ME 610-102: Applied Heat Transfer (Spring 2024)
Lecture: M. 6:00PM – 8:50PM (CKB 207) (Dr. Lee)

Instructor: Dr. Eon Soo Lee (Office: MEC 313, email: (eonsoo.lee@njit.edu), Phone 973-596-3318.)
Office Hr: **Mon/Thu 12:00 - 1pm** at MEC313
or an appointment by email at the WebEx room: https://njit.webex.com/meet/lee2000njit.edu

TA: Niladri Talukder & Yudong Wang (MEC 333-E) (nt22@njit.edu & yw35@njit.edu)

Objective: To understand heat transfer mechanisms and apply the heat transfer relations for the analysis of real-world heating/cooling energy systems or thermal systems.

Required Background: Pre-requisite.
Math- Differential equations, PDE/ODE;
Thermodynamics – mass balance, energy balance, heat and entropy
Fluid mechanics- boundary layer theory, N-S equation, laminar/turbulent flow, internal/external flow, flat plate/duct flow;
Heat Transfer – undergraduate basic heat transfer: conduction, convection, radiation, Energy balance/momentum balance.

Text books and related materials
Incropera and DeWitt, Fundamentals of Heat and Mass Transfer, 7th ed. John Wiley & Sons 2013, or similar
(Other versions of the textbook are also fine.)

Substitute WebEx classroom (for emergency case)

Meeting link:
https://njit.webex.com/njit/j.php?MTID=m022240901df6b797b03ce226f4131d31

Meeting number:
2631 449 2508

Meeting password:
ME610spr2024@6pm

Join from a video or application
Dial 26314492508@njit.webex.com
You can also dial 173.243.2.68 and enter your meeting number.

Join by phone
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 26314492508

Global call-in numbers
https://njit.webex.com/njit/globalcallin.php?MTID=ma2f2a91f2bf42234180a6c2ed1538113

Note: If we plan to move to the substitute WebEx classroom by any reason just in case, I will give you prior notices by email through Canvas system and in classes before the event. (e.g. snowstorm, weather impact, or academic conference attendance, etc)

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I. Lecture Schedule:

Week		Contents	HW	Remarks
1	(1/22)	Ch1: Intro to HTR and basic modes of heat transfer Ch2: Heat diffusion equation and Boundary conditions		Drop DL (1/22)
2	(1/29)	Ch3: 1-D steady state Cond.- plane wall, radial system Ch3: 1-D steady state cond. – heat generation system Ch3: 1-D steady state cond. – fin analysis, Fin efficiency		
3	(2/5)	Ch4: 2-D steady state cond. - SoV; shape factor Ch4: 2-D steady state cond. - finite difference method Ch5: Transient Cond. – lumped capacitance method	HW1 (Ch1-3)	
4	(2/12)	Ch5: Transient Cond. – one-term approximation: plane wall; radial system Ch5: Transient Cond. – semi-infinite solid; constant T or heat flux Ch5: Transient Cond. – finite difference method		
5	(2/19)	Ch6: Intro to Conv. – Boundary Layer, conv coefficient Ch6: Intro to Conv. – Boundary Layer equation, Non-dim parameters Ch6: Intro to Mass Transfer	HW2 (Ch4-5)	
6	(2/26)	**Exam1 - (ch1-ch5) Conduction**		
7	(3/4)	Ch7: External flow – Flat plate in parallel flow Ch7: External flow – Cylinder in cross flow, Sphere, Ch7: External flow – Mass transfer	HW3 (Ch6)	
8	(3/11)	Spring Break		
9	(3/18)	Ch8: Internal flow –fully developed analysis: hydrodynam. & thermal Ch8: Internal flow –const T & heat flux analysis, convection correlations (duct flow) Ch8: Internal flow – mass transfer		
10	(3/25)	Ch9: Free convection – laminar BL, Boussinesq approx., Empirical relations Ch10. Pool boiling, film boiling, forced tube boiling, film condensation Ch11. HEX- parallel/counter flow analysis Ch11. HEX- Effectiveness-NTU method	HW4 (Ch7-8)	
11	(4/1)	**Exam2 - (ch6-ch8) Convection Heat & Mass Transfer**		Withdrawal DL (4/1)
12	(4/8)	Ch12. Radiation, Opaque & Blackbody, Wien's Displacement law, S-B law, Real surface (e, a, r, t), Kirchhoff's law Ch13. Radiation exchange: View factor, blackbody surface	HW5 (ch9-11)	
13	(4/15)	Ch13. Radiation exchange: blackbody, opaque, gray surfaces Ch14. Introduction to Diffusion Mass Transfer		
14	(4/22)	Ch14. Introduction to Diffusion Mass Transfer- Fick's law, mass diffusion equations Ch14. mass diffusion equations, BC/IC	HW6 (ch12-13)	
15	(4/29)	**Final project presentation (slide due 4/29, 6pm)** **Final project report (due 5/2. 6pm. Reading Day2)**	HW7 (ch14)	
16	(5/6)	**Exam3 (Ch9-14) Convection + Radiation + Mass Transfer**		

