

Columbia University
Graduate School of Architecture, Planning and Preservation

A4111: AT I, ENVIRONMENTS IN ARCHITECTURE Environmental Systems/ MEP

Time: Fall, Tuesday 9:30AM-12:30PM
Location: Avery 114
Credits: 3
Instructors: Shanta Tucker (shanta.tucker@atelierten.com)
Office Hours: by appointment
TAs: Elizabeth Cohn (elc2153@columbia.edu)
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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, case studies and guest lectures. Assignments will combine software and hand calculations in the application of the principles introduced in the lectures. 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. As per GSAPP policy, absence of more than two classes (excused and unexcused) results in a failing grade. (20% of final grade)
- Assignments:** Complete and submit all assignments on the respective due dates (30% of final grade). Assignments will be carried out individually. While student interaction and collaborative learning is encouraged students have to carry out all work required to finish assignments on their own unless an assignment specifically requires a

group in which case each individual will receive the same grade as others in the group. Assignments are timestamped on Courseworks and should be uploaded before the time noted on the assignment due date/time.

Exams: There will be 1 mid-term assessment during the semester and a final written exam (50% of the final grade). The mid-term and final exam will be open book/computer; students are expected to bring relevant materials to the classroom and use their computers for the mid-term and exam.

Grades: All assignments, the mid-term 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 books are recommended for additional reading:

Lechner, Norbert. *Introduction to Architectural Science: The Basis of Sustainable Design 3rd Edition*. Routledge, Oxon, 2014. ISBN-13: 978-0415824989

Stein and Reynolds, *Mechanical and Electrical Equipment for Buildings*. 12th edition

Daniels, *The Technology of Ecological Building, 1997*

Szokolay, Steven. *Introduction to Architectural Science: The Basis of Sustainable Design*. Burlington, MA: Architectural Press, 2004. ISBN: 9780750658492

A copy of these books has been put on reserve in the library.

Handouts of lectures with 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.

Software

Several different software packages already available on the GSAPP supplied lab computers will be used to complete assignments. At a minimum, these include: *Climate Consultant* and *COMFEN*. They are also available for free download on your personal computer.

Helpful software and conceptual tutorials:

- <http://sustainabilityworkshop.autodesk.com/buildings/sun-and-shadow-studies-bim>

Course Schedule

9/06 Week 1: **Introduction, Course Overview / Building Physics/ Site and Solar:** Definitions, Units, Fundamental Laws, Heat Transfer, Phase and State Change. 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.

9/13 Week 2: **Comfort , Psychrometrics**, Thermal Comfort Factors, Evaluation of Thermal Comfort, Psychrometric Chart.

- Assignment 2: Evaluating Thermal Comfort Factors.
- 9/20 Week 3: **Building Fabric Losses:** Material Properties, Conduction, Thermal Storage, Moisture Transfer, Infiltration, Examples.
- Assignments 1 due, Assignment 2 due.
 - Assignment 3: R-Value Calculations, Steady State Heat Loss, Condensation.
- 9/27 Week 4: **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.
- 10/04 Week 5: **Air Distribution:** Ventilation Losses, Ventilation Requirements, Indoor Air Quality Concerns Natural and Mechanical Ventilation Concepts, Definitions, Systems, Distribution, Equipment Sizing, Design Integration, Examples.
- Assignment 4: HVAC scavenger hunt
- 10/11 Week 6: **Heating and Cooling:** Definitions, Heat Sources, Heating and Cooling Systems, Examples. Introduction to Thermal Simulation.
- Assignment 4 due.
- Assignment 5: Building Heat Gain Simulation.
- 10/18 Week 7: **Energy Systems:** Definitions, Energy Conversion, Applications, Equipment, Examples.
- Midterm Assessment (exam)**
- Assignment 5 due.
- Assignment 6: Energy Efficiency Evaluation
- 10/25 Week 8: **Alternative Energy Systems/Benchmarking:** Definitions, Passive and Active Solar Systems, Wind Energy, Ground Coupled Systems, Examples. Life Cycle Analysis, Payback Calculations, Current Initiatives, LEED System/Scorecard
- Assignment 6 due.
- 11/01 Week 10: **Lighting Part I:** Definitions, Properties of light, Units, Lighting Criteria, Visual Comfort, Lighting Fixtures, Architectural Lighting Design process
- Guest Lecture (Rebecca Mintz, Lighting Designer, Atelier Ten)
- 11/08 Week 11: NO CLASS

- 11/15 Week 12: **Vertical Circulation, Fire Protection and Plumbing Systems**
- 11/22 Week 13: **Daylighting and Acoustics Basics**
Lighting Part II: Daylighting, Lighting Integration, Controls, Electrical Building Systems, Examples.
Acoustics: Definitions, Environmental Noise and Noise Control, Noise of Buildings and Occupants, Room Acoustics, Calculation Techniques.
Assignment 7: Lighting Simulation.
- 11/29 Week 14: **Guest Lectures:** Daylighting (extended presentation) and Acoustics
Guest Lecture (Michael Esposito, Environmental Designer, Atelier Ten)
Guest Lecture (Terence Caulkins, Acoustic Engineer, Arup)
- 12/06 Week 15: Last class
Assignment 7 due.
- 12/13 Final Exam posted on courseworks.
- 12/20 Week 16: **FINAL EXAM, TAKE HOME FORMAT, DUE 12:30 ON COURSEWORKS.**