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ME 407-002: Heat Transfer

Eon Soo Lee

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ME 407-002/HM2: Heat Transfer
Lecture: T/R 4.00 PM - 5.20 PM (WebEx)

(2021 Spring)
(E.S. Lee)

Instructor: Dr. Eon Soo Lee (Phone: 973-596-3318) (Email: onsoo.lee@njit.edu)
Office hour: **through WebEx. T/Th 12:00 PM -1:00 PM** or an appointment

Objective: To understand the basic heat transfer modes of conduction, convection and radiation, and build up the ability to apply the heat transfer relations for the analysis of heating, cooling or thermal systems through HWs, Exams and Project.

Pre-requisite: Math 222 – Differential Equations (PDE) or equivalent,
ME 304 – Fluid Mechanics,
ME 311 – Thermodynamics I

Required Text books and related materials

Incropera and DeWitt, An Introduction to Heat Transfer, 6th edition. John Wiley & Sons 2011, or equivalent. (Older or newer version also fine for the lecture.)

ME 407-002/HM2 Class Meeting Room Information

Tuesday, Thursday 4-5:20pm

Meeting link: WebEx meeting link posted at Canvas to students

Meeting number: WebEx meeting link posted at Canvas to students

Password: announced at the class Canvas to students

- A Few Meeting options:
 - Office hour – just a short email (see below for details)
 - Before or After the class – just a short email or show-up at the time
 - Separate time arrangement by email
 - All meetings will use the same link as the lecture meeting link.
- Office hour meeting will use the same meeting link as the lecture meeting link. If you have questions, please send me an email prior to the office hour meeting to ensure the meeting open and prepare for the question.
- Exam will use the same link as the lecture link unless separately announced.

Weekly Lecture Schedule

Week	Contents	HW due	Remarks
1	(1/19) Heat transfer course introduction, syllabus, project guideline. Ch1: Intro to HTR (conduction, convection, radiation) (Thermodynamics)		
2	(1/26) Ch2: Intro to conduction (Fourier's Law, Diffusion equation) Ch2: Intro to conduction (transient behavior).		Add/Drop DL (1/30)
3	(2/2) Ch3: 1-D steady Cond.- plane wall, radial system w/o heat generation. Ch3: 1-D steady cond. – heat generation system.	HW1 (ch1&2)	
4	(2/9) Ch3: 1-D steady cond. – fin analysis Ch4: 2-D steady cond.- SoV; shape factor	HW2 (ch3)	
5	(2/16) Ch4: 2-D steady cond.- finite difference method (Quiz #1) Ch5: Transient Cond. – lumped capacitance method		
6	(2/23) Ch5: Transient Cond. – one term approximation; semi-infinite solid Ch5: Transient Cond. – finite difference method (explicit)	HW3 (ch4)	
7	(3/2) Ch5: Transient Cond. – finite difference method (implicit) Ch6: Intro to Conv. – Boundary Layer, conv coefficient	HW4 (ch5)	
8	(3/9) Ch6: Intro to Conv. –Non-dim parameters and Reynolds Analogy Midterm (Conduction. Ch1-5)		Project TBA
9	(3/16) Spring Recess week		
10	(3/23) Ch7: External flow – Flat plate in parallel flow + (Midterm review) Ch7: External flow – Cylinder in cross flow, Sphere	HW5 (ch6)	Planning report
11	(3/30) Ch8: Internal flow –fully develop, constant T & constant heat flux analysis Ch8: Internal flow- heat transfer correlations, entry length effect	HW6 (ch7)	Withdraw DL (4/5)
12	(4/6) Ch9: Free convection – laminar BL, Boussinesq approx., similarity, & Ch10. Pool boiling, film boiling, film condensation (Quiz #2)	HW7 (ch8)	Good Friday (4/10)
13	(4/13) Ch11. HEX- parallel and counter flow analysis, LMTD method Ch11. HEX- Effectiveness-NTU method		
14	(4/20) Ch12. Radiation, Blackbody, Wien's Displacement law, S-B law, Kirchhoff's law Ch13. View factor	HW8 (ch9-11)	Progress report
15	(4/27) Ch13. Radiation exchange: blackbody Ch13. Radiation exchange: opaque, gray body	Practice HW (ch12-13)	
	(5/4) No class (Tue => Friday class meet)		Final report
	Final Exam (Convection – Radiation)		

* This schedule is subject to change during the actual running of the semester.

Grading Policies (Honor section will be separately graded from Regular section.)

(1) Grading (total 110): Grading Scale: A (>90), B (>80), C (>70), D (>60), otherwise curved.

- Homeworks (10)
- Two Quizzes (20)
- Midterm (20)
- Final (30)
- Project (30)

* Class Attendance/participations are important though it does not have explicit grading points. Qualitative evaluation to be considered.

