ARCHITECTURE AND ENERGY SYSTEMS

SYLLABUS

Kiel Moe       email: MOE@NEU.EDU
Office hours: Tues/Fri: 1:45-3pm

11:45-1:25 Tuesday
11:45-1:25 Friday
“And do you know what ‘the world’ is to me? Shall I show it to you in my mirror? This world: a monster of energy, without beginning or end;... not something blurry or wasted, not something endlessly extended, but set in a definite space as a definite force, and not a space that might be ‘empty’ here or there, but rather as a force throughout, as a play of forces and waves of forces, at the same time one and many, increasing here, and at the same time decreasing there; a sea of forces flowing and rushing together, eternally changing, eternally flooding back, with tremendous years of recurrence, with an ebb of flow of its forms; out of the simplest forms striving towards the most complex, out of the stillest, most rigid, coldest forms towards the hottest, most turbulent, most self-contradictory, and then again returning home to the simple out of this abundance, out of the play of contradictions back to the joy of concord, still affirming itself in this uniformity of its courses and its years, blessing itself as that which must return eternally, as a becoming that knows no satiety, no disgust, no weariness: this, my Dionysian world of the eternally self creating, the eternally self-destroying, this mystery world of the twofold voluptuous delight, my ‘beyond good and evil’”

Nietzsche
Course description:
Energy systems in architecture are introduced to students as a problem of knowledge and design. Any understanding of Architecture and Energy Systems integrates a range of topical knowledge: from the molecular to the territorial, from the material to the immaterial, from the instantaneous to the millennial. Presenting these agencies and systems in a coherent view for architects is the object of this course. Architecture and Energy is understood primarily a formal issue in architecture: students will learn to shape architecture based on an understanding of energy, thereby enabling a range of sustainable practices.

There is a focus on fundamental scientific principles underlying the thermal, visual, and aural behavior of buildings as well as productive representational techniques that rapidly develop an architect’s intuition about energy flows and in doing so, amplify architecture in its milieu. Every architecture is in a specific milieu, an idiosyncratic vortex of matter and energy. Thus, building systems can no longer be understood by spatial and material configurations alone. Rather their dynamic, performative, and immaterial aspects must also be understood and designed. Time and duration are essential aspects of Architecture and Energy Systems. The dynamics, performances, and effects of architecture all arrive in time, not space. Architects ought to be more seduced, curious about the vital, time-imbued milieu of Architecture and Energy Systems.

Increasingly, our understanding of Architecture and Energy Systems must also account for their situation within a social, political, and cultural milieu. All theses forces, from the social to material to energy fields, help define the milieu of architecture. Any energy system contains hard and soft technologies that must be understood if the system is to be understood at all. Hard technologies include the brute matter of architecture and its systems, the source of those materials, and their assembly. Soft technologies include energy as well as the social, economic, and political substrate of a project. An advanced understanding of the milieu will sponsor a deeper, more poignant understanding of Architecture and Energy Systems.

Architecture and Energy Systems in the twenty-first century will no longer emerge from the poor technicians and engineers of architecture. Rather, advanced Architecture and Energy Systems will emerge from architects with studied and practicable physical theories, a theory of technology and a theory of the body, a new alloy of the material and immaterial effects in architecture. This course will introduce architecture students to Architecture and Energy Systems as both a problem of knowledge and design as well as the pragmatics of integrated Architecture and Energy Systems.

Course outcomes
- A theory of technology/energy for each practicing architect
- A (new) theory of form and the object for each practicing architect
- A practicable theory of morphogenetic decisions in architecture
- A practicable theory of matter and energy (the milieu) for each practicing architect
- A non-trivial understanding of sustainability

Course prerequisites
This course requires that the below listed prerequisites be completed satisfactorily before you will be allowed to take this course. If it is discovered that you have not completed these prerequisites, you may be dropped from the course at any time during the semester.

- PHY 141 Physics 1 for Engineers
- MTH 241 Calculus 1 for Engineers
- ARC U356 Structures 1: Statics
- RC U357: Structures 2: Tectonics

Attendance
Attendance is required at all lectures. Active note taking is required and will ultimately be graded. Two or more excused absences will result in the reduction of the final letter grade. More than three unexcused or excused absences will result in a failure of the course. Some content in the lectures may seem abstract, opaque, new, or otherwise deserves clarification. Wise and curious students will ask questions, seek clarification, and thoroughly understand the content of the readings and discussed in the lectures.

Texting, taking/making phone calls, browsing the web, instant messaging or engaging any form of media that is not taking notes will amount to an absence in this course. To that end, there are to be no open laptops, cell phones, or other electronic devices allowed during lectures and discussions. If you need to engage these media, please do so outside of class.

