SYLLABUS

DESCRIPTION

Lecture course on the basic design of buildings and their systems to satisfy the requirements for a comfortable and healthy indoor environment. Topics include the application of thermodynamics, fluid dynamics, and heat and mass transfer in providing comfort.

LECTURES
2:00 - 3:15 Tuesday, Thursday
DUAN G125

INSTRUCTOR
Michael J. Brandemuehl
ECCE 246A, 303 492 8594
(In Larson Lab offices, above CAD Lab)
michael.brandemuehl@colorado.edu

Office Hours: 4:30 – 5:30 Tuesday
2:00 – 4:00 Wednesday

TEACHING ASST.
Emily Rader
ECCE 168
emily.rader@colorado.edu

Problem Session: 6:00 – 7:30 pm Tuesday, Room ECCR 1B55

Office Hours: 11:00 – 12:30 Thursday

TEXT
McQuiston, F.C., J.D. Parker, and J.D. Spitler. 2005. *Heating, Ventilating, and Air Conditioning: Analysis and Design, Sixth Edition*. John Wiley & Sons, New York

WEB PAGE
http://culearn.colorado.edu

EVALUATION

Hour Exam	20%
Homework	20%
Quizzes	10%
Projects	50%

OBJECTIVES

The overall objective of this course is to introduce students to the principles and techniques for analysis and design of energy-efficient systems for maintaining a comfortable, healthy, and productive indoor environment in buildings. Upon successful completion of the course, students will have:

1. The ability to identify the criteria and metrics for a comfortable and healthy indoor environment. These criteria and metrics are determined by human physiology, but for practical design purposes, are also dictated by building codes and standards.
2. The ability to identify and analyze the characteristics of weather, building construction, and building operations as they define the requirements for comfortable and healthy indoor environment.
3. The ability to analyze the heating, ventilating, and air conditioning requirements of residential and small commercial building. Given the need to maintain a comfortable and healthy indoor environment, you will be able to determine HVAC loads (i.e., the requirements) as a function of a building's physical characteristics, its use, and its climatic

location. The analyses will be performed by applying basic engineering knowledge with hand calculations and computer simulation.

4. The ability to select and size heating and cooling equipment to meet HVAC requirements. This ability requires knowledge of alternative HVAC equipment performance, the interactions among system components, and the interactions of the system with the building loads.
5. The ability to evaluate the impact of building design decisions on HVAC equipment size and cost, annual HVAC energy consumption and cost, and environmental impact of energy consumption on power plant emissions.

EVALUATION

Your understanding of the course material and your ability to apply the material to engineering problems will be evaluated through a combination of homework assignments, quizzes, examinations, and projects. Homework will be assigned and graded weekly. Several of the homework assignments may also involve small experiments or real building data analysis.

The comprehensive problems or projects will be more involved than the homework and will typically include design tasks. Four projects will be assigned during the semester on the topics of thermal comfort, design of a small boiler system for heating, and design of a commercial building system using packaged rooftop air conditioning equipment.

One midterm examinations will be given during the semester. The final course evaluation will be in the form of a final individual class project. In addition, short quizzes will be administered throughout the semester at the beginning of class on most Thursdays.

COMPUTER TOOLS

Design and analysis of comfort control systems for real buildings are not performed by hand with pencil and paper alone. Rather, there are many computer-based tools available to the engineer. Some of these tools are comprehensive computer simulation programs that calculate building conditions and energy consumption hour-by-hour throughout the year. Other tools provide an environment or component models that allow faster calculation of user-defined problems.

- Spreadsheet programs, specifically Microsoft Excel, will be used for much of our analysis. In addition to the well-known calculation capabilities of these programs, we will also explore using VisualBasic programs to extent Excel beyond simple spreadsheet calculations. These tools will be particularly helpful for load and psychrometric analysis.
- eQUEST is a simulation program for design and analysis of the energy performance of buildings. This state-of-the-art analysis program performs hourly simulations of heating and cooling energy requirements in buildings, including effects of passive solar energy and daylighting. The program is one of several that are appropriate for LEED certification. You will use the program in two of your projects to evaluate design decisions on building energy use. The program is installed in the Bechtel Lab.
- A CD of supplemental programs and data tables is packaged with the textbook. The CD includes tools for many common design and analysis tasks.
- EES (Engineering Equation Solver) is an analysis tool that solves simultaneous sets of equations. The program allows the user to type a group of equations using arbitrary variable names. Provided that the problem is fully defined, the program will solve for all variable values. Most valuable, the program has built-in functions for thermophysical properties of gases and liquids. While the program is a valuable tool for any engineering analysis, it will be

particularly useful for psychrometric process analysis. The program is installed in the Bechtel Lab and is available for legal download from the course website.

GENERAL INFORMATION

1. If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and http://www.Colorado.EDU/disabilityservices. If you have a temporary medical condition or injury, see guidelines at http://www.colorado.edu/disabilityservices/go.cgi?select=temporary.html
2. Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. See full details at http://www.colorado.edu/policies/fac_relig.html. In this class, students are expected to notify the instructor by the end of the second week of the semester of any conflicts with scheduled exams or assignments. Accommodations will be made on an individual basis.
3. Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See polices at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code
4. The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH, the above referenced policies and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh.
5. All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/.

