

San Jose State University
Department of Mechanical and Aerospace Engineering
ME 211, Advanced Heat Transfer, Fall 2016

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| Instructor: | Younes Shabany |
| Office Location: | ENG 348 |
| Telephone: | (408)313-8391 |
| Email: | yshabany@yahoo.com |
| Office Hours: | Tuesdays 4:00–5:30 PM |
| Class Days/Time: | Tuesdays and Thursdays 6:00 – 7:15 PM |
| Classroom: | Clark 202 |
| Prerequisites: | ME114 or Equivalent |

Canvas and Course Messaging

Copies of the course materials such as the syllabus, course notes, assignments, homework solutions, etc. will be posted on the Canvas site for the class. I will be using this system for any communication with the class. This system will also allow you to have discussions or chat with others in the class. This feature may be especially helpful if you need assistance on a homework problem.

To log in, go to the Canvas URL <http://sjsu.instructure.com>. Log in with your 9-digit SJSU ID and password you use for your SJSUOne account. For questions on the use of Canvas, please check out http://www.sjsu.edu/at/ec/canvas/student_resources/index.html

You are responsible for regularly checking with the messaging system through Canvas. You can set up your Canvas account to forward all email sent to your Canvas account to any other email address you wish.

Course Description

Conduction, convection and radiation heat transfer, including conjugate problems. Numerical methods and use of the computer to solve heat transfer problems.

Course Goals

- To provide an advanced understanding of the basic modes of heat transfer
- To demonstrate different techniques used in solving heat transfer problems
- To teach basics of research and engineering in heat transfer

Student Learning Objectives

- To demonstrate a deep understanding of different modes of heat transfer
- To gain problem solving skills in conduction, convection and radiation heat transfer.
- To learn how to analyze heat transfer problems in engineering applications
- To learn elements of research in heat transfer

Required Texts/Readings

Textbook

“Advanced Heat and Mass Transfer”, Amir Faghri, Yuwen Zhang and John Howell, Global Digital Press, 2010

- Course notes and other relevant references will be provided to supplement the textbook.

Other References

- “Fundamentals of Heat and Mass Transfer” by F. Incropera and D. DeWitt,
- “Heat Transfer: Thermal Management of Electronics” by Younes Shabany.
- “Conduction Heat Transfer” by Vedat S. Arpaci
- “Heat Conduction” by M. Necati Ozisik
- “Convection Heat Transfer”, by Adrian Bejan
- “Convection Heat Transfer” by Vedat S. Arpaci and Poul S. Larsen
- “Convective Heat and Mass Transfer” by W. M. Kays, M. E. Crawford and B. Weigand
- “Thermal Radiation Heat Transfer” by Robert Siegel and John Howell
- “Radiation Heat Transfer” by Michael F. Modest

Classroom Protocol

- Class attendance and arriving on time are necessary.
- Participation in class discussions is encouraged.
- No cell phone or computer use is allowed during the lecture.

Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc.

- Refer to the current semester’s [Catalog Policies](http://info.sjsu.edu/static/catalog/policies.html) section at <http://info.sjsu.edu/static/catalog/policies.html>.
- Add/drop deadlines can be found on the [current academic calendar](http://www.sjsu.edu/academic_programs/calendars/academic_calendar/) web page located at http://www.sjsu.edu/academic_programs/calendars/academic_calendar/.
- The [Late Drop Policy](http://www.sjsu.edu/aars/policies/latedrops/policy/) is available at <http://www.sjsu.edu/aars/policies/latedrops/policy/>. Students should be aware of the current deadlines and penalties for dropping classes.
- Information about the latest changes and news is available at the [Advising Hub](http://www.sjsu.edu/advising/) at <http://www.sjsu.edu/advising/>.

Assignments

- Individual and team homework assignments will be given.
- Homework assignments will challenge students’ problem solving capability and may require using computer tools such as Excel.
- Homework sets have to be turned in before the lecture starts on the date they are due.

- Homework sets may be submitted with a maximum of one week delay, but with 10% penalty.
- Homework shall be professional, neat and easy to follow.
- In addition to homework assignments, each student will do one term project.

Grading Policy

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| Homework: | 40% |
| Midterm: | 20% (Thursday, October 20, Class Time) |
| Term Project or paper: | 20% (Due Date: Thursday, December 1, Class Time) |
| Final: | 20% (Thursday, December 15, 5:15 – 7:30 PM) |

- The dates for midterm and final exams are final and will not change.
- All students shall plan to take the midterm and final tests on these dates.
- If you can not take either the midterm or the final test on these dates, only due to circumstances beyond your control, please let me know two weeks in advance to make alternative arrangements.

Term Project or Paper Requirements

- Choose an engineering problem or a research paper in the area of heat transfer and send your selected topic to me for approval.
 - ✦ The topics have to be defined by **September 15, 2016**.
- Understand
 - ✦ how was the engineering problem solved or how will it be solved.
 - ✦ the contents of the research paper and any background information needed to support that research.
- Perform some of the calculations needed to solve the engineering problem or to support the claims in the research paper.
- Write an engineering report or research paper based on your own work.
 - ✦ The report or paper has to be divided into sections such as Abstract, Objectives, Motivations, Introductions (including literature survey), Main Topics (such as Theory, Experimental Setup, Analytical or Numerical Methods, Results), Conclusions and References.
 - ✦ The report or paper has to be typed and delivered in hard copy by **December 1, 2016**.
- Prepare a PowerPoint presentation to present your work to the class. This presentation
 - ✦ shall have similar sections as the report or paper.
 - ✦ shall not take more than 10 minutes.
 - ✦ shall not include too many words.
- The project or paper will be graded based on the quality of the work itself, the report, and the presentation.

