4.401/4.464 Environmental Technologies in Buildings – Syllabus

Term:	Fall 2026
Department:	Architecture
Instructor:	Christoph Reinhart (creinhart@mit.edu)
Teaching Assistants:	4.401 Jeffrey Na (jhna@mit.edu) 4.464 Ben Taube (taube@mit.edu)
Time & Location:	Lecture - Mondays 11.00 - 12:30, 3-133 Lecture - Wednesdays 11.00 - 12:30, 3-133 4.464 Lab - Fridays, 10:00 - 11.00, W41-1402 4.401 Lab - Fridays, 11:00 - noon, W41-1119

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. 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 **Dec 2**. 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. **Your group will need a Windows laptop for that day.** Check with METIS if you need to borrow one. 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. Up to two unexcused absences per term.
- Timely completion of assignments. Late assignments will not be accepted.
- Completion of a group course project. The goal of the course project is to develop and present an environmental concept for a small office or multi-unit residential building. Example projects from previous class iterations can be found here. Final presentations for 4.401 will be on **Dec 4**. Presentations for 4.464 will be scheduled during Exam Week (**Dec 14 to 18**).
- Preparation of 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 (2/10 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 LBNL Building Performance Database (https://bpd.lbl.gov/explore). How much better is the AIA building than the average? What design strategies contribute the most to the savings? (3/10 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. (4/10 points)
  - Discuss what you like and/or dislike about the building and its environmental concept. (1/10 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%)

Since a central goal for this subject is to help you develop the ability to evaluate and critically discuss the environmental performance of a building, you are prohibited from using AI tools to auto-generate or manipulate physics-based simulation results and discouraged from creating text that discusses your findings for you. AI tools may be used for creating images to communicate your design intent for the final course presentation.

Any work submitted using AI tools beyond these acceptable uses may be considered a violation of academic integrity, with the possibility of a referral to the Office of Student Conduct and Community Standards (OSCCS).

Software

Throughout the course we will be using the following software packages. **You will need 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 7 or 8 installed on their laptops or workstations. The Department of Architecture provides free Rhino access to all students.
- ClimateStudio is a highly optimized daylighting and energy modeling plug-in for Rhino. We will be using ClimateStudio for assignments on solar radiation, daylighting and energy simulations. Installation instructions for ClimateStudio will be provided during the first week of class.
- KOALA is a standalone cross-platform app that support 2D heat transfer analysis and U-value calculations of complex building assemblies. KOALA outputs equivalent homogenous construction assemblies that can be directly imported in ClimateStudio for a more accurate whole building energy analysis.

Bibliography

Information required for completing all assignments will be provided through the lecture notes, selected online materials as well as the *Driven Design I* and *Daylighting Handbook Volumes I + II* textbooks which can be purchased for a total $36 inclusive shipping from this Back-to-school sale link. All orders require a US postal address. The link will be active until September 18, 2026.

Wk	**Monday Lecture for 4.401/4.464 11.00 – 12.30, Room 3-133**	**Wednesday Lecture for 4.401/4.464 11.00 – 12.30, Room 3-133**	**Reading***	**Material to review before Friday lab**	**Friday Lab** 4.464 10.00–11.00, Room W41-1402 4.401 11.00–noon, Room W41-1119	**Assignment (individual I group, due date)**
1		**Sep 9 12:30pm** L01 Course Introduction | Climate Change and the Building Sector		• Go through CANVAS - Course software steps	**Sep 11** Lab: Review course software; finish introductions	**Ass 1** Essay (individual, Sep 18)
2	**Sep 14**; L02 Energy Use in Buildings	**Sep 16**– No class (instructor traveling)	CDD1, CCD2	• Introduction CS GUI (video) • Building Performance Database (web site)	**Sep 18** Lab: Form groups, pick site and conduct benchmarking using LBNL database	**Ass 2** Personal Benchmarking (individual, Sep 25)
3	**Sep 21** L03 High Performance Buildings	**Sep 23** L04 Understanding Climate – Solar Radiation	DH3, DH6, CDD3	• Direct Shading Study (video)	**Sep 25** Lab: Direct shading concept exercise	**Ass 3** Direct Shading Study (individual. Oct 2)
4	**Sep 28** L05 Understanding Climate – Wind, Temp. and Rel. Humidity	**Sep 30 L06** Climate File Quiz + Active Solar	DH9	▪ Solar Radiation Analysis (video) ▪ Sizing a PV System (video)	**Oct 2** Lab: Introduction to Course Project; Net Zero Feasibility Study	**Ass 4** Net Zero Feasibility Study (group, Oct 9)
5	**Oct 5** L07 Thermal Balance + Comfort	**Oct 7** L08 Light and Human Vision	CDD4, DH1, DH2, DH4	▪ CBE Thermal Comfort Tool (video)	**Oct 9** Lab: Thermal comfort study; Photometry	**Ass 5** Thermal Comfort Study (individual, Oct 16)
6	**Oct 13** L09 Daylighting Design Principles	**Oct 14** L10 Daylight Simulations + Daylight Availability Metrics	DH5, DH10, DH11	• CS GUI for Daylighting (video)	**Oct 16** Lab: Analize daylight availability of your Net Zero Feasibility massing model	**Ass 6** Daylit Precedence & Massing | Daylight Availability Study (group, Oct 23)
7	**Oct 19** L11 Visual Comfort	**Oct 21** Daylighting Desk Crit (J Na and B Taube)	DH13, DH14,	▪ Annual Glare Study (video)	**Oct 23** Lab: Glare measurement and view rating	**Ass 7** Visual Comfort (group, Oct 30)
8	**Oct 26** L12 Electric Lighting + Controls + Occupant Behavior	**Oct 28** L13 Load Calcs & Internal Gains	DH15, CDD5	▪ Electric Lighting (video)	**Oct 30** Lab: Electric Lighting in a small space	**Ass 8** Electric Lighting (group, Nov 6)
9	**Nov 2** L14 Thermal Mass + Heat Flow	**Nov 4** L15 Insulation Materials	CDD6, CDD7	▪ Tutorial: Thermal Model Setup (video)	**Nov 6** Lab: Build a thermal baseline model of your favorite massing	**Ass 9** Thermal Model Setup (group, Nov 13)
10	**Nov 9** L16 Window Technologies + Shading	**Nov 11** No class (federal holiday)	DH16	• Internal loads & envelope upgrades (video)	**Nov 13** Lab: EUI study + Koala	**Ass 10** EUI Study (group, Nov 20)
11	**Nov 16** L17 Indoor Air Quality + Fresh air requirements	**Nov 18** L18 Ventilation			**Nov 20** Lab: Ventilation requirements; Intro to simulation game	**Ass 11** Ventilation Requirements (group, Dec 4)
12	**Nov 23** L19 HVAC for Small Buildings	**Nov 25** AIA student presentation 4.401			**Nov 27** No Lab (Thanksgiving)	
13	**Nov 30**; L20 HVAC for Large Buildings	**Dec 2** AIA student presentations 4.464 + Simulation Game			**Dec 4** Final Project Presentations for 4.401	
14	**Dec 7** L21 Acoustics I [Guest lecture: Ben Markham]	**Dec 9** L21 Acoustics I [Guest lecture: Ben Markham]				
15	**Dec 14- 18 TBD** Final Project Presentations for 4.464					

*) DH = Daylighting Handbooks; CDD = Climate Driven Design