



**Architecture 575a**  
**The thermal environment: warm-ups**

**Units: 3**  
**Fall 2024, 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 10-11AM or by appointment.

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^ *Crown Fountain*, Jaume Plensa, Chicago, 2004

## 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 thermal environment is both an observable scientific condition, as well as a culturally and socially produced human perception. This class considers both aspects, investigating the ways the architectural project can be wielded toward both efficient performance and individual comfort.

This class will explore the thermal environment by considering the role of design “concepts” and “strategies” in architecture, particularly our need to warm up the cold conceptual leftovers of the Modern architecture project to meet the climate crisis. We define “concepts” as spatial and material organizations, like an atrium, and consider “strategies” as applied systems like external façade shading devices. Each week will explore building physics related to the science and experience of the thermal environment related to the concepts and strategies within the discipline of architecture. Students will learn by exploring concepts and strategies through assignments and their integration into their studio projects for the semester.

## Course Approach

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 CO<sub>2</sub> 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. Develop the ability to engage numerical models and software platforms used for analyzing the thermal environment in outdoor and indoor architectural contexts.

### **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 software program. The course will use Grasshopper (a visual scripting program embedded within Rhino) 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.

We will assess and explore available environmental scripts within Grasshopper and Rhino throughout the semester and in context of your studio projects.

1. Review the Ladybug Tools (LBT) website for Ladybug and Honeybee  
<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. Check out UC Berkeley's Clima tool:  
<https://clima.cbe.berkeley.edu/>
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. Readings are mandatory, although students will also be given references that are voluntary and provided for those students who need additional understanding on weekly topics. It is expected that students complete the required readings prior to class to engage in discussion prior to the lecture; questions for the

readings will be assigned each week and students will be expected to engage them in class. The readings may change throughout the semester, but that will be announced in class. Readings area available in Brightspace on the class page.

### **Week 1 / Microclimates**

1. Benedito, Silvia. "Atmosphere as Program," in *Atmosphere Anatomies: On Design, Weather, and Sensation*. Zurich, Switzerland: Lars Muller Publishers, 2021. Pages 168-209.
2. Meadows, Donella and others. "The Basics," in *Thinking in Systems*. White River Junction, Vermont: Chelsea Green Publishing, 2008. Pages 11-34.
3. US EPA. *Urban Heat Island Basics*, 2016.
4. REFERENCE: Lechner, Norbert. "Climate," in *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*. Hoboken, New Jersey: Wiley, 3rd Edition, 2008. Pages 79-129.

### **Week 2 / Solar Architecture**

1. Olgyay, Victor. "Solar Control," in *Design with Climate*. Princeton: Princeton University Press, 1963. Pages 64-83.
2. Stein, Richard G. "A history of comfort with low technology," in *Architecture and Energy*. New York: Anchor Press, 1977. Pages 23-47.
3. Kallipoliti, Lydia. Case studies from *The Architecture of Closed Worlds*. Zurich: Lars Muller Publishers, 2018. Pages 157-171.
4. REFERENCE: Daniels, Klaus. "Daylighting" in *Advanced Building Systems*. Basel, Switzerland: Birkhauser, 2003. Pages 444-460.
5. REFERENCE: Kwok, Alison G. and Walter T. Grondzik. "Lighting," in *The Green Studio Handbook: Environmental Strategies for Schematic Design, First Edition*. Oxford: Architectural Press, 2007. Pages 56-91.

### **Week 3 / Computational models**

1. Moe, Kiel. "What your body already knows," in *Thermally Active Surfaces in Architecture*. New York: Princeton Architectural Press, 2010. Pages 68-83.
2. Barber, Daniel. "Conditioning," in *Modern Architecture and Climate: Design before Air Conditioning*. Princeton: Princeton University Press, 2020. Pages 248-269.
3. Brager, Gail, and Mark DeKay. "Beyond Comfort," in *Experiential Design Schemas*. San Francisco: Oro Editions, 2023. Pages 30-69.
4. REFERENCE: Lechner, Norbert. "Heat: Basic Principles," in *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*. New York: Wiley, 3rd Edition, 2008. Pages 49-61.

### **Week 4 / Earth architecture**

1. Dethier, Jean, et al. "In Praise of Earth Architecture," in *The Art of Earth Architecture*. New York: Princeton Architectural Press, 2020. Pages 8-25.
2. Browning, William and Catherine Ryan and Joseph Clancy. *14 Patterns of Biophilic Design*. New York: Terrapin Bright Green, 2014. Pages 1-18.
3. Narath, Albert. "Introduction," in *Solar Adobe: Energy Ecology and Earthen Architecture*. Minneapolis: University of Minnesota Press, 2024. Pages 1-27.

### **Week 5 / Landscape buildings**

1. Myers, William. "Beyond Biomimicry," in *Bio Design: Nature Science Creativity*. New York: The Museum of Modern Art, 2018. Pages 10-75.
2. Brager, Gail, and Mark DeKay. "Habitat Fringe," in *Experiential Design Schemas*. San Francisco: Oro Editions, 2023. Pages 266-269.
3. REFERENCE: Benyus, Janine. "Echoing Nature," in *Biomimicry: Innovation Inspired by Nature*. New York: William Morrow, 1997. Pages 1-10.
4. REFERENCE: Pawlyn, Michael. "Biomimicry" in *Green Design: From Theory to Practice*. London: Black Dog Publishing, 2011. Pages 33-40.

