ME 419: Heat Transfer

Instructor: Prof. Srikanth Gopalan (Mechanical Engineering and Materials Science)
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Office Hours: Thursdays 3:00-4:00 PM in-person and on Zoom if required outside office hours

Discussion TA: Ziqing (Jack) Zhao (jack7z@bu.edu)

Office hours: TAs: Yuanzhi Li (tigerlee@bu.edu), time and place TBD
Daniel Van Lewen (danielvl@bu.edu), time and place TBD

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

Course schedule:
Lectures: MW 2:30 – 4:15 PM Location: EPC 207
Discussions: B2: Wednesday 10:10 – 11:00 AM in EPC 203
B3: Tuesday 11:15 AM – 12:05 PM in EPC 206
Discussions of same week cover same topic.

Health and Safety: Masks are required to be worn over mouth and nose at all times when attending lectures or discussions. Students, instructors, and TAs are required to follow all University guidelines with respect to testing and mask wearing in all university buildings.

Diversity and Inclusion: I strive to create a learning environment that supports all my students with a diversity of backgrounds, experiences, perspectives, and identities (including race, gender, class, sexuality, religion, ability, etc.). Please talk to me if you feel like your performance in the class is being impacted by your experiences inside or outside of class. If something happened in class 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. My goal is to provide ALL of you with the best learning experience possible.

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

Blackboard: Used for class announcements, information, assignments, review material, additional notes, discussion forums, and schedule. Blackboard is also used for quizzes unless otherwise communicated by the instructor or TA throughout the semester.

Course Communication: Questions about 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. 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 on blackboard.

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 and reports (4 pages maximum).
Quizzes (15%): Six (6) online quizzes (floating time) roughly every 2 weeks (best 5 count).
Midterm 1 (15%): In-class timed exam.
Midterm 2 (15%): In-class timed exam
Final Exam (20%): In-class timed exam during finals week.
Participation (5%): In class participation, attending office hours, and initiating and participating in discussions on Blackboard.

Pre-lecture recordings: Recordings of mathematically detailed derivations will be posted as a narrated video at least 1 day ahead of many lectures. Students are expected to watch the recording BEFORE the lecture and familiarize themselves with the content, which includes the use of the textbook. It is necessary you watch the lectures prior to coming to class to make sure you ask questions on muddy points in the recording. Recordings are posted to the lecture folders 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. Since some students might have to quarantine/isolate due to Covid at some point during the semester, affected students must contact the instructor ahead of the lectures that they will miss so that a recording of the lecture can be shared with them.

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 two discussion sections per week, covering the same topic. Students should attend the discussion section that they are registered for. Discussions are led by the TA. During discussions, the TA will address students' questions, review class topics, and solve practice problems. 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.

Homework: Ten (10) problem sets will be posted on gradescope at least one week before their due dates. Problem sets are due on Fridays by the end of day in the weeks indicated on the course schedule. Late homework will not be accepted. Students must upload their *handwritten* solutions to gradescope: either photos of the handwritten solutions converted to a pdf file 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 1-2 weeks (topics indicated on course schedule). The 5 best quizzes count towards the final grade. Scheduling conflicts have to be communicated to Prof. Gopalan **at least 3 days in advance**.

Exams: There are two (2) midterms during the semester and one (1) final exam during finals period, as listed in the schedule. The midterms take place during regularly scheduled class time. The Final Exam is cumulative by nature.

- ***The midterms are currently scheduled for Mondays during lecture time. However, early in the semester we will poll all students for their preference between Mondays and Wednesdays for the midterms. Hence, the midterm schedule might change. Note: Lab 1 falls in the same week as midterm 1.***
- 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 in week 6 and 9, respectively. Each student should be registered for one of the lab block B sections here: https://www.bu.edu/eng/departments/me/general-resources-students/current-undergraduate-students/lab-blocking/. Lab reports are due on Fridays in the first full weeks of classes following the lab exercise. Lab reports are submitted through Gradescope.

- Lab reports are limited to **4 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 lab reports will be accepted for grading up to **one** (1) week late with a 10-point late penalty provided that the student is in correspondence with Prof. Gopalan before the original due date.
- Collaboration for the labs is strongly encouraged, e.g. through meetings and discussions between students to address experimental issues, discuss possible solutions, and work out data analysis.

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/