MECH-420 Heat Transfer

Catalog Data Credit (4-0-4) Four Lecture Hours

Prerequisites MECH-322, Fluid Mechanics

Description This course covers the principles of heat transfer by conduction, convection, and radiation. Energy conservation approaches, fins analysis, steady state and transient problems, numerical analysis, analysis, and selection of heat exchangers, and radiation shields are discussed.

Textbook Bergman, Lavine, DeWitt, Incropera, Introduction to Heat Transfer, 8th Edition, John Wiley & Sons.

References Dr. K. J. Berry; Engineer, Educator, Entrepreneur

Professor **Dr. K. J. Berry, P.E., Professor of Mechanical Engineering**
Room 1101 Mott, jberry@kettering.edu,

Lectures: ZOOM/BLACKBOARD

ZOOM LINK: Dr. Berry's Classroom: FOLLOW THE PATH

OH: R/6:30PM-8:30PM/LC

Course Learning Objectives

Upon completion of this course, the student will be able to:

1. Identify the three modes of heat transfer: conduction, convection and radiation for a given energy system [ABET Student Outcome: 1].
2. Analyze physical heat transfer problems by reducing them to workable mathematical models [ABET Student Outcome: 1].
3. Solve heat conduction problems in steady-state and transient conditions through application of rate equations and the conservation of energy law [ABET Student Outcome: 1].
4. Solve convective heat transfer problems by determining convective heat transfer coefficients and the corresponding heat transfer rate for forced and natural, external and internal convective heat transfer problems [ABET Student Outcome: 1].
5. Design heat exchangers and analyze their performance [ABET Student Outcomes: 1,2,5,6].
6. Solve radiation heat transfer problems incorporating surface radiative properties [ABET Student Outcome: 1].
7. Utilize suitable numerical techniques and computer tools in the formulation and solution of open-ended heat transfer design problems in a project team setting [ABET Student Outcomes: 1,2,5].

Prerequisites by topic

1. Partial derivatives
2. Thermodynamics and fluid mechanics principles covered in prerequisites
3. Basic computer skills (MS Word, Excel and MATLAB, or equivalents)

Topics covered

Week *Topic*

1. Conduction, convection, radiation basics; rate equations; energy balance and the control volume and control surface concepts
2. 1-dimensional steady-state conduction, plane and radial geometries; heat diffusion equation; boundary and initial conditions
3. Thermal resistance models, heat generation problems; design of fins
4. Two-dimensional steady-state conduction; numerical methods
5. Transient conduction problems
6. Dimensionless analysis; forced external convection problems
7. Forced internal convection problems, natural convection problems
8. Heat exchanger fundamentals; U-factor calculation; LMTD and ε-NTU methods
9. Heat exchanger design and analysis; phase-change heat exchangers
10. Radiation heat transfer design; effects of surface properties; view factors
11. Final examination

Schedule Two 120-minute sessions per week. Terms Offered: All

Computer usage Basic computer skills (MS Word, Excel and MATLAB or equivalent). Students may use IHT and FEHT software provided with text for open-ended heat transfer design problem solving.

Design Project Design project solving current technical problems involving heat transfer principles.

Relationship to professional component

This course is 90% engineering science and 10% engineering design.

Prepared by Dr. K. J. Berry, Professor of Mechanical Engineering, ASME FELLOW

GRADING POLICY

Attendance, conduct, and class participation will be considered for the final grade. The final grade will be tentatively determined as follows:

Quizzes	0%-30%
Exams/Project	40%-70%
Final exam	30%

There are no makeup exams or quizzes.

GRADING SCALE

A	94-100
A-	90-93
B+	86-89
B	83-85
B-	76-79
C	73-75
C-	70-72
D+	65-69
D	60-64
F	<59

CONDUCT POLICY

Student must behave properly to be fair to anyone else in the classroom. Students who, in the opinion of the instructor, exhibit unprofessional, inappropriate and/or disruptive (i.e., chattering) behavior in the classroom will be dismissed from the class. Readmission to class will only occur upon the written recommendation of the ME Department Head.

ELECTRONIC DEVICES POLICY

The use of laptops, cell phones, iPhones, iPods, and any other devices for entertainment purposes or texting is STRICTLY PROHIBITED during lecture, except for following lecture PPT online. Students who repeatedly disregard this policy will be asked to leave the classroom.

COMMON STATEMENT ON ETHICS IN THE UNIVERSITY AND ACADEMIC INTEGRITY

Kettering University values academic honesty and integrity. Cheating, collusion, misconduct, fabrication, and plagiarism are serious offenses. Each student has a responsibility to understand, accept, and comply with the University's standards of academic conduct as set forth in our statement, "Ethics in the University," and "Academic Integrity" as well as policies established by individual professors. For more information, refer to the Student Life section of the current Undergraduate Catalog. Undergraduate catalogs are located at http://www.kettering.edu/undergraduate.This information is also noted in the Student Handbook.

