Syllabus

(*note: material distinct from the undergraduate version of this course is indicated in red text.*)

ARCH 6532
Environmental Systems II
Fall 2015

Course Info.
3 credit hour lecture
TBD
TBD

Instructors
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Required Text
Grondzik, et al., **Mechanical and Electrical Equipment for Buildings**, 11th ed. (2010), J. Wiley, Hoboken, NJ

Supplementary handouts and readings will be suggested at appropriate times during the semester.

Overview, Objectives, Outcomes
This course is the second of a two-term sequence. The first course, ARCH 6531 Environmental Systems I, is concerned with basic physics and how the building and its occupants passively respond to various energy flows within and through buildings. This course focuses on the active systems in buildings and how they impact the design of the building and vice versa. Topics include:

I. **Heating, ventilation, and air conditioning** (HVAC)
   i. Basic thermodynamics and psychrometrics
   ii. Primary equipment for cooling: removal of thermal energy by 'uphill' thermal energy transfer, and redistribution of thermal energy by 'downhill' transfer
   iii. Primary equipment for heating: supply of thermal energy by 'downhill' and 'uphill' thermal energy transfer
   iv. Secondary equipment: for distribution/control of heating and cooling effect, ventilation, and humidity control
II. **Artificial lighting**
   i. Radiometry, photometry, and other basics
   ii. Characteristics of various artificial light sources and fixtures
   iii. Design, distribution, and control
III. **Plumbing, vertical transportation, fire safety**
IV. **Electrical distribution systems**
V. **Codes**

Overview, Objectives, Outcomes

The objective of this course is to equip you with an understanding of these systems sufficient for you to design a building in concert with building systems and to communicate meaningfully with design engineers. The learning outcomes of this course are:

1. **The ability to identify, comprehend the operation of, and specify (generally and conceptually) HVAC equipment in concert with a building design**
   Whereas Environmental Systems I concentrates on how a building responds to its thermal environment, Environmental Systems II is concerned with the active control of buildings' thermo-fluid environment for occupant health and comfort. Emphasis is placed on the *how* and *why* of these systems, with the *what* thus proceeding naturally. The integration of this equipment with a building and their impact on design parameters is also emphasized.
2. **Estimate delivered and primary energy consumption and emissions, and use such estimates in support of design decision-making**
3. **The ability to design basic artificial lighting systems**
   Whereas Environmental Systems I treats natural illumination, this course is concerned with artificial illumination. You will be expected to understand the nature of light, the human response to light, characteristics of artificial lighting systems, and assemble a lighting system which satisfies human needs.
4. **Comprehend and specify building service systems**
   The previous outcomes deal with the active conveyance of thermal energy, air, and visual light energy in a building. This outcome focuses on the transport of water and electricity to fulfill occupant needs, the conveyance of building occupants, and the systems to effect such transport.

Homework assignments and exams are designed with these objectives in mind and graded accordingly.

As a core course in the accredited Master of Architecture program, the following NAAB Student Performance Criteria from the 2014 NAAB Conditions for Accreditation are treated in this course:

1. **Ability: B.6 Environmental Systems**
   Ability to demonstrate the principles of environmental systems' design, how design criteria can vary by geographic region, and the tools used for performance assessment. This demonstration must include active and passive heating and cooling, solar geometry, daylighting, natural ventilation, indoor air quality, solar systems, lighting systems, and acoustics.
2. **Understanding: B.8 Building Materials and Assemblies**
   Understanding of the basic principles used in the appropriate selection of interior and exterior construction materials, finishes, products, components, and assemblies based on their inherent performance, including environmental impact and reuse.
3. **Understanding: B.9 Building Service Systems**
   Understanding of the basic principles and appropriate application and performance of building service systems, including lighting, mechanical, plumbing, electrical, communication, vertical transportation, security, and fire protection systems.

Overview, Objectives, Outcomes

In these criteria, *ability* and *understanding* mean the following, according to the NAAB 2014 Conditions for Accreditation:

1. **Ability**: Proficiency in using specific information to accomplish a task, correctly selecting the appropriate information, and accurately applying it to the solution of a specific problem, while also distinguishing the effects of its implementation.
2. **Understanding**: The capacity to classify, compare, summarize, explain, and/or interpret information.