University Policies

Academic integrity

Your commitment as a student to learning is evidenced by your enrollment at San Jose State University. The [University's Academic Integrity policy](http://www.sjsu.edu/senate/S07-2.htm), located at <http://www.sjsu.edu/senate/S07-2.htm>, requires you to be honest in all your academic

course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The [Student Conduct and Ethical Development website](http://www.sa.sjsu.edu/judicial_affairs/index.html) is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a failing grade and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include your assignment or any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy S07-2 requires approval of instructors.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the [Disability Resource Center](http://www.drc.sjsu.edu/) (DRC) at <http://www.drc.sjsu.edu/> to establish a record of their disability.

Tentative Topics and Schedule

| Week | Date | Topic | Course Note | Textbook Reading |
|------|----------------------------------|---|-------------|---|
| 1 | August 25 | Conservation Equations Conservation of Mass Conservation of Momentum Conservation of Energy | 1 | 2.2.1 – 2.2.3 2.3.1 – 2.3.3 |
| 2 | August 30 September 1 | Heat Conduction Heat Conduction Equation Steady State and Transient Heat Conduction Boundary and Initial Conditions | 2 | 3.1 |
| 3 | September 6 September 8 | Numerical Solution of Heat Conduction Equation Steady State and Transient Heat Conduction Solution Techniques | 3 | 3.4 |
| 4 | September 13 September 15 | Boundary-Layer Approximations and Analogies Two-Dimensional Conservation Equations Boundary Layer Approximations Normalized Boundary Layer Equations Reynolds Analogy Last Day to Define Project | 4 | 4.1 – 4.5 4.10 |
| 5 | September 20 September 22 | Introduction to Turbulent Flows Nature of Turbulence Time-Averaged Governing Equations Closure Problem and Turbulence Modeling Turbulent Shear Stress and Turbulent Heat Flux Prandtl Mixing Length Model Velocity and Temperature Distribution Near a Wall k- ϵ Model | 5 | 2.5 4.11.1 4.11.2 4.11.3 |
| 6 | September 27 September 29 | Integral Method | 6 | 4.7 |
| 7 | October 4 October 6 | Forced Convection External Heat Transfer Laminar Flow over a Flat Plate, Similarity Solution Turbulent Flow over a Flat Plate, Reynolds Analogy | 7 | 4.6.1 4.11.4 |
| 8 | October 11 October 13 | Forced Convection Internal Heat Transfer Laminar and Turbulent Fully-Developed Flows Friction Factor and Convection Heat Transfer Coefficient for Laminar and Turbulent Flows | 8 | 5.1 5.2 5.3 5.9 |
| 9 | October 18 October 20 | Natural Convection Heat Transfer Natural Convection Boundary Layer Equations Laminar Flow over a Vertical Plate, Similarity Solution and Integral Method Turbulent Flow over a Vertical Plate, Integral Method Natural Convection over Inclined and Horizontal Plates Natural Convection over Cylinders and Spheres Natural Convection in Enclosures Midterm Exam | 9 | 6.1 6.2.2 6.2.3 6.4.1 6.4.2 6.4.3 6.4.4 6.5.1 6.5.2 |

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| 10 | October 25 October 27 | Boiling Heat Transfer Boiling Convection Coefficient Boiling Modes Pool Boiling Regimes; Free Convection, Nucleate, Transition and Film Boiling Critical Heat Flux, Minimum Heat Flux Forced Convection Boiling | 10 | 8.1 8.2 8.3 8.4 8.5 8.6.1 |
| 11 | November 1 November 3 | Condensation Heat Transfer Modes of Condensation Film Condensation Dropwise Condensation | 11 | 7.1 7.2 7.3.1 7.3.3 |
| 12 | November 8 November 10 | Radiation Heat Transfer in Non-Participating Media Radiation Intensity Emissive Power, Irradiation and Radiosity Black Body Radiation Real Surface Radiation; emissivity, absorptivity, reflectivity and transmissivity | 12 | 9.1 9.2 9.3.1 9.3.2 |
| 13 | November 15 November 17 | Radiation Heat Transfer in Non-Participating Media Kirchhoff's Law and its Application Solar and Atmospheric Radiation View Factors Radiation between Surfaces | 12 | 10.1 10.2 |
| 14 | November 22 November 24 | Radiation Heat Transfer in Participating Media Participating Medium; Absorption, Scattering and Emission The Equation of Radiation Transfer Radiation Heat Flux Vector, Conservation of Radiation Molecular Internal Energy; Rotational, Vibrational and Rotational-Vibrational Spectra Total Emissivity and Absorptivity of H ₂ O and CO ₂ No Class – Thanksgiving Holiday | 13 | 10.5 |
| 15 | November 29 December 1 | Microscale and Nanoscale Heat Transfer Microscale and Nanoscale Transport Phenomena Microscale Heat Conduction Forced Convection in Microchannels Project Reports Due | 14 | 1.4.3 3.6.1 5.8.1 5.8.2 |
| 16 | December 6 December 8 | Project Presentations | | |
| | December 15 | Final Exam | | |