Common Statement on Students with Documented Disabilities:

- The University will make reasonable accommodations for persons with documented disabilities.
- Students need to register with Wellness Center every term they are enrolled in classes.
- To be assured of having services when they are needed, students should contact the Wellness Center during the first week of each term.
- Note that it is the student's responsibility to arrange accommodations with each professor as the Wellness Center cannot approve a class absence.
- http://www.kettering.edu/studentlife/docs/student_handbook.pdf (page 26)
- http://www.kettering.edu/registrar/docs/2011-12UndergraduateCatalog.pdf (page 46)

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HOW TO APPROACH THE COURSE

- Read/scan the material to be covered and understand objectives of chapter
- Attend class/take notes
- Compare notes with book material
- Ideally should write a new set of notes
- Complete practice problems
- Compare your work with solutions
- Always remember to PACE yourself
- KEEP UP with the course material
- Develop your study techniques
- **UNDERSTAND AND FOLLOW THE ROAD MAP**

HOW TO APPROACH EXAMS/QUIZZES

- **DO NOT WAIT THE DAY BEFORE THE EXAM TO STUDY**
- Keep up and just review the material
- RELAX and then PACE yourself
- Read/scan all questions first
- Cut down your losses, do not spend too much time on one problem
- ***BEST TO PRESENT YOUR APPROACH AND THOUGHT PROCESS, RATHER THAN RANDOM UNCONNECTED RAMBLINGS JUST TO PUT SOMETHING ON PAPER WITH NO LOGIC OR MEANING.***

BEST ADVICE FOR SUCCESS

MECH-420 with Dr. Berry has pushed me to limits I did not know I had. But I can say with 100% certainty I am a better student and will be a better engineer as a direct result of it. Taking this course with Dr. Berry was a blessing. You will work hard in this course, but you will MASTER the concept as they apply to the real world.

TENTATIVE SCHEDULE, READING MATERIAL, AND PRACTICE PROBLEMS Session	Subject	Reading Material	Practice Problems for 8th edition
1.1	Introduction	Sect. 1.1-1.2	1.1, 1.4, 1.6, 1.7, 1.10, 1.13, 1.16, 1.19,1.21, 1.23,1.24
1.2	Surface Energy Balance **QUIZ/ASSIGNMENT**	Sect. 1.3-1.6	1.26, 1.35, 1.36, 1.39, 1.40, 1.48, 1.50, 1.51, 1.56
2.1-2.2	Intro to Conduction **QUIZ/ASSIGNMENT**	Sect. 2.1- 2.4	2.6, 2.8, 2.9, 2.11, 2.16, 2.26,2.34, 2.35, 2.39, 2.40, 2.43, 2.46, 2.48, 2.52
3.1	1D Conduction	Sect. 3.1-3.5	3.3a, 3.4a, 3.6abc, 3.13, 3.17, 3.20, 3.21, 3.22, 3.23, 3.24, 3.39, 3.41
3.2	Resistance Network **QUIZ/ASSIGNMENT**	Sect. 3.1	3.48, 3.51, 3.53, 3.56, 3.57, 3.63, 3.68, 3.69, 3.74, 3.77, 3.84, 3.86, 3.92
4.1	Fins	Sect. 3.6	3.102, 3.113, 3.114, 3.118, 3.122
4.2	Fins Efficiency	Sect. 3.6	3.124, 3.125, 3.126
5.1	**EXAM I**		
5.2	Transient Lumped Conduction	Sect. 5.1-5.3	5.6, 5.10, 5.11, 5.13, 5.23, 5.25, 5.26, 5.27, 5.45, 5.47,5.48a, 5.49a
6.1	Transient Conduction	Sect. 5.4-5.7	5.52, 5.53, 5.59, 5.61, 5.67, 5.71, 5.72, 5.78, 5.79, 5.85,
7.1	Convection	Sect. 6.1-6.7	6.2, 6.3, 6.7, 6.8, 6.18, 6.31, 6.36, 6.41, 6.45
7.2	Flow over a flat plate	Sect. 7.1-7.3	7.1a, 7.2ab, 7.7, 7.17, 7.19, ,7.20a, 7.20b, 7.22, 7.22, 7.25, 7.27, 7.32, 7.33, 7.36, 7.38, 7.39,7.41, 7.42, 7.49, 7.50
8.1	External Flows **QUIZ/ASSIGNMENT**	Sect. 7.4-7.6	7.54ab, 7.55ab, 7.60, 7.65
8.2	Internal Flow	Sect. 8.1-8.6	8.1, 8.3, 8.4ab, 8.5, 8.20, 8.24, 8.25, 8.26a, 8.28, 8.37, 8.42, 8.49, 8.50, 8.54,
9.1	Free Convection	Sect. 9.1-9.6	9.4, 9.7, 9.9, 9.16, 9.22, 9.35, 9.39, 9.52, 9.53, 9.77, 9.95
9.2	Heat Exchangers	Sect. 11.1-11.3	11.11, 11.12, 11.13, 11.15, 11.16, 11.19, 11.20, 11.21, 11.32, 11.34
10.1	ε-NTU Method **EXAM II**	Sect. 11.4-11.5	11.48, 11.49, 11.51, 11.57, 11.62, 11.63a, 11.64,
10.2	Radiation	Sect. 12.1-12.4	12.14, 12.15, 12.20
11.1	Radiation Between Surfaces	Sect. 13.1-13.2	13.1, 13.42, 13.49, 13.57, 13.67, 13.69, 13.70
	FINAL EXAM		

The instructor reserves the right to modify the time, order, and content of the course schedule.