4.430 High Performance Facades / Daylighting

Term: Spring 2019
Department: Architecture
Instructor: Christoph Reinhart (creinhart@mit.edu)
Teaching Assistant: Irmak Turan (ituran@mit.edu)

Time & Location:
Lecture - Tuesdays 9.30 - 11:00, Room 1-150
Lecture - Thursdays 9.30 - 11:00, Room 1-150
Lab – Thursdays 11:00 - 12.00, Room 1-132

Prerequisites
4.401/4.464 or permission of instructor
Access to a newer Windows computer or laptop

Course Description

The primary focus of this course is the study of natural and electric lighting in an architectural context. The course promotes the integration of occupant comfort, energy efficiency and daylight availability throughout the design process and places an emphasis upon the role light can play in shaping architecture. Students will learn a series of design techniques from advanced daylight simulations of occupant comfort and circadian health to view analysis using high dynamic range photography and physical model testing using a heliodon. Throughout the course, students will work in groups and apply these techniques to develop a holistic daylighting/electric lighting concept for the MET Warehouse, SAP's new home.
During the first few weeks, we will review methods to predict the annual amount of daylight in spaces as well as how to set up advanced models for any type of surface found in the built environment from laptops and smartphones to trees and advanced glazing systems. Students will learn how to calibrate their simulations with respect to a high dynamic range photograph that they can take with their personal camera (if available).

As the term progresses, students will learn how to design and analyze more advanced façade systems from light redirecting mirrors to switchable glazings and aerogel panels. They will then use this knowledge to explore advanced daylighting options for the MET Warehouse, a challenging adaptive reuse project. Such options may include heliostats to direct sunlight deep into the building, atria design and water reflections of indoor pools to add visual interest to the space. Apart from simulations, students will also build physical models of parts of their design and test them in a heliodon.

In order to learn how to design healthy and delightful spaces, students will be exposed to the latest research regarding the effect of light on human health as well as mathematical attempts to quantify “visual interest.” Related guest lectures will be delivered by researchers from Harvard Medical School and the University of Washington. During the final portion of the class, we will be introducing the exploding world of digital lighting systems, i.e. the merging of solid state lighting with innovative control algorithms. Students will learn about the hardware and software requirements for such lighting systems during visits to Philips Lighting Research and Lam Partners and apply those concepts to their lighting proposals for the MET Warehouse.

Learning Objectives

At the end of this course students will …

- be able to formulate their own definition of what constitutes ‘good’ lighting,
- know about the latest research and design analysis methods to develop healthy and comfortable spaces and
- have acquired a skill set that will make them immensely attractive to architecture design and environmental consulting firms.
Requirements

Attendance of all lectures is mandatory. Unless otherwise noted assignments are due on Thursdays before class. Assignments will build on each other and help students to work on their course project throughout the term. We will have three in class presentations to review progress and collect feedback.

Methods of Assessment

Grades will be determined based on the quality and quantity of completed assignments, participation in class discussions, and the quality of in class presentations. Class participation, assignments and presentations will be worth 10%, 50% and 40% of your grade, respectively, for a total of 100%. Presentations will be graded based on the
- clarity of the project’s (day)lighting objectives,
- originality and inner logic of the design techniques used,
- comprehensiveness of the final design solution,
- overall quality of the presentation.

Academic Integrity

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 DIVA 4 only runs under Windows.**

- **Rhinoceros** 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 or 6 installed on their laptops or workstations. You can install a 90 day demo version of Rhino 6 from [http://www.rhino3d.com](http://www.rhino3d.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 and energy simulation. Students may request free licenses for their laptops from the [Solemma website](http://www.diva4rhino.com/).

- **ALFA (Adaptive lighting for alertness)** is Solemma’s new circadian lighting design software that lets architects, lighting designers, and health professionals predict and control non-visual effects of light in the human body, in order to create environments that are safer, healthier, and more productive.

