ME 812
Conductive Heat Transfer
MWF 9:10 AM – 10:00 AM
1257 Anthony Hall

Instructor: Dr. Craig W. Somerton, Associate Professor
Office: 2439 Engineering Building
Hours: W 10:30-11:30, TuTh 1:30-2:30
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Course Web Site: www.egr.msu.edu/classes/me812/somerton/

Catalog Course Description

Theory of steady and unsteady heat conduction. Derivation of describing equations and boundary conditions. Numerical methods. Nonlinear problems.

About the Course

This course is focused on the development of the required modeling skills concerned with the mode of heat transfer called conduction. Modeling involves taking a complex physical situation, simplifying it to a physical model, which can then be represented by a set of equations. The solution of theses equations allows one to predict the performance of the physical situation, which is the final result of the modeling process. To be a successful modeler begins with an understanding of the physical nature of heat conduction and thermal conductivity. Then a general differential equation that models energy conservation in a conduction problem must be developed. This general equation will then be simplified for the physical situation under consideration. Based on the nature of this simplified equation a mathematical approach is chosen that will generate a solution to the problem. Calculations can be made from the mathematical solution in order to predict the performance of the physical model.

Course Goals

1. To understand the physical nature of heat conduction and thermal conductivity.
2. To formulate a mathematical model for a heat conduction problem.
3. To solve the mathematical representation of heat conduction problems.
4. To calculate the performance of the heat conduction system using the mathematical solution.

Textbooks

1. V. S. Arpaci, Conduction Heat Transfer Abridged Edition, Pearson Custom Publ., 1991 (TJ260.A7).
2. An undergraduate heat transfer textbook such as: Incropera and DeWitt or Cengel. An older edition will work fine.

Suggested References

1. Özişik, M. Necati, Heat Conduction, 2nd edition, John Wiley & Sons, New York, 1993 (QC321 .O34 1993).
2. J. V. Beck, K.D. Cole, A. Haji-Sheikh, & B. Litkouhi, 1992, Heat Conduction Using Green's Functions,Hemisphere Publishing (TJ260.H3854)
3. J. V. Beck, B. Blackwell, & C. St. Clair, Jr. 1985, Inverse Heat Conduction, Wiley-Interscience(QC320.B4)
4. H. S. Carslaw & J. C. Jaeger, 1959, Conduction of Heat in Solids, 2nd ed., Oxford University Press (QC321.C28)
5. B. Gebhart, 1993, Heat Conduction and Mass Diffusion, McGraw-Hill (QC321.G42)
6. G. E. Meyers, 1987, Analytical Methods of Conduction Heat Transfer, Genium Publishing
7. M. N. Özişik, 1968, Boundary Value Problems of Heat Conduction, Dover (QC321.O33)
8. D. Poulikakos, 1994, Conduction Heat Transfer, Prentice Hall (TJ260.P634)
9. J. Taler & P. Duda, 2006, Solving Direct and Inverse Heat Conduction Problems, Springer
10. L. Wang, X. Zhou, & Z. Wei, 2008, Heat Conduction, Springer

Course Outline

Week of	**Topics**
August 27	Physical nature of heat conduction and thermal conductivity
September 3	Heat conduction equation. Derivation with an arbitrary control volume. Derivation using a differential element.
September 10	One dimensional, steady heat conduction. Cartesian, cylindrical, and spherical geometries. Thermal resistance model. Composite walls and fins. Method of Frobenius. Temperature dependent thermal conductivity.
September 17	One dimensional, steady heat conduction. Cartesian, cylindrical, and spherical geometries. Thermal resistance model. Composite walls and fins. Method of Frobenius. Temperature dependent thermal conductivity.
September 24	One dimensional, steady heat conduction. Cartesian, cylindrical, and spherical geometries. Thermal resistance model. Composite walls and fins. Method of Frobenius. Temperature dependent thermal conductivity.
October 1	Two dimensional, steady heat conduction. Separation of variables method. Superposition. Special functions.
October 8	Two dimensional, steady heat conduction. Separation of variables method. Superposition. Special functions.
October 15	One dimensional transient heat conduction. Lumped system analysis, distributed system analysis, semi-infinite solid, Laplace transform methods, separation of variables method, first term approximation, similarity solution, finite difference method, multidimensional transient heat conduction. Thermal circuit model.
October 22	One dimensional transient heat conduction. Lumped system analysis, distributed system analysis, semi-infinite solid, Laplace transform methods, separation of variables method, first term approximation, similarity solution, finite difference method, multidimensional transient heat conduction. Thermal circuit model.
October 29	Multi-dimensional transient heat conduction. Neuman product principle. Separation of variables method.
November 5	Use of Duhamel's theorem.
November 12	Green's function method
November 19	Green's function method
November 25	Finite element approach
December 3	Anisotropic solids

