4.401 Architectural Building Systems – Course Syllabus

Term: Fall 2014
Department: Architecture
Instructor: Christoph Reinhart (creinhart@mit.edu)
Teaching Assistant: Jeff Geisinger (jgeis01@mit.edu)

Time & Location:
Lecture - Mondays 9:30 - 11:00, Room 1-150
Lecture - Mondays 9:30 - 11:00, Room 1-150
Lab - Fridays, 10:00 - 12.00, Room 9-250

Course Description

The primary focus of this course is the study of the thermal, luminous and acoustic 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 and light can play in shaping architecture.

Following a review of how to analyze a site’s climate and local energy mix, the first part of the course is dedicated to the principles of heat storage and heat flow in and around 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 LEED design charrette will be organized during class on October 22. During the game, students will compete in groups who develops the building with the lowest energy use within a given cost budget. The second part of 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 last part of the course consists of introductions to natural ventilation concepts and building acoustics.

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 acoustic 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. Project presentations should include:
  - Overall design approach and environmental features
  - Thermal analysis and predicted energy use
  - Daylighting analysis
- Preparation of 20 minute in–class group presentations on one of the AIA Cote Top Ten Projects 2014 (http://www.aiatopten.org/). Presentations should have the following format:
  - Overview of the main environmental features of the building
  - Discussion of predicted energy use
  - Daylighting massing study of the building
  - Discuss what you like and/or dislike about the building and its environmental concept (5 minutes).
- Active participation in class discussions.

Methods of Assessment:

Grades will be determined based on:

- Quality and timely submission of completed assignments (45%).
- Course project presentation (30%).
- Case study presentation (15%).
- Participation in class discussions (10%).
- Members of the winning groups in the ‘Building Optimization Game’ on Oct 22 will receive additional 10% points.

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.

- **Rhino 5** forms the CAD backbone of all environmental analysis tools that we will be using in this class. Students should therefore ideally have working version of Rhinoceros 5 installed on their laptops or workstations. You can install a 90 day demo version of Rhino 5 from [http://www.rhino3d.com/](http://www.rhino3d.com/).
- **Grasshopper** (latest release): Some of the plugins further require Rhino’s parametric scripting environment Grasshopper, which can be downloaded free of charge from [http://www.grasshopper3d.com/](http://www.grasshopper3d.com/).
- **DIVA-for-Rhino** is a daylighting and energy modeling plug-in for Rhino ([http://diva4rhino.com/](http://diva4rhino.com/)). We will be using DIVA for assignments on solar radiation and daylighting. Students may request free licenses for their laptops from the DIVA-for-Rhino web site or use DIVA on the MIT lab computers.
- **Ladybug** is another Grasshopper plugin that support the display of annual climate files used for building and daylighting simulations. To run the plugin you will need to install Phyton for Grasshopper ([www.food4rhino.com/project/ghpython](http://www.food4rhino.com/project/ghpython)) and the plugin itself ([http://www.grasshopper3d.com/group/ladybug](http://www.grasshopper3d.com/group/ladybug))

Bibliography

Information required for completing the assignments will be provided through the lecture notes, selected online materials as well as the *Daylighting Handbook Volume I* which can be purchased on the book’s web site ([http://www.daylightinghandbook.com/](http://www.daylightinghandbook.com/)) or directly from the instructor. The following list of textbooks is recommended for additional reading.

