SYLLABUS

DESCRIPTION

Lecture course on the analysis of buildings and their systems to satisfy the requirements for a comfortable, healthy, and productive indoor environment. Topics include the application of physics, electrical circuits, thermodynamics, fluid mechanics, and heat transfer for the design and analysis of energy efficient buildings. Topics include indoor environmental quality, solar energy, building thermal analysis, building electrical systems, and lighting analysis.

LECTURES	12:30 - 1:45 Tuesday, Thursday ECCR 1B08
INSTRUCTOR	Michael J. Brandemuehl ECCE 246A, 492-8594 michael.brandemuehl@colorado.edu

	Office Hours:	2:00 – 4:00 Tuesday 11:00 – 12:00 Wednesday	*Tentative*

TEXT   Stein, B., J.S. Reynolds, W.T. Grondzik, and A.G. Kwok. 2006. *Mechanical and Electrical Equipment for Buildings, 10th Edition*. New York: John Wiley & Sons.

FURTHER READING   Kreider, J.F., P.S. Curtiss, A. Rabl. 2002. *Heating and Cooling of Buildings: Design for Efficiency, 2nd Edition.* New York: McGraw Hill.

McQuiston, F.C., J.D. Parker, and J.D. Spitler. 2005. *Heating, Ventilating, and Air Conditioning: Analysis and Design, 6th Edition*. New York: John Wiley & Sons.

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

Steffy, G.R. 2002. *Architectural Lighting Design, 2nd Edition*. New York: John Wiley & Sons.

IESNA. 2000. *IESNA Lighting Handbook, 9th Edition*. New York: Illuminating Engineering Society of North America.

Chapman, S.J. 2002. *Electrical Machinery and Power Systems Fundamentals*. New York: McGraw Hill.

Hughes, S.D. 1988. *Electrical Systems in Buildings.* Delmar Publishers, Inc.

WEB PAGE   http://ceae.colorado.edu/~brandem/buildingenergysystems/

EVALUATION

Exams	40%
Homework and projects	50%
Participation	10%

OBJECTIVES

The overall objective of this course is to apply engineering science principles 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 the ability to:

1. identify the criteria and metrics for a comfortable and healthy indoor environment. These criteria and metrics are determined by human physiology, including thermal comfort and visual perception. For practical design purposes, the criteria and metrics are also influenced by building codes and standards.
2. analyze the heating, ventilating, and air conditioning requirements of residential and small commercial buildings. 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.
3. 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.
4. analyze and evaluate the impact of alternative daylighting and electrical lighting designs for residential and small commercial buildings. Given sources of light in a room, you will be able to evaluate the behavior of the light within the space.
5. identify and understand the mechanisms by which electrical energy is distributed to and utilized within buildings.

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 projects. Homework will be assigned and graded weekly. Several of the homework assignments may also involve small experiments or real building data analysis.

There will be several comprehensive problems or projects during the semester that will be more involved than the homework and will typically include design tasks. These projects will include building thermal analysis, heating and cooling loads for a small commercial building, and simple lighting design using the lumen method.

Two examinations will be given during the semester – one on thermal analysis and one on electrical and lighting analysis. A final integrated analysis project will be assigned in place of a tradiational final examination.

COMPUTER TOOLS

Design and analysis of environmental 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. Throughout the semester, you will gain experience with several of these tools.

- 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 solar, lighting, and psychrometric analysis.

- Energy-10 is a simulation program for design and analysis of residential and small commercial buildings. This state-of-the-art analysis program performs hourly simulations of heating and cooling energy requirements in small buildings, including effects of passive solar energy and daylighting.
- 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.
- 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 (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. While the program is a valuable tool for any engineering analysis, it will be particularly useful for psychrometric process analysis.

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 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. See full details at http://www.colorado.edu/policies/fac_relig.html
3. The University of Colorado at Boulder policy on Discrimination and Harassment (http://www.colorado.edu/policies/discrimination.html), the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies 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 and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh
4. 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.

COURSE OUTLINE

Topic	Objectives	Skills	Lectures
Introduction	Understand relevance and importance of energy in buildings	Evaluate design alternatives based on economic analysis and building rating systems	1. Introduction, energy use in buildings 2. Economic analysis and the LEED rating systems
Thermal Comfort and Psychrometric Analysis	Understand factors affecting thermal comfort	Measure and assess thermal comfort	3. Psychrometrics for comfort 4. Psychrometrics for heating and cooling 5. Thermal comfort models
Heat Transfer in Buildings	Understand role of building envelope construction for comfort and system design	Use building envelope characteristics to calculate heat transfer into buildings	6. Thermal characteristics of buildings envelope 7. Solar energy 8. Solar shading 9. Application of heat transfer concepts 10. Transient heat transfer in buildings
Heating and Cooling of Buildings	Analyze heating and cooling needs system for residential and commercial buildings buildings	Calculate heating and cooling loads. Apply passive strategies for improved comfort and energy	11. Design heating loads 12. Design cooling loads 13. Heating and cooling load applications 14. Basic heating and cooling equipment 15. Low-energy heating and cooling strategies
Electrical Systems in Buildings	Understand electrical utilization in buildings	Identify and apply electrical concepts to building analysis	16. Electrical circuits fundamentals 17. Motors 18. Building electrical distribution 19. Basic electrical design
Behavior of Light	Understand fundamentals of light, human vision, and the behavior of light in buildings	Use the language of illumination engineering. Calculate illuminance levels on surfaces in rooms	20. Light and vision 21. Illumination terms and fundamental relationships 22. Fundamental calculations 23. Classical optics 24. Radiative transfer 25. Radiative transfer
Lighting Equipment and Design	Understand behavior of electrical lighting equipment.	Analyze lighting system in simple building spaces.	26. Electric lighting sources 27. Ballasts and luminaires 28. Simple lighting design 29. Simple lighting design
Codes and Standards	Understand role of codes and standards	Identify major codes and standards for building design	30. Introduction to codes and standards

- 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.
- You are encouraged to work together on homework if it helps you learn the material. However, each student must submit a separate solution.
- Late homework will not be accepted.