

Columbia University
Graduate School of Architecture, Planning and Preservation

A4112 Environmental Systems/ MEP

Time: Spring, Friday 10:00AM-1:00PM
Location: Avery 114
Credits: 3
Instructor: Nico Kienzl (nico.kienzl@atelierten.com)
Office Hours: by appointment
TA: Scott Overall (spo2107@columbia.edu)
Rebecca Riss (rer2140@columbia.edu)

Course Overview

This course addresses the fundamentals and application of environmental control systems in buildings. Heating, cooling, ventilation, lighting, and acoustics are discussed based on the physical laws that govern the exchange of energy between building and environment and how they relate to human comfort. Electrical, plumbing, fire protection and circulation are introduced in this context as required systems to make buildings fit for occupation.

Class time will be divided into lectures, hands on introductions of software tools and quantitative methods, guest lectures, as well as student presentations of the assignments. Assignments will combine software and hand calculations in the application of the principles introduced in the lectures. Some assignments will cross over to the design studio and students are encouraged to apply lessons learned in this class to their studio explorations.

Educational Objectives

The goal of this course is to enable students to understand the interaction of natural and constructed environments in order to develop and quantify appropriate responses that create comfortable and efficient buildings. Through the focus of this course on the dynamic relationship of external environmental forces, building, and occupants students will learn how to manipulate this relationship through building form and orientation, construction and materiality, and mechanical, electrical and hydronic systems. The ability and confidence in making both quantitative and qualitative statements about building performance will help students in integrating these considerations into their future design work. It will enable them to develop design solutions that are derived from fundamental principles and do not have to rely on formalistic or empiric solutions. Ultimately students will be able to understand the impact of their design decisions on building performance.

Course Requirements

Attendance: Students are required to attend all lectures and workshops and participate actively in the course discussion. While students might use their laptops to take class notes, students are asked to be respectful of others and not work on other things on their laptops during class.

Assignments: Complete and submit all assignments on the respective due dates (50% of final grade). Assignments will be carried out individually or in groups depending on the assignment. While student interaction and collaborative learning is encouraged

students have to carry out all work required to finish an assignments on their own or within their group.

Exams: There will be 1 short quiz during the semester and a final written exam (50% of the final grade). The quiz and exam will be open book.

Grades: All assignments, the midterm and the final exam will be graded on a point system and the final grade will depend on the total number of points achieved during the semester. Grades will be scored according to the following scale: >90% High Pass, 60-90% Pass, 50-60% Low Pass, <50% Fail..

Readings

The course has no required text book but the following book are recommended for additional reading:

Norbert Lechner. Heating Cooling Lighting. Design Methods for Architects.
Stein and Reynolds, Mechanical and Electrical Equipment for Buildings.
Daniels, The Technology of Ecological Building

A copy of these books will be put on reserve in the library.
Handouts of important concepts and equations will be made available via courseworks prior to each lecture. These handouts form the basis for the assignments and exams. Further reading material will be recommended where appropriate.

Course Schedule

- 1/24 Week 1: **Introduction, Course Overview / Building Physics:** Definitions, Units, Fundamental Laws, Heat Transfer, Phase and State Change.
- 1/31 Week 2: **Site and Solar:** Climate Zones, Local Climate Influences, Regional Building Responses, Solar Path, Shading Geometry, Sources of Weather and Climate Information.

Assignment 1: Site Analysis, Solar Path Diagrams, Shading.
- 2/7 Week 3: **Comfort and Psychrometrics:** Definitions, Thermal Comfort Factors, Evaluation of Thermal Comfort, Psychrometric Chart.

Assignment 1 due.

Studio – pinup site analysis.

Assignment 2: Evaluating Thermal Comfort Factors.
- 2/14 Week 4: **Building Fabric Losses:** Material Properties, Conduction, Thermal Storage, Moisture Transfer, Infiltration, Examples.

Assignment 2 due.

Assignment 3: R-Value Calculations, Steady State Heat Loss, Condensation.
- 2/21 Week 5: **Building Gains:** Material Properties of Glass, Solar Heat Gain, Glazing Systems, Shading Systems , Internal Gains, Building Heat Balance, Examples. Introduction to Simulation and Advanced Facades.

Assignment 3 due.

- 2/28 Week 6: **Air Distribution:** Ventilation Losses, Ventilation Requirements, Indoor Air Quality Concerns Natural and Mechanical Ventilation Concepts, Definitions, Systems, Distribution, Equipment Sizing, Design Integration, Examples.
 Guest Lecture (tbd)
Studio – present Façade Ideas from Assignment 2.
- 3/7 Week 7: **Heating and Cooling:** Definitions, Heat Sources, Heating and Cooling Systems, Examples. Introduction to Ecotect Thermal Simulation.
 Assignment 4: Building Heat Gain Simulation.
 Guest Lecture (tbd)
- 3/14 Week 8: **Energy Systems:** Definitions, Energy Conversion, Applications, Equipment, Examples.
 Guest Lecture (tbd)
 Assignment 4 due.
 Assignment 5: Energy Efficiency Evaluation, Energy Diagram of Studio Project.
- 3/21 Week 9: **Spring Break:** no class
- 3/28 Week 10: **Alternative Energy Systems:** Definitions, Passive and Active Solar Systems, Wind Energy, Ground Coupled Systems, Examples. **Midterm Quiz**
 Assignment 5 due.
- 4/4 Week 11: **Benchmarking/ Architecture 2030/ LEED:** Life Cycle Analysis, Payback Calculations, Current Initiatives, LEED System/Scorecard.
Studio – Systems Pinup – present energy diagram from Assignment 5.
- 4/11 Week 12: **Lighting:** Definitions, Units, Daylighting, Artificial Lighting, Visual Comfort, Lighting Design, Examples.
 Guest Lecture (tbd)
 Assignment 6: Lighting Simulation.
- 4/18 Week 13: **Acoustics:** Definitions, Environmental Noise and Noise Control, Noise of Buildings and Occupants, Room Acoustics, Calculation Techniques.
 Guest Lecture (tbd)
 Assignment 6 due.
- 4/25 Week 14: **Vertical Circulation, Fire Protection and Plumbing Systems**
- 5/2 Week 15: No Class
- 5/6 Week 16: **FINAL EXAM.**