ME 419: Heat Transfer

Spring 2020 Section A2

Instructor: Prof. Joerg Werner (Depart. of Mechanical Engineering and Materials Science)
Office: EMA 220 (730 Commonwealth Ave)
Email: jgwerner@bu.edu
Office Hours: Tuesday 12:30-13:30 (if you have class during this time, but would like to meet, please email instructor to find a suitable time)

Discussion TA: Paria Hashemian Email: paria@bu.edu
Office Hours: Tuesday 2:00-3:00 PM Office hour location: TBA
(for section A1: Jason Lucas; jlucas@bu.edu)

Lab TA: Chu-Yao Chou Email: cychou07@bu.edu

Course schedule:
Lectures: MW 2:30 - 4:15 PM (PHO 211)
Discussions: W 10:10 - 11:00 LSE B03
Labs: 2 labs – location and times will be announced on blackboard. Sign up for time slots.

Textbook (required): *Fundamentals of Heat and Mass Transfer* by Bergman, Lavine, Incropera & Dewitt, 6th, 7th or 8th Edition (Instructor will use 8th Edition as reference). Only eBooks available directly from publisher at this point.

Website: Blackboard (announcements, assignments, review material, confusion notes)

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

Course Description: While thermodynamics covers the end states of processes, heat transfer tells us about the nature and rate of movements of thermal energy within the process. Understanding and controlling heat (thermal energy) is critical for many engineering systems. This course covers the fundamentals of heat transfer from a macroscopic perspective and aims to develop a physical and analytical understanding of the three modes of heat transfer (conduction, convection, radiation), with an emphasis on modeling and simplifying approximations to solve real-world engineering problems. Examples are taken from several fields including manufacturing, electronics, consumer products, and energy systems.

Topics Covered:
1. Steady and unsteady conduction
2. Natural and forced convection
3. Introduction to boiling, condensation and evaporation
4. Radiant heat exchange
5. Mass Transfer Analogy

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

Course Communication
Questions about Homework problems, Laboratories, and Exam/Quiz review topics should be 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 not be answered via direct email, only through Discussions.

Grading:
Homework (5%): Problem sets (10) assigned roughly every week
Lab reports (20%): Two laboratory exercises
Quizzes (10%): Two closed-book quizzes; self-written formula sheet permitted
Exam I (15%): Closed-book exam; formula sheets will be provided
Exam II (20%): Closed-book exam; formula sheets will be provided
Final Exam (25%): Closed book exam; formula sheet will be provided.
Participation (5%): Will be evaluated on overall participation in class and discussion

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, 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 and mass 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. Develop the analogous understanding between Fourier's Law for heat transfer and Fick's Law for mass transfer.

Reading Assignments: Course lectures will coincide with the textbook for each topic as listed below 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.

Homework:
Homework assignments will be posted on blackboard. Tentative due weeks are on the syllabus. Homework can be turned in at the beginning of class, but are due on **Thursdays before 5 PM** of indicated week (at the ME front office 110 Cummington Mall, **office closes at 5 PM**).

- Late homework will not be accepted.
- For each problem you should clearly show all work (given, asked for, equations, assumptions, math, answer).

Lab exercises:
There will be two lab exercises for this course. Sign-up sheets will be posted in advance of the labs on blackboard. The experiments will be done in groups, but lab reports will be done individually.

- Reports are limited to a strict **4 page length limit**. pages beyond 4 will not be graded
- Cover pages are strongly discouraged, as they will count toward the 4-page limit
- Fonts must be 11 pt or larger, margins must be 1" or larger
- Individual laboratory reports can be turned in at the beginning of class, but are due on **Tuesday by 5 PM** of indicated week (at the ME front office 110 Cummington Mall).
- Email submission is acceptable **in cases of emergency**; email both Prof. Werner and the TA.
- Late labs will be accepted for grading for up to week late with a 10% late penalty provided that the student is in correspondence with Prof. Werner. Labs will only be accepted beyond this point with prior approval by Prof. Werner and will be subject to greater late penalties.
- Students are expected to physically complete the laboratory exercise. If a student fails to sign up or misses their lab timeslot, he or she should reach out to the lab TA immediately to see if there might be another open slot. If not, the student can receive lab data to complete the report, and the report will be subject to a 25% penalty.