### **Week 6 / High-performance envelopes**

1. Lang, Werner. "Is it all 'just' a façade? The functional, energetic and structural aspects of the building skin," in *Building Skins: Concepts Layers Materials*, edited by Christian Schittich. Basel, Switzerland: Birkhauser, 2001. Pages 28-47.
2. Moe, Kiel. "De-fragmentation of Buildings and Practices," in *Thermally Active Surfaces in Architecture*. New York: Princeton Architectural Press, 2010. Pages 94-117.
3. Loughran, Patrick. "Energy" in *Falling Glass*. Basel: Birkhauser, 2003. Pages 82-103.
4. Brager, Gail, and Mark DeKay. "Cooling Conversions," in *Experiential Design Schemas*. San Francisco: Oro Editions, 2023. Pages 274-277.
5. REFERENCE: Smith, David Lee. "Thermal Calculations," in *Environmental Issues for Architecture*. Hoboken, New Jersey: Wiley, 2011. Pages 199-211.

**[No Week 7 due to fall recess]**

### **Week 8 / Courtyard buildings**

1. Benedito, Silvia. "Atmosphere as Shared Situation," in *Atmosphere Anatomies: On Design, Weather, and Sensation*. Zurich, Switzerland: Lars Muller Publishers, 2021. Pages 210-269.
2. Brager, Gail, and Mark DeKay. "Tempered Pathway," in *Experiential Design Schemas*. San Francisco: Oro Editions, 2023. Pages 188-203.

### **Week 9 / Atrium design**

1. Daniels, Klaus. "Natural Ventilation" in *Advanced Building Systems*. Basel, Switzerland: Birkhauser, 2003. Pages 182-199.
2. Olgyay, Victor. "Bioclimatic Approach," in *Design with Climate*. Princeton: Princeton University Press, 1963. Pages 14-23.
3. Kriken, John Lund. "Town Planning and Cultural and Climatic Responsiveness in the Middle East," in *Design for Arid Regions*. New York: Van Nostrand Reinhold Company, 1983. Pages 97-120.

### **Week 10 / Canopy buildings**

1. Beneytez-Duran, Rafael. "The Materiality of Air," in *Log*. New York: Anyone Corporation, 2024. Pages 28-40.
2. Heschong, Lisa. "Necessity" in *Thermal Delight in Architecture*. Cambridge: MIT Press, 1979. Pages 1-17.

### **Week 11 / Fabric structures**

1. Addington, Michelle. "The Unbounded Boundary," in *Thermodynamic Interactions*. Barcelona: Actar Publishers, 2017. Pages 79-87.

## **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: 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. Students should select a space that could be replicated easily as a 3D model within a Rhino context, with surrounding structures.

### **Assignment #2: Analyzing Microclimates**

**Assignment #3-10 will be announced during the semester.**

**Final Project** The final project will encompass a complete thermal environmental analysis and design concept based on and integrated into the student's studio project for the semester. The

project will include concept sketches, analysis (both desktop and simulations), and documentation for presentation. Students will also summarize their proposed thermal environmental concept with an illustrated essay based on the semester's readings.

## Grading Breakdown

The total grade for this course will be based on the following; a rubric will be provided for the final project.

Assignment	Points	Rated % of Total Grade
Assignments 1-10	100	65%
Final Project	50	25%
Class participation / discussions	30	10%
<b>TOTAL</b>	<b>180</b>	<b>100%</b>

## 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 online prior to class time on the day they are due.

## Grading Timeline

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

## 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. 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

Wk	Day	Topics / assignments	Assigned	Due	Readings due
1	Aug. 29	Course introduction, the science of heat, the body in relation to heat, extreme heat and climate	Asn#1	n/a	Readings are assigned and to be completed for discussion for the next class. Refer to the readings list above.
2	Sep. 5	Outdoor rooms, microclimates, thermal conditions in urban design	Asn#2	Asn#1	Week 1
3	Sep. 12	Solar architecture	Asn#3	Asn#2	Week 2
4	Sep. 19	Computational models for thermal environments (online lecture, with assignment coordination)	Asn#4	Asn#3	Week 3
5	Sep. 26	Earth architecture	Asn#5	Asn#4	Week 4
6	Oct. 3	Landscape buildings	Asn#6	Asn#5	Week 5
7	Oct. 10	[NO CLASS: FALL RECESS]	n/a	n/a	
8	Oct. 17	High-performance envelopes, double-skin facades, Passivhaus, and winter gardens	Asn#7	Asn#6	Week 6
9	Oct. 24	Courtyard buildings, passages, balconies, and terraces	Asn#8	Asn#7	Week 8
10	Oct. 31	Atrium design	Asn#9	Asn#8	Week 9
11	Nov. 7	Canopy buildings	Asn#10	Asn#9	Week 10
12	Nov. 14	Fabric structures	Final Project	Asn#10	Week 11
13	Nov. 21	Project reviews	Final Project		
14	Nov. 28	[NO CLASS: Thanksgiving]			
15	Dec. 5	Final project presentations in class		Final Project Draft	
16		Final project <u>report</u> DUE		Final project <u>report</u> due.	

## Statement on Academic Conduct and Support Systems

### Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), 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 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](#).

### Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment. Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13). Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

### 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](mailto: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](mailto: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.