CAE 331/513: Building Science — Fall 2018

Illinois Institute of Technology — 3 credit hours
Department of Civil, Architectural and Environmental Engineering

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Course Unique Number(s)
CAE 331 Section 01: 10405 (undergraduate)
CAE 513 Section 01: 15258 (graduate in-class); CAE 513 Section 02: 17668 (graduate online)

Classroom and Meeting Time
Robert A. Pritzker Science Center 121, Tuesdays and Thursdays, 1:50 PM – 3:05 PM

Prerequisites
CAE 209 Thermal Fluids Engineering II, or MMAE 322 Heat and Mass Transfer, or CHE 302 Heat and Mass Transfer Operations

Instructor
Brent Stephens, Ph.D., Associate Professor, Architectural Engineering
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Office Hours
Office hours are by appointment only. Please email me to schedule an appointment. Or stop by when you see my office door open to see if I'm free.

Course Catalog Description
Study of the physical interaction of climate (humidity, temperature, wind, sun, rain, snow, etc.) and buildings. Topics include psychrometrics, indoor air quality, indoor thermal comfort, heat transfer, air infiltration, solar insolation, and heating and cooling load calculation.

Instructor's Course Objectives and Learning Outcomes
To introduce students to physical phenomena that affect building design and performance. By taking this course students will be able to:

1. Describe the role of building components and building environmental systems in energy consumption, peak electricity demand, thermal comfort, and human exposures to indoor airborne pollutants.
2. Describe and quantify fundamental heat and mass transfer properties and processes in buildings, including conduction, convection, radiation, psychrometrics, thermodynamics of refrigeration systems, fluid flows, and mass balances.
3. Calculate peak heating and cooling loads for buildings using commercially available software.
4. Understand types of HVAC equipment for residential and commercial construction and how they operate.
5. Understand fundamental ventilation and indoor air quality concepts.
6. Understand strategies to improve energy efficiency in buildings.
7. Understand relevant codes and standards for energy efficiency in buildings.
8. Critically analyze claims about building components and environmental systems from product manufacturers, contractors, and building designers.

Textbook
You should purchase a copy of the 2017 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals (IP unit version) for use in this class and your future courses. The ASHRAE Handbook of Fundamentals isn't exactly a textbook, but rather is a deep and authoritative resource for many aspects of building engineering. We reference it directly for almost every topic in this class, and you will also continue to use it in future required and elective courses, including CAE 464 HVAC Systems Design, CAE 465/526 Building Energy Conservation Technologies, CAE 463/524 Building Enclosure Design, CAE 495 Capstone Senior Design, and several others.

The ASHRAE Handbook of Fundamentals costs $209 to the general public, but costs only $49 to ASHRAE student members. And ASHRAE student membership is only $20 per year. So I highly encourage you to become an ASHRAE member (you will learn about the benefits of doing so in this class) and purchase the Handbook of Fundamentals as a student member (total cost of $69). You can purchase the handbook, as well as a student membership, directly through me, or online: https://www.ashrae.org/communities/student-zone/membership-and-meetings/student-membership-benefits.

I will have hardcopies of the IP unit version of the ASHRAE Handbook of Fundamentals (it is sold in hardcopy in IP and SI units separately). The hard copy also comes with a CD with both SI and IP versions of the Handbook on it, so you will have access to both even if you buy the IP hardcopy version. You will be able to write a check to ASHRAE for the cost of the Handbook and ASHRAE membership and give it to me; in turn, I will be able to provide you with a hard copy and CD of the Handbook.

References (optional; will be given handouts when necessary)
In addition to the ASHRAE Handbook of Fundamentals, I will also rely on several other materials in this course. These materials are entirely optional for the student; handouts will be given when necessary so that no one is required to purchase these items.

ASHRAE 90.1-2013. *Energy Standard for Buildings Except Low-Rise Residential Buildings.*

Janis, R.R. and Tao, W.K.Y. 2009. *Mechanical and Electrical Systems in Buildings*. Pearson Prentice Hall. ISBN: 978-0-13-513013-1.

Kuehn, T.H., Ramsey, J.W., and Threlkeld, J.L. 1998. *Thermal Environmental Engineering*. Prentice Hall. ISBN: 0-13-917220-3.

McQuiston, F.C., Parker, J.D., and Spitler, J.D. 2005. *Heating, ventilating, and air conditioning: analysis and design*. John Wiley & Sons, Inc. ISBN: 0-471-47015-5.

Mitchell, J.W. and Braun, J.E. 2013. *Principles of Heating, Ventilation, and Air Conditioning in Buildings*. John Wiley & Sons, Inc. ISBN: 978-0-470-62457-9.

Moss, K.J. 2007. *Heat and Mass Transfer in Buildings* (Second Edition). Taylor & Francis. ISBN: 978-0-415-40908-7.

Reddy, T.A., Kreider, J.F., Curtiss, P.S., and Rabl, A. *Heating and Cooling of Buildings: Principles and Practice of Energy Efficient Design* (3rd Edition), CRC Press, Taylor & Francis Group. ISBN: 978-1439899892.

Straube, J. and Burnett, E. 2005. *Building Science for Building Enclosures*. Building Science Press. ISBN: 0-9755127-4-9.

Wang, S.K. 2000. *Handbook of air conditioning and refrigeration* (2nd edition). McGraw-Hill. ISBN: 0-07-068167-8.