Bibliography

- Information required for completing the assignments will be provided through the lecture notes, select online materials as well as the *Daylighting Handbook Volume I and II* which can be purchased directly from the course instructor for $20 each or on Amazon for $48.
<table>
<thead>
<tr>
<th>week</th>
<th>Tuesday Lecture for 4.430 9.30 – 11.00, Room 1-150</th>
<th>Thursday Lecture for 4.430 9.30 – 11.00, Room 1-150</th>
<th>Weekly Reading*</th>
<th>Friday Lab for 4.401/4.464 : 11.00 – 12.00, Room 1-150</th>
<th>Assignment (due date)</th>
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<tbody>
<tr>
<td>1</td>
<td>Feb 5 L01 Course introduction + framework for daylighting</td>
<td>Feb 7 L02 Daylight availability metrics + MET case study</td>
<td>DH1, DH5, DH11, GH4</td>
<td>Feb 7 Lab: Software Installation and Review + Tour of the MET</td>
<td>Ass 1 – Essay Daylighting &amp; Adaptive Reuse (Feb 14)</td>
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<td>2</td>
<td>Feb 12 L03 Daylight simulations + HDR photography</td>
<td>Feb 14 L04 Optical surface characterization – Electronic surfaces, trees and glass</td>
<td>DH10, DH12</td>
<td>Feb 14 Lab: Characterizing surfaces + HDR photography</td>
<td>Ass 2 – Calibrated HDR study (Feb 28)</td>
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<td>3</td>
<td>Feb 19 No class due to Presidents Day</td>
<td>Feb 21 Student presentations I – MET massing study</td>
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<td>Feb 21 Presentations continued</td>
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<td>4</td>
<td>Feb 26 L05 Dynamic façade technologies</td>
<td>Feb 28 L06 Integrated thermal/lighting simulations</td>
<td>DH14, DH16, GH8, GH13, GH14</td>
<td>Feb 28 Lab: Dynamic façade analysis</td>
<td>Ass 3 – Dynamic Façade study (Mar 7)</td>
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<td>5</td>
<td>Mar 5 L07 Nonvisual effects of light (Guest Lecture S Lockley, Harvard Medical School)</td>
<td>Mar 7 L08 Circadian lighting design using ALFA (Guest Lecture J Sargent, Solemma)</td>
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<td>Mar 7 Lab: Circadian lighting analysis using ALFA (J Sargent)</td>
<td>Ass 4 – Spectral lighting study (Mar 14)</td>
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<td>6</td>
<td>Mar 12 L09 Physical model analysis</td>
<td>Mar 14 Physical model building workshop (I Turan)</td>
<td>DH8</td>
<td>Mar 14 Workshop continued (I Turan)</td>
<td>Ass 5 – Physical model building (Apr 4)</td>
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<td>7</td>
<td>Mar 19 No class – Instructor traveling</td>
<td>Mar 21 L10 Visual Interest (Guest Lecture S Rockcastle, University of Oregon)</td>
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<td>Mar 14 Visual interest simulations</td>
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<td>8</td>
<td>Mar 25 to 29 MIT Spring Break</td>
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<td>9</td>
<td>Apr 2 L12 Giare</td>
<td>Apr 4 Heliodon model testing</td>
<td>DH13</td>
<td>Apr 4 L13 Testing continued</td>
<td>Ass 6 – Heliodon animations (Apr 11)</td>
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<td>10</td>
<td>Apr 9 L12 View and connectivity (I Turan)</td>
<td>Apr 11 L13 Student Presentations II – MET dynamic façade concept</td>
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<td>Apr 11 Presentations continued</td>
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<td>11</td>
<td>Apr 16 Patriots Day</td>
<td>Apr 18 L14 Building a lighting web app workshop (TBD)</td>
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<td>Mar 14 Workshop continued (TBD)</td>
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<td>12</td>
<td>Apr 23 L15 Lighting controls</td>
<td>Apr 15 L16 Digital lighting I (Guest Lecture Dan Weissman, Lam Partners)</td>
<td>DH15</td>
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<td>Ass 7 – Lighting control concept (May 2)</td>
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<td>13</td>
<td>Apr 30 L17 Digital Lighting II (Zhao)</td>
<td>May 2 L18 Modeling lighting controls</td>
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<td>14</td>
<td>May 7 Meeting with groups</td>
<td>May 9 Student Presentations III – MET Complete (day)lighting concept</td>
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<td>15</td>
<td>May 14 Field trip (Color Kinetics)</td>
<td>May 16 No class</td>
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