Heat and Mass Transfer – ENGR 334
Abilene Christian University
Spring 2016

Catalog Description

This course is a study of the rates of heat and mass transfer using the fundamental mechanisms of conduction, convection and radiation. **Prerequisites:** ENGR 381 and Math 361; **Corequisite:** ENGR 333. **Credit hours:** 3

Class Meeting Times and Location

This class meets on Tuesday and Thursday from 9:30 a.m. to 10:50 a.m. in Foster Science Building Room 379, but changes in time and location may occur with changes in department scheduling.

Required Text and Software

Text: *Heat and Mass Transfer Fundamentals and Applications*, 5th Edition, Y. Cengel and A. Ghajar, McGraw-Hill, 2015.
Software: *Connect* by McGraw-Hill; software access is provided with the text.

Contact Information

Name:	Rich Jinkerson, PE, Associate Professor of Engineering and Physics
Office:	Foster Science 317D
Phone:	325-674-2165 Cell: (817) 454-6163 (Text or Call)
Email:	Richard.jinkerson@acu.edu
Office hours:	MW 8:00 a.m. - 9:30a.m., TR 1:00 p.m.-4:00 p.m. Additional office hours can be arranged by appointment.

Intended Audience

This course satisfies a specified elective requirement for engineering majors and will normally be taken in the third year of the engineering degree program. Prerequisite skills require completion of ENGR 381 and MATH 361 and completion or concurrent enrollment in ENGR 333.

The mission of ACU

To educate students for Christian service and leadership throughout the world.

The mission of the College of Arts and Sciences

To educate students for worldwide Christian service and leadership through programs of study and other learning experiences that blend a liberal arts education with professional and career education.

The mission of the Engineering and Physics Department

The ACU engineering program strongly supports the university's mission of educating students for Christian service and leadership throughout the world. In support of this mission, ACU engineering graduates will attain:

-A deep and broad understanding of engineering principles and practices as evidenced by professional employment, continued professional development, and graduate study in engineering or other professional fields.
- An extensive knowledge of the innovative design processes unique to engineering professionals as demonstrated by using critical thinking skills to contribute to the scientific and technical literature, patents and intellectual property, professional societies, and creative designs.
-A thorough understanding of Christian service and leadership as shown in their commitments to professionalism, ethics, and service and leadership within the engineering profession, the church and society.

Teaching Philosophy

Engineering and physics are respected professions. The public places great trust in these professionals as honest, competent, and ethical individuals. Many codes of ethics for these fields indicate that a commitment to protecting the health, safety, and welfare of the public is of paramount importance. These values are in harmony with Christian principles and ideals as exhibited in passages from the Bible. Christian engineers should be honest (Matthew 5:37), work hard to ensure competency (Colossians 3:23), and put the interest of the public ahead of his or her own (Luke 6:31). In keeping with these principles this course will be taught so that students may gain an appreciation for the professional nature of engineering and physics. The instructor encourages the discussion of topics that relate to the integration of faith and professional responsibilities.

Class Format

Class time will usually be spent in lecture and discussion that builds on the treatment in the text of heat transfer principles. Class participation will not be graded formally, but active engagement by students will enhance the learning process. Reading before class will make the discussions more useful. Preparation should also be made so that a student is ready to assist in derivation and solution work if invited to do so. As students study example problems they should work to understand the reasons for problems being solved in a particular way. Developing the ability to understand why a solution step is appropriate is part of the process of gaining the skill for design decisions that will be made as an engineer.

Learning Objectives

This courses provides significant direct focus on the following ABET Student Program Outcomes:

(a) An ability to apply knowledge of mathematics, science, and engineering
(e) An ability to identify, formulate, and solve engineering problems
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

These program outcomes are promoted and actualized through instruction, graded homework assignments and examinations.

Competencies and Measurements

	Competency	Measurement
1	Calculate rates of heat transfer with conduction, convection and radiation.	Homework; Quizzes; Exam 1
2	Apply analytical and numerical methods to model and solve heat conduction problems in multiple coordinate systems.	Homework; Quizzes; Exam 2
3	Develop an understanding of forced and natural convection in engineering systems.	Homework; Quizzes; Exam 3
4	Analyze and select heat exchangers using standard methods.	Homework; Quizzes; Exam 3
5	Solve general problems involving both heat and mass transfer.	Homework; Quizzes; Exam 4

Course Policies

Academic Integrity

Academic integrity involves completion of assigned academic work for each class by the individual or group responsible for the work. Violations of academic integrity and other forms of cheating include the intention to deceive, mislead, or misrepresent, and are therefore forms of lying. Such actions are contrary to behavioral norms that flow from the nature of God. Academic misconduct includes, but is not limited to: failing to give credit to sources used in a work in an attempt to present the work as one's own; submitting papers or projects obtained from another source as one's own; falsifying information orally or in writing; and receiving, giving, or using unauthorized aid on examinations or quizzes. An example of academic misconduct might be copying an instructor's solution without permission and sharing the solution with classmates; all participants in this activity would be guilty of academic misconduct. Such actions may result in, but are not limited to, a zero grade for the assignment and/or a failing grade in the course. The department chairman, the Dean of the College of Arts and Sciences and the Dean of Student Life will also be notified of this activity. The full university policy, including the process for appealing a decision, may be found at the link: http://www.acu.edu/academics/provost/policies/index.html.

