

ME 419: Heat Transfer

Instructor: Prof. James Bird

Email: jbird@bu.edu

Office Hours: Thursday 1PM through zoom, meeting ID on blackboard

Discussion TA: Garam Lee (garamlee@bu.edu)

Office hour and Lab TAs:

Thy Vu (thyvu98@bu.edu), Office Hours: Thursday 7-8 PM (Zoom)

Ryan Murphy (murphyry@bu.edu) Office Hours: Wednesday 5:30-6:30 PM (Zoom)

Prerequisites: ME 303 (Fluids) & ME 304 (Thermodynamics) or equivalent. Familiarity with engineering mathematics with partial differential equations.

Course schedule:

Lectures: MW 12:20 - 2:05 PM Location: PHO 206 (max of 27 students in-class)
Lectures are live-streamed and recorded on Zoom (meeting ID on blackboard)

Discussions: B1: Monday 2:30 - 3:20 PM in PHO 206
B3: Tuesday 11:15 AM - 12:05 PM in PHO 206
B2: Wednesday 10:10 - 11:00 AM in COM 209
Discussion sessions also live-streamed on Zoom, meeting ID on blackboard.
Discussions of same week cover same topic.

Textbook: *Fundamentals of Heat and Mass Transfer* by Bergman, Lavine, Incropera & Dewitt, 6th, 7th, or 8th Edition (Instructor will use 7th and 8th Edition as reference).

Expectations Regarding Safety: Masks are required to be worn over mouth and nose at all times when attending lectures or discussions on campus in-person, as well as when in University buildings before and after those in-person session. A minimum of 6 feet distance should be kept between everyone whenever possible. Students, instructor, and TA are required to follow all University guidelines with respect to daily symptom checks, testing, social distancing, and mask wearing when they leave their dorm or home and inside University buildings.

Diversity and Inclusion: We consider our classrooms to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. If something was said in class, discussion, or office hours that made you feel uncomfortable, please let me know, or a trusted person (e.g. academic advisor) that can relay your concerns to me anonymously. Our goal is to provide everyone with the best learning experience possible.

Religious accommodations: We are aware of and in agreement with Boston University's Policy on Religious Observance, whereby absences for any religious beliefs are understood and missed assignments on such occasions will be given a chance to be made up. We require advanced notification at least a week for such occasions.

Blackboard: Used for class announcements, information, assignments, review material, additional notes, discussion forums, zoom IDs and schedule. Blackboard is also used for quizzes and exams unless otherwise communicated by the instructor or TA throughout the semester. **NOTE** that while grade assignments will be posted for your review, we do NOT use the

Blackboard GradeCenter to calculate semester grades. Ignore any interpretation of your grade based on whatever Blackboard-reported “points” that are displayed

Zoom: Used for all lectures, discussions, and office hours. Zoom is also required for students attending in-person lectures (phone app sufficient when in classroom). Make sure to equip your computer and/or phone with the zoom app and link your BU account to it. **Passcode: ME419**

Course Communication: Questions about homework problem sets, labs, and exam/quiz review topics should be brought up in office hours, discussions, during appropriate lecture times, or posted to the appropriate discussion board on Blackboard (we will be using **Pronto**). To ensure fair access of information to all students, questions concerning any course material sent to the instructor via email will be posted to the discussion board.

Course Description: While thermodynamics covers the start and end states of processes, as well as their total energy transfer, heat transfer tells us about the nature and rate of movements of thermal energy within the process. Understanding the various processes involved in and thereby controlling the transfer of heat (thermal energy) is critical for most engineering systems. This course covers the fundamentals of heat transfer from a macroscopic and engineering perspective, and aims to develop a physical and analytical understanding of the three modes of heat transfer (conduction, convection, radiation), with an emphasis on simplifying approximations and empirical correlations to solve real-world engineering problems. The main topics that this course covers are: Steady conduction in one and two dimensions; Non-steady (transient) conduction in one-dimensional systems; Forced and natural convection (external and internal); Introduction to boiling, evaporation, and condensation; Application to heat exchangers; Radiation heat exchange; Mass Transfer Analogies.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. Understand and differentiate between the three modes of heat transfer: conduction, convection, and radiation.
2. Derive and simplify the Heat Equation using convection and radiation as boundary conditions in both steady and transient states.
3. Understand the fundamental relationships between fluid flow, and convective heat transfer.
4. Apply the appropriate empirical correlations for forced and natural convection to determine convective heat transfer coefficients, with a focus on understanding the role of dimensionless parameters in heat transfer analysis.
5. Understand the differences between black body and gray body radiation.
6. Understand and apply geometrical arguments to radiation heat transfer, including the derivation and use of view factors for multi-surface systems.
7. Develop the analogous understanding between Fourier’s Law for heat transfer and Fick’s Law for mass transfer.