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

II. Grading Policies

(1) Grading Basis (total 100%): A, B/B+, C/C+ & F
- Homework (20%): overall HWs
- Exam1, 2, 3 (60%): 20% per each exam
- Final Project (20%): presentation (10%) + final report (10%)

* “No exam” without prior permission goes to ZERO point in the exam.
* No make-up exam policy for this class.

(2) Final project: (Team basis). Check the details for “Final Project Guideline” pages.
- 2-3 members/one team.
- One (1) presentation and one (1) final report, per each team: Team-based grading. (NOTE: there might be significant difference within a team, if not actively participated.)
- Real life heat transfer problem: problem description, model development, analysis, BCs, ICs, etc
- Multimode-coupled analysis could usually be more complicated and evaluated better.
- Fundamental analytical analysis is a MUST, to be clearly shown first.
- Computational methods can be supplemental, in addition to the fundamental analysis.

(3) Homework (Individual HWs)
Submission:
- Late submission: Accepted within 1-week time frame, with 10% off on grading.
- Late submission more than 1-week: ZERO point, and NOT accepted for grading.
- Submission to Canvas: upload the scan file of your hand-written HWs.

Format Guideline:
- MUST follow the guideline below, in order to avoid the penalty up to maximum 30% points.
- Cover page: course name and number, Due date, Submitted date, Student Name, ID#,
- Problems completed/not completed/not tried, MUST be explicitly indicated on the cover page.
- Each problem MUST start on a separate page. (No more than 1 problem on a page)
- Problem solution procedure:
  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: The problem is solved in a systematic and logical manner, **showing all steps**, the fundamental equation from which the analysis begins and numerical values (with units) shown.
  vii. Answers clearly marked with a box. (ex: | q = 100 watts |)

(4) Exams Requirements
(a) Simple Scientific Calculator (Reset on exam)
(b) Closed book and notes. Formula to be provided on the problem sheets.
(c) No tele-communication tools, such as cell phone, lab-top. No share of calculator.

(5) Active Participation
(a) Late or no attendance will be counted except prior permission.
(b) Participation credit: Pay attention to lectures, Q&A and instructor’s direction; and Final project participation.

III. Course Website

Canvas: https://njit.instructure.com/courses/32496 (UCID login required)

- Announcement: Check and Update your contact email address in Canvas. Everything will be emailed through it.
- Every notice, change and exam information will be posted on Canvas Announcement and sent through it.
- Assignment: HWs will be posted and emailed through Canvas. HW/Project submission on it.
- Modules: lecture notes to be posted.

IV. Academic Integrity

NJIT Honor Code is strictly enforced over the course of all the activities including Reports and EXAM.

**** 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"*

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Final Project Guideline

A. Team Size and Role

1. Standard size of team is **2-3 students**.
2. Formulate your team by yourself with your choices and preferences

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, convention and radiation- mixed problem is preferred. or the problem with at least two of heat transfer mode mixed is preferred.