Attendance Policy

Attendance with prompt arrival is expected for all class sessions. Absence or tardiness will negatively affect performance on homework and examinations. Classes will typically involve the presentation and discussion of new material, discussion of reading assignments from the text, or the consideration of problem solutions. Students are required to attend at least 80% of class meetings in order to receive credit for the course. Absences cannot exceed 6 times regardless of the reason. A student who misses more than 20% of the scheduled classes will be dropped from the class with a grade of WF, which is averaged in the students GPA as a grade of F.

Grading Policy

Course Assignments	Due Date	Weight
Homework assignments and due dates are included in the Daily Schedule. Homework will use the software package *Connect* that is provided by the textbook publisher. Each homework problem will have points assigned based upon the level of effort that is required to solve the problem, and the student will see the number of points for each problem when the assignment is started. Homework will be due at 8:00 AM on the date shown on the Daily Schedule. **No late homework will be accepted.** Students are encouraged to	**Shown on the Daily Schedule**	**40%**

allocate time in advance of the due date to start on the homework, and to visit with the instructor when difficulties are encountered with particular problems. Working together on problems is also encouraged, but all solutions presented for credit must be defensible by the student submitting them for credit and must be consistent with the academic integrity policy. Overt copying of another student's work is not acceptable. Care should also be exercised in becoming too dependent on a study partner because the study partner will not be available for assistance during exams. The final homework grade will be calculated as a percentage ratio of the number of points awarded to the number of points possible.		
Quizzes Quizzes will be unscheduled and normally given at the beginning of a class period. The quizzes may use the online *Connect* software application that is used for homework, with students logging on by laptop, or they may be handed out on paper. The quizzes will be short with a limited time period for completion. The final grade for quizzes will be calculated as a percentage ratio of the number of points awarded to the number of points possible.		**10%**
Regular Exams Four examinations are scheduled for this class, with dates and times for the exams shown on the Daily Schedule. Each exam will focus on material covered during the period immediately preceding the exam, but each exam will build on concepts and skills that have been developed in the course until that time. All students are expected to take each exam at the scheduled times. Each student will be allowed to bring one single-sided 8½ X 11 sheet of handwritten notes to the exam containing content that is selected by the student.	**Exam 1 – February 2** **Exam 2 – March 1** **Exam 3 – April 7** **Exam 4 – April 28**	**10%** **10%** **10%** **10%**
Final Exam The final examination will be comprehensive and will cover material from throughout the period of the course.	**May 6**	**10%**

Calculation of Final Course Grade*

90% and above . . . . A
80% - 89% . . . . B
70% - 79% C
60% - 69% . . . . D
59% and below . . . . F
*Instructor reserves the right to decrease the lower bound for grade cut-offs.

ADA Compliance Statement

Abilene Christian University is dedicated to removing barriers and opening access for students with disabilities in compliance with ADA and Section 504 of the Rehabilitation Act. The Alpha Scholars Program facilitates disability accommodations in cooperation with instructors. In order to receive accommodations, a student must be registered with Alpha Scholars Program, and must complete a specific request for each class in which he or she needs accommodation. If a student has a documented disability and wishes to discuss academic accommodations, he or she may call the office directly at 325-674-2667.

ENGR 334 Heat and Mass Transfer
Spring 2016 Daily Schedule

Text: Cengel and Ghajar: Heat and Mass Transfer, 5th Edition, McGraw-Hill (2015)
Instructor: Rich Jinkerson, P.E.
Email: Richard.jinkerson@acu.edu

Class	Date	Day	Chapter	Class Agenda	Homework from Lecture in *Connect*	HW Due Today
1	1/12	Tu	1	• Introductions • Course Policy Statement • 1-1 to 1-4 • Thermodynamics and Heat Transfer • Engineering Heat Transfer • Heat and Other Forms of Energy • First Law of Thermodynamics	1-Introduction to Heat Transfer	
2	1/14	Th	1	1-5 to 1-11 • Heat Transfer Mechanisms • Conduction • Convection • Radiation • Simultaneous Heat Transfer Mechanisms	2-Heat Transfer Mechanisms	1
3	1/19	Tu	2	2-1 to 2-3 • Basic Heat Conduction • One-Dimensional Heat Conduction • General Heat Conduction	3-Heat Conduction 1	2
4	1/21	Th	2	2-5 to 2-7 • Boundary and Initial Conditions • Steady One-Dimensional Heat Conduction Problems • Variable Thermal Conductivity	4-Heat Conduction 2	3
5	1/26	Tu	3	3-1 to 3-5 • Steady Heat Conduction in Plane Walls • Thermal Contact Resistance • Heat Conduction in Cylinders and Spheres • Critical Radius of Insulation	5-Heat Conduction 3	4
6	1/28	Th	3	3-6 to 3-8 • Heat Transfer from Finned Surfaces • Heat Transfer in Common Configurations	6-Heat Conduction 4	5
7	2/2	Tu		EXAM ONE • HEAT AND MASS TRANSFER – CHAPTERS 1-3		6