Grading:

Homework (10%): Ten (10) problem sets assigned roughly every week (best 9 count).

Lab reports (20%): Two (2) laboratory exercises.

Quizzes (10%): Six (6) online quizzes (floating time) roughly every 2 weeks (best 5 count).

Midterm (20%): “In-class” timed exam administered online.

Final Exam (30%): Timed exam administered online during finals week.

Participation (10%): 1/3 from pre-lecture recording and 2/3 from live lecture polls (90% count).

Pre-lecture recordings: Recordings of mathematical and conceptual derivations will be posted as a narrated video at least 1 day ahead of most lectures (indicated in schedule). Students are expected to watch the recording BEFORE the lecture and familiarize themselves with the content, which includes the use of the textbook. Recordings contain embedded questions to gain feedback on the “muddy” parts that need to be further addressed in class. Pre-lecture recordings make up 1/3 of the participation grade: 50% for answering the questions, 50% for accuracy. Recordings are posted to the lecture folders on blackboard. Note: The schedule and topics of pre-recordings are subject to adjustment throughout the semester, and the schedule will be consistently updated on blackboard.

Lectures: The scheduled lectures will focus on the conceptual aspects of the topics to build an intuitive understanding of the subject matter, and the application of the concept in engineering and problem solving. Students have the option to attend the class online or in the classroom until capacity is reached. Only students who signed up through the InClassLfA app are allowed to come to the classroom. All lectures are live streamed on zoom for all students to attend and participate, and recorded. The stream will mostly consist of the instructor’s shared electronic whiteboard and slides that the lecture material is presented on, as well as audio of the instructor. Recordings and lecture notes will be made available to all students on blackboard, but are not a substitute for attending the lectures.

Lecture participation: Throughout the lectures, interactive polls will be used to review the topics and concepts and to gain feedback of the students’ understanding of the material. The polls are multiple choice/answer-type questions. The participation in these polls is required for all students, in-class AND remote. For in-class students, using Zoom on a phone is sufficient to participate in the polls. Participation in the polls make up 2/3 of the participation grade. The instructor reserves the right to change the grading scheme of participation, for example to include accuracy of answers to some degree towards the grade, with prior notification to the students and not retroactively.

Reading Assignments: Course lectures and pre-recordings coincide with the textbook for each topic as listed on the Course Schedule. Students are expected to familiarize themselves with material before coming to class to fully engage in classroom discussions and to revisit the learned material after class by practicing associated problems.

Discussions: There are officially two discussion sections associated with our class. However, due to our extreme coordination with the other ME419 section, students may choose to register for the discussion sections associated with that class. Each student may attend any discussion section online, and can attend in-person for the session that they registered and signed up for (InClassLfA app). Discussions are led by the TA. During discussions, the TA will address students’ questions, review class topics, and solve practice problems. All discussions are live-streamed on zoom for all students to attend and participate. Recordings and selected discussion notes will be made available to all students on blackboard, but are not a substitute for attending the discussions live. Students are encouraged to submit questions to the TA before the discussions to ensure the best possible preparation. The prepared topics covered in the discussions of the same week will be the same.

