**HEAT TRANSFER (1459)** **SPRING 2007**

**UNITED STATES COAST GUARD ACADEMY**
**DEPARTMENT OF ENGINEERING**

**Course Description:** Application of Fourier's law of conduction to one and two-dimensional steady and non-steady state heat flow problems. Newton's Law of Cooling applied to problems of forced convection. Analysis of heat transfer systems and engineering design using mass and energy continuity concepts. Radiation heat transfer with black and gray surfaces. Design applications.

**Course Objectives:** To instruct the students on the fundamental theory and application of heat transfer including the analysis of basic heat transfer by conduction, convection, and radiation. The students are to be able to apply basic theory and empirical data to general one-dimensional problems and to less complex two- and three-dimensional problems. The students apply their knowledge to a design and construction project.

**Text:** Fundamentals of Heat and Mass Transfer, 5th Ed. by Frank P. Incropera, David P. De Witt

**References**: As required.

**Instructors:** LT Michael Plumley ext: 6521 Office: M102B
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| **Grading:** | Homework/Quizzes | 30 % | Exams (3) | 45 % |
|---|---|---|---|---|
| | Final Exam | 25 % | | |

**Grades:** Grades will be based on the following scale:
A: 90-100 B: 80-89.9 C: 70-79.9
Their will be plus and minus categories as appropriate.

**Course Structure:** Lectures, reading, and homework will be integrated to promote effective use of time and development of engineering analysis and problem solving skills. You will need to be proactive, think critically, and use your time effectively. Your learning and motivation are your responsibility. If the expectations for any instruction are unclear it is your responsibility to seek clarification from the instructor. Lack of understanding of the instructions or citing of alternate standards used by past instructors or other students are not valid reasons for unacceptable submittals. This course is provided at great expense to the taxpayer and shall be conducted accordingly.

Reading: Reading assignments are listed in the schedule. Students should read each section prior to lecture at a level that prepares them to participate in class. Students should go back to the text after class to develop a detailed understanding for homework, quizzes, and tests. Unannounced quizzes may be given throughout the semester to assess your understanding of the reading and course material.

Lecture: It is assumed students have completed the assigned reading and will ask questions. Student mastery of the material will be assumed if questions are not asked. Lecture time will generally be devoted to definitions, key concepts, and the solution of example problems. Students are expected to bring the following to class: notebook, text, pencil, and calculator. Proper military etiquette will be observed at all times and a lack of attention is unacceptable. Failure to respect this will result in removal from class, remediation under the conduct system, and grade reduction on applicable assignments.

Homework: The homework problems on the course schedule are subject to change. Each homework assignment is weighted for grading purposes based on instructor assessment of degree of difficulty.

Homework shall be on the class podium prior to the beginning of class on the date due. Late homework will be accepted for half credit at any time up to the start of the next scheduled exam. Homework submitted after the start of class or in the wrong format will be considered late.

Homework shall be completed in composition books with lined or blank pages. Begin each problem on a new page. Each page shall have at least ½" margins on all sides. Titles across first page must include: **"Date", "Assignment Number", "Page # / Total # of Pages"**. Subsequent pages shall include **"Page # / Total # of Pages"**. Include a detailed problem statement by identifying "**Given**" information, what you must "**Find**", your "**Audience**", appropriate sketches, and calculations with explanations and assumptions. Explanations shall include sources of equations, material properties, figures or tables used, and comment on the solution. Answers must be clearly identified.

Your presentation of homework should focus on communicating effectively what you have done, why you have done it, and how you have done it. You are responsible for the failures of technology, so plan ahead, save early, and save often. Neatness counts. Excessive messiness or spelling and grammatical errors shall be deemed unacceptable. Any attached pages must be neatly glued or taped.

Exams and Quizzes: Formal exam dates are specified on the course schedule. The final exam is mandatory and will be given at that time and place scheduled by the registrar.

Collaboration, Assistance, and Documentation**:** Small group collaboration with other students on homework in which each student works on and understands the solution to each problem is encouraged and permitted unless specifically instructed otherwise. All assistance or guidance, written or otherwise, from someone or something other than the student submitting it for credit must be documented on each submittal with a brief statement specifying the type and source of collaboration. *EFFECTIVE 2/21/07: the use of specific instructor solution manuals in any engineering course at CGA (including Heat Transfer) is specifically prohibited. All electronic and print copies of Incropera & Dewitt Solution Manuals in your possession should be destroyed immediately. Do not distribute information regarding the location of such information as this is a violation of both this policy and copyright law.*

Course Notebook: As part of the requirements for ABET you must maintain a complete course notebook. The notebook must contain all notes taken in class, handouts, and all graded materials (problem and design assignments and exams). The notebook should be arranged chronologically and should be tabbed. Submission of a complete course notebook at the time of the final examination is a requirement for passing. Failure to comply may result in grade reduction of up to one letter grade at the end of the semester. Your notebooks will be returned to you.

