. In addition to the support available at the Chez Veterans Center (https://chezveteranscenter.ahs.illinois.edu/), members of the National Guard or Reserves and active-duty military personnel with military obligations (e.g., deployments, training, drills) are encouraged to communicate these, in advance whenever possible, to the instructor. The policy for Excused Absences and Departure from the University for U.S. Military or other U.S. National Defense Services can be found at https://studentcode.illinois.edu/article3/part3/3-313.

Enjoy the course!