# MAE 310 - Heat Transfer Fundamentals

## Fall 2024 – Sections 001, 602, 605

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**Lectures:** TuTh 3:00-4:15pm, 2213 EB III
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**Grader:** TBD
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### 1.1. Course prerequisites:

MA 341 and C- or better in MAE 201

### 1.2. Required Textbook:

Fundamentals of Heat and Mass Transfer, 8th Ed, by Bergman, Lavine, Incropera & DeWitt, John Wiley & Sons, 2020. International and previous editions are not recommended. (All-in e-book)
Course materials are delivered electronically on the class Moodle site. You have free access to materials through the drop/add date.

### 1.3. Course Support:

wolfware.ncsu.edu/
http://engineeringonline.ncsu.edu

### 1.4. Student learning outcomes for the course

**Course Motivation:** This course is an introduction undergraduate level class on heat transfer. It provides the basic tools necessary for the analysis of thermal conduction, thermal convection, and thermal radiation.

**Course Objectives:** The students will be asked to demonstrate their knowledge of the material covered in MAE 310 through their mastery of the following course objectives. Through the study of MAE 310 the students will be able to:

1. Determine surface temperature or heat rate by performing control surface energy balances;
2. Calculate heat rate using Fourier's law, Newton's law of cooling, and the Stefan-Boltzmann law;
3. Calculate interface temperatures, and or, heat rates for 1-D steady state heat transfer problems using the electrical resistance circuit analogy;
4. Determine the temperature distribution, heat rate, and performance of 1-D fins;
5. Determine 2D steady-state temperature distributions using finite difference techniques;
6. Determine 1D transient temperature distributions using separation of variables and finite difference techniques;
7. Determine 3D transient temperature distributions using the product solution technique;
8. Understand the concept of a velocity and thermal boundary layer, calculate boundary layer thickness, displacement thickness, momentum thickness, wall shear stress and convective heat transfer coefficient and determine whether the boundary layer is laminar or turbulent;

9. Calculate convective heat transfer rates for external forced convection of flat plates, cylinders, spheres and tube bundles;
10. Calculate convective heat transfer rates for internal laminar and turbulent flow for fully developed and developing flows;
11. Calculate convective heat transfer rates for buoyancy driven flows over flat plates, cylinders, spheres and in enclosures;
12. Determine the total and spectral blackbody emissive powers, surface radiation properties and radiation view factors;
13. Calculate surface temperature or heat rate of gray diffuse surface enclosures.

## 1.5. Projected schedule and reading assignments

| Date | | Topic | Readings |
|---|---|---|---|
| Aug. | 20 | Course outline, Intro to heat transfer, Cons. of energy | 1.1, 1.2 |
| | 22 | Fourier's law, Newton's law of cooling | 1.3, 2.1, 2.2 |
| | 27 | Examples, radiation HT, derivation of HCE | 1.2 |
| | 29 | 1D SS heat cond., thermal resistance, contact resistance | 2.1, 2.3, 2.4 |
| Sep. | 3 | Composite systems, contact resistance, radial systems | 3.1.3,3.1.4,3.3 |
| | 5 | Heating elements, finned surfaces | 3.3.1, 3.5 |
| | 10 | Fin selection, fin arrays, contact resistance, review | 3.6 |
| | 12 | 2D SS heat conduction, shape factors, separation of variables | 4.1, 4.2 |
| | 19 | 2D SS heat conduction, FD method, computer project | 4.4 |
| | 24 | **Test 1** | |
| | 26 | Transient heat conduction – lumped model | 5.1, 5.2 |
| Oct. | 1 | Transient analytic solutions - plane wall, | 5.5, 5.6 |
| | 3 | Semi-infinite solids, product solution | 5.7, 5.8 |
| | 8 | Convection, flow regimes, Reynolds number | 6.1-6.3 |
| | 10 | Boundary layer flow | 7.1-7.3 |
| | 17 | Flow over cylinders, spheres, flow over tubes | 7.4-7.6 |
| | 22 | **Test 2** | |
| | 24 | Internal flow – laminar, developing | 8.2-8.3 |
| | 29 | Internal flow – turbulent | 8.4-8.6 |
| | 31 | Empirical correlations, natural convection | 7.1, 9.1-9.5 |
| Nov. | 5 | Horizontal plates, channels, enclosures | 9.6-9.8 |
| | 7 | Thermal radiation | 12.1-12.3 |
| | 12 | **Test 3** | |
| | 14 | Blackbody radiation | 12.4 |
| | 19 | Definition of view factors | 13.1 |
| | 21 | Diffuse-gray surface rad. exchange, radiation shields | 13.3 |
| | 26 | Solar radiation, environ. properties, temp. measurement | 12.8 |
| Dec. | 3 | Review | |
| Dec. | 10 | **Final Exam, Tuesday, 3:30 – 6:00pm** | |

