Massachusetts Institute of Technology
4.411J/EC.713J/4.412
D-Lab Schools: Building Technology Laboratory

A Therapeutic and Medical Outreach Facility in Siem Reap, Cambodia

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Units: 2-4-6 (Institute Lab)

Prerequisites: 8.01, 18.01

Schedule:	Lecture	Wednesday, 9:30-11:00 a.m., 1-132
	Lab	Monday 2:00-5:00 p.m., N51-350
	Office hours	to be announced and on request

Description

Over the last two years, students in 4.411J/EC.713J developed a design for the We Yone (Friendly Hands) Learning Centre (WYLC) in Masiaka, Sierra Leone, now finishing construction and about to be opened by long-term course partner, the US-Africa Children's Fellowship (USACF). This term, the course will focus on the design of a therapeutic and medical outreach facility envisioned by Safe Haven, an organization in Siem Reap, Cambodia that is committed to helping children with disabilities. Our goal is to work with Safe Haven's staff (particularly the founding director and the in-country director) to produce the best possible thermal comfort in a building that provides a safe working environment and is structurally sound, climate-appropriate, resource-respectful, and affordable. The focus on the physical environment for learning and now therapies that support learning builds on previous work within the Building Technology Program and the D-Lab Schools: Building Technology Lab course in Cambodia, Haiti, Nepal, Pakistan, Sierra Leone, Singapore, and South Africa.

Our investigation this term will include present and future climate analysis; building materials, structural design and construction methods that improve current local practice; daylighting; ventilation; indoor and outdoor thermal comfort; and building electrical systems, including photovoltaic panels. We will develop and assess design proposals, aided by critiques from Safe Haven personnel, and support them in sufficient detail to enable Safe Haven to obtain construction bids.

The course is set up as a series of short studies and lab-based projects, to be performed in teams formed to take best advantage of the skill sets of class participants. Planned experiments include fabrication and structural testing of low- and no-cement blocks, daylighting measurements to establish reasonable threshold illuminance values for planned activities, and use of heat-stress meters to define acceptable and, perhaps, unacceptable environmental conditions. Necessary in-class instruction in simulation software will be supplemented by online tutorials. Results of these investigations will be compiled in a report, prepared in stages and submitted in final version at the end of the term.

Software we anticipate using includes Rhino and the associated Grasshopper visual scripting program, which will allow us to analyze climate, daylight, airflow, and thermal comfort within a design framework that easily obtains necessary geometrical information from a CAD model.

Course objectives:

- Develop an understanding of culture, education systems, climate and construction methods and materials in the country and local region of the school under consideration
- Develop an ability to analyze climate, its impact on the thermal comfort of school occupants and its influence on building design.
- Through experiments, application of engineering fundamentals and simulations, learn to quantify key aspects of building performance, including daylighting, moderation of indoor temperature, natural ventilation, and structural integrity and efficiency.
- Improve written and oral communication skills, including an ability to present design concepts and building performance to a non-technical audience.

Evaluation criteria:

The course grade will be based on participation in class and lab reports. Weekly assignments will require work that will be incorporated into the reports and may be presented orally in labs for discussion and feedback but will not be graded. Participation is crucial to the success of the course. Attendance in lab and lecture will be noted. Poor attendance, particularly in lab, will result in a reduced grade.

You will typically be encouraged to work in groups of 2-4, depending on the lab and available resources. Lab reports are prepared on a group basis: one report per group. Group composition may evolve during the term, as a function of the needs of students and the discretion of the instructor.

Course work will be weighted as follows:

Interim report #1	25%
Interim report #2	25%
Final report	20%
Final presentation	20%
Attendance and participation	10%

The course includes a final presentation that the MIT registrar will schedule during the final-exam period. There are no quizzes.Interim reports should be submitted on time; short extensions due to personal circumstances must be requested before the deadline. Interim lab reports received more than one week after the published deadline will be penalized 10% of full credit. The final report may be submitted as late as 5 p.m. on Friday, December 22, with no grading penalty; absent very short extensions for extraordinary circumstances, submittals after this date and time will receive no credit. The instructor and TA aim to return graded reports within one week of submission. Schedule adjustments will be considered as necessary to accommodate major studio reviews, other significant deadlines, or the impact of local weather on experimental work.

An MIT 12-unit course, including this one, should require on average no more than 12 hours of work per week, in and out of class sessions. If your workload consistently exceeds this amount, please cut back and/or inform the instructor.

The instructor and teaching assistant consider this classroom to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Personal and medical issues can make it hard to focus on academics. If you find that something is getting in the way of your ability to attend class, complete work, or take an exam, you should contact a dean in Student Support Services (S3). The deans will provide you with support and help you determine next steps. You can reach out to a dean you have worked with in the past, join their virtual help queue (https://sicp-s3.mit.edu/queue), or e-mail s3-support@mit.edu.