Note-1: "NO EXAM" goes to ZERO point.

- except only for the **instructor-approved & officially documented** excuse from Dean of Students (**80 % Rule**: 80 % of the weighted performance of the other exams of the subject student)
- However, No Midterm or Final goes to ZERO or the minimum of the class, depending on the excuse.

Note-2: There will be **NO make-up test** in this class.

(2) **Homework: Individual HW submission**

- **No cover page nor sorted HWs will not accepted for grading (zero point).** (see S1. HW cover page for details)
- **HWs are due at 12 PM (Noon) on the due date.**
 - o Late submission until **11:59 PM** on the due date - **30% loss** in grading.
 - o Late submission over **11:59 PM** on the due date – Not Accepted for grading (zero point).
- **Each problem MUST start on a new page. Don't put multiple problems on one page.**
- **Each problem should have the following sections:**
 - i. **Known:** A brief summary of the problem, "in your own words".
 - ii. **Find:** Quantities to be determined.
 - iii. **Schematic:** Sketch the physical system
 - iv. **Assumptions:** Assumptions to be used in solving the problem are listed.
 - v. **Properties:** Material properties needed, values and sources.
 - vi. **Analysis:** Solve a problem in a systematic and logical manner, **showing all steps.**
 - vii. **Final Answers MUST be clearly indicated within a box.**
- **20% loss if not follow each guideline.**

(3) **Final project:** (see the details on the information and guidelines in S2. and S3. Final Project)

- **2 members/team (Leader + Recorder) or Single member team**
- **Planning Report, Progress Report, Final Report** to be submitted on each deadline.
- Real life heat transfer problem: problem description, model development, analysis, BCs, ICs, etc
- Project progress meeting (if necessary) with professor after Midterm. See the details in S4. **Project Progress Meeting Guideline.**

(4) Exam Requirements (see the details in S5. Exam Guideline.)

- **Quizzes:** **Single formula sheet only. (One side only accepted)**
- **Midterm/Final:** **Single formula sheet only. (Both sides of one sheet accepted)**
- **Simple Calculator** (No programmable calculator). No share of calculator.
- No tele-communication tools, such as cell phone, lab-top, smart watch, etc.

NJIT Canvas <https://njit.instructure.com/courses> (UCID login required)

- Check and update your contact email address in Canvas. Everything will be emailed through it.
- Every notice, changes and HWs, Exams information will be posted on Canvas, and sent through it.

**** **NJIT Honor Code – Strictly Enforced******

<http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf>.

S1: HW Cover Page Guideline

- **Individual HW submission**
- **Encourage the discussion to understand the problems with your peer group.**
- Each HW will be posted on Canvas, and emailed by the Canvas.

- HWs MUST be submitted with cover page as followed by the example format.
- **HW cover page is a MUST**: write HW# and the corresponding chapter, submission date, name, etc as shown below.

HW cover page example

ME 407-001: Heat Transfer.

HW Set #1 (Chapter 1 & 2)

Name, ID 312-31-xxx

DUE date and time: February 4, 2021 (12 Noon)

Submission date: 2/4/2021
(or a different date if submitted on the different date)

Problem solved: total 4 problems answered out of 5
1-3,
1-15,
2-5,
2-17

Problem Not solved: 1
2-23

ME 407-HM2: Heat Transfer

Honor section students:
Additionally,
Must also solve honor section problem (H) if applicable.

Problem solved: total 6 problems answered out of 7
1-3,
1-15, (regular section)

plus honor section problems to be solved, if given.
2-19H
2-35H

S2. FINAL PROJECT Information

I. Schedule and Grading

(1) Term project schedule and Due:

- Planning Report (4/1. Thu. 12 Noon): 2 or more pages
- Progress Report (4/22. Thu. 12 Noon): up to 10 pages
- Final Report (5/6. Thu. 12 Noon): max. 15 pages excl. cover page, table of contents, references, and appendix. (Reading Day-2)

Note: Late Submission grading:

- Late submission until **11:59 PM** on the due date - 30% loss in grading.
- Late submission after **11:59 PM** on the due date – Not Accepted for grading (zero point).

(2) Grading percentage: Out of Total Project percentage (100%).