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## Achieving Educational Outcomes

This course, which is required of all ME and NA&ME majors, is intended to help you achieve some of the desired outcomes of an undergraduate engineering program. The accrediting agency for engineering programs, ABET, has specified the following as required outcomes for all undergraduate engineering majors. Areas shown in italics indicate that some knowledge development should occur as a result of completing this course. Those areas in bold and italics indicate outcomes that are intended to have significant knowledge development by your experience in this course.

Engineering programs must demonstrate that their graduates have:

***1. An ability to apply knowledge of mathematics, science and engineering***
*2. An ability to design and conduct experiments as well as to analyze data*
*3. An ability to design a system, component or process to meet desired needs*
*4. An ability to function on multi-disciplinary teams*
***5. An ability to identify, formulate and solve engineering problems***
6. An understanding of professional and ethical responsibility
***7. An ability to communicate effectively***
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context
*9. A recognition of the need for and an ability to engage in life-long learning*
*10. A knowledge of contemporary issues*
***11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.***
***12. An ability to develop as leaders in the Coast Guard.***

Additional ABET requirements for graduates of Mechanical Engineering programs include:

*1. Knowledge of chemistry and calculus based physics with depth in at least one;*
***2. Ability to apply advanced mathematics through multivariate calculus and differential equations;***
*3. Familiarity with statistics and linear algebra;*
*4. The ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems.*

Additional ABET requirements for graduates of Naval Architecture and Marine Engineering programs include:

1. Ability to apply probability and statistical methods to naval architecture and marine engineering problems;
***2. Basic knowledge of fluid mechanics, dynamics, structural mechanics, materials properties, hydrostatics, and energy/propulsion systems in the context of marine vehicles;***
3. Familiarity with instrumentation appropriate to naval architecture and/or marine engineering.

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***Tentative Schedule-Revised 13MAR07***

| # | Day | Date | Lecture | Reading (Due) {6th} | Homework (Assigned) {6th} | HW (Due) |
|---|---|---|---|---|---|---|
| 1 | F | 1/12 | Course Intro/Expectations; | | 1: Handout | |
| | **M** | **1/15** | **MLK Day Holiday Leave** | | | |
| 2 | W | 1/17 | Control Surfaces and Conduction, Convection, Radiation; | 1.1-1.7, Syllabus | 2: 1.6, 1.23, 1.33 | 1 |
| 3 | F | 1/19 | Thermal Conductivity & Material Properties | 2.1-2.5 | 3: *skip* | |
| 4 | M | 1/22 | Conduction –Conduction Equation & BC's – Gen'l | 2.3, 2.4 | 4: 1.39a, | |
| 5 | W | 1/24 | Conduction – Conduction Equation - Solutions 1 – 3D, Gen'l | 2.3, 2.4 | 5: 2.14 {handout} | 2-4 |
| 6 | F | 1/26 | Conduction – Conduction Equation - Solutions 2 – 1D, Steady, Thermal Circuits 1 (Intro) | 3.1, 3.2 | 6: 3.7 | |
| 7 | M | 1/29 | Conduction – Conduction Equation - Solutions 3 – 1D, Steady, Thermal Circuits 2 (Applications) | 3.1, 3.2 | 7: 3.23 | |
| 8 | W | 1/31 | Conduction – Conduction Equation - Solutions 4 – 1D, Steady, Thermal Circuit 3 (Radial) | 3.3 – 3.4 | 8: 3.50 | 5-7 |
| 9 | F | 2/2 | Conduction – Conduction Equation - Solutions 5 – 1D, Steady, w/ heat gen | 3.5 | 9: 3.96a | |
| 10 | M | 2/5 | Conduction – Conduction Equation – Solutions 6 - 1D, Steady, Extended Surfaces | 3.6 | 10: 3.119 | |
| 11 | W | 2/7 | Conduction – Conduction Equation – Solutions 7 - 1D, Steady, Extended Surfaces Efficiency | 3.7 {3.8} | 11: 3.147 {3.146} | 8-10 |
| 12 | F | 2/9 | *Exercises 1* | | 12: *skip* | |
| **13** | **M** | **2/12** | **EXAM 1** | | | |
| 14 | W | 2/14 | Conduction - Conduction Equation – Solutions 8 - 2D, Steady, Graphical Methods | 4.1, 4.3 {4.1,4.3, 4S.1} | 13: 4.19 {handout} | 11-12 |
| 15 | F | 2/16 | Conduction - Conduction Equation – Solutions 9 - 2D, Steady, Analytical Methods | 4.2 | 14: 4.2 | |
| | **M** | **2/19** | **Pres Day Holiday Leave** | | | |
| 16 | | | | | | |
| 17 | W "M | 2/21 | Conduction - Conduction Equation – Solutions 10 - 2D, Steady, Numerical Methods 1 | 4.4-4.6 | 15: 4.78 {4.76} | 13-14 |
| 18 | F | 2/23 | Conduction - Conduction Equation – Solutions 11 - 2D, Steady, Numerical Methods 2 | 4.4-4.6 | 16: *skip* | |
| 19 | M | 2/26 | Conduction - Conduction Equation – Solutions 12 - 1D, Trans, Lumped Capacitance | 5.1-5.3 | 17: *skip* | |
| 20 | W | 2/28 | *Exercises 2* | | 18: 5.8 {5.9} | 15-16 |
| 21 | F | 3/2 | Conduction - Conduction Equation – Solutions 13 - 1D, Trans, Analytical Methods 1 | 5.4-5.7 | 19: 5.30 {5.34} | |
| 22 | M | 3/5 | Conduction - Conduction Equation – Solutions 14 - 1D, Trans, Analytical Methods 2 | 5.4-5.7 | 20: *skip* | |
| 23 | W | 3/7 | Conduction - Conduction Equation – Solutions 15 - 1D, Trans, Numerical Methods 1 | 5.9-5.10 {5.10} | 21: 5.106 | 17-20 |
| 24 | F | 3/9 | Conduction - Conduction Equation – Solutions | 5.9-5.10 | 22: *skip* | |

