4.401/4.464 Environmental Technologies in Buildings – Syllabus

Term:	Fall 2022
Department:	Architecture
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Time & Location:	Lecture - Mondays 11.00 - 12:30, Room 9-354 Lecture - Wednesdays 11.00 - 12:30, Room 9-354 Lab - Fridays, 10:00 - 12.00, Room 3-442

Course Description

Welcome to 4.401/4.464! The primary focus of this course is the study of the thermal, luminous and acoustical behavior of buildings. The course examines the basic scientific principles underlying these phenomena and introduces students to a range of technologies and analysis techniques for designing comfortable indoor environments. Students will be challenged to apply these techniques and explore the role energy, light and sound can play in shaping architecture.

Following a review of how to analyze a site's climate and local energy mix, the course will introduce students to the art and science of lighting buildings along with rules of thumb and computer-based methods for analyzing daylight within and around buildings. The third part of the course is dedicated to the principles of heat storage and heat flow into and out of buildings. Basic manual and computer-based methods to predict the energy use of buildings will also be discussed. In order to introduce students to the effective use of computer simulations during design, a *Building Optimization Game* that mimics a sustainable design charrette will be organized on Nov 17. During the game, student groups will compete who develops the building with the lowest energy use within a given cost budget and for a given climate. The last part of the course provides an overview of building acoustics and sound attenuation.

The course format consists of semiweekly lectures and weekly labs. Individual and group assignments as well as in-class presentations and exercises will help students to study the use of environmental technologies in contemporary buildings.

Learning Objectives

The course aims to help students to:

- understand and apply the scientific principles underlying the thermal, luminous and acoustical behavior of buildings,
- learn to evaluate the pros and cons of a range of technologies for creating comfortable indoor environments,
- conduct a series of design analysis workflows regarding climate, building energy use and daylighting and
- acquire the knowledge required to critically discuss/present the environmental concept of a building.

Requirements

The following deliverables will be required to pass this class:

- ❑ Attendance of semiweekly lectures and Friday Labs.
- ❑ Timely completion of assignments. Late assignments will not be accepted.
- ❑ Completion of a group course project. The course project will be to develop and present an environmental concept for a small office building. More details will be provided later in the term. Final presentations for 4.401 will be on Dec 3. Presentations for 4.464 will be scheduled during Exam Week.
- ❑ Preparation of 15 minute in–class group presentations on one of the AIA Cote Top Ten Projects for the current year (http://www.aiatopten.org/). Presentations will be timed and should have the following content:
  - Overview of the main environmental features of the building (3/15 points)
  - Discussion of predicted energy use. Review predicted and actual energy use for the building according to the AIA website and assess how both compare to the Energy Star portfolio manager baseline as well as a simple Energy Use Intensity study using ClimateStudio. How much better is the AIA building than the average? What design strategies contribute the most to the savings? (5/15 points)
  - Daylighting performance. Construct a simple 3D model of the whole or key spaces within the building. The model does not have to be very detailed, but should include the major façade openings and elements so that you can evaluate how daylight is being distributed and controlled throughout the building. (5/15 points)
  - Discuss what you like and/or dislike about the building and its environmental concept. (2/15 points)
- ❑ Active participation in class discussions.

Methods of Assessment

Grades will be determined based on:

- ❑ Quality and timely submission of completed assignments (55%)
- ❑ Final course project (25%)
- ❑ AIA case study presentation (10%)
- ❑ Participation in class discussions (10%)

Please familiarize yourself with MIT's Academic Integrity Expectations at http://web.mit.edu/academicintegrity/.

Software

Throughout the course we will be using the following software packages. You will be needing a Windows computer since ClimateStudio only runs under Windows.

- Rhinoceros forms the CAD backbone of all environmental analysis tools that we will be using in this class. Students should have a working version of Rhinoceros 6 or 7 installed on their laptops or workstations. The Department of Architecture provides free Rhino access to all students.
- ClimateStudio is a high optimized daylighting and energy modeling plug-in for Rhino. We will be using ClimateStudio for assignments on solar radiation, daylighting and energy simulation. Students can retrieve a download link and MIT-wide, educational site license code for ClimateStudio from CANVAS.

Bibliography

Information required for completing all assignments will be provided through the lecture notes, selected online materials as well as the *Daylighting Handbook Volumes I + II* which can be purchased directly from Building Technology Press or on Amazon for $36 per volume. Details for reduced pricing options for students in this class will be shared during the first lecture.