- i. Project Planning Report (20%) – “**MUST-submit**” item
- ii. Progress Report (30%)
- iii. Final Report (50%)

II. Deliverables and Grading Consideration

(1) Planning Report: **[MUST item]**

- Cover page – title, team info if composed of 2 members, submission date
- 2+ pages introduction report excluding cover page.
- Project theme, topics
- Details and specific target, what to study, which topic to choose, what materials to study, etc
- Project planning and schedules
- Schedule to work
- An overview and tentative abstract for your project plan
- Any progress by the time

(2) Progress Report (~ 10 pages)

- Main content development
- Base materials for final report preparation to be developed
- Many key contents to be roughly developed at this time

(3) Final Project Report (~ 15 pages)

- Introduction/Objective
- Problem statement and formulation
- Theoretical principles and Development
- Analysis
- Results
- Discussion or new findings
- Content completeness
- Overall report organization

S3. Final Project Guideline

A. Team Size and Role

1. Standard size of team is **2 students**. (single member team acceptable)
2. Formulate your team by yourself with your choices and preferences
3. Team role recommended: Leader + Recorder
 - **Leader**: team meeting coordination, meeting date/time/place coordination, meeting agenda coordination. Keep the project moving, etc. Keep the team on task and get involved. **Final project submissions.**
 - **Recorder**: meeting recording/minutes, sharing the meeting outcomes, etc. Project progress check and update, sharing the status of the project, etc. **Final report guideline check. Final project double check.**

***Note: All the project reports (planning, progress, final reports) **MUST** be submitted by the same individual (ex. Leader) within the team, to avoid the cross-plagiarism over the series of reports.**

B. Scope of Project Problem

1. You need to create your own problems from our real life systems. For example, engine, engine cooling radiator, boiler, computer chip cooling, swimming suit, satellite, jet engine, etc
2. More creative problem is preferred.
3. Conduction, convection and radiation- mixed problem is preferred. or the problem with at least two of heat transfer mode mixed is preferred.

C. Standard Report Guideline (Final project page limit: Max. 15 pages)

General section:

1. cover page: course name, team member information and roles, project title, submission date, etc
2. abstract (~ 0.5 pg)
3. role description of each team member in the project activities and developments of each section (~ 0.5 pg).
4. table of contents (~ 1 pg)

Technical Narrative sections:

5. motivation, objectives, etc (~ 1 pg)
6. introduction and background of the problem, (~ 2-3 pg)
7. model development, model geometry, assumptions, etc: detail descriptions (2- 3 pg)
8. theory: detailed explanations of the thermal or heat transfer theory applied to the problems. (2-3 pg)
9. Analysis: analytical or computational analysis, explanations of computational approaches, etc (2-4 pg)
10. Results and discussion: Not only showing figures, graphs, but also explaining them, etc (2-3 pg) and more for better project report if necessary.
 - The page numbers in each parenthesis is only for suggestions, not for a limit. However, the total page should be within 15 pages.

References and Appendix: (No limit. These are not included in the limit of 15 pages.)

- i. References: Provide the detail information of each references.
- ii. Appendix if any. (Materials that are not included in the body section due to the page limit can be attached.)

D. Writing Format Guideline

1. **Page limit: maximum 15 pages**, excluding Cover page, Table of contents, References and Appendix.
2. Writing Format:
 - **Letter size page,**
 - **1-inch margin,**
 - **Font size 11 for body text,** (Bigger font for heading is OK.)
 - **Times New Roman or Arial font,** (Bold or italic font acceptable for outlines or highlights.)
 - **Single-spaced line.**

***Note: 20% loss if not follow the guideline on writing format, page limit and proper sections.**

E. Evaluation – Final project evaluation guideline:

I. General section: (10%) – Not counted in the 15-page limit

1. cover page: course name, project team members and roles, project title, submission date, etc
2. abstract
3. role description of each team member in the project activities and developments
4. table of contents

II. Technical Narrative sections: (80%) – (15-page limit)

5. motivation, objectives, etc (~ 10%)
6. introduction or background of the problem, (~ 10%)
7. model development, model geometry, assumptions, etc: detail descriptions (~ 10%)
8. theory: detailed explanations of the thermal or heat transfer theory applied to the problems. (~ 20%)
9. Analysis: analytical or computational analysis, explanations of computational approaches, etc (~20%)
10. Results and discussion: Not only showing figures, graphs, but also explaining them, etc (~10%)

* Note-1: The percentage of each individual section above is a standard example, but the actual percentages may be subject to the development of the contents of the submitted project outcomes.

III. References and Appendix: (10%) – Not counted in the 15-page limit.

- A. References (Details of each references MUST be provided in this section.)
- B. Appendix (Any materials not included in the body section due to the page limit can be attached.)

Example evaluation:

- 90%: strong background study, model develop, analysis, in-depth analysis, conv/cond/rad mix-up problem
- 80%: Good, may be a typical problem, good-to-fair analysis, or results are generally good,
- 70%: Fair at many sections, typical problem, generally fair-to-weak analysis, results are generally fair,
- 60%: Weak overall, poor analysis/result/discussion, overall contents NOT complete or weak,

* *Plagiarism checker (Copy from other project reports, web sources, book sources, etc) will be performed: Honor Code strictly reinforced.*

=> Copy from other reports or improper quotes will result in the critical loss (up to 50 %) in grading, depending on the level of plagiarism.

