ME 320: Heat Transfer
Spring 2024

Instructor: Max Friestad
Office: 3422 Mech Engr Lab (MEL)
E-mail: friesta2@illinois.edu
Office Hours: 1:30-2:30 pm, MW (virtual or by appointment only)

Lab Manager: Prof. Blake Johnson
Office: 2113 Mech Engr Lab (MEL)
E-mail: bejohnso@illinois.edu

Lectures: 3:00-3:50 am, MWF, 4100 Sidney Lu Mech Engr Bldg

Course Website: via Canvas https://canvas.illinois.edu/

Required Text: Fundamentals of Heat and Mass Transfer, 8th Edition, by Theodore L. Bergman, Adrienne S. Lavine, published by Wiley.

Course Description:
Heat transfer is an energy transfer that is widely involved in scientific research and engineering applications. This course focuses on the three modes of heat transfer, i.e. conduction, convection, and radiation. Students will learn how to understand, analyze, and design for scenarios involving heat transfer. Beyond heat transfer, students will strengthen their general understanding of thermodynamics and fluid mechanics, sharpen their mathematical skills, and improve their experimental data collection and analysis. Heat transfer is a rich area for engineering research, and contemporary problems related to biological systems, micro/nano-systems, food production and preservation, human comfort, and sustainability will require the creative application and extension of our current knowledge. We will strive to make this part of your education interesting and exciting—with the hope that you may play a role in solving some of these problems.
Prerequisite: ME 200 and ME 310 (or TAM 335)

Topics include:
1) Introduction (concept of heat transfer)
2) Conduction
   - Heat diffusion equation
   - 1-D steady-stage conduction
   - 2-D steady-state conduction
   - Transient conduction
3) Convection
   - Convection boundary layer
   - External flow
   - Internal flow

- Free convection (natural convection)
- Heat exchangers

4) Radiation
   - Processes and properties
   - Radiation exchange between surfaces

Learning Objectives:

At the end of this course, students should be able to:

1) identify and explain the three heat transfer modes: conduction, convection, and radiation;
2) analyze the 1-D and 2-D steady-state conduction, and apply the lumped-capacitance method and 1-D model for the analysis of transient conduction;
3) analyze the external, internal, and free convection;
4) conduct the design and performance analysis of heat exchangers involving two fluid streams;
5) identify, explain, and analyze the properties of radiation, and analyze the radiation exchange between blackbody surfaces, as well as the radiation exchange between diffuse-and-gray surfaces.

Course Grading:

Laboratory 25%

Lecture 75%

- Project 5%
- Midterm Exam 1 15%
- Midterm Exam 2 15%
- Midterm Exam 3 15%
- Final Exam 25%

Exam Policy:

All exams will be open-book. A calculator is the only electronic device permitted during the exams. Notes and a collection of relevant equations and correlations is encouraged. The tentative schedule for the exams can be found in the teaching calendar. Students have up to one week, from the date of return, to ask for a re-grade of their exam. Please examine the posted solutions carefully before asking for a re-grade as it is possible to have a lower score after the second grading. The midterm exam with the lowest score will be dropped in calculation of the final grade. Students with exam conflicts should contact me via email so arrangements can be made.

I will assign grades so that the final class average score is close to the five-year average score of the course ME 320.

Project:

Students will create their own heat transfer problem based on a situation they find interesting. Introduce the problem with a short description and a schematic or images. Write one page (12pt double-spaced) and include at least one page of hand-written analysis using the tools learned in-class. Up to four students may work together on the

same project. However, one additional page of either writing or analysis is necessary for each additional group member. Answer the following questions in your writing:

1) What is known?
2) What is to be found?
3) What assumptions need to be made to use the equations in your analysis?
4) Where and how do these assumptions cease to be reasonable?
5) Where, if at all, do each of the three main modes of heat transfer occur?

In your analysis, include the relevant equations and representative values for your particular situation (a reasonable estimate is encouraged). If the solution to the problem can not be found with the tools learned in the course, explain why and suggest how you might solve the problem.

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; 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. http://www.disability.illinois.edu/.