Course Requirements
There are five requirements for this course:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>% of Grade</th>
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<tbody>
<tr>
<td>1 Reading Notes</td>
<td>12%</td>
</tr>
<tr>
<td>2 Project</td>
<td>40%</td>
</tr>
<tr>
<td>3 Exam 1</td>
<td>25%</td>
</tr>
<tr>
<td>4 Exam 2</td>
<td>20%</td>
</tr>
<tr>
<td>5 an electronic course binder</td>
<td>3%</td>
</tr>
</tbody>
</table>
Reading Notes:

For each reading, summarize the reading in a three to five sentence summary and then produce an annotated outline of the content for use as a future reference (studying for exams, future studios, and taking the ARE). These notes will be graded for their capacity as a source for future reference and it should be written and organized as such. The Reading Notes should also document aspects of the content that are not clear. The grades will be a plus (+) or a check (✓) or a minus (—), for good, acceptable, and poor respectively. The Reading notes are due at the beginning of each class.

Project:

A series of related assignments that follow the lecture and reading content sequentially develop the design of a simple building with energy and climate as a determinant generators and factors of architectural decisions. The degree to which an understanding of energy in architecture shapes the building and its responses are integrated into the building are the primary grading criteria for this project.

Exams:

There will be exams on the content of the lectures and readings. The exams will focus on key vocabulary, concepts, and principles from the lectures and readings. Expect to answer theoretical questions in essay form, diagram various energy principles and flows, define terms, and generally be responsible for any content in the readings and lectures.

Course binder

A binder of the course material is required. It should have distinct sections for lecture notes for each lecture, notes from the readings for each lecture, the readings themselves, the accumulated process assignments for the project, and the final project itself. The aim is to produce a resource for future reference and will be graded on its potential as a reference. It is 3% of your final grade, enough to drop or raise your grade by a +/-.

Grades:

A: Superior work. True Excellence. Students work is original and of exceptional intellectual quality, is very well written, represented, and complete. The graphics, documentation, and text reveal original thinking. All work is supported by wide textual documentation, is structurally inventive, and is thorough and complete.
B: Good work. Students work is of high intellectual quality, is well written, is supported by textual documentation, progresses logically, and is complete.
C: Average work. Meets the requirements. Students work is of average intellectual quality, is intelligible, is supported by some textual documentation, progresses logically, and is complete.
D: Students work is of below average intellectual quality, is written poorly, is not adequately supported by textual documentation, progresses illogically, and/or is incomplete.
F: Students work is of unacceptable intellectual quality, badly written, unsupported, illogical, and/or incomplete.
For more detail refer to http://www.architecture.neu.edu/student_resources/grading_policy/studio_course

Grade Inquiries/Changes

Any grade inquiries/changes will only be discussed in person, during office hours—not through email. If you want to discuss your grade, take the following steps: assemble your reading notes, assignments, attendance record and exams from the semester; record their grades in a spreadsheet according to the above percentages; and write a one page analytic summary of the perceived differences and construct an argument for what and why you discern a different grade. After completing this work, make an office hours appointment and bring this documentation to the appointment so that we can objectively discuss your grade. No grade changes will be discussed without this documentation.

NAAB Student Performance Criteria

The work that students produce toward their degree granted by the School of Architecture is the property of the School of Architecture. The complete course work from selected students shall be collected by the School for each course taught for the National Architecture Accreditation Board [NAAB] documentation. Students are encouraged to document their work for their personal portfolio if it is requested by the School for the NAAB, but the work must be submitted to the professor no later than one week after final exams week. This course meets the following NAAB Student Performance Criteria to the extent designated:

12.15: Sustainable Design Ability
12.19: Environmental Systems Ability
12.22: Building Service Systems Understanding
Academic Honesty

Northeastern University is committed to the principles of intellectual honesty and integrity. All members of the Northeastern community are expected to maintain complete honesty in all academic work, presenting only that which is their own work in tests and assignments. If you have any questions regarding proper attribution of the work of others, contact your professor prior to submitting work for evaluation. For more detail refer to http://www.osccr.neu.edu/policy.html