8	2/4	Th	4	4-1 to 4-2 • Lumped System Analysis Transient Heat Conduction in Large Systems	7- Transient Heat Conduction	
9	2/9	Tu	5	5-1 to 5-3 • Finite Difference Formulation of Differential Equations • Numerical One-Dimensional Steady Heat Conduction	8- Numerical Methods in Conduction 1	7
10	2/11	Th	5	5-4 to 5-5 • Numerical Two-Dimensional Steady Heat Conduction • Numerical Transient Heat Conduction	9-Numerical Methods in Conduction 2	8
11	2/16	Tu	6	6-1 to 6-4 • Physical Mechanism of Convection • Fluid Flow Classification • Velocity Boundary Layer • Thermal Boundary Layer	10-Convection and Flow 1	9
12	2/18	Th	6	6-5 to 6-8 • Laminar and Turbulent Flows • Heat and Momentum Transfer in Turbulent Flow • Differential Convection Equations • Convection Equation for Flat Plate	11-Convection and Flow 2	10
13	2/23	Tu	6	6-9 to 6-11 • Nondimensional Convection and Similarity • Friction and Convection Coefficients • Heat and Momentum Transfer Analogies	12-Convection and Flow 3	11
14	2/25	Th	7	7-1 to 7-4 • Drag and Heat Transfer in External Flow • Parallel Flow over Flat Plates • Flow across Cylinders and Spheres • Flow across Tube Banks	13-External Flow	12
15	3/1	Tu		**EXAM TWO** HEAT AND MASS TRANSFER – CHAPTERS 4-7		13
16	3/3	Th	8	8-1 to 8-4 • Introduction to Internal Flow • Average Velocity and Temperature • Entrance Region General Thermal Analysis	14-Internal Flow 1	
17	3/8	Tu	8	8-5 to 8-6 • Laminar Flow in Tubes • Turbulent Flow in Tubes • Transitional Flow in Tubes	15-Internal Flow 2	14

18	3/10	Th	9	9-1 to 9-3 • Physical Mechanism of Natural Convection • Equation of Motion and Grashof Number • Natural Convection over Surfaces	16-Natural Convection 1	15
19	3/22	Tu	9	9-4 to 9-6 • Natural Convection from Finned Surfaces and PCBs • Natural Convection Inside Enclosures • Combined Natural and Forced Convection	17-Natural Convection 2	16
20	3/24	Th	10	10-1 to 10-3 • Boiling Heat Transfer • Pool Boiling • Flow Boiling	18-Boiling Heat Transfer	17
21	3/29	Tu	10	10-4 to 10-7 • Condensation Heat Transfer • Film Condensation • Film Condensation Inside Horizontal Tubes • Dropwise Condensation • Non-Boiling Two-Phase Flow Heat Transfer	19-Condensation Heat Transfer	18
22	3/31	Th	11	11-1 to 11-3 • Types of Heat Exchangers • Overall Heat Transfer Coefficient • Analysis of Heat Exchangers	20-Heat Exchangers 1	19
23	4/5	Tu	11	11-4 to 11-6 • Log Mean Temperature Difference Method • Effectiveness-NTU Method • Heat Exchanger Selection	21-Heat Exchangers 2	20
24	4/7	Th		**EXAM THREE** HEAT AND MASS TRANSFER – CHAPTERS 8-11		21
25	4/12	Tu	12	12-1 to 12-6 • Blackbody Radiation • Radiation Intensity • Radiative Properties • Atmospheric and Solar Radiation	22-Thermal Radiation 1	
26	4/14	Th	13	13-1 to 13-6 • View Factor Relations • Radiation Heat Transfer: Black, Diffuse & Gray Surfaces • Radiation Shields and Radiation Effects • Radiation Exchange with Emitting and Absorbing Gases	23-Thermal Radiation 2	22

27	4/19	Tu	14	14-1 to 14-5 • Introduction to Mass Transfer • Analogy between Heat and Mass Transfer • Mass Diffusion • Boundary Conditions • Steady Mass Diffusion Through Walls	24-Mass Transfer 1	23
28	4/21	Th	14	14-6 to 14-10 • Water Vapor Migration in Buildings • Transient Mass Diffusion • Diffusion in a Moving Medium • Mass Convection • Simultaneous Heat and Mass Transfer	25-Mass Transfer 2	24
29	4/26	Tu		Review Session		25
29	4/28	Th		• **EXAM FOUR** • HEAT AND MASS TRANSFER – CHAPTERS 12 -14		
30	5/6	Fr		• **FINAL EXAM** 8:00-9:45 AM		