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|---|---|---|---|---|---|---|
| | | | 16 - 1D, Trans, Numerical Methods 2 | {5.10} | | |
| | **M** | **3/12** | **SPRING BREAK LEAVE** | | | |
| | **W** | **3/14** | **SPRING BREAK LEAVE** | | | |
| | **F** | **3/16** | **SPRING BREAK LEAVE** | | | |
| 25 | M | 3/19 | Forced Convection- Gen'l Convection Equations | 6.1-6.4, 6.5-6.10 | 23: 6.11 {6.2} | |
| **26** | **W** | **3/21** | **Exam 2** | | | 21-22 |
| 27 | F | 3/23 | Forced Convection – Gen'l Equations – Analytical and Empirical Solutions - Flat Plate, Laminar 1 | 7.1, 7.2.1, 7.3 | 24: 7.1 (air & water) | |
| 28 | M | 3/26 | Forced Convection – Gen'l Equations – Analytical and Empirical Solutions - Flat Plate, Laminar 2 | 7.1, 7.2.1, 7.3 | 25: 7.2 | |
| 29 | W | 3/28 | Forced Convection –Empirical Solutions – Flat Plate, Turbulent | 7.2.2 | 26: Handout | 23-25 |
| 30 | Th "F | 3/29 | Forced Convection – Gen'l Equations – Analytical and Empirical Solutions - Pipes, Laminar 1 | 8.1-8.4 | 27: 8.73 {8.70} | |
| | **F** | **3/30** | **ETHICS FORUM** | | | |
| 31 | M | 4/2 | Forced Convection –Analytical and Empirical Solutions - Pipes, Laminar 2 | 8.1-8.4 | 28: *skip* | |
| 32 | W | 4/4 | Forced Convection –Empirical Solutions – Pipes, Turbulent Flow 1 | 8.5-8.7 | 29: 8.53 {handout} | 26-28 |
| 33 | F | 4/6 | Forced Convection –Empirical Solutions – Pipes, Turbulent Flow 2 | 8.5-8.7 | 30: *skip* | |
| 34 | M | 4/9 | Forced Convection –Empirical Solutions – Subm Bodies w/ Turbulent Flow | 7.4-7.5 | 31: 7.58 | |
| 35 | W | 4/11 | Forced Convection –Empirical Solutions – Tube Banks w/ Turbulent Flow | 7.6 | 32: 7.87 | 29-31 |
| 36 | F | 4/13 | Forced Convection –Heat Exchanger Intro | 11.1 – 11.2 | 33: Handout | |
| 37 | M | 4/16 | Forced Convection –Heat Exchanger LMTD and NTU Methods | 11.3 – 11.4 | 34: 11.14 | |
| 38 | W | 4/18 | Forced Convection –Heat Exchanger Selection | 11.6 - 11.7 | 35: 11.36a | 32-34 |
| **39** | **F** | **4/20** | **EXAM 3** | | | |
| 40 | M | 4/23 | *Exercises 3* | | 36: skip | |
| 41 | W | 4/25 | Radiation – Introduction | 12.1-12.3 | 37: 12.2 | 35-36 |
| 42 | F | 4/27 | Radiation – Introduction | 12.4-12.5 | 38: 12.19 {12.17} | |
| 43 | M | 4/30 | Radiation – Gray Surfaces & Environmental | 12.6-12.9 | 39: TBD | |
| | W | 5/2 | *Exercises 4* | | | 37-39 |
| | **TBD** | **TBD** | **FINAL EXAM** | | | |

- Not all assignments are listed. Students are responsible for recording changes.
- Instructor will not field homework questions on the day the assignment is due.