Course Assignments and Evaluation

Assignments consist of homework assignments, a project, and exams; weightings are:

i. 6–7 homework assignments: 50%
ii. Project: 10%
iii. 2 tests and a final exam: 40%

Homework: Homework is the venue to exercise knowledge gained in class and through readings. You don't really know something until you do it, and homework is where you will first 'do'. Homework advances you toward achieving the course's learning outcomes.

Project: The project is an extension of the project from 6531 and uses the same *normative* whole-building energy model, but considers more inputs to and outputs from the model. Whereas the 6531 project was only concerned with the thermal energy loads (demands) of the building, this project will broaden its scope to include the energy delivered to the building to meet those thermal loads – as well as lighting, plug, etc. loads. The relationship of emissions resulting from building operation to the choice of active systems in the building are also explored. Feedback from this model will be used to inform, and justify, design decisions that improve the performance of a building you have designed in studio, and thus fulfills the second learning outcome listed above.

Tests and Exams: The tests and final exam will emphasize both practical competency and conceptual understanding which you will build up through your effort in the homework and through class discussion. Tests and exams will be of open books/open notes format. The first text will cover HVAC systems; the second test will cover the remaining topics. The final exam will be cumulative.

In both homework and exams, you will be graded based on the correctness of quantitative answers where appropriate, although partial credit will be given if your work demonstrates some understanding of the material. Note that a quantitative answer with a correct numerical value but incorrect unit will be counted as incorrect. Five dollars is not five cents. The project will be evaluated differently: because uncertainties abound in as-built buildings, the numerical correctness of your analyses cannot be fairly assessed. Therefore your will be judged similarly to the 3231 project: firstly, and primarily, based on the thoughtfulness of your analysis, secondly on the judgment shown in translating an architectural model to a performance model if applicable, and thirdly on the graphic quality of your submittal if applicable.

Course Assignments and Evaluation

Submissions and makeup policies: Homework is to be turned in at the beginning of class on the day it is due. If turned in between the time I begin the lecture and the end of class, it will be docked 10%. If it is turned in later that same due day, it will be docked 50%. No submissions will be accepted after the due day unless you have prior approval from me. If you are going to be absent for the midterm for a good reason, I will arrange a time for you to make up the exam or (preferably) take it early.

All assignments will be given a point value based on the difficulty and amount of work required. Your grade within a category will be based on the total points in that category and not on the percentage values of the individual assignments in that category. The weightings for each category are above.

The grade scale is:

Percentage	**Letter Grade**
90-100	A
80-89	B
70-79	C
60-69	D
0-59	F

Other Policies

Office hours: See above; do not hesitate to ask for help: it's my job. If the listed office hours are inconvenient, shoot me an email and I'll set up a time. Or try my office – if my door is open or cracked, I'm available. If it's closed I'm unavailable (don't even knock).

Academic integrity: Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please see The Georgia Institute of Technology 2012-2013 Catalog at http://www.catalog.gatech.edu/. Refer specifically to section XVIII entitled "Academic Honor Code" at http://www.catalog.gatech.edu/rules/1.php for the principles, policies, and procedures governing issues of academic integrity.

Collaborative work: I allow appropriate collaboration on homework assignments, but not on projects and (obviously) tests and exams. Here, 'appropriate collaboration' refers to, e.g. a group discussion that helps you understand and think through a problem and enables you to work the problem yourself; it **does not** mean others do the work for you. There is a fine line between appropriate and inappropriate collaboration, and I expect you to use your judgment on this matter. The guiding principle is that you must ultimately be able to do the work yourself, but collaboration that helps develop this ability is appropriate.

Other Policies

Accommodation of disabilities: Any student with a disability that may require accommodation should contact ADAPTS (Access Disabled Assistance Program for Tech Students) at (404) 894.2564 or http://www.adapts.gatech.edu/ to make an appointment to discuss his or her special needs and obtain an accommodations letter. He or she should also schedule an appointment to speak with the instructor.

Emergencies: In case of emergency (e.g., fire, accident, or criminal act), please call the Georgia Tech Police at (404) 894.2500. Please note that Perry Minyard, IT Support Administrator for the College of Architecture, is also a firefighter and an Emergency Medical Technician (EMT) certified in performing CPR.