Sustainability

There is little lecture content, if any, in this course that is not informed by and directed towards sustainable principles. While there has been a good deal of hand-waiving and spilt ink about sustainability over the past years, it is the position of this course is that if sustainability is important then it should be simply integrated into technical and social practice rather than remain the province of a few isolated individuals on the fringe that claim and market it as an area of specialty. Most of ‘sustainability’ is common sense from technical, ecological, economic, and social viewpoints. These principles best represent intelligent practices rather than a litany of narrowly defined recycled rhetoric, hand-waiving statistics, self-righteousness, overly deterministic design methods, isolated ‘green’ demonstration projects, environmental eschatology, and/or misplaced moralities. Practice will clearly change in this century. Therefore, the aim here is to integrate these best theories and practices directly into the content of this building systems course and thus into practice, without the hand-waiving litany. It makes more sense to directly integrate sustainable practices rather than differentiating them from presumably unsustainable, yet taught practices. This course is focused on Architecture and Energy Systems that incorporate intelligent practices, including principles of sustainability. Sustainability is a definite pretext of the course, but only as a pretext for intelligent practice in the twenty-first century.
<table>
<thead>
<tr>
<th>WEEK</th>
<th>CLASS DATE</th>
<th>TOPIC</th>
<th>READINGS DUE [for that day] [optional reading]</th>
<th>ASSIGNMENT DUE</th>
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<tr>
<td>1</td>
<td>9/10/2010</td>
<td>S1 Intro: Step Into Liquid</td>
<td>r1: Syllabus</td>
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<tr>
<td>2</td>
<td>9/14/2010</td>
<td>S2 Energy and Form</td>
<td>r2: Olygay, Botkin, Kwinter</td>
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<td>9/21/2010</td>
<td>S4 Contexts: Micro</td>
<td>r4: Lechner Chapters 3 &amp; 4</td>
<td>P1: Base Building</td>
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<td></td>
<td></td>
<td>[EcoTect tutorial]</td>
<td>[download Ecotect trial]</td>
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<td>4</td>
<td>9/28/2010</td>
<td>S6 Contexts: Sources</td>
<td>r6: Lechner Chapters 2.15-20+ 8 (all) + Banham + Bankier Gale</td>
<td>P2: Adapt for Climate</td>
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<td>5</td>
<td>10/1/2010</td>
<td>S7 Systems: Structural Solutions: Heating</td>
<td>r7: Lechner Chapter 7</td>
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<td>6</td>
<td>10/5/2010</td>
<td>S8 Systems: Structural Solutions: Cooling</td>
<td>r8: Lechner Chapter 9 + 10.1-10.4+10.11-10.16</td>
<td>P3: Adapt for Heat</td>
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<td>8</td>
<td>10/19/2010</td>
<td>S12 Milieus: Light</td>
<td>r12: Lechner Chapter 12.2-12.19</td>
<td>P5: Adapt for Air and Envelope</td>
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<td>10/22/2010</td>
<td>S13 Milieus: Daylight</td>
<td>r13: Lechner Chapter 13 +Addington,“Energy…”</td>
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<td>9</td>
<td>10/26/2010</td>
<td>S14 Milieus: Power-Operated lighting</td>
<td>r14: Lechner Chapter 14</td>
<td>P6: Adapt for Daylight/Shading</td>
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<td>10/29/2010</td>
<td>S15 Milieus: Sound</td>
<td>r15: Emily Thompson_Listening to Modernity</td>
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<td>10</td>
<td>11/2/2010</td>
<td>S16 Milieus: Acoustics</td>
<td>r16: SZOKOLAY_Intro to Arch Science Sound</td>
<td>P7: Revise and Integrate</td>
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<td>S17 Milieus: Water</td>
<td>r17: ALLREAD LESLIE_Plumbing Electrical</td>
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<td>11</td>
<td>11/9/2010</td>
<td>EXAM 1</td>
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<td>Study for Exam</td>
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<tr>
<td></td>
<td>11/12/2010</td>
<td>S18 Matter is Energy</td>
<td>r18: Moe, Fernandez-Galliano, Whyte</td>
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<td></td>
<td>11/19/2010</td>
<td>S20 Matter is Energy: Mapping Matter</td>
<td>r20: Cronan, DeLanda</td>
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<td>14</td>
<td>11/26/2010</td>
<td>Thanksgiving</td>
<td>No Class</td>
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<td>tbd</td>
<td>EXAM 2</td>
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</table>
Required Textbook
Note: other required readings provided.

Reading Assignments

Tasks:
1. Download the appropriate reading(s) or read from the text book.
2. READ each reading at least twice before you begin your summary.
3. WRITE a single, high quality three to five sentence summary for each reading. In all cases court brevity. The summary should be short but thorough, capturing in a few words the primary knowledge of each reading. It is very difficult to concisely and completely communicate the content of an entire article in a few of good sentences. However, this type of writing is increasingly important in your discipline. So provide adequate time to write, review, edit, and revise your work at least a couple of times before you submit it. It is important that the writing is clear, direct, and that every word counts. What you leave out is often as important as what you include. The scientific abstract, where complete theoretical understanding is conveyed directly and concisely, is the model for these reading summaries. The summary should objectively focus on the key knowledge contained in each reading. This summary is NOT a flaccid paragraph about your opinion of the reading or any other type of subjective reading response. It is a summary of the content of the reading. Note the difference. Keep your readings, your reading notes, and summaries together with your responses in your course binder.
4. WISE students will also write an outline/annotated outline of the reading for future reference.
5. WRITE any additional questions or comments you have about the reading.
6. Print a hardcopy of your response/outline.
7. HAND IN your reading assignment at the beginning of each class.
8. NO late submissions, no excuses, no extensions, no emailed responses accepted. none.