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday Lecture (9.30 – 11.00, Room 1-150)</th>
<th>Wednesday Lecture (9.30 – 11.00, Room 1-150)</th>
<th>Reading*</th>
<th>Friday Lab (10.00 – 12.00 9-250)</th>
<th>Assignment (due date)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Sep 3 L01 Course Introduction</td>
<td>Energy Use in Society</td>
<td>Sep 5 Hand out HOBO data loggers + Software Overview [Geisinger &amp; Reinhart]</td>
<td>Ass 1 – Essay &amp; Personal Carbon Balance (Sep 5)</td>
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<td>2</td>
<td>Sep 8 L02 Energy Use in Buildings</td>
<td>Sep 10 L03 Understanding Climate – Solar Radiation</td>
<td>DH1, DH3, DH6</td>
<td>Sep 12 DIVA Shading Study + Ladybug [Reinhart &amp; Mackey]</td>
<td>Ass 2 – Direct Shading and Sunpath Diagrams (Sep 17)</td>
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<tr>
<td>3</td>
<td>Sep 15 L04 Wind Understanding Climate - Temperature and Rel. Humidity</td>
<td>Sep 17 L05 Thermal Comfort + Case Studies</td>
<td>IBPSA3</td>
<td>Sep 19 Student Holiday (no lab)</td>
<td>Ass 3 – Psychrometric Chart (Sep 24)</td>
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<tr>
<td>4</td>
<td>Sep 22 L06 Thermal Mass &amp; Heat Flow</td>
<td>Sep 24 L07 Insulation Materials</td>
<td>Sep 26 ArchSim I Shoebox [Dogan &amp; Geisinger]</td>
<td>Ass 4 Best Insulation Value (Oct 1)</td>
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<tr>
<td>5</td>
<td>Sep 29 L08 Radiation Maps Active and Passive Solar</td>
<td>Oct 1 Instructor Traveling (no class)</td>
<td>DH9</td>
<td>Oct 3 DIVA II Radiation Maps + ArchSim II PV [Geisinger + Dogan]</td>
<td>Ass 5 – Internal Gains and Designing a PV System (Oct 8)</td>
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<tr>
<td>7</td>
<td>Oct 13 No Class (Columbus Day)</td>
<td>Oct 15 Instructor Traveling (no class)</td>
<td>IBPSA2</td>
<td>Oct 17 ArchSim III Multi-Zone Energy Models [Dogan &amp; Geisinger]</td>
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<td>9</td>
<td>Oct 27 L15 Simulation Game Student Presentations</td>
<td>Oct 29 L16 HVAC Systems</td>
<td>Oct 31 Daylit Area Exercise + HDR Workshop [Reinhart &amp; Geisinger]</td>
<td>Ass 8 – Daylit Area Study &amp; Basic Photometry (Nov 5)</td>
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<tr>
<td>10</td>
<td>Nov 3 L17 Photometry, Daylighting and Daylighting</td>
<td>Nov 5 L18 Daylight Availability Rules of Thumb and Massing Studies</td>
<td>DH2, DH4, DH5</td>
<td>Nov 7 Material Properties + DIVA III Daylight Availability Calculations [Reinhart]</td>
<td>Ass 9 - Daylit Availability Study (Nov 12)</td>
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<tr>
<td>11</td>
<td>Nov 10 L19 Daylight Simulations &amp; Metrics</td>
<td>Nov 12 Electric Lighting + Controls</td>
<td>IBPSA9</td>
<td>Nov 14 Individual Course Project Discussions [Reinhart]</td>
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<td>12</td>
<td>Nov 17 Natural Ventilation - Physical Principles; Manual Methods</td>
<td>Nov 19 Natural Ventilation - Simulation Approaches</td>
<td>CIBSE</td>
<td>Nov 21 AIA Presentations: Sustainability Treehouse</td>
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<tr>
<td>13</td>
<td>Nov 24 AIA Presentations: ASU Student Health Services</td>
<td>Nov 26 AIA Presentations: Edith Green Gateway Center</td>
<td>CIBSE</td>
<td>Nov 21 AIA Presentations: Sustainability Treehouse</td>
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<td>14</td>
<td>Dec 1 Discuss Course Projects</td>
<td>Nov 28 Thanksgiving (No Lab)</td>
<td>Dec 3 Final Project Presentations</td>
<td>CIBSE = AM10 Natural Ventilation in Non Domestic Buildings</td>
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<tr>
<td>15</td>
<td>Dec 8 Building Acoustics I</td>
<td>Dec 10 Building Acoustics II</td>
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*) DH = Daylighting Handbook I; IBPSA = Building Performance Simulation for Design and Operation (from course Reader); CIBSE = AM10 Natural Ventilation in Non Domestic Buildings
History of ECE Courses Offered. Course List. Undergraduate Courses (400 and below).

ENG EK 103 Computational Linear Algebra
ENG EK 131 Electric Guitar (E1, E2)
ENG EK 131 From heart monitoring to Kinect gaming: Seeing the invisible (E1, E2)
ENG EK 131 Photonics – Engineering with Light (E3, E4)
ENG EK 210 Introduction to Engineering Design
ENG EK 307 A1 Electric Circuits
ENG EK 307 A2. Electric Circuits
ENG EK 307 A3 Electric Circuits
ENG EC 400 Optics and Waves for Engineers
ENG EC 401 Signals and Systems
ENG EC 402 Introduction to Control Systems
ENG EC 410 Introduction to Electronics
ENG EC 412 Analog Electronics
ENG EC 413 Computer Organization
ENG EC 415 Software Radios

Our systems for managing the provision of international qualifications and education programmes for students aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at www.cambridgeinternational.org/ISO9001. These skills build confidence and support work in other subject areas as well as in mathematics. responsible, through learning and applying skills which prepare them for future academic studies, helping them to become numerate members of society. The syllabus gives you the flexibility to design a course that will interest, challenge and engage your learners. You are responsible for selecting a suitable combination of components to support your learners’ further study. Architecture (ARCH) 527. Architectural Design: Building Systems (Revision 1).

Delivery Mode: Individualized study online. For those students interested in pursuing a career as a registered architect, this course contributes to the RAIC Syllabus Diploma. Information about the RAIC Syllabus Diploma is available on the RAIC website. This course is intended to increase your understanding of major buildings systems, from the standpoints of design requirements for human occupancy, through a detailed examination of a design process that stresses integration and a comprehensive approach to building energy analysis. Outline. The course is divided into three major parts, and is further divided into a total of ten units, as listed below: Part 1: Human Factors in Building Design. 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 and light can play in shaping architecture. Following a review of how to analyze a site’s climate and local energy mix, the first part of the course is dedicated to the principles of heat storage and heat flow in and around buildings. 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. Curriculum and syllabus. (applicable to students admitted from 2016-17 onwards). For Bachelor of Architecture (B.Arch.) Course of Study Computer Applications in Architecture - I
History of Architecture - II
Mechanics of Solids
Architectural Graphics - II
Building Construction and Materials - I
Architectural Design - II
Visual Arts - II
NCC, NSS, NSO. Total. L 1.