ARC 496D/596D: Daylighting, Health, and Behavior

Spring 2019
3-credit units
Instructors: Altaf Engineer, Assistant Professor

This course is a recommended elective for MS.Arch. students in the Health and the Built Environment (HBE) program and for master's level and upper level undergraduates interested in pursuing careers that integrate human health and wellbeing in the built environment.

This course explores specific Technology topics in depth; it may be taken up to four times under different topics by permission of the Stream Coordinator.

Daylighting influences the social, cultural, and behavioral aspects of spaces. Daylight can be used as a creative medium; it can be sculpted and controlled to impart a spirit of place as well as influence physical and mental health outcomes.

This course focuses on the critical analysis and design of daylighting systems for human comfort, physical and psychological wellbeing. Students will investigate the phenomenon of natural light in built environments via observations and surveys, study how these findings may impact human behavioral and social factors in design, and how they may be implemented to achieve multiple goals of sensory design, comfort, wellbeing, and productivity. We will study the integration of natural and artificial lighting systems in the building design process. We will test various daylighting design strategies discussed in class via group and individual projects which will include daylighting measurements, observations, photography, and computer simulations.

Upon successful completion of this course, students will be able to:

1. Formulate their own definitions of what constitutes good daylighting.
2. Understand how daylighting strategies impact occupants' health, behavior, and performance via qualitative research methods.
3. Learn how to use daylight as a creative medium in design, integrate it with artificial lighting systems in a building, develop a comprehensive lighting strategy for their project, and communicate it via suitable presentation and documentation techniques.

In addition, students who complete the graduate course will be able to:

1. Synthesize and communicate design recommendations and implications based on existing daylighting, health, and behavior research into a research report or publication.

Course structure and organization

This course meets once a week and is comprised of interactive lectures and student participation and presentations, both informal and formal. The course is broken into the following phases:

- **Introduction** to the science of daylighting and its relationship to health and behavior
- **Module 1:** Case study and precedent analysis
- **Module 2:** Daylighting Improvements
- **Module 3:** Daylighting Design: Final course project

There are regular reading assignments and assigned tasks for each module. Students will also present design recommendations in each module. In their final assignment they will present a new daylighting scheme for their individual studio project or an existing space on campus based on the International Velux Award guidelines.

Course objectives

During this course, students will:

1. Analyze an existing daylighting scheme and create a new, improved scheme via measurements, observations, photography, and simulation techniques.
2. Study and critique existing scientific research on daylighting, health, and wellbeing.
3. Translate research findings, both from daylighting literature and course assignments, into design recommendations in their individual projects.

This course is designed to achieve the learning objectives indicated. Because architecture is an art as well as a science, and because every student and student-group present new challenges in the teaching of design, instructors may add, alter, or modify assignments, criteria, or project weights in order to adapt to evolving circumstances that are inherent in the practice of Architecture, and also to evaluate students' abilities to make such adaptations. The Instructor will notify the students in advance of such changes; students for their part will notify the professor within one week of such notification if the proposed changes will cause undue hardship. Students acknowledge the dynamic nature of this course.

The graded components of this course and their criteria of evaluation are currently anticipated to be as follows, but are subject to change as set forth above:

Texts

Reading assignments are outlined on the syllabus; these assignments should be supplemented with more in-depth research and readings by students. Do not rely solely on web-based sources. While you will have a number of these referenced within the class, please be aware that the instructor knows that these sites are creditable and reliable. The instructor may frequently recommend other sources for in-depth readings. Student should also be prepared to share useful sources that they find on their own, with other classmates. All class sessions will in part, be group discussion format.

Projects

1. **Case study and precedent analysis:** Perform an in-depth case study of daylighting in an existing building on campus or in a geographically close area. Discuss your building selection with the instructor before proceeding with the study. Focus on the lighting features of the building using class lectures, examples and case studies described in the textbook and additional readings, as reference guides. Gather information on the building space, document lighting strategies by photographs, and collect illumination measurements with light meters (to be provided by instructor). Select one large space/room in the building such as a large classroom, conference room, auditorium, library reading room, atrium, or art gallery for a more in-depth, daylighting analysis. Measure illumination levels in different parts of the room. Select two precedent studies that employ daylighting strategies similar to what you would like to pursue in the next assignment: #2, Daylighting design. Present your analysis of the existing space, along with a minimum of two precedent studies, in a slideshow to the class. Further details of presentation requirements will be discussed in class.