Grading:
Your grade on the reading assignments will be the sum of the marks for each of the following categories:
Comprehension: your ability to discern and comprehend the key concepts of each reading
Summary: your ability to concisely and thoroughly communicate the key concepts of each reading
Writing: your ability to articulate clearly and precisely your summary (grammar, word choice, brevity)

+ above average comprehension, summarization, and/or writing.
✓ average comprehension, summarization, and/or writing. (this is the baseline, you go up or down from here)
– below average comprehension, summarization, and/or writing.
0 unacceptable comprehension, summarization, and/or writing.
## Bibliography

### Core Texts

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Call Number</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniels, Klaus.</td>
<td>The Technology of Ecological Building</td>
<td>NA2542.35 .D3613</td>
<td>1997 oversize</td>
</tr>
<tr>
<td>McMullen, Randall</td>
<td>Environmental Science in Building</td>
<td>TH6021.M33</td>
<td>2001</td>
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</tbody>
</table>

### Theory and Literature

<table>
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<tr>
<th>Author</th>
<th>Title</th>
<th>Call Number</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>Fernández-Galiano, Luís</td>
<td>Fire and Memory</td>
<td>NA2542.3. F4713</td>
<td>2000</td>
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<tr>
<td>Heschong, Lisa</td>
<td>Thermal Delight</td>
<td>NA2541.H7</td>
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### Air

<table>
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<th>Author</th>
<th>Title</th>
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<tbody>
<tr>
<td>Clements-Croome, Derek</td>
<td>Naturally Ventilated Buildings</td>
<td>TH674.N38</td>
<td>1997</td>
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<tr>
<td>Givoni, Baruch.</td>
<td>Man, Climate and Architecture</td>
<td>NA2541.G58</td>
<td>1976</td>
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<tr>
<td>Olgyay, Victor.</td>
<td>Design with Climate</td>
<td>NA 2540.0 44</td>
<td>1963</td>
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### Energy

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<th>Author</th>
<th>Title</th>
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<tbody>
<tr>
<td>Behling, Sophia</td>
<td>Solar Power</td>
<td>NA2542.3.s.843</td>
<td>2000 oversize</td>
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<tr>
<td>Cottom-Winslow,</td>
<td>Environmental Design: Architecture and Technology</td>
<td>NA2542.35.C68</td>
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<tr>
<td>Owen and Steemers,</td>
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<tr>
<td>Thomas, Randall</td>
<td>Photovoltaics and Architecture</td>
<td>K1087.P4845</td>
<td>2001</td>
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<tr>
<td>Watson, Donald.</td>
<td>Climatic Design</td>
<td>TJ163.5.884 W38</td>
<td>1983 oversize</td>
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### Light

<table>
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<tr>
<th>Author</th>
<th>Title</th>
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<tbody>
<tr>
<td>Guzowski, Mary</td>
<td>Daylighting for Sustainable Design</td>
<td>NA2542.3.G89</td>
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<tr>
<td>Lam, William</td>
<td>Sunlight as a Form-Giver for Architecture</td>
<td>NA2542.35.L35</td>
<td>1986</td>
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### General

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Call Number</th>
<th>Year</th>
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<tbody>
<tr>
<td>Baker &amp; Steemers</td>
<td>Energy and Environment in Architecture</td>
<td>NA2542.3.s.843</td>
<td>2000</td>
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<tr>
<td>Barnett, Dianna.</td>
<td>A Primer on Sustainable Building</td>
<td>NA7117.5.P75</td>
<td>1995</td>
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<tr>
<td>Daniels, Klaus.</td>
<td>Low Tech Light Tech High Tech</td>
<td>NA2543 .T43 D36</td>
<td>1998</td>
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<tr>
<td>Givoni, Baruch.</td>
<td>Climate Considerations in Building and Urban Design</td>
<td>NA2541.656</td>
<td>1994</td>
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<td>Foster, Wayne</td>
<td>The Selective Environment</td>
<td>NA2542.36.H38</td>
<td>2002</td>
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<td>Hawkes, Dean, Mendler</td>
<td>The HOK Guidebook to Sustainable Design</td>
<td>NA2542.M445</td>
<td>2000</td>
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<tr>
<td>McDonald &amp; Steemers</td>
<td>Climate Responsive Design</td>
<td>NA2541.H93</td>
<td>2000</td>
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<tr>
<td>Ruck, Nancy C.</td>
<td>Building Design and Human Performance</td>
<td>NA2542.4.885</td>
<td>1989</td>
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<td>Scott, Andrew</td>
<td>Dimensions of Sustainability</td>
<td>NA2750 .D68</td>
<td>1998</td>
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<td>Slessor, Catherine</td>
<td>Eco-Tech: Sustainable Architecture and High Tech.</td>
<td>NA2542.35 .E62</td>
<td>1997 oversize</td>
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<td>Smith, Peter</td>
<td>Architecture in a Climate of Change</td>
<td>NA2542.3.S65</td>
<td>2001</td>
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<tr>
<td>Zeither, Laura.</td>
<td>The Ecology of Architecture</td>
<td>NA2542.35 .J45</td>
<td>1996 oversize</td>
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</tbody>
</table>
EXAM 1 (10,000 POINTS EACH) WRITE NAME:

2. True / False: A good day lighting strategy for a building admits as much sunlight as possible.
3. Operative temperature is best described as:
   (a) including the effects of dry bulb temperature and relative humidity
   (b) the average of mean radiant temperature and air speed
   (c) including the effects of dry bulb and mean radiant temperatures
   (d) a temperature that describes how hot it “feels” in a space

4. Heat of vaporization and heat of fusion are examples of which kind of heat? ___________________________

5. Which one of the following is not correct about north lighting?
   A) North windows give the most even (constant) lighting.
   B) A warm white light is received through north windows on a clear day
   C) North lighting is best for climates that have no cold winters.
   D) In very hot climates, north windows should be protected by vertical fins.

6. As a source of captured solar energy, deep earth temperatures are similar to:
   A) mean annual temperature   B) mean summer temperature
   C) mean spring and fall temperature   D) mean winter temperature

7. What are the ‘free’/renewable sources of energy in the milieu every project site? (identify four)

8. What is a thermal bridge in a building envelope and what problems does it engender?

9. Which is more efficient for moving thermal energy in a building: air or water? Why?

10. In the most general terms, draw the massing of a building on an open site: one for a warm/temperate climate and one for an extremely cold climate. (a general plan and section diagram will do. hint: The focus is on basic climate-appropriate shapes.)
11. Define and Diagram the following modes of heat transfer:

<table>
<thead>
<tr>
<th>Diagram</th>
<th>definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convection</td>
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<tr>
<td>Conduction</td>
<td></td>
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<tr>
<td>Radiation</td>
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</table>


13. Give three specific and different reasons why exterior shading devices such as overhangs are better than dark tinted glazing on south windows with a venetian blind on the interior as a solar control strategy.
   1. 
   2. 
   3. 
14. Conductance is best described as:
   (a) a direct measure of the ability of a unit thickness of material to resist heat flow
   (b) a direct measure of the ability of a unit thickness of material to permit heat flow
   (c) a direct measure of the ability of any stated thickness of material to permit heat flow
   (d) a direct measure of the ability of any stated construction assembly to permit heat flow

15. Define the following terms: sensible heat, latent heat, VAV, and hydronic.
   Sensible heat:

   Latent heat:

   VAV:

   Hydronic:

16. Which one of the following is not correct?
   A) A stud is a “thermal bridge” in a conventional modern framed wall.
   B) Use “selective low-e” glazing when cool daylight is needed.
   C) A radiant barrier must face either an air space or a vacuum.
   D) “S.I.P.” is an acronym for Solar Insulation Panel.

17. In the plan and section to the right, show the pressure created by the wind on all sides of the building. Add (+) or (-) symbols within the parentheses.

18. The psychrometric chart is used to:
   (a) establish the extent of heat gains and losses through the building envelope
   (b) analyze HVAC system operating conditions
   (c) determine the efficiency of heating/cooling equipment
   (d) make a initial decision regarding local or central system options
19. Correctly label the following in the diagram, using their number in the diagram boxes.
   1. Convective Loop
   2. Longwave Radiation
   3. Shortwave Radiation
   4. Radiant Transfer

20. Explain what “thermal lag” is and how it works.
Critique the building projected on the screen with respect to its energy systems. To do so, describe the respective systems and their performance. Cite the ‘structural solutions’ and ‘power-operated solutions’. State the merits and problems associated with that system and performance. Use (+/-) bullet points as good/bad notes about the building.

1. **Sources of Energy** (just list sources of energy)

2. **Massing** (size, shape, orientation, location, treatment)

<table>
<thead>
<tr>
<th>3. Heating Strategy</th>
<th>Major Systems</th>
<th>Minor Systems</th>
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<tbody>
<tr>
<td>Structural</td>
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<tr>
<td>Power-Operated</td>
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</tbody>
</table>
4. Cooling Strategy

5. Building Envelope

6. Ventilation
7. Daylight/Lighting

8. Acoustics

9. Relationship of systems to the human body

10. Embodied Energy and Carbon footprint
11. Given your assumptions about the building, its systems, and performance, use the space below to state and draw the 3 most important changes you would recommend to alter the building and its performance while not detracting from its architectural ambitions but rather amplifying its ambitions.
60', 100'

**P0: Teams for Project Assignments:**
You will work with one other person on a semester long project that applies course content to a modest design project.

1. 

2. 

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11. 

12. 

P1: Base Building

This base building will be the basis of subsequent project assignments. The building is inherently abstract and somewhat generic. While the building should be elegant and well-proportioned, the intent in the first phase is to simply develop an armature for later elaboration.

Work accordingly. The suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign.

