

ME 164

Fundamentals of Heat and Mass Transfer

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WFUV: ME 4 WF 10:00–12:30 | WFWX: ME 4 WF 13:00–15:30 | THXY: E-LAB TTh 14:30–17:00.

COURSE OBJECTIVES

This course recalls, reinforces, and extends knowledge of transport phenomena (i.e. transport of mass, momentum, energy), and focuses on heat transfer (i.e. conduction, convection, and radiation). It requires a *strong* grasp of core engineering principles of thermodynamics and fluid mechanics. Computational methods and tools are incorporated when and where they are needed. This course aims to:

- Reinforce and extend students' knowledge of transport phenomena so they can use it to model, analyze, and design thermal products and systems.
- Provide students with the ability to model and analyze conduction, convection, and radiation heat transfer processes and scenarios.
- Introduce students to mass transfer processes and scenarios.
- Let students apply their knowledge of numerical methods on the modeling and analysis of complex heat and mass transfer processes and scenarios.
- Enhance students' analytical, problem-solving, experimentation, and communication skills via a reasonable number of guided and unguided problem-solving exercises, brief reports, and formal experiments.

LEARNING OUTCOMES

After successful completion of the course, students should be able to:

- Explain the fundamentals and engineering applications of conduction, convection, and radiation heat transfer, and diffusion and convection mass transfer.
- Identify, model, and analyze heat and mass transfer processes and scenarios.
- Use computational methods and tools to model and analyze complex heat and mass transfer processes and scenarios.
- Systematically solve engineering problems involving heat and mass transfer.
- Design and conduct heat and mass transfer experiments.
- Communicate information in the context of thermal and fluids engineering effectively.

REFERENCES

- Bergman, T. L., Lavine, A. S., Incropera, F. P., & DeWitt, D. P. (2011). *Fundamentals of Heat and Mass Transfer* (7th ed.). Hoboken, NJ: Wiley.*
- Lienhard IV, J. H., & Lienhard V, J. H. (2015). *A Heat Transfer Textbook* (4th ed.). Cambridge, MA: Phlogiston Press.
- Bejan, A., & Kraus, A. D. (2003). *Heat Transfer Handbook*. Hoboken, NJ: Wiley.
- Nellis, G., & Klein, S. (2009). *Heat Transfer*. New York, NY: Cambridge University Press.

CALENDAR

Lecture	Topics	Activities
0	Course introduction	
Introductory Concepts of Heat Transfer		
1	Modes of heat transfer Systematic problem solving	R1: 1.0–1.2, 1.4–1.5
2	The relationship of thermodynamics and heat transfer	R2: 1.3, 1.6–1.7
Fundamentals of Heat Conduction		
3	Fourier's law Thermal properties pertinent to heat conduction	A1; R3: 2.0–2.2
4	Heat diffusion	R4: 2.3–2.5
5	1-D S-S conduction I: plane walls	A2; R5: 3.0–3.2
6	1-D S-S conduction II: radial systems and energy generation	R6: 3.3–3.5
7	1-D S-S conduction III: extended surfaces	A3; R7: 3.6
8	2-D S-S conduction I: shape factors and heat rates	R8: 4.0–4.1, 4.3
9	2-D S-S conduction II: finite difference method	A4; R9: 4.4–4.6
10	Transient conduction I: lumped capacitance analysis	R10: 5.0–5.3
11	Transient conduction II: finite difference method	A5; R11: 5.10–5.11
Fundamentals of Forced Convection and Introduction to Mass Transfer		
12	Convection I: boundary layers and convection coefficients	R12: 6.0–6.3
13	Convection II: boundary layer equations and normalization	A6; R13: 6.4–6.5
14	Convection III: dimensionless parameters and analogies	R14: 6.6–6.8
Internal and External Flows		
15	External flows I: parallel flow over flat plates	A7; R15: 7.0–7.3
16	External flows II: cylinders, spheres, and banks of tubes <i>End of midterm exam coverage</i>	R16: 7.4–7.6
17	Internal flows I: hydrodynamics and heat transfer	A8; R17: 8.0–8.3
18	Internal flows II: flows in tubes	R18: 8.4–8.6
Fundamentals of Free Convection		
19	Free convection I: fundamental considerations	A9; R19: 9.0–9.3
20	Free convection II: basic flow types	R20: 9.4–9.6
Basic Analysis and Design of Heat Exchangers		
21	Heat exchangers I: fundamentals and the LMTD method	A10; R21: 11.0–11.3
22	Heat exchangers II: Effectiveness-NTU method and design	R22: 11.4–11.7
Fundamentals of Radiation		
23	Radiation I: fundamentals	A11; R23: 12.0–12.3
24	Radiation II: blackbodies and idealized ones	R24: 12.4–12.8
25	Surface radiation I: blackbodies and idealized ones	A12; R25: 13.0–13.3.2
26	Surface radiation II: special cases Multimode heat transfer	R26: 13.3.3–13.4
27	Radiation with participating media	A13; R27: 13.5–13.7
Heat Transfer Experiments		
28	Experiment day 1	R28: TBD
29	Experiment day 2 <i>End of final exam coverage</i>	A14; R29: TBD
Beyond the Fundamentals of Heat and Mass Transfer		
30	Denouement: thermal and fluids engineering industries	

REQUIREMENTS

- *Readings.* 29 instances at 0% each. Students should read assigned readings before corresponding lectures.
- *Assignments.* 14 instances at 1.5% each. Collaboration is highly encouraged and allowed but copying is not. All should be submitted in due time; failure to do so will result to a grade of 5.0.
- *Exams.* The midterm exam is 30% and the final exam is 30%. Scores are out of 100 and should not go below 30.
- *Experiment.* 1 instance at 19%. The experiment requires 1 lab report. It should be submitted in due time; failure to do so will result to a grade of 5.0.