

# ME 502: Thermal Systems

## Spring 2025

**Instructor: Dr. Ke Tang**

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Office Hours: 3:00 – 4:00 pm, TR

**Lectures:** 1:00 – 2:50 pm, TR, 2045 Sidney Lu Mech Engr Bldg

**Course Website:** via Canvas <https://canvas.illinois.edu/>

**Reference Books:**

(1) Thermal System Design and Simulation, by Dhar, P. L., Amsterdam, Netherlands: Academic Press, 2017 (PDF version is available at U of I library.)

(2) Fundamentals of Engineering Thermodynamics, by M. Moran, H.N. Shapiro, D.D. Boettner, et al., 5<sup>th</sup>, 6<sup>th</sup>, 7<sup>th</sup>, 8<sup>th</sup>, or 9<sup>th</sup> edition

(3) Fundamentals of Fluid Mechanics, by B.R. Munson, D.F. Young, T.H. Okiishi, et al., 6<sup>th</sup>, 7<sup>th</sup>, 8<sup>th</sup>, or 9<sup>th</sup> edition

(4) Fundamentals of Heat and Mass Transfer, T.L. Bergman, A.S. Lavine, F.P. Incropera, et al., 7<sup>th</sup>, or 8<sup>th</sup> edition

(5) Python Crash Course, by E. Matthes, 2<sup>nd</sup> edition

**Course Description:**

This course focuses on the simulation and optimization of thermal systems, including steady-state simulation and transient-behavior simulation. The simulation will be performed on both the component level and the system level. Generally, the heat and mass transfer processes involved in heat exchangers are important for the functions of thermal systems. Thus, the component-level simulation will focus on heat exchangers. Single-phase water-glycol flow, liquid-vapor two-phase flow (i.e. flow condensation and flow boiling), dry-air flow, and humid-air flow will be involved in the heat exchanger simulation. Thermodynamics (including psychrometrics), fluid mechanics, heat and mass transfer will be applied in the simulation. The control logic will be figured out and programmed in the simulation for the system-level modeling. The optimization analysis of the heat exchanger performance, as well as the system performance, will be discussed. Python will be used for programming. The database of CoolProp will be used to retrieve the fluid properties. Students will learn the knowledge and gain the skills of simulation and optimization of thermal systems by working through projects. To broaden their horizons and improve their capability in thermal system design, students will be required to read the papers regarding heat and mass transfer and state-of-the-art research on thermal systems. The pedagogies of project-based learning, research-based learning, learning by doing, and active learning are used to plan the learning activities.

Prerequisite: ME 402 Design of Thermal Systems

**Topics:**

- Steady-state simulation:
  - Engine-cooling radiator
  - Micro-channel (mini-channel) condenser
  - Micro-channel (mini-channel) evaporator (dry-condition)
  - Cooling coil (wet-condition)
  - Micro-channel (mini-channel) evaporator (wet-condition)
  - Air conditioner employing a vapor-compression refrigeration cycle
- Transient-behavior simulation:
  - Battery cooling system

**Objectives:**

This course will help students gain the knowledge and skills of thermal system simulation and optimization, deepen their understanding of the working principle of thermal systems, sharpen their capability of analyzing the performance features of thermal systems from the viewpoint of thermal science, and improve their ability to present the features of thermal systems based on simulation results. The simulation and optimization of thermal systems are widely utilized in the field of thermal science and engineering, encompassing both academic research and industrial applications. I will strive to make this part of your education interesting and exciting—with the hope that you may play a role in solving some problems of thermal systems.

**Course Grading:**

5% Classwork

15% Literature Review and Presentation

60% Projects

10% Midterm Project Presentation

10% Final Project Presentation

The final letter grade will be assigned using the following numerical cutoffs:

97 – 100	A+	93 – 97	A	90 – 93	A-
87 – 90	B+	83 – 87	B	80 – 83	B-
77 – 80	C+	73 – 77	C	70 – 73	C-
67 – 70	D+	63 – 67	D	60 – 63	D-
0 – 60	F				

The classwork will include regular in-class assignments and in-class discussions. There will be a discussion peer evaluation form completed by your group members during the discussions. The in-class discussions will be graded according to the peer evaluation. For the students in the asynchronous online section, individual work must be submitted via the Canvas course website for both the regular in-class assignments and the in-class discussions (present your idea about the topics discussed in class). The classwork submission must be on time and no late submission will be accepted. For on-campus students, “on time” means at the end of the class. For online students, please refer to the classwork assignment posted on the course website via Canvas. On-campus students can

email me ahead of time to request a leave of excused absence and in this way on-campus students can be exempt from classwork. No classwork assignments will be dropped off.

