



Architecture 575a
Systems: The Thermal Environment,
or *Whose climate is it anyway?*

Units: 3
Fall 2023, Thursdays from 11:00 AM to 1:50 PM.

Location: Watt Hall (WAH) room B1 (on the basement level).

Instructor: Russell Fortmeyer

Office: N/A

Office Hours: Thursdays from 10:00 to 11:00 PM by appointment.

Contact Info: russellfortmeyer@gmail.com

Course Description

Every year is now the hottest year on record. Our cities trap heat and exacerbate harsh conditions for occupancy. Rampant development encroaching into impossible ecosystems turn to firestorms and then wash away. Coastal cities face near ruin. Our global political system sits idle, frozen in paralysis and focused on maintaining wealth in the hands of the privileged.

Architecture can play a significant role in shaping humanity's response to the needs of sustainability, climate change, and resilience. The performance of architecture—how it modulates energy and resource consumption and production, creates comfortable and productive spaces for people, and actively responds to dynamic environmental conditions—is increasingly its primary role in our cities, often at the expense of aesthetic and cultural criteria. Architecture must now actively and productively engage our stressed natural systems.

The course will begin with an exploration of the constraints of climate, basic physics, and how the human body responds to climate, as well as the conceptual models that govern the thermal environment, basic heat transfer theories, and thermodynamics. We will particularly consider the way comfort has been defined in the context of systemic racism in Western societies and then exported as a global “standard.”

Students will engage in a comprehensive analysis of site opportunities and constraints, climate risk, and models for contextualizing climate and its culture. Each successive lecture will then build on these constraints to study how architecture has developed in response, with lectures devoted to site design and analysis in terms of the impact of various geographic regions.

Specific focus will be given to environmental systems design, active and passive heating and cooling (Heating, Ventilation, and Air Conditioning, or HVAC), natural and mechanical ventilation, building controls and networks, indoor air quality, and outdoor microclimates. We will identify how the project of architecture can use integrated environmental systems as a generative force for design, one that does not neglect social and cultural values, even while advancing strategies like Zero Net Carbon (ZNC) buildings or the emerging circular economy.

Learning Objectives

By the end of the course, students will:

1. Understand the fundamental scientific principles governing the thermal environment and explain how they can be applied to evaluate factors such as building envelope performance, resource consumption, indirect CO₂ emissions, and conditions impacting human thermal comfort.
2. Understand the concept of climate justice and be able to explain why contemporary building thermal management practices present ethical and political concerns.
3. Understand and be able to use the psychrometric chart.
4. Understand the factors and assumptions that underlie contemporary definitions of human thermal comfort used to regulate the indoor climate of modern buildings.
5. Have the ability to discuss why diversity among populations of building occupants is poorly accounted for in contemporary thermal comfort models and be able to propose environmental concepts that better support the varying preferences, needs and expectations of building occupants.
6. Have the ability to perform an analysis of local climatic conditions to identify appropriate environmentally responsive design strategies for a given project and site location.
7. Have the ability to conduct an analysis of solar geometry and solar insolation for a given project and site location to inform a broad range of architectural design considerations (e.g. project orientation, massing and form, location and sizing of fenestration, glazing material selection, etc.).
8. Have the ability to identify and select environmentally sound building technologies for controlling the indoor thermal environment to provide comfort while minimizing energy consumption.

9. Have the ability to develop, document and present a holistic building thermal energy concept in an early-stage design scenario.
10. Have familiarity with the California Title-24 Section 6 requirements for buildings, California legislation mandating carbon reduction targets, and other model codes for addressing the energy and comfort performance of HVAC systems.

Course Notes

It is expected that students will come to class with their laptop computer and be prepared to work using the software listed below.

Technological Proficiency and Hardware/Software Required

This course assumes that the student begins the class with basic proficiency using the Rhino 7 software program. The course will use Grasshopper (a visual scripting program embedded within Rhino 7) as well as the free environmental analysis plugins and associated software listed below. No experience with any software (other than Rhino) is expected or required. Students are encouraged to download and install these programs prior to the start of the semester to gain familiarity. It is highly recommended that new users also join the online community discussion forum listed below.

1. Review the Ladybug Tools (LBT) website to learn about LBT
<https://www.ladybug.tools/>
2. Follow these instructions to download and install Ladybug Tools as well as Radiance and Open Studio (Make sure to read the installation instructions carefully and follow all steps)
<https://github.com/ladybug-tools/lbt-grasshopper/wiki>
3. Join this forum for additional support and to be a part of the community of users
<https://discourse.ladybug.tools/>
4. Download Climate Consultant here:
<https://www.sbse.org/resources/climate-consultant>
5. Bookmark the Center for the Built Environment Online Tools
<https://cbe.berkeley.edu/resources/tools/>
6. Other tools that will be introduced during the semester.

Required Readings and Supplementary Materials

Weekly readings will be assigned from handouts and online resources. We will primarily use the following textbooks, which are recommended to be purchased:

- Environmental Issues for Architecture. David Lee Smith. Wiley, 2011.
- Advanced Building Systems: A Technical Guide for Architects and Engineers. Klaus Daniels. Birkhauser, 2003.
- Green Studio Handbook. Alison Kwok and Walter Grondzik. Architectural Press, 2007.
- Other readings will be announced in class and provided online.