2. **Daylighting Improvements:** Based on lighting deficiencies found in your survey and analysis of the existing space and precedent studies, suggest a design improvement—through modifications or additions or both—in the form of daylighting strategies. This new strategy should focus on the following improvements: 1) Introduce daylight into spaces currently without daylight 2) Get daylight to penetrate deeper into spaces with some daylighting already, via light shelves, skylights, or other innovative strategies. Present this improvement to the instructor in the form of drawings, sketches, and 3D models in class and get approval to proceed with a final model. Construct a 3D computer model for testing daylighting strategies for the selected space in VELUX software. Present VELUX daylighting analysis images and renderings of your scale models with improvements, and daylight measurements of illuminance levels in a sky simulator to the class in a slideshow. This presentation should effectively demonstrate how you have improved the daylighting scenario in the room, potentially leading to implications for occupant satisfaction, health, productivity, and energy savings in the entire building. Further details of presentation requirements will be discussed in class.

3. **Daylighting Design:** The goal of this exercise is for you to create an effective daylighting design scheme for your individual projects. Select one large space in your design studio project or design a new space with the goal of demonstrating efficient daylighting strategies and integrating it with the artificial lighting scheme. Examples of such spaces include meeting rooms, conference rooms, class rooms, auditoriums, a large retail space, one residential space

(such as the living room), etc. Create a three-dimensional computer model, a physical model, or a combination of both so that your renderings and photographs represent an accurate, real-world lighting scenario. Class time will be allotted to discuss ideas, show progress and get feedback from instructor as well as peers. Review the International Velux Design Award (http://iva.velux.com) brief, document as per award guidelines, and present in a final review.

References

General

Ander, Gregg D. *Daylighting Performance and Design*. New York: Van Nostrand Reinhold, 1995.

Baker, Nick and Koen Steemers. *Daylight Design of Buildings: A Handbook for Architects and Engineers*. New York: Earthscan, 2014.

Brown, G. Z., and Mark DeKay. *Sun, Wind & Light: Architectural Design Strategies* (2nd ed.). New York: J. Wiley, 2001.

Cuttle, Christopher. *Lighting Design: A Perception-based Approach*. New York: Routledge, 2015.

Engineer, Altaf, and Kathryn H. Anthony. *Shedding New Light on Art Museum Additions: Front Stage and Back Stage Experiences.* New York: Routledge, 2018.

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Grosslight, Jane and Jeffrey W. Verheyen. *Light, Light, Light: Effective Use of Daylight and Electric Lighting in Residential and Commercial Spaces*. Tallahassee, FL: Durwood Publishers, 1998.

Lam, William M. C. *Sunlighting as Formgiver for Architecture*. New York: Van Nostrand Reinhold, 1986.

Lechner, Norbert. *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*. New York: Wiley, 2014.

Livingston, Jason. *Designing with Light : The Art, Science and Practice of Architectural Lighting Design*. Hoboken, New Jersey: Wiley, 2014.

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Plummer, Henry. *Masters of Light: Twentieth-century Pioneers.* Tokyo: a+u Pub. Co., 2003.

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Tregenza, Peter, and Michael Wilson. *Daylighting: Architecture and Lighting Design*. New York: Routledge, 2013.

Tregenza, Peter and David Loe. *The Design of Lighting*. New York: Routledge., 2014.

Useful web links:

Center for the Built Environment (CBE), University of California, Berkeley: http://www.cbe.berkeley.edu

Designing with Light companion site: http://www.designinglight.com

Daylighting Pattern Guide: http://patternguide.advancedbuildings.net/

Daylighting Whole building Design Guide (WBDG): http://www.wbdg.org/resources/daylighting.php

"Daylight Dividends", Lighting Research Center research and case studies: http://www.lrc.rpi.edu/programs/daylighting/

Sun position calculation: http://www.susdesign.com/sunposition/index.html

Sun angle calculation: http://www.susdesign.com/sunangle/

UC Davis, California Lighting Technology Center: http://cltc.ucdavis.edu/index.php

U.S. Department of Energy High Performance Buildings Database: http://www.eere.energy.gov/buildings/highperformance/case_studies/index.cfm\