

ME EN 7670 ADVANCED RADIATION HEAT TRANSFER

Department of Mechanical Engineering University of Utah Fall 2010

INSTRUCTOR:

Mathieu Francoeur 2126 MEB 801-581-5721 mfrancoeur@mech.utah.edu

CLASS SCHEDULE: M,W,F 3:05 – 3:55 pm WEB L122

PREREQUISITES: ME EN 3650 (Heat Transfer) and graduate status

- **OFFICE HOURS:** By appointment
- **OBJECTIVES:** Provide the student with a fundamental understanding of radiation heat transfer. At the end of the class, the student should be comfortable with the blackbody concept and surface properties, radiative exchanges between surfaces, the radiative transfer equation and the associated solution methods.
- **REQUIRED TEXTBOOK:** M.F. Modest, <u>Radiative Heat Transfer</u>, 2nd Edition, Academic Press, 2003.
- **OTHER TEXTBOOK:** R. Siegel and J. Howell, <u>Thermal Radiation Heat Transfer</u>, 4th Edition, Taylor & Francis, 2002.
- **CLASS NOTES:** PowerPoint presentations will be distributed to the students. Other documentation will be distributed as necessary.
- **HOMEWORK:** In general, homework will be assigned on a weekly basis. Homework will be collected at the beginning of the class period when due. <u>No late homework will be accepted, unless the student</u> <u>has a valid reason.</u>

EXAMS: There will be two exams (take-home).

PROJECT: Students are allowed to choose their own project following their research interests, subject to approval of the instructor. At the end of the semester, the student is expected to submit a report consisting of an extensive literature review of the chosen subject.

The student should be able to identify the researchers in the field of interest, understand the scientific literature, and summarize it in a comprehensive document (including associated physical and mathematical modeling if applicable). The report should be made as professional as possible. At the end of the semester, the student will give a 10-15 minute oral presentation.

GRADING:	Homework: Exams: Project:	40% 40% (20% each) 20%
GRADING SCALE:	90 - 100%: 80 - 89%: 70 - 79%: 60 - 69%: below 60%:	A B C D E

Final grading scale may be lowered down by the instructor based on the overall class performance, but will not be raised.

CHEATING POLICY: Since engineering is a group activity, students are highly encouraged to help each other to learn the course material and to discuss the homework assignments. However, all homework and exams submitted <u>must be each student's personal work</u>. Students submitting work showing evidence of copying will receive zero credit.

TOPICS TO BE COVERED (SUBJECT TO CHANGE):

1. Fundamentals of Thermal Radiation

- 1.1 Introduction (Section 1.1)
- 1.2 Nature of thermal radiation (Section 1.2)
- 1.3 Basic laws and blackbody concept (Sections 1.3 and 1.4)
- 1.4 Definitions of solid angles, radiative intensity and radiative heat flux (Sections 1.5 to 1.7)
- 1.5 Introduction to radiation characteristics of various media (Sections 1.10 to 1.14)

2. Radiative Properties of Surfaces

- 2.1 Predictions of radiative properties from electromagnetic wave theory (Chapter 2)
- 2.2 Radiative properties of real surfaces (Chapter 3)

3. Radiation Transfer between Surfaces Separated by Transparent (Non-Participating) Media

3.1 View factors (Chapter 4)

- 3.2 Radiation transfer between gray and diffuse surfaces (Chapter 5)
- 3.3 Radiation transfer between nongray surfaces (Sections 7.1 and 7.2)

4. Radiation Transfer in Participating Media

4.1 Introduction (Sections 9.1 and 9.2)

- 4.2 Attenuation of radiation: absorption and out-scattering (Section 9.3)
- 4.3 Augmentation of radiation: emission and in-scattering (Section 9.4)
- 4.4 The radiative transfer equation (RTE) (Sections 9.5 to 9.8)
- 4.5 Coupling the RTE with the energy equation (Sections 9.9 to 9.12)
- 4.6 Overview of solution methods for the RTE (Section 9.13)

5. Exact Solutions of the RTE in One-Dimensional Plane-Parallel Gray Media

5.1 Formulation of the problem (Sections 13.1 and 13.2)

- 5.2 Radiative equilibrium of a non-scattering medium (Section 13.3)
- 5.3 Radiative equilibrium of a scattering medium (Section 13.4)
- 5.4 Specified temperature field (non-radiative equilibrium) (Section 13.5)
- 5.5 Concluding remarks (Section 13.8)

6. Approximate Solutions of the RTE

- 6.1 Approximate methods for one-dimensional media (Chapter 14)
- 6.2 The discrete ordinates method (Chapter 16, excluding section 16.4)
- 6.3 The Monte Carlo method (*if time permits) (Chapter 20)
- 6.4 Brief overview of other existing solution methods (Optional reading: Chapters 15 and 17)

7. Treatment of Collimated Irradiation

- 7.1 Steady-state RTE with collimated irradiation (Sections 18.1 to 18.3)
- 7.2 Short-pulsed collimated irradiation and transient effects (Section 18.4)

8. Near-Field Thermal Radiation

Notes

CLASS SCHEDULE (TENTATIVE):

Week	Dates	Topic (see p. 3)	Remark
1	08/23 - 08/27	1	
2	08/30 - 09/03	1	
3	09/06 - 09/10	2	No class on 09/06 (Labor Day)
4	09/13 - 09/17	3	Project Topic (09/13)
5	09/20 - 09/24	3	
6	09/27 - 10/01	3	
7	10/04 - 10/08	4	Midterm Exam
8	10/11 - 10/15		No class (Fall Break)
9	10/18 - 10/22	4	
10	10/25 - 10/29	5	
11	11/01 - 11/05	6	
12	11/08 - 11/12	6	
13	11/15 - 11/19	6	
14	11/22 - 11/26	7	No class on 09/26 (Thanksgiving)
15	11/29 - 12/03	8	Project Report (12/03)
16	12/06 - 12/10	8	Final Exam
17	12/13 - 12/17		Oral Presentations (Final Exam Period, 12/17 3:30 pm to 5:30 pm)