COURSE OUTLINE

Topic	Objectives	Skills	Lectures
Introduction	Understand relevance and importance of comfort and energy in buildings	Experience with comfort in real buildings	1. Introduction, energy use in buildings 2. Overview of mechanical systems
Moist Air	Understanding the behavior of moist air	Measure and assess thermal comfort	3. Psychrometrics properties 4. Psychrometrics for heating and cooling 5. Calculation tools
Indoor Environment and Comfort	Understand factors affecting thermal comfort	Assess thermal comfort and indoor environmental quality	6. Thermal comfort 7. Indoor air quality
Heating and Cooling Loads	Understand role of basic building envelope construction and internal heat gains for comfort and system design	Calculate heating and cooling loads for small buildings	8. Simple heat transfer in building envelopes 9. Glazing and insulation materials 10. Transient heat transfer 11. Infiltration 12. Solar geometry 13. Solar shading and windows
Heating System Design	Design heating system for small commercial building	Select and size heating equipment for small buildings	14. Introduction to ASHRAE Standards 15. Design heating loads 16. Basic heating equipment 17. Water distribution systems 18. Piping design 19. Pumps 20. Heating design example
Cooling System Design	Design cooling system for small commercial building	Select and size cooling equipment for small buildings	21. Design cooling loads 22. Software for design analysis 23. Basic cooling equipment 24. Alternative cooling equipment 25. Diffuser selection 26. Cooling design example
Integrated Design	Design heating, ventilating, and cooling system for commercial building	Use rating system for green building design	27. Introduction to sustainable design (LEED) 28. Systems for sustainable design

DETAILED COURSE OUTLINE

DRAFT

	Topic	
8/25	1. Introduction, energy use in buildings	
8/26	2. Overview of mechanical systems	
9/1	3. Psychrometrics properties	
9/3	4. Psychrometrics for heating and cooling	
9/8	5. Calculation tools	
9/10	6. Thermal comfort	
9/15	7. Indoor air quality	
9/17	8. Simple heat transfer in building envelopes	
9/22	9. Glazing and insulation materials	
9/24	10. Transient heat transfer	
9/29	11. Infiltration	
10/1	12. Solar geometry	
10/5	13. Solar shading and windows	
10/8	14. Introduction to ASHRAE Standards	
10/13	15. Design heating loads	
10/15	16. **Exam**	
10/20	17. Basic heating equipment	
10/22	18. Water distribution systems	
10/27	19. Piping design	
10/29	20. Pumps	
11/3	21. Heating design example	
11/5	22. Design cooling loads	
11/10	23. Software for design analysis	
11/12	24. Basic cooling equipment	
11/17	25. Alternative cooling equipment	
11/19	26. Diffuser selection	
12/1	27. Cooling design example	
12/3	28. Introduction to sustainable design (LEED)	
12/8	29. Systems for sustainable design	
12/10	30. Project Q&A	

- Homework will be collected each Thursday at the *beginning* of class. The assignment for each week will be distributed in class and posted on the website at least one week before the due date. The dates marked in **bold** correspond to dates on which homework will be collected. Each bold date is a Thursday.
- You are encouraged to work together on homework if it helps you learn the material. However, each student must submit a separate solution.
- Homework solutions for the week will be available by 5:00 p.m. on Friday. The electronic solutions will be placed on the course web page.
- Late homework will not be accepted without prior authorization.

ACCREDITATION THROUGH ABET

The Accreditation Board for Engineering and Technology (ABET) is a professional accrediting organization that accredits specific academic programs to assure quality in education. Accreditation is a voluntary, non-governmental process of peer review. It requires an educational program to meet certain, defined standards or criteria. More information can be found on the ABET website at http://www.abet.org.

ABET A-K OUTCOMES

As part of the accreditation process, ABET sets general criteria for students, faculty, facilities, educational objectives, and institutional support, as well as program criteria for specific engineering disciplines. One major criterion is a set of desired program outcomes, the so-called "a-k" outcomes. These are listed in their entirety below.

Engineering programs must demonstrate that their graduates have:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs
d) an ability to function on multi-disciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

MAPPING OF COURSE OBJECTIVES TO ABET A-K OUTCOMES

Course Objective	Outcomes
The ability to identify the criteria, metrics, and mechanisms for a comfortable and healthy indoor environment.	f, h, i, j
The ability to identify and analyze the characteristics of weather, building construction, and building operations as they define the requirements for comfortable and healthy indoor environment.	a, e, k
The ability to analyze the heating, ventilating, and air conditioning requirements of residential and small commercial buildings.	a, e, k
The ability to select and size heating and cooling equipment to meet HVAC requirements.	c, g, k
The ability to evaluate the impact of building design decisions.	c, d, e, f, g, h, j, k