F. Submission Format and Due Date

1. Submission materials and Due Dates
 - **Planning Report** (4/1. Thursday. 12 Noon)
 - **Progress Report** (4/22. Thursday. 12 Noon)
 - **Final Report** (5/6. Thursday. 12 Noon)
2. Canvas & Email submission (Both is a MUST.)
 - **Canvas submission** (Primary) – Upload **PDF** file only to Canvas system.
 - **Email submission** (Additional) - **Word and PDF** files (Both), **in addition to Canvas**.
 - **MS word & pdf** format, **both** files MUST be **submitted**.
3. Email submission format
 - * Email submission to my email <eonsoo.lee@njit.edu>.
 - (ex) Planning Report submission
 - **File name** format: "**2021S-ME407-002 HT Planning Report (Name1, 2)**"
 - **Email title** format: "**2021S-ME407-002 HT Planning Report (Name1, 2)**".
 - (ex) Honor Section student
 - **File and Email** format: "**2021S-ME407-HM2 HT Planning Report (Name1, 2)**"
4. Submissions not following the guideline will result in **20% loss in grading**.

S4. Project Progress Meeting (if necessary)

1. Objective: Project members can have an optional project meeting with the instructor of the class, to get a guidance and advices on the project and to have a discussion for a possible way of solution or progress to the completion of the project problem
2. Meeting time and arrangement
 - i. Meeting date: around the time frame in the middle of project progress
 - ii. Duration of the meeting: ~ less than 15 min/team
 - iii. The slot (30 min to 1 hour) Before or After each class meeting may be open and available for the project meeting if necessary.
 - iv. If a team needs a separate meeting time other than around the class time, it needs to be arranged by the team leader through email with the instructor. Each team will internally communicate and decide the meeting time with the leader.
 - v. Team Leader is responsible for the communication with all the team member before communicating with the instructor.
 - vi. Project progress materials should be emailed to the instructor at least 24 hrs before the meeting time, for the prior review and understanding.
 - vii. Meeting slots will be filled by first-come-first-serve basis through the email.
 - viii. Key email information should be included in every email communication:
 - Team member name and each role,
 - Project title, and a short explanation of the project
 - Question with One sentence explanation representing the question.

S5. Exam Guideline (Remote video synchronous exam)

1. Exam requirements

- **Closed book, closed note:** No lecture notes or lecture materials allowed.
- **Formula sheet: letter-size one-page formula sheet** only allowed.
 - : (single-face) for Quizzes, (both-face) for Midterm/Final.
 - : No example problems nor any part of a solution process allowed;
 - : Formula only allowed.
 - : Formula sheet to be reviewed before the exam.
- No cellphone or computer use (no keyboard/mouse) allowed during the exam.
- Pen, eraser, calculator, only allowed.
- **Blank sheets for your answer to be put on the desk.**
- Your working desk needs to be clean except for the allowed above.
- **Mouse/Keyboard/Electronics should be away from the working area during Exams.**

2. Video setting requirements

- **Video setting:** Video has to be **set to capture** the followings **all the time during the exam.**
 - : your face or head,**
 - : both hands,**
 - : your working desk area,**
 - : your formula sheet.**
 - : your answer sheets.**
- Be careful of both of your hands: Don't get any of your hands out of the screen during the exam!!!
- Clean out all the other papers or materials from your desk or working area.
- Problems will be shown on your screen through WebEx.
- Screens should be optimized before the start of the exam.
- Strongly recommend to use a **separate webcam** at a distance from your desk to capture all the view.

3. How to raise your Questions during Exam?

- Raise your hand for questions, and wait until I give you a chance to ask questions.
- **Do NOT use any mouse, computer or electronic devices until you are told to do so, during Exams.**

4. Submission of the answer sheet.

- Scan your answer sheets and create one single pdf file
- Upload the file to the Exam link. (Same as the other assignment)
- Uploading time is limited within 5-10 minutes after the end of the exam.
- **During uploading, video must keep turned on, and NOT be turned off.**
- Late submission will not be accepted, and be going to be zero point. (be familiar with the uploading)

Again,

- Clean out your desk except for the allowed materials.
- Be sure to check all the settings before the start of the exam.
- All the other materials than the above is going to be considered as cheating.

This is the requirement to be eligible to take the quiz over the online mode.

Please be ready and set your video before Exams.

S6. NJIT Honor Code

**NJIT Honor Code is strictly enforced
over the course of all the activities including HWs, EXAMs and
Projects.**

****** NJIT Honor Code – Strictly Enforced******

<http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf>.

“Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at:

<http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf>.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu”