# ME 419: Heat Transfer

**Instructor:** Prof. Joerg Werner (Mechanical Engineering and Materials Science)
Email: jgwerner@bu.edu
Office Hours: Wednesday 5:00-6:30 PM in EMA Room 220, 730 Commonwealth Ave. (above BUild Lab) and on Zoom (938 2915 6436)

**TAs:** Neila Gross (ngross1@bu.edu); Tae Ki Kim (taekikim@bu.edu),
Office hours: 11 AM – 12 PM Fridays, alternating between ERB 301 at 44 Cummington Mall and EMB 121 at 15 St. Mary's Street (see Pronto)

**Homework Help:** Justin Tran – Thu 5:25-6:25 (ENG 245, 110 Cummington Mall)

**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: PSY B53
Discussions: M 2:30 - 3:20 (MCS B37), T 11:15-12:05 (264), W 10:10-11:00 (264), W 2:30 - 3:20 (MCS B37). All discussions (B1-B4) of same week cover same topic

**Health and Safety:** Masks are recommended to be worn over mouth and nose during lectures or discussions. Students, instructors, and TAs should not attend in-person events if feeling unwell or tested positive for COVID 19 over the last 5 days. Lecture recordings will be made available.

**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 outside of class, or the environment inside class. If something was said in class that made you feel uncomfortable, please let me know, or a trusted person (e.g., academic advisor) who 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, 6$^{th}$, 7$^{th}$, or 8$^{th}$ Edition (Instructor will use 8$^{th}$ Edition as reference).
**On reserve at library**

**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.

**Gradescope**: Used for submission of problem set solutions and lab reports.

**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 Pronto discussion board (access available through 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 Pronto discussion board (anonymized).

**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-state 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 (diffusion and convection).

**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 for simplified one- and two-dimensional systems.
3. Develop the analogous understanding between Fourier's Law for heat transfer and Fick's Law for mass transfer.
4. Understand the fundamental relationships between fluid flow, and convective heat transfer.
5. 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.
6. Understand the differences between black body and gray body radiation.
7. Understand and apply geometrical arguments to radiation heat transfer, including the derivation and use of view factors for multi-surface systems.

**Grading:**
Homework (10%): Ten (10) problem sets assigned roughly every week (best 9 count).
Lab reports (20%): Two (2) laboratory exercises and reports (5 pages maximum).
Quizzes (10%): 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 (10%): 1/3 from pre-lecture recording and 2/3 from live lecture polls (90% count).

**Pre-lecture recordings:** Recordings and accompanying slides of mathematical and conceptual derivations will be posted as a narrated video at least 1 day ahead of most lectures as 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. Watching the pre-lecture recordings and completing the questions is part of the participation grade. Recordings are posted to the respective 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. Lecture recordings will be made available prior to exams.

**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. Participation in the polls make up 2/3 of the participation grade. A smart phone is sufficient to participate in the polls. If you cannot or prefer not to use your phone, please contact the instructor ahead of time to find an alternative solution.

**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 four (4) discussion sections per week, covering the same topic. Students should prioritize the discussion section that they are registered for, but can attend any of the discussion sections. Discussions are led by the TA. During discussions, the TA will address students' questions, review class topics, and solve practice problems. 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 around 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. Solutions submitted up to 24 hours late will have a 10 point grade reduction. No submission of problem set solution beyond 24 hours late are 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/touchpad. 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. 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). Quizzes will be administered through blackboard unless otherwise communicated by the instructor. The quizzes are accessible between 6 AM and 11 PM (Boston time) on the date indicated in the course schedule (not during class time). Once started, quizzes have to be finished in a single sitting with a time limit of 20 minutes. Each student has three (3) attempts per quiz, questions will differ between attempts. The highest scoring attempt counts per quiz and the five (5) best quizzes count towards the final grade. Scheduling conflicts have to be communicated to the course instructor **at least 3 days before the scheduled quiz**.

**Exams:** There are two (2) midterms during the semester, as listed in the schedule, and one (1) final exam during finals period. The midterms take place during regularly scheduled class time. 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 or other accommodations for exams must supply proper documentation from the Office of Disability Services **at least 7 days in advance** of an exam.

**Labs:** There will be two (2) experimental exercises ("labs") for this course. Each student should have registered for one of the lab sections (C1-C4) and will execute the lab during the scheduled lab section time in the respective weeks shown on the class schedule. Lab reports are due as indicated in the schedule and submitted through Gradescope.

- 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 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. Werner 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/

**Important Semester Dates:**
- February 23, 2023: Last Day to Drop Standard Courses (without a "W" grade)
- March 31, 2023: Last Day to Drop Standard Courses (with a "W" grade)