Literature about heat and mass transfer, as well as state-of-the-art research on thermal systems, will be provided. Students must complete the literature review report in PowerPoint format. The literature review report must be submitted on time, and no late submission will be accepted. The literature review report will be presented and discussed in class. For the students in the asynchronous online section, the presentation of the literature review report must be recorded in the .mp4 format and submitted. Student's face must show up in the presentation video. The recorded presentations will be shown and discussed in class. The time for the presentation is  $10 \pm 0.5$  min. The in-class presentation by the on-campus students and the submission of the recorded presentation by the online students must be on time, and no late in-class presentation or late submission of the recorded presentation will be accepted. Both the literature review report and the presentation will be graded. The schedule of the presentations can be found in the teaching calendar posted on the course website. The submission of the literature review report for all students and the submission of the recorded presentations for the online students are due the day before the scheduled in-class presentation. For instance, the presentation of paper 101 is scheduled for Feb. 4<sup>th</sup>, so the related submission is due on Feb. 3<sup>rd</sup>.

All the projects are individual projects. Everything submitted for projects must be computer generated. The project work must be submitted via the Canvas course website, including a PDF file of their project report, as well as a ZIP file including all the simulation files, e.g. Python code, etc. An extension of one day can be granted, but it will be accompanied by a 20% reduction in your score. No project assignments will be dropped off.

One project completed in the first half semester will be presented for the midterm project presentation. One project completed in the second half semester will be presented for the final project presentation. The PowerPoint slides for the presentation must be submitted on time and no late submission will be accepted. Both the PowerPoint slides and the presentation will be graded.

The excused absence from class and the late submission beyond a one-day extension can be considered only if you ask for a leave or an additional extension in advance. It is the students' responsibility to make sure of the successful submission of their work. After the submission of your work on the Canvas course website, please immediately check if your work has been submitted successfully. If not, please redo the submission. If the resubmission online fails, you must email me your work for submission, as well as the evidence of the work completion on time, by the following day of the due date. The instructor will decide whether the work can be accepted or not. It is also the student's responsibility to make sure that their work is submitted correctly and completely. 0 points will be assigned for a wrong submission. No resubmission will be accepted for an incomplete submission.

Do not duplicate anyone's work. Any duplication identified during the grading process will result in sanctions according to the Academic Integrity Policy in the Student Code.

## **ADDITIONAL INFORMATION FOR THE UNIVERSITY OF ILLINOIS AND THE GRAINGER COLLEGE OF ENGINEERING**

### **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 will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (<https://studentcode.illinois.edu/article1/part4/1-404/>). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code: <https://studentcode.illinois.edu/article1/part4/1-401/>. As a student, it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at <https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/>. Ignorance of these policies 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.

### **Anti-Racism and Inclusivity Statement**

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 Campus Belonging Resources (<https://diversity.illinois.edu/diversity-campus-culture/belonging-resources/>). Based on your report, Members of the Office of the Vice Chancellor for Diversity, Equity & Inclusion staff 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.

## **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-of-care/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 McKinley Health Center (<https://mckinley.illinois.edu/>). Or the Counseling Center (<https://counselingcenter.illinois.edu/>). For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

## **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://conflictresolution.illinois.edu>; [conflictresolution@illinois.edu](mailto:conflictresolution@illinois.edu); 333-3680) for disciplinary action.

## **Emergency Response Recommendations**

Emergency response recommendations can be found at the following website: <http://police.illinois.edu/emergency-preparedness/>. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. <http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/>.

## **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.

## **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 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)

If you are in immediate danger, call 911

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

### **Religious Observances**

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/community-of-care/resources/students/religious-observances/> to request appropriate accommodations. This should be done in the first two weeks of classes.

### **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: <https://wecare.illinois.edu/resources/students/#confidential>.

Other information about resources and reporting is available here: <https://wecare.illinois.edu/>.

### **Students with Disabilities**

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail [disability@illinois.edu](mailto:disability@illinois.edu). <http://www.disability.illinois.edu/>.