Homework Assignments
There will be several homework assignments during the course that will involve hand calculations, development of spreadsheets, and/or learning the basics of some commercially available software packages typically used in industry. Some general rules for homework assignments are as follows:

- HW assignments will be posted online on Blackboard (BB).
- Undergraduate and graduate students enrolled in the in-class sections should submit hardcopies of their HW at the beginning of class.
- Hardcopy HW assignments should be ***neatly printed, preferably on engineering paper***.
- Multiple page submissions of any hardcopies must have all pages stapled together.
- Students enrolled in the online section should submit HW solutions in PDF format via Blackboard (BB). Handwritten HW must be scanned and converted to PDF by online students. Multiple pages must be converted to a single PDF for submission.

Late Homework Policy
Homework is due at the beginning of class on the day that it is due. Do not work on HW during the lecture. Late HW will receive a 5-point deduction for every day that it is late, *including weekends*.

Exams
Three closed-notes in-class exams will be given in this course: two exams during the semester on topics covered in the course in the period between each exam and one final exam. The final exam is comprehensive. Both undergraduate and graduate students will take the same exams.

Grading
This is a mixed undergraduate and graduate course; there is an additional final deliverable for graduate students. Graduate students will be required to complete a technical research project in addition to the regular HW and exam requirements. The project will involve researching, writing a literature review, and conducting a technical analysis on a specific topic in building science. For all students, course grades will be determined by the total number of points accumulated through HW assignments, exams, and for graduate students, their final project deliverables. The total number of points available in each category is listed in the table below. The percentage of total points required for various letter grades is also given.

Grading	HW	Exam 1	Exam 2	Final exam	Final project	Total
Undergraduate	300	250	250	300	n/a	1100
Graduate	300	250	250	300	300	1400

Grading scale	A	B	C	D	F
UG and G	90% and up	80.0-89.9%	70.0-79.9%	60.0-69.9%	<60.0%

Personal Problems
If you have illness or personal problems that will affect your performance during the course of the semester, please let me know as soon as possible. “After the fact” provides little protection unless there are extreme circumstances. Contact me by phone or e-mail at any time.

Students with Disabilities
Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources. The Center for Disability Resources (CDR) is located in Life Sciences Room 218, telephone (312) 567-5744 or email: disabilities@iit.edu.

Academic Honesty
It is your responsibility to be familiar with IIT's Code of Academic Honesty. The Code of Academic Honesty can be found online:
http://www.iit.edu/student_affairs/handbook/information_and_regulations/code_of_academic_honesty.shtml

You must submit your own work for homework. You are encouraged to discuss and even work with other students on homework (unless explicitly told otherwise), but material that is submitted must be your own work. For group project assignments, each group is to submit their own work. For a first violation of the IIT Code of Academic Honesty for a homework or project, the homework will receive a grade of zero for all involved students and the students will be reported to the Designated Dean for Academic Discipline (DDAD). For a first violation of the Code of Academic Honesty for a major project or an examination, the student will receive a failing grade for the course and the student will be reported to the DDAD. For a second violation, the student will receive also failing grade for the course and be reported to the DDAD.

Course Topics and Tentative Schedule

Week	Lecture	Date	Lecture Topics	HW Due	Handbook chapter
1	1	Aug 21	Introduction to building science		Chapter 34, 38
	2	Aug 23	Pre-requisite review, energy concepts, and units		
2	3	Aug 28	Heat transfer in buildings: conduction part 1		Chapter 4, 25, 26
	4	Aug 30	Heat transfer in buildings: conduction part 2	HW1	
3	5	Sep 4	Heat transfer in buildings: convection		
	6	Sep 6	Heat transfer in buildings: radiation		
4	7	Sep 11	Heat transfer in buildings: combined modes		
	8	Sep 13	Heat transfer in buildings: fenestration	HW2	Chapter 15
5	-	Sep 18	Exam review: example problems		
	-	Sep 20	**Exam 1**		
6	9	Sep 25	Human thermal comfort		Chapter 9
	10	Sep 27	Introduction to HVAC systems		
7	11	Oct 2	Psychrometrics: fundamentals and chart		Chapter 1
	12	Oct 4	Psychrometrics: equations		
8	13	Oct 9	Mechanical systems and psychrometric processes	HW3	
	14	Oct 11	Mechanical systems and psychrometric processes		
9	15	Oct 16	Mechanical systems and psychrometric processes		
	16	Oct 18	Air and water: pressures and flows	HW4	Chapter 21
10	-	Oct 23	*Campus building science tour*		
	-	Oct 25	**Exam 2**		
11	17	Oct 30	Ventilation and indoor air quality		Chapter 10, 11
	18	Nov 1	Ventilation and indoor air quality		
12	19	Nov 6	Infiltration and natural ventilation	HW5	Chapter 16
	20	Nov 8	Heating load calculations		Chapter 14, 17, 18
13	21	Nov 13	Cooling load calculations		
	22	Nov 15	Cooling load calculations		
14	23	Nov 20	Cooling load calculations	HW6	
	-	Nov 22	*No class – Thanksgiving Day*		
15	24	Nov 27	Energy estimation and design for efficiency		Chapter 19
	25	Nov 29	Building codes, standards, and guidelines		Chapter 35
Final	n/a	TBD	**Final exam, week of Dec 3**		
		Dec 9	**Graduate student projects due 11:59 pm (Sun)**	Grad projects	