1. Design a generic building according to the following parameters:
   - From 1,200 up to 1,800 total square feet on 1.5 levels
   - up to 28,000 cubic feet (as measured from the outside)
   - up to 25% of the exterior all and roof surface may be glazed
   - there should be an internal core with a bathroom and a stair serving a mezzanine
   - walls, floors, roofs, etc should have a nominal thickness
   - the site for the building is a rural meadow (roughly 60’x100’) surrounded by 30’ high forests on a south facing slope (1:6 slope) in Southern Arizona, the Colorado Mountains, near Chicago, Vancouver, Houston, Minneapolis, or Charlottesville, VA. The site will remain constant throughout the project-pick one and stick with it. It is part of this first assignment to draw and model the site!

2. Document your design:
   - provide a site plan, state which climate you have selected
   - provide a primary floor plan (with north arrow and upper floors indicated with dashed lines)
   - a primary north/south section through primary spaces and the site
   - elevations + diagrammatic glazing ratio data
   - at least one exterior perspective
   - combine these drawings with a graphic scale with associated data about size and ratios neatly on a single PDF sheet

notes for every submission:
   - only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
   - ensure your name and project number is on each sheet
   - the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
   - the projects will be assessed for
     CONTENT: quality and completeness of required content (40%)
     EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
     PRESENTATION: graphic clarity, accuracy of text (20%)
   - hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
   - only use office hours for questions
   - always and only do excellent work.
P2: Adapt for Climate & Contexts

In this phase of the project, you will adjust your base building from P1 to its climate using techniques discussed in class (or scrap it and start over with the new information). In most cases, the massing of the building will likely be fundamentally different, in other cases the massing should be substantially transformed. Likewise, the fenestration strategy will likely be different. You must use the EcoTect Weather Tool as the basis of these design decisions and discuss the changes in those terms.

1. Fit Building to Climate & Contexts

   - perform a climate analysis for your site
   - determine which climate data is of particular consequence for your climate and building
   - develop a hierarchy of climate data information and present it accordingly - which data matters for your climate and contexts? Why? (mindless output of data will receive a very low mark)
   - reflexively critique your base P1 building according to the data evident in this phase of climate analysis
   - identify and label its problems and potentials
   - thoughtfully transform your base building according to the data and strategies prompted by the climate analysis

2. Document your critique and design:

   - page 1: document your interpreted and edited EcoTect climate analysis in Illustrator
   - page 2: document your critique of the P1 building with a text summary and notes + leaders (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at an indicated scale:
     - a new primary floor plan (with north arrow and upper floors indicated with dashed lines)
     - a new primary north/south section through primary spaces and the site
     - new elevations + diagrammatic glazing ratio data
     - at least one new exterior perspective
     - combine these drawings with a graphic scale with associated data about size and ratios neatly on a single sheet (mind clear and neat graphics, please!)

notes for every submission:

   - only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
   - ensure your name and project number is on each sheet, staple these sheets, please.
   - the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
   - the projects will be assessed for
     - CONTENT: quality and completeness of required content (40%)
     - EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
     - PRESENTATION: graphic clarity, accuracy of text (20%)

   - hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
   - use office hours for questions
   - always and only do excellent work.
P3: Adapt for Heating

In this phase of the project, you will adjust your base building from P2, making further adjustments to its climate response while also adding both structural and/or power-operated heating strategies that are suitable for its climate.

1. Fit Building for Heating
   - based on your EcoTect climate analysis and notes from the reading and lecture, determine an appropriate heating strategy for your building and climate.
   - reflexively critique your P2 building according to the data evident in this phase of climate analysis
     - identify and label its problems and potentials
   - thoughtfully transform your base building for heating according to the data and strategies prompted by the climate analysis

2. Document your critique and design:
   - page 1: document your interpreted and edited EcoTect climate analysis for heating strategies
   - page 2: document your critique of the P2 building with a text summary and notes + leaders
     (the areas in question should be immediately evident). ONE SHEET
   - page 3: document your adjusted building design at an indicated scale:
     - a new primary floor plan (with north arrow and upper floors indicated)
     - a new primary section through primary space, visualizing the thermodynamics of your heating strategy
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a SINGLE SHEET
     - add additional diagrams to articulate the heat transfer processes your heating strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)

notes for every submission:
- only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
- ensure your name and project number is on each sheet
- the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
- the projects will be assessed for
  CONTENT: quality and completeness of required content (40%)
  EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
  PRESENTATION: graphic clarity, accuracy of text (20%)
- hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
- use office hours for questions
- always and only do excellent work.
P4: Adapt for Cooling

In this phase of the project, you will adjust your base building from P3, making further adjustments to its climate response while also adding structural and/or power-operated cooling strategies that are suitable for its climate.