C. Standard Report Guideline

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: Total 15 pages maximum.

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 shown above are only for suggestions, not for a limit. However, the total page of Technical Narrative sections 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 reference.
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 for Technical Narrative Section**, excluding Cover page, Table of contents, References and Appendix.
2. Writing Format:
   - **Letter size page,**
   - **1-inch margin,**
   - **Font size: 12 for Times New Roman, 11 for the other font** (Bigger font for headings is OK.)
   - **Single-spaced lines.**

*Note: Penalty up to 30% loss maximum if not follow the guideline on writing format, page limit and proper sections.

E. Evaluation – Final project evaluation guideline:

I. General section: (10%)

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

<u>II. Technical Narrative sections: (80%)</u>
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%)

<u>* Note-1:</u> 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.

<u>III. References and Appendix:</u> (10%)
A. References (Details of each reference 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:
100 - 90%: strong background study, model develop, analysis, in-depth analysis, conv/cond/rad mix-up problem
89 - 80%: Good, may be a typical problem, good-to-fair analysis, or results are generally good,
79 - 70%: Fair at many sections, typical problem, generally fair-to-weak analysis, results are generally fair,
69 - 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, strictly prohibited.): Honor Code strictly reinforced.*
=> Copy from other reports or improper quotes will result in the critical loss (up to 100 %) in grading, depending on the level of plagiarism.

F. Submission Format and Due Date

- Submission materials and Due Dates
  - Final Presentation slides: (4/29. Mon. 6 PM) Presentation Day.
  - Final Report: (5/2. Thu. 6 PM) Reading Day2.

- **Canvas submission** – Upload **PDF (or Word/PPT)** files only.

- Late Submissions guideline:
  - Late submission within 24-hour time frame: 10% off on grading.
  - Late submission between 24-hour and 1-week time frame: 30 % off on grading.
  - Late submission after 1-week time frame: ZERO point, and NOT accepted for grading.

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Project 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 progress to the completion of the project scope.

2. Meeting time and arrangement (when requested by team)

   i. Meeting date: to be arranged on request by individual team, in the middle of project progress.

   ii. Duration of the meeting: ~ less than 30 min/team

   iii. The slot (15-30 min) Before or After each class meeting or an appointment may be available on request for the project meeting.

   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.

   v. Team Leader is responsible for the communication with all the team members.

   vi. Project progress materials should be emailed to the instructor at least 24 hrs before the meeting time, for the prior review.

   vii. Key information MUST be included in every email communication with the instructor:

      - Team member names
      - Project title
      - A short explanation of the project scope
      - Question(s)
      - Supporting materials for the explanation of questions, or the up-to-date progress materials of your project, or system pictures of your project and schematic drawings of the scope of your analysis, etc.

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Exam Guideline (for Onsite exam)

Exam requirements:

- Closed book, closed note: No lecture notes or lecture materials allowed.
- No Formula sheet allowed.
  - Key Formulas including relevant relations will be provided on the exam sheets.
  - However, Basic formulas should be memorized:
    - For example, basic fundamental relations such as Fourier's law of conduction, Newton's law of convection, Stefan-Boltzmann's Law of radiation won't be provided. However, the other details such as Stefan-Boltzmann constant value will be provided if it’s relevant to the problem. Also, material properties or constant values will be provided.
    - In conduction chapters, basic thermal resistance relation or concept such as 1-D linear relation in cartesian coordinate system will not be provided. (Cylindrical or spherical coordinate relation will be provided if it’s considered.)
    - In convection chapters, basic non-dimensional parameters such as Reynolds number relation (rho*U*D/mu), Prandtl Number relation (nu/alpha), Nusselt Number relation (h*D/k), will not be provided on the problem sheet.
    - In radiation chapters, basic relations such as Stefan-Boltzmann Law, Wien's displacement law, black body radiation relation, will not be provided.
  - If you have any questions, please let me know to clarify.
- No cellphone allowed during the exam.
- Pen, eraser, simple scientific calculator (Reset before the exam. No wifi/Bluetooth), only allowed.