SYLLABUS

Objective

The overall objective of this course is to prepare students for professional practice in the area of mechanical system design for commercial buildings. Upon completion of the course, students will possess the skills to calculate heating, cooling, and ventilation requirements, design and evaluate conventional HVAC systems to meet these requirements in the context of codes and standards, and design and evaluation low energy systems for sustainable buildings.

Scope

Students in this course will develop methods for energy-conscious design of heating, ventilating, and air conditioning systems in commercial buildings, based on a thorough understanding of component and system performance and a broad desire to achieve optimal energy efficiency in the context of prevailing codes and standards. The topics generally cover load calculations, distribution equipment and systems (e.g., fans, pumps, heat exchangers), and primary equipment and systems (e.g., chillers, cooling towers, boilers). We will focus on several factors related to the heating and cooling of commercial buildings.

- The first element deals with heating, cooling, and ventilating requirements in commercial buildings. These load calculations form the basis for HVAC system design and have a profound impact on the building system energy consumption. While the management and reduction of building loads is the first step in energy efficient building design, we will have defer rigorous consideration of building design to other courses in the program.
- The second element of the course focuses on HVAC equipment, including the primary equipment for providing heating and cooling in buildings and the secondary air and water distribution system equipment. We will include both theoretical discussions of equipment performance as well as practical methods for system design and equipment sizing. We will include a specific focus on heat exchangers.
- The third element addresses the role of HVAC systems and building energy use in integrated and sustainable building design. The issues include the economic impact of HVAC design decisions on both the initial costs of the building and the continuing operating costs. We will specifically explore alternative low-energy systems and their role on overall building system performance.
- The fourth element of the course addresses the role of codes, standards, and sustainable design guidelines in the design of building HVAC systems. We will specifically focus on ANSI/ASHRAE standards for comfort, indoor air quality, and energy consumption (Standards 55, 62, and 90.1, respectively) and the LEED rating system of the U.S. Green Building Council.

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, examinations, and a series of design projects. Two midterm examinations will be given during the semester.

Computer Tools

Design and analysis of HVAC systems for real buildings are seldom performed exclusively by hand with pencil and paper. Rather, there are many computer-based tools available to the engineer. Throughout the semester, you will gain experience with several of these tools.

- A number of tools and examples have been developed in Microsoft Excel and in stand-alone form. Almost every HVAC-related textbook today comes with a CD of such tools, including tools for psychrometrics, cooling loads, and duct and pipe analysis and design.
- EES (Engineering Equation Solver) is an analysis tool that solves simultaneous sets of equations. Provided that the problem is fully defined (e.g., same number of independent equations as variables), the program will solve for all variable values. Most valuable, the program has built-in functions for thermophysical properties of gases and liquids. The program is installed in the Bechtel Lab.
- Many HVAC equipment manufacturers have developed computer tools for HVAC system design. These tools include load calculations, duct design, piping design, heat exchanger analysis, and

equipment selection. Several of these computer tools, including the suite of programs from The Trane Company, are installed in the Bechtel Lab.

Other 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
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. In this class, {{insert your procedures here}} See full details at http://www.colorado.edu/policies/fac_relig.html.
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/.

GENERAL INFORMATION

Lectures: 3:30 – 4:45 p.m., Tuesday & Thursday, ECCR 1B08

Website: http://ceae.colorado.edu/~brandem/aren4110

Instructor: Michael J. Brandemuehl
ECCE 246 (above CAD Lab)
(303) 492-8594, michael.brandemuehl@colorado.edu

Office Hours: 1:30 – 2:30 Tuesday ***(Preliminary)***
10:00 – 12:00 Wednesday

Required 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

Optional Text: ASHRAE. 2005. *Handbook: Fundamentals*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta.

ASHRAE. 2004. *Handbook: HVAC Systems and Equipment*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta.

All students are encouraged to become student members of ASHRAE and obtain the ASHRAE *Handbook: Fundamentals*. The *Handbook: HVAC Systems and Equipment* is available and recommended for students who expect to work professionally in the areas of HVAC system design and analysis. As a student member, you will also receive the monthly ASHRAE *Journal*. The cost of membership, the *Journal*, and the handbook will be $55. The additional handbook is available for $39.

Evaluation:

Homework	15%
Participation	10%
Design Projects	30%
Exam	25%
Final Project	20%

Final Presentation: Tuesday, May 9, 10:30 a.m. – 1:00 p.m.

Graduate Differential

This course is cross-listed as both a graduate and undergraduate course. Graduate students in the course will be expected to develop deeper theoretical understanding of HVAC system principles. They will also be required to submit an additional project report. The topic of the report will be individually determined, but is expected to be based on independent readings and examination of an HVAC topic.

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Course Outline

	Class	Topic
1/16	1.	Introduction and design overview
1/18	2.	HVAC system anatomy
1/23	3.	HVAC systems (Tour)
1/25	4.	Load calculations
1/30	5.	Trane TRACE Program Tutorial
2/1	6.	Psychrometric Applications
2/6	7.	Ventilation and ASHRAE Standard 62
2/8	8.	Water flow and pressure drop in pipes
2/13	9.	Pumps and valves
2/15	10.	Piping system design
2/20	11.	Heat and mass transfer fundamentals
2/22	12.	Heat exchangers
2/27	13.	Cooling coils
3/1	14.	Coil design and selection
3/6	15.	Radiant heating and cooling
3/8	16.	Airflow and pressure drop in ducts
3/13	17.	Fans and dampers
3/15	18.	Room airflow and diffusers
3/20	19.	Duct system design and analysis
3/22	20.	Midterm Exam
4/3	21.	ASHRAE Standard 90.1 and LEED
4/5	22.	Air handler systems
4/10	23.	Chillers
4/12	24.	Cooling towers
4/17	25.	Thermal energy storage
4/19	26.	Central plant design
4/24	27.	Underfloor air distribution
4/26	28.	Dedicated outdoor air systems
5/1	29.	Ground source heat pumps
5/3	30.	Acoustics

Notes: Odd-numbered classes are on Tuesday

Projects

A significant portion of the course evaluation will be based on several HVAC design projects in actual existing and planned buildings. Projects will include:

- Design and sizing of piping system
- Heat exchanger design
- Design and sizing of an air distribution
- Design and selection of a complete HVAC system