## 1.6. Grading

| | |
|---|---|
| Homeworks | 15% |
| Test 1 | 15% |
| Test 2 | 15% |
| Test 3 | 15% |
| Final Exam | 40% |

The final grade will be based on the final average and determined as follows:

| **Letter** | **A+** | **A** | **A-** | **B+** | **B** | **B-** | **C+** | **C** | **C-** | **D+** | **D** | **D-** | **F** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Highest,% | 100.0 | 96.9 | 92.9 | 89.9 | 86.9 | 82.9 | 79.9 | 76.9 | 72.9 | 69.9 | 66.9 | 62.9 | 59.9 |
| Lowest,% | 97.0 | 93.0 | 90.0 | 87.0 | 83.0 | 80.0 | 77.0 | 73.0 | 70.0 | 67.0 | 63.0 | 60.0 | 0 |

Plus/minus grades will be used for the borderline cases based on attendance, homework grades, and improvement in test and exam grades. No incompletes are accepted for this course without verifiable, written doctor's note indicating more than one week's incapacitation.

## 1.7. Course Policies

### 1.7.1 Exams

Exams are closed books/closed notes. Equation sheet and tables will be provided. All materials submitted for grading must be on one side of clean paper. Credit will not be given for answers without supporting analyses. There must be no collaboration on the exams. The preliminary exam schedule is provided in the class syllabus. Please contact the instructor as soon as possible if you have a time conflict with the proposed schedule.

### 1.7.2 Homeworks

Homeworks will be assigned on Thursday of the current week of class and will be due on Thursday of the next week. The homeworks will be posted as Moodle Assignments set up for electronic submission and grading. Please submit your files as PDF (preferred) or web image files. There is a limit of 10 files/10 MB total for each submission. The homeworks will be graded electronically. Only four (4) of the submitted problems will be graded. The problems for grading will be selected randomly. Each problem will be given 25 points. The maximum for each homework will be 100 points. The homework solutions will be posted as PDF files.

### 1.7.3 Office hours

I will conduct my office hours in person and on Zoom. The time will be selected based on a Moodle poll. Option for irregular office hours: you can always set up an appointment for a meeting in person or on Zoom.

### 1.7.4 Instructor's policies on incomplete grades and late assignments

Incompletes are accepted only for medical reasons. Makeup work, if any, must be arranged within two weeks of due date at the option of the instructor, prior to two weeks before the end of classes. Arrangements for missed tests will be made on an individual basis provided you have an acceptable, certifiable excuse.

### 1.7.5 Instructor's policies on attendance

Students are expected to attend all classes, and attendance may be recorded from time to time and may be used to determine grades for borderline cases. NCSU policy on attendance, including what

constitutes an 'Excused Absence,' is at http://policies.ncsu.edu/regulation/reg-02-20-03. If you are quarantined or otherwise need to miss class because you have been advised that you may have been exposed to COVID-19, you should not be penalized regarding attendance or class participation. However, you will be expected to develop a plan to keep up with your coursework during any such absences.

### 1.7.6 Instructor's Academic Integrity statement

The faculty acknowledges the existence of the University policy on academic integrity found in the http://studentconduct.ncsu.edu/ and expects students to adhere to it. It is the expectation of faculty that students neither give nor receive unauthorized aid on any test, exam, or special assignment. The faculty recognizes the value of discussions by students regarding weekly homework assignments in student groups, with teaching assistants, and the faculty. However, homework assignments submitted for grading must be the product of the student submitting the work. Possession of copies of a solution manual by students is prohibited.

### 1.7.7 Student Wellness

As a student, you may experience a range of personal issues that can impede learning, such as strained relationships, increased anxiety, alcohol/drug concerns, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may impact your ability to participate in daily activities. It is very important that you have a support system and that you ask for help when you are struggling. The Counseling Center at NC State offers confidential mental health services for full time NC State students, including same-day emergency services. Please visit https://counseling.dasa.ncsu.edu/ to get connected.

### 1.7.8 Statement for students with disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities at http://policies.ncsu.edu/regulation/reg-02-20-01.

### 1.7.9 Statement on personal communication devices

All personal communication devices must be turned off during the tests. The use of silent mode during regular class is allowed.

### 1.7.10 Class evaluation

Online class evaluations will be available for students to complete during the last week of class. Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any particular student responded to any question, and students will never know the ratings for any particular instructor. More information about ClassEval is available at https://oirp.ncsu.edu/classeval/

*Note: this syllabus is not a contract and can be altered at any point with advanced notice to accommodate the educational goals of the course.*