1. Fit Building for Cooling
   -based on your EcoTect climate analysis and notes from the reading and lecture, determine an appropriate cooling strategy for your building and climate.
   -reflectively critique your P3 building according to the data evident in this phase of climate analysis
     -identify and label its problems and potentials
     -thoughtfully transform your base building for cooling according to the data and strategies prompted by the climate analysis

2. Document your critique and design:
   -page 1: document your interpreted and edited EcoTect climate analysis for cooling strategies, use minimal text to help document the lessons gleaned from the analysis. The focus should be on the interpreted graphics from ecotect. Remember, do not merely print data from ecotect, but rather graphically process it to highlight your understanding of its key outcomes.
   -page 2: document your critique of the P3 building with a text summary, redline revision bubbles and leaders (the areas in question should be immediately evident).
   -page 3: document your adjusted building design at a graphically indicated scale:
     -provide a new primary floor plan (with north arrow and upper floors indicated) perhaps with key ecotect data underlays
     -a primary new section through primary space, indicating the thermodynamics of your cooling strategy in the exterior and interior space; indicate materials when part of the strategy
     -new elevations with diagrammatic glazing ratios
     -at least one new exterior perspective
     -combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single PDF sheet
     -add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)

notes for every submission:
- only submit vector-based drawings and diagrams (no pixel-based images - renderings)
- ensure your name and project number is on each sheet, staple sheets together
- the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
- the projects will be assessed for
  CONTENT: quality and completeness of required content (40%)
  EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
  PRESENTATION: graphic clarity, accuracy of text (20%)

-hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
- use office hours for questions
- always and only do excellent work.
P5: Adapt for Air and Envelope

In this phase of the project, you will adjust your base building from P4, making further adjustments to its climate response while also advancing more specific information about the building’s envelope strategies.

1. Fit Building for Air and Envelope
   - based on your EcoTect climate analysis and notes from the reading and lecture, determine an appropriate ventilation strategy for your building and climate as well as an envelope strategy. Include wind data.
   - reflexively critique your P4 building according to the data evident in this phase of climate analysis
   - identify and label its problems and potentials
   - thoughtfully transform your base building with a coherent and responsive building ventilation envelope strategy

2. Document your critique and design:
   - page 1: document your interpreted and edited EcoTect climate analysis for cooling strategies, use minimal text to help document the lessons gleaned from the analysis. The focus should be on the interpreted graphics from ecotect. Remember, do not merely print data from ecotect, but rather graphically process it to highlight your understanding of its key outcomes.
   - page 2: document your critique of the P4 building with a concise text summary, redline revision bubbles, etc (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at a graphically indicated scale:
     - provide a new primary floor plan (with north arrow and upper floors indicated) perhaps with key ecotect data underlays
     - a primary new section through primary space, indicating the thermodynamics of your cooling strategy in the exterior and interior space; indicate materials when part of the strategy
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single PDF sheet
     - add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)
   - page 4: draw typical ground floor, wall, and roof construction assemblies in section through your entire envelope.
     - Emphasize the thermal envelope and label the material assemblies

Notes for every submission:
   - only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
   - ensure your name and project number is on each sheet
   - the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
   - the projects will be assessed for
     CONTENT: quality and completeness of required content (40%)
     EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
     PRESENTATION: graphic clarity, accuracy of text (20%)
   - hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
   - use office hours for questions
   - always and only do excellent work.
P6: Adapt for Daylight/Shading Design

In this phase of the project, you will adjust your base building from P5, making further adjustments to its climate response while also advancing daylighting strategies.

1. Fit Building for Daylight/Shading Design
   - based on your EcoTect climate analysis and notes from the reading and lecture, determine an appropriate daylight/shading strategy for your building and climate. Include solar diagrams in particular.
   - reflexively critique your P5 building according to the data evident in this phase of climate analysis
   - identify and label its problems and potentials
   - thoughtfully transform your base building with a coherent and responsive daylighting/shading strategy

2. Document your critique and design:
   - page 1: document your interpreted and edited EcoTect climate analysis for daylight/shading strategies
   - page 2: document your critique of the P5 building with a text summary and notes + leaders
     (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at an indicated scale:
     - provide new floor plans - both (with north arrows) and light/shadow range reach for winter and summer
     - a new section through primary space, indicating the actual behavior of light in your space
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single PDF sheet
   - add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)

Notes for every submission:
- only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
- ensure your name and project number is on each sheet
- the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
- the projects will be assessed for
  CONTENT: quality and completeness of required content (40%)
  EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
  PRESENTATION: graphic clarity, accuracy of text (20%)
- hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
- use office hours for questions
- always and only do excellent work.
P7: Revise and Integrate
In this phase of the project, you will adjust your base building from P6, revising it based on feedback. The aim here is to alter any aspects of the building that are not well-integrated as a simple, lower-technology/higher performance whole. The approaches and strategies will vary in this phase of work, depending on your project. Note: this is primary an opportunity to adjust both the building and its representation.

1. Integration
   - based on your EcoTect climate analysis and notes from the reading and lecture, evaluate the integration of your strategies: identify and label its problems and potentials
   - thoughtfully transform your base building with a more coherent and integrated approach.