Homework: Ten (10) homework assignments (problem sets) will be posted on gradescope at least one week before their due dates. Homework are due on Thursdays (end of day) in the weeks indicated on the course schedule. Homework submitted on Fridays are subject to a 10% penalty. Later homework will not be accepted. Students must upload their *handwritten* solutions to gradescope: either photos of the handwritten solutions on paper or a pdf file of the solutions handwritten on a tablet or touchpad/screen. For each problem you should clearly show all work

(given, asked for, properties, assumptions, equations, math, answer). Individual homework problems are graded on a 100/80/50/0 scale. The 9 best homework grades count towards your final grade.

Quizzes: Six (6) quizzes will be administered throughout the semester, as indicated on the course schedule. Quizzes will be administered through blackboard unless otherwise communicated by the instructor. The quizzes are accessible between 8 AM and 8 PM (Boston time) on the date indicated in the course schedule. Once started, quizzes have to be finished in a single sitting with a time limit of 20 minutes. Quizzes will test the conceptual understanding and short analytical problems of the course material covered in the prior 2-3 weeks (topics indicated on course schedule). The 5 best quizzes count towards the final grade. Scheduling conflicts have to be communicated to Prof. Bird **at least 3 days in advance**.

Exams: There is one (1) midterm during the semester and one (1) final exam during finals period, as listed in the schedule. Each exam will take place on blackboard, the midterm during regularly scheduled class time (pending further information). The Final Exam is cumulative by nature.

- Missing an exam due to vacation is not excusable. Arrangements will be made on a case-by-case basis for documented emergencies or University conflicts (**7 days prior arrangement**).
- Students requiring additional time to complete examinations must supply proper documentation from the Office of Disability Services **at least 7 days in advance** of an exam.

Lab: There will be two (2) experimental exercises (“labs”) for this course. The first lab is performed by students at their own time and place with materials easily available and the lab kit (multimeter with thermo-probe) provided. The second lab is set up on campus and students read out the data through an online video feed. Detailed instructions for the two labs are provided in separate documents. Some information and requirements below:

- Lab reports are limited to **5 pages in length**. Pages beyond the page limit will not be graded.
- The instructor and the TA are available for lab-specific questions during office hours.
- Late labs will be accepted for grading up to **one** week late with a 10-point late penalty provided that the student is in correspondence with Prof. Bird before the original due date.
- Collaboration for the labs is strongly encouraged, e.g. through video calls between students to address experimental issues, discuss possible solutions, and work out data analysis.

Lab 1:

- Students need access to: Bowl/cup, water, ice, Aluminum foil.
- Students are expected to individually complete the lab exercise and write an individual lab report in their own words, and create their own graphs, data figures, and analyses.
- There are separate due dates for submitting the raw data after completion of the lab experiment, and for the lab report as indicated on the course schedule.

Lab 2:

- Students read out data from an online video feed over the course of a week.
- Students are assigned in groups of three. Each student reads out data at random times and the data is shared within the group.
- Students can write an individual lab report, or a group lab report with their assigned group.

Optional Lab 3:

- For extra credit, students can execute and analyze an optional lab for a maximum of 5% towards the final grade. Details to follow in the second half of the semester.

Policy on collaboration: Collaboration is encouraged on homework and labs. However, students must turn in their own work in their own words. No collaboration is permitted on exams.

Boston University Academic Conduct Code:

Honesty is a core value of Boston University. Any violations of BU academic honesty and integrity standards will be pursued through appropriate University channels. This includes, but is not limited to cheating, plagiarism and misrepresentation. Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work, which includes any help from online tutoring services during quizzes and exams. Knowingly allowing others to represent your work as their own is as serious an offense as submitting another's work as your own. If you have any questions as to what constitutes an honor code violation, please ask. *Ignorance is not an excuse for cheating.* BU's Academic Conduct Code: <http://www.bu.edu/academics/policies/academic-conduct-code/>

Drop and Withdrawal Dates:

The last day to DROP (with no 'W' on your record): March 1st

The last day to WITHDRAW (with a 'W' on your record): April 2nd

Incompletes:

Incompletes will be permitted only for extenuating circumstances and must be arranged Prof. Bird as soon as such a circumstance arises. This situation only pertains to assignments whose due dates have not yet passed.