Changes to syllabus: With the exception of grading policies, parts of this syllabus may change as deemed appropriate by the instructor; you will be given notice of such changes in advance. The schedule is likely to change a little as the semester evolves, and important changes such as due dates or dates of tests and exams will be announced.

Representative Schedule

ARCH 6532
Environmental Systems II

Week	Day	Date	Topic	Reading	Assignment
	M	8/18	Course introduction; HVAC overview	MEEB 9.1-9.3, 9.5(a-b)	
1	W	8/20	'Uphill' thermodynamic cycles: 'pumping heat'		
	F	8/22	Primary equipment: 'uphill' for cooling	MEEB 9.5(c)	
	M	8/25	Primary equipment: 'uphill' for cooling	MEEB 9.8, 10.3(b-c)	
2	W	8/27	Primary equipment: 'uphill' for heating & cooling	MEEB 10.3(e), 9.7(a-e,k), 10.3(a)	HW 01
	F	8/29	Primary equipment: 'downhill' for heating		
	M	9/01	**Labor Day Holiday**	MEEB 8.12, 9.6(c-f)	
3	W	9/03	Site visit: primary equipment at Holland Plant		
	F	9/05	Site visit recap; primary equipment: 'downhill' for cooling		HW 02
	M	9/08	Site visit recap; intro to secondary equipment	Remainder of MEEB Ch. 9 and 10	
4	W	9/10	Intro to secondary equipment: unitary and non-unitary		
	F	9/12	HW review; secondary equipment: unitary basics		
	M	9/15	Secondary equipment: VRF systems; non-unitary systems		HW 03
5	W	9/17	Secondary equipment: economizers, energy recovery, dual-duct		
	F	9/19	Secondary equipment: multizone, CAV vs. VAV		
	M	9/22	Secondary equipment: VAV cont'd., all-water systems		
6	W	9/24	Secondary equipment: DOAS systems		HW 04
	F	9/26	Site visit: secondary equipment in Klaus		
	M	9/29	Site visit recap; in-class ARE quiz		
7	W	10/01	grad assignment: overview of project		Project assigned
	F	10/03	Review		
	M	10/06	Exam 1		
8	W	10/08	Exam 1 review	MEEB Ch. 11	
	F	10/10	**(Drop Day)**; Light: basics and human perception	MEEB Ch. 12.7-12.26	

Representative Schedule

ARCH 6532
Environmental Systems II

Week	Day	Date	Topic	Reading	Assignment
	M	10/13	**Fall break**		
9	W	10/15	Special presentation: use of a whole building energy model		
	F	10/17	Artificial lighting: sources, luminaires	MEEB Ch. 13 & 15	
	M	10/20	Artificial lighting: sources, luminaires, lumen method		
10	W	10/22	Artificial lighting: lumen method		
	F	10/24	Artificial lighting: lumen method	MEEB Ch. 20-23	
	M	10/27	Water and plumbing: fluid statics, losses in pipe flow		HW 05
11	W	10/29	Water and plumbing: water supply, waste and drainage	MEEB Ch. 25-28	(project due)
	F	10/31	Electrical systems: basics of electricity		
	M	11/03	Electrical systems: basics, distribution		HW 06
12	W	11/05	Electrical systems: power factor, transformers, switch/panelboards		
	F	11/07	Electrical systems: branch circuits, overcurrent, grounding	MEEB Ch. 31	
	M	11/10	Vertical transportation		
13	W	11/12	Vertical transportation	MEEB 24.1-24.4	HW 07
	F	11/14	Fire protection		
	M	11/17	Fire protection		
14	W	11/19	Review		
	F	11/21	Exam 2		
	M	11/24	Exam 2 review;		
15	W	11/26	Course recap		
	F	11/28	**Thanksgiving holiday**		
	M	12/01	WPFE : **no class**		
16	W	12/03	WPFE : **no class**		
	F	12/05	WPFE : **no class**		
	M	12/08			
	T	12/19			
17	W	12/10			
	Tr	12/11			
	F	12/12	**Final exam: 11:30 am – 2:20 pm**		