Final Exam: Monday, December 12, 2012, 7:45-9:45 a.m. 1257 Anthony Hall

Grading

There will be two 50 minute exams during the semester and a comprehensive final exam. There will also be weekly homework assignments. A numerical grade for the course will be based on the following weighting:

20% each 50 minute exam + 45% final exam + 15% homework total

The course grade will be based upon the distribution of the numerical grade calculated with the formula above and will be guided by a straight scale. The student will do no worse than a grade based upon a straight scale:

above 90% = 4.0
above 85% and below 90% = 3.5
above 80% and below 85% = 3.0
etc.

I reserve the right to base the student's course grade solely on the final exam score, if it benefits the student.

Hot or Not?

Three times during the semester the class will be introduced to a real world heat transfer phenomena and will be asked to explain the process. This will entail writing a one page essay on the topic at a level that a non-technical, educated person can understand. Craig Gunn, Director of Communications for the ME Department, will grade these and they will count in the Homework total.

Course Learning Objectives

1. Students understand the connection between thermodynamics and heat transfer.
2. Students understand the conductive heat transfer on the microscopic scale.
3. Students can derive a differential heat conduction equation for different geometries.
4. Students can solve the differential heat conduction equation in one dimension for different geometries.
5. Students can apply the thermal circuit model.
6. Students can obtain a solution to the fin equation for different and varying cross-sectional area.
7. Students can use the separation of variable technique to solve steady, multidimensional heat conduction problems.
8. Students can use a variety of different mathematical methods to solve one dimensional transient heat conduction problems.
9. Students can transform the differential heat conduction equation into a finite difference representation.
10. Students can apply Duhamel’s theorem.
11. Students understand the use of Greens functions in solving heat conduction problems
12. Students understand the application of finite element analysis to solve heat conduction problems.
13. Students can formulate a heat conduction problem in anisotropic solids

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Department of Mechanical Engineering

Plagiarism is not tolerated in the Department of Mechanical Engineering. It shall be punished according to the student conduct code of the University. Integrity and honesty are essential to maintain society's trust in the engineering profession. This policy is intended to reinforce these values.

For the purpose of this policy, plagiarism means presenting, as one's own, without proper citation, the words, work or opinions of someone else.

A. You commit plagiarism if you submit as your own work:

1. Part or all of an assignment copied from another person's assignment, including reports, drawings, web sites, computer files, or hardware.

2. Part or all of an assignment copied or paraphrased from a source, such as a book, magazine, pamphlet, web site, or web posting, without proper citation

3. The sequence of ideas, arrangement of material, pattern or thought of someone else, even though you express them in your own words. Plagiarism occurs when such a sequence of ideas is transferred from a source to a paper without the process of digestion, integration and reorganization in the writer's mind, and without acknowledgement in the paper.

B. You are an accomplice in plagiarism and equally guilty if you:

1. Knowingly allow your work, in preliminary or finished form, to be copied and submitted as the work of another.

2. Prepare an assignment for another student, and allow it to be submitted as his or her own work.

3. Keep or contribute to a file of assignments with the clear intent that these assignments will be copied and submitted as the work of anyone other than the originator of the assignment. (The student who knows that his or her work is being copied is presumed to consent to its being copied.)

(based upon the MSU English Department's policy on plagiarism at: http://www.msu.edu/unit/engdept/undergrad/plagiarism.html**)**