Provisional Schedule

Lecture	9/6	Course overview; intro to Safe Haven; thermal comfort and climate fundamentals; investigations of outdoor thermal comfort with Kestrel heat-stress trackers
Lab	9/11	Characterizing Cambodia; climate investigation with Climate Studio or alternatives; thermal comfort basics and metrics; sharing data from Kestrel heat-stress trackers
Lecture	9/13	Online visit with Safe Haven personnel; outdoor and indoor thermal comfort metrics; prediction of satisfactory classroom conditions
Lab	9/18	Materials and construction, fabrication of low-cement blocks
Lecture	9/20	Wall materials and design, structural and thermal performance
Lab	9/25	Testing to failure of low-cement blocks Preview of daylighting measurements in physical models with heliodon
Lecture	9/27	Lighting fundamentals; daylight measurements to establish/confirm illuminance target
Lab	10/2	Daylight and glare simulations and physical models to assess window area and location
Lecture	10/4	Fundamentals of natural ventilation: hydrostatic equation, ideal gas law, Bernoulli's equation, orifice equation; guidelines for interim report #1
	10/6	**Add Date**
	10/9	**Indigenous Peoples Day holiday** – no class. Tuesday, October 11 is also a student holiday
Lecture	10/11	Buoyancy- and wind-driven airflows; airflow mass and energy balances
Lab	10/16	Thermal comfort revisited: results of measurements and assessments of thermal sensation; Overcoming excessive heat and humidity via local and room-level increases in airflow and radiative cooling; use of Berkeley CBE and Princeton thermal comfort tools
Lecture	10/18	Indoor air quality, including particulates and CO_2; **interim report #1 due**
Lab	10/23	Airflow in developed areas; impact of obstructions. Indoor and outdoor airflow simulations using computational fluid dynamics and airflow-energy balances
Lecture	10/25	Thermal fundamentals: steady-state heat transfer, properties of wall and roof materials and windows
Lab	10/30	Whole-building energy balances using Rhino and Honeybee to estimate indoor thermal comfort, identify overheating periods and calculate electricity consumption for lights and fans; morphed weather files to estimate climate change;

Lecture	11/1	Equipment for cooling and dehumidification
Lab	11/6	Design, sizing and performance evaluation of dehumidification and sensible cooling systems; guidelines for interim report #2
Lecture	11/8	Radiative cooling
Lab	11/13	Assessment of local electricity supply systems; design of PV power and energy storage systems
Lecture	11/15	Whole-building structural systems; embodied energy and carbon; **interim report #2 due**
Lab	11/20	Design charrette
Lecture	11/22	window design: shutters and shades
	11/22	**Drop Date**
	11/23-24	**Thanksgiving and Institute holidays**
Lab	11/27	Roof design, with emphasis on trusses
Lecture	11/29	review of designs with Safe Haven personnel
	Lab	12/4 Simulations of designed buildings
Lecture	12/6	water usage and sanitation options
	TDB	**D-Lab Fall Showcase / Party, in person or virtual; placeholder for our contribution (web page or other) December 8 a possibility**
Lab	12/11	Assessment of simulations for final report and presentation
Lecture	12/13	Low-carbon architecture: a global perspective
	12/13	**Last day of classes**
	12/18-22	MIT final exam period; the MIT registrar will schedule a slot for our final presentations; **Final report and presentation due**

References (no required textbooks)

Murdoch, Joseph B. *Illumination Engineering From Edison's Lamp to the Laser Second Edition* 2003, Vision Communications ISBN 1-885750-05-6

Reinhart, Christoph F. *Daylighting Handbook I: Fundamentals, Designing with the Sun* 2014 ISBN 9780692203637

Reinhart, Christoph F. *Daylighting Handbook II: Daylight Simulations | Dynamic Facades* 2018 ISBN 9780578407098

Canvas

This course has a Canvas site, where homework assignments and instructions will be posted and where lab reports can be submitted electronically.

Academic integrity + honesty

Academic integrity is a serious issue. Data sources must include attribution. Lab reports must reflect the thoughts and efforts of team members, unless noted. Please familiarize yourself with MIT's Academic Integrity expectations at http://web.mit.edu/academicintegrity/.

Software

At appropriate times in the course, you will be asked to install most or all of the following software, for which (near) current download links are provided.

Rhino 7.0 - https://www.rhino3d.com/download - Grasshopper is included with the download. We have used the Windows version in the past. Ladybug Tools are now available for Windows and Mac OS but those who use Climate Studio will need the Windows version. Proceed with caution. There is a free 90-day evaluation version; longer-term usage requires a $195 educational license or access through the Department of Architecture's IT group, https://stoa.mit.edu/.
ClimateStudio – https://www.solemma.com/climatestudio
https://www.climatestudiodocs.com/Installers/download.php?software=cs&version=networked -- includes daylighting and building energy analysis and visualization; we will use it for daylighting analysis. A choice of versions can be made within Rhino by entering CSversion in the command line. The MIT license code (please do not share) is MITSAP:0snfbhv5xx34yb04 ; you will need to enter it only once. Windows only.
Eddy3D (https://www.eddy3d.com) is a freely downloadable tool that runs in Grasshopper (Windows only) to assess airflow around buildings and wind pressures on building surfaces.
Ladybug Tools – https://www.ladybug.tools/index.html – the insects (Ladybug, Honeybee, Dragonfly and Butterfly) provide grasshopper plug-ins for analysis and visualization of climate, thermal comfort, building energy use and airflow.
CoolVent - http://coolvent.mit.edu/download/ - a good way to assess the impact of wind-driven or buoyancy-driven airflows on building temperatures. Windows only.

CC WorldWeatherGen (http://www.energy.soton.ac.uk/ccworldweathergen/) morphs weather files to account for projected regional climate change.
CBE Thermal Comfort Tool - http://comfort.cbe.berkeley.edu is an online program developed by the Center for the Built Environment at UC Berkeley that locates specified environmental and occupant conditions within a region of acceptable thermal parameters.
CBE Clima Tool - https://clima.cbe.berkeley.edu is an online program that displays climate data extracted from EnergyPlus weather (epw) files.
Climate Consultant (http://www.energy-design-tools.aud.ucla.edu) is a freely downloadable tool that runs under Windows or Mac OS and provides a relatively comprehensive set of non-customizable graphical presentations of data from standard weather files. We prefer Ladybug and the CBE thermal comfort and climate tools but acknowledge that Climate Consultant is easy to use for standard climate information.