2. Document your critique and design:
   - page 1: document your interpreted and edited EcoTect climate analysis to support your transformations
   - page 2: document your critique of the P6 building with a text summary and notes + leaders
     (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at an indicated scale:
     - provide new floor plans—both (with north arrows) and light/shadow range reach for winter and summer
     - a new section through primary space, indicating the actual behavior of light in your space
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single PDF sheet
   - add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)

notes for every submission:
  - only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
  - ensure your name and project number is on each sheet
  - the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
  - the projects will be assessed for
    CONTENT: quality and completeness of required content (40%)
    EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
    PRESENTATION: graphic clarity, accuracy of text (20%)
  - hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
  - use office hours for questions
  - always and only do excellent work.
P8: Material as an Energy System

In this phase of the project, you will adjust your base building from P7, revising it based on an embodied energy analysis.

1. Embodied Energy Analysis
   - calculate the quantity of all the materials in your building assemblies by weight and volume
   - calculate the embodied analysis of the building using the Inventory of Carbon & Energy Version 1.6A
   - thoughtfully transform your base building with a lower embodied energy approach

2. Document your critique and design:
   - page 1: document your interpreted and edited EcoTect climate analysis to support your transformations
   - page 2: document your critique of the P7 building with a text summary and notes + leaders
     (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at an indicated scale:
     - provide new floor plans—both (with north arrows) and light/shadow range reach for winter and summer
     - a new section through primary space, indicating consequential forms of energy in the space
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single sheet
   - add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)
   - page 4: draw the new, adjusted ground floor, wall, and roof assemblies through your entire envelope.
     - Emphasize the thermal envelope and label the material assemblies.

notes for every submission:
   - only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
   - ensure your name and project number is on each sheet
   - the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
   - the projects will be assessed for
     CONTENT: quality and completeness of required content (40%)
     EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
     PRESENTATION: graphic clarity, accuracy of text (20%)
   - hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
   - use office hours for questions
   - always and only do excellent work.
P9: Final Project (Optional & completed individually)

In this phase of the project, you will rapidly develop an entire building project for a new climate, providing a summary of the building and its performance. This is your last opportunity to revise, amend or otherwise your project for the final project grade. This grade will replace your lowest project grade from the semester. (note: if you worked in a cold climate, move to the desert, if you worked in the desert, move to a cold climate).

- From 1,200 up to 1,800 total square feet on 1.5 levels
- up to 28,000 cubic feet (as measured from the outside)
- up to 25% of the exterior all and roof surface may be glazed
- there should be an internal core with a bathroom and a stair serving a mezzanine

1. Document your building.

- page 1: document your new interpreted and edited EcoTect climate analysis to support your strategies
- page 2: Heating Strategy
- page 3: Cooling Strategy
- page 4: Building Envelope and Embodied Energy Strategy
- page 5: Ventilation & Day Light Strategy

On each page, provide relevant plans, sections, exterior views, climate data, etc for each strategy. Each page is a miniature version of the weekly assignments you have previously completed.

notes for every submission:
- only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
- ensure your name and project number is on each sheet
- the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
- the projects will be assessed for
  - CONTENT: quality and completeness of required content (40%)
  - EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
  - PRESENTATION: graphic clarity, accuracy of text (20%)
- hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
- use office hours for questions
- always and only do excellent work.
**P9: Final Submission**

In this phase of the project, you will collect and document the entire building project, providing a summary of the building and its performance. This is your last opportunity to revise, amend or otherwise your project for the final grade.

1. Document your building.
   - page 1: document your interpreted and edited EcoTect climate analysis to support your transformations
   - page 2: document your critique of the P8 building with a text summary and notes + leaders
     (the areas in question should be immediately evident).
   - page 3: document your adjusted building design at an indicated scale:
     - provide new floor plans-both (with north arrows) and light/shadow range reach for winter and summer
     - a new section through primary space, indicating consequential forms of energy in the spaces
     - new elevations with diagrammatic glazing ratios
     - at least one new exterior perspective
     - combine the above drawings with a graphic scale with associated data about size and ratios neatly on a single sheet
     - add additional diagrams to articulate the heat transfer processes your cooling strategy: conduction, convection, and electromagnetic radiation (this may vary in scale depending on the project)
   - page 4: draw the new, adjusted ground floor, wall, and roof assemblies through your entire envelope.
     - Emphasize the thermal envelope and label the material assemblies.

notes for every submission:
- only submit vector-based drawings and diagrams (no pixel-based images will receive any credit)
- ensure your name and project number is on each sheet
- the suggested software include AutoCAD, Sketch-up, Adobe Illustrator, and InDesign
- the projects will be assessed for
  - CONTENT: quality and completeness of required content (40%)
  - EFFICACY: the selected strategies, their integration into the building, and their potential fitness (40%)
  - PRESENTATION: graphic clarity, accuracy of text (20%)

hand in project submissions at the beginning of class. hard copies only. no late submissions. none.
- use office hours for questions
- always and only do excellent work.