Quizzes:
There are 2 quizzes throughout the semester. Each quiz will take place during the first 20 minutes of the class. Each quiz will cover a block of lectures as noted in the schedule.

- Each quiz is closed book, but a one page (8.5x11 inch) formula sheet may be brought in and used during the quiz. This formula sheet must be handwritten solely by the student and will be collected with the quiz.
- Students requiring additional time to complete examinations must supply proper documentation from the Office of Disability Services **at least 3 days in advance** of an examination to the instructor so suitable arrangements can be made.

Exams:
There are 2 in class exams and one final exam during finals period, as listed in the Course Schedule. Each exam will take place over an entire class period. Each exam will cover a block of lectures as noted in the schedule. The Final Exam is cumulative.

- 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 3 days in advance** of an examination to the instructor so suitable arrangements can be made.

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. 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***. You may access the BU Academic Conduct Code at: http://www.bu.edu/academics/policies/academic-conduct-code/

Proposed Course Schedule (Please note: changes/updates to this schedule will be posted on Blackboard):

ME 419 A2 - Spring 2020 **Updated: January 17, 2020**

Lecture	Date	Day	Topic	Textbook Reading	Labs and Due Dates
1	1/22/2020	Wednesday	Introduction to Heat Transfer	Chapter 1	
2	1/27/2020	Monday	Introduction to Conduction: The Heat Equation	Chapter 2	
3	1/29/2020	Wednesday	Solving the Heat Equation: Boundary Conditions	2.4, 3.1-3.3	
4	2/3/2020	Monday	1D Steady Conduction: Thermal Circuits	2.3-2.5, 3.1-3.5	
5	2/5/2020	Wednesday	Fins & Finned Surfaces	3.5, 3.6, 3.10	Problem Set #1
6	2/10/2020	Monday	2D & 3D Steady Conduction	4.1-4.3	
7	2/12/2020	Wednesday	Transient Conduction: Lumped Systems **Quiz 1: Conduction (Lecture 1-5)** ***Lab 1 Occurs During This Week***	5.1-5.3	Problem Set #2
8	2/18/2020	Tuesday	Monday Schedule on Tuesday: Unsteady Conduction (Slabs, spheres, cylinders)	5.1-5.6	
9	2/19/2020	Wednesday	Semi-infinite Bodies	5.7-5.8	Problem Set #3
10	2/24/2020	Monday	2D & 3D Transient Conduction, Conduction Review		
11	**2/26/2020**	**Wednesday**	**Exam 1: Conduction (Lecture 1-9; Chapters 1-5)**		Problem Set #4
12	3/2/2020	Monday	Introduction to Convection: Fluids and Mass Transfer	6.1-6.3	Lab #1
13	3/4/2020	Wednesday	Boundary Layers and Dimensionless Numbers	Chapter 6	
14	3/16/2020	Monday	External Forced Convection by Correlations	7.1-7.3	
15	3/18/2020	Wednesday	Applications of External Forced Convection	7.4-7.9	Problem Set #5
16	3/23/2020	Monday	Internal Forced Convection	8.1-8.5	
17	3/25/2020	Wednesday	Application of Internal Forced Convection **Quiz 2: Convection (Lecture 12-15)** ***Lab 2 Occurs During This Week***	Chapter 8	Problem Set #6
18	3/30/2020	Monday	Natural Convection	Chap 9	
19	4/1/2020	Wednesday	Boiling & Condensation	10.1-10.5	Problem Set #7
20	4/6/2020	Monday	Heat Exchangers; LMTD method; Convection Review	11.1-11.6	
21	4/8/2020	Wednesday	**Exam 2: Convection (Lectures 12-19; Chapters 6-10)**		Problem Set #8
22	4/13/2020	Monday	Heat Exchangers: Effectiveness-NTU Method	11.4-11.6	Lab #2
23	4/15/2020	Wednesday	Radiation	Chapter 12-13	Problem Set #9
24	4/22/2020	Wednesday	The Three Modes of Heat Transfer in Practice	Chapters 1-13	
25	4/27/2020	Monday	The Mass Transfer Analogy: Fick's Law	14.1-14.5	
26	4/29/2020	Wednesday	Review		Problem Set #10