Wk	Monday Lecture for 4.401/4.464 11.00 – 12.30, Room 9-354	Wednesday Lecture for 4.401/4.464 11.00 – 12.30, Room 9-354	Weekly Reading*	Material to review before Friday lab	Friday Lab 4.464 10.00 – 11.00, Room 3-442 4.401 11.00 – noon, Room 3-442	Assignment (due date)
1		**Sep 7** L01 Course Introduction		• Go through CANVAS Course Software steps	**Sep 9** Lab 01 Course Software & Course Project	**Ass 1** Essay (Sep 15)
2	**Sep 12** L02 Energy Use in Buildings	**Sep 14** L03 Understanding Climate – Solar Radiation	CDD1, CDD2, DH3, DH6	• Introduction CS GUI • Shading Study	**Sep 16** Lab 02 Direct Shading Massing Exercise	**Ass 2** Direct Shading Study (Sep 22)
3	**Sep 19** L04 Understanding Climate – Wind, Temperature and Rel. Humidity (remote lecture)	**Sep 21** Lab Exercise Thermal Comfort Study (TBD)	CDD3	CBE Thermal Comfort Tool	**Sep 23** No labs (student holiday)	**Ass 3** Thermal Comfort Study (Sep 29)
4	**Sep 26** L05 Thermal Comfort + Climate File Game	**Sep 28** L06 Active Solar	CDD4, DH4, DH9	▪ Solar Radiation Analysis ▪ Sizing a PV System	**Sep 30** Lab 03 Thermal Comfort Study	**Ass 4** P1 Climate, Benchmark & PV (Oct 6)
5	**Oct 3** L07 Light and Human Vision + Photometry	**Oct 5** L08 Daylighting Design Principles	DH1, DH2, DH5		**Oct 7** Lab 04 Benchmarking & Onsite PV	**Ass 5** P2 Daylit Precedence & Massing (Oct 13)
6	**Oct 11** No Class (Indigenous Peoples Day)	**Oct 13** L09 Daylight Simulations + Daylight Availability Metrics	DH10, DH11	• CS GUI for Daylighting • LEED Daylight Credit	**Oct 14** Lab 05 Daylight availability simulations	**Ass 6** P3 Daylight Availability (Oct 20)
7	**Oct 17** L10 Visual Comfort	**Oct 19** L11 Electric Lighting + Controls + Occupant Behavior	DH13, DH14, DH15	▪ Annual Glare Study ▪ Electric Lighting Tutorial	**Oct 21** Lab 06 Glare & Electric Lighting	**Ass 7** P4 Glare + Electric Lighting (Oct 27)
8	**Oct 24** L12 Thermal Mass + Heat Flow	**Oct 26** L13 Insulation Materials + Window Technologies		▪ EUI with ClimateStudio 1/3 ▪ EUI with ClimateStudio 2/3	**Oct 28** Lab 07 Introduction CS Energy [AA & RW]	**Ass 8** P5 EUI Study I: Loads & Envelope (Nov 3)
9	**Oct 31** L14 Shading + Integrated Façade Design	**Nov 2** L15 Ventilation	DH16	▪ EUI with ClimateStudio 3/3 Ventilation	**Nov 4** Lab 08 Modeling Natural Ventilation	**Ass 9** P6 EUI Study II: Ventilation & Shading (Nov 10)
10	**Nov 7** L16 Internal Gains + Load Calculations	**Nov 9** L17 HVAC for Small Buildings		• Familiarize yourself with the simulation game.	**Nov 11 No labs (Veterans Day)**	
11	**Nov 14** L18 HVAC for Large Buildings [Irani]	**Nov 16** Simulation Game in class			**Nov 18** Discussion simulation game	**Ass 10** Simulation Game Analysis (Nov 24)
12	**Nov 21** AIA student presentations I	**Nov 23** AIA student presentations II			**Nov 25** No Lab (Thanksgiving)	
13	**Nov 28 L19** Acoustics I [Markham]	**Nov 30** AIA student presentations III		• Bring a working energy model of your building.	**Dec 2** HVAC Exercise [Ali Irani]	**Ass 11** P6 HVAC Design (Dec 8)
14	**Dec 5** L20 Meetings with 4.401 Groups [Reinhart]	**Dec 7** HVAC tour [Norford]			**Dec 9** Final Project Presentations for 4.401	
15	**Dec12 L20** MIT Acoustics II [Markham]	**Dec 14** No Class (Core I review)				
16	**Dec 16 - 22 Exam Week** Final Project Presentations for 4.464					

*) DH = Daylighting Handbooks http://buildingtechnologypress.com/; CDD = Climate Driven Design: Draft chapters will be shared in class