Description and Assessment of Assignments

A brief synopsis of each assignment is provided below. Each assignment consists of a series of sections. Students will be graded on the level of completeness, accuracy and quality of work presented for each section.

Assignment #1: Climate Analysis

Each student will choose a climate in Southern California and perform a climate analysis. Students will identify and document the critical aspects of climate and site/climate risks that should be considered for design and propose effective strategies based on analysis and project case study research.

Assignment #2 Site Microclimate Study

Students will identify a “marginal” public space in Los Angeles and analyze the climatic conditions, materials, environmental strategies (either natural or designed), and propose a simple intervention to improve conditions in relation to pedestrian health and comfort.

Assignment #3: Solar and Radiation Analysis

Assignment #4: Comfort and Heat Analysis

Assignment #5: Integrated Design Case Study and Envelope Detail

Assignment #6: Passive Design Analysis and Envelope Performance Study

Assignment #7: Ventilation Analysis

Assignment #8: Historical Heating and Cooling Study

Assignment #9: HVAC Concepts

Assignment #10: Carbon Analysis

Final Project: Environmental Systems Design Development and Representation: Bioclimatic, Zero Carbon Retrofit: Students will develop a series of drawings and a written report documenting the integration of appropriate environmental control strategies for a project in response to climatic and programmatic analyses, with the intent being to decarbonize an existing building in Los Angeles.

Grading Breakdown

The total grade for this course will be based on:

Assignment	Points	% of Grade
Assignments 1-10	100	75%
Final Project	34	25%
TOTAL	134	100%

Grading Scale

Course final grades will be determined using the following scale

A	95-100%
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

All assignments must be completed and uploaded to Blackboard prior to class time on the day they are due.

Grading Timeline

Work will be graded within two weeks of the due date.

Extra Credit

There is no extra credit awarded for this course.

Attendance and Late Work

Attending classes is a basic responsibility of every USC student who is enrolled in courses at the School of Architecture. Although any student should be evaluated primarily on their demonstrated knowledge through project development, papers, quizzes, and exams, the School believes important skills such as verbal presentation, design discussion and articulation of critical issues within each course are equal additional measures of demonstrated knowledge, particularly for our professional degree programs.

More than two unexcused absences may result in a failing grade. More than two instances of unexcused tardiness will be counted as an absence. Work turned in late will not be accepted unless a serious circumstance prevented the work from being completed and submitted on schedule. Timely communication with the instructor is necessary for late work to be accepted.

Any student not in class within the first 10 minutes is considered tardy, and any student absent (in any form including sleep, technological distraction, or by leaving mid class for a long bathroom/water break) for more than 1/3 of the class time can be considered fully absent. If arriving late, a student must be respectful of a class in session and do everything possible to minimize the disruption caused by a late arrival. It is always the student's responsibility to seek means (if possible) to make up work missed due to absences, not the instructor's, although such recourse is not always an option due to the nature of the material covered.

Course Schedule: A Weekly Breakdown

- Readings should be completed by the date shown on the calendar.
- Check Blackboard for weekly readings.
- There will be no in class final exam. Instead, each student will be responsible for completing a substantive final project (and report) that will be due at the scheduled time of the final and must be submitted on Blackboard by that time. A specific due date will be posted on Blackboard.

Wk	Day	Topic	Assigned	Due	Readings
1	Aug. 24	Course introduction, climate and site context, climate risk, social justice	Asn#1		Meadows, Thinking in Systems (ch1), others
1					
2	Aug. 31	Climate justice and urban microclimates	Asn#2	Asn#1	
2		Presentation and discussion of climate analysis work			
3	Sep. 7	Heat transfer, thermodynamics, psychrometrics, thermal comfort and the body	Asn#3	Asn#2	
3					
4	Sep. 14	Architecture of the sun: solar geometry, shading, and passive design	Asn#4	Asn#3	
4		Site solar orientation / overshadowing analysis using LB/HB.			
5	Sep. 21	Heating and cooling loads calculation, ventilation demands, building occupancies, indoor air quality	Asn#5	Asn#4	
5					
6	Sep. 28	High-performance envelope design for environmental control (via zoom)	Asn#6	Asn#5	
6		Solar radiation analysis, physical principles, surface properties, solar control system design considerations			
7	Oct. 5	Materials and thermal mass in design of passive systems	Asn#7	Asn#6	
7					
8	Oct. 12	[NO CLASS: FALL RECESS]	n/a	n/a	
8					
9	Oct. 19	Ventilation design, natural or otherwise	Asn#8	Asn#7	
9					
10	Oct. 26	Passive heating and cooling, design strategies, cultural context, analysis models	Asn#9	Asn#8	
10					

11	Nov. 2	High-performance HVAC systems, space planning, integrated design	Asn#10	Asn#9	
11					
12	Nov. 9	High-performance HVAC systems continued, building controls, commissioning and tuning, informatics and behavioral change	Final Project	Asn#10	
12					
13	Nov. 16	Carbon, decarbonization, whole-building LCA, refrigerants in cooling, district energy plants	Final Project		
13		Final project initial presentation and review			
14	Nov. 23	[NO CLASS: Thanksgiving]			
15	Nov. 30	Final project presentations		Final Project Draft	
16		Final project <u>report</u> DUE (See BB for specific due date)		Final project <u>report</u> due. See BB for due date	

Statement on Academic Conduct and Support Systems

Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.