CAE 465/526: Building Energy Conservation Technologies **Fall 2022**
3 credit hours

Building Energy Conservation Technologies
Illinois Institute of Technology
Department of Civil, Architectural and Environmental Engineering

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Course Unique Number
CAE 465 Section 01: 15250 (undergraduate) – In class
CAE 465 Section 02: 15239 (undergraduate) - Online
CAE 526 Section 01: 15243 (graduate) – In class
CAE 526 Section 02: 15244 (graduate) - Online

Classroom, Meeting Time, and Instructional Method
HH 005, Wednesdays, 1:50 PM – 4:30 PM

Course Website
All content will be provided on Blackboard

Prerequisites
CAE 331/513 Building Science (with some flexibility)

Instructor
Mohammad Heidarinejad, Ph.D., P.E. Assistant Professor, Architectural Engineering
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Teaching Assistant
Mingyu Wang
Office: Alumni Memorial Hall Room 217
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Office Hours
Instructor: 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. I have an open door policy.

Teaching Assistant: TBD

Course Catalog Description
Identification of the optimal energy performance achievable with various types of buildings and service systems. Reduction of infiltration. Control systems and strategies to achieve optimal energy performance. Effective utilization of daylight, heat pumps, passive and active solar heaters, heat storage and heat pipes in new and old buildings.

Instructor's Course Objectives and Learning Outcomes

To introduce students to both theory and hands-on applications of building energy conservation technologies to design energy efficient buildings. By taking this course, students will be able to:

1. Analyze energy consumption patterns in the buildings
2. Understand impacts of the building rating systems and sustainability measures to design energy efficient buildings
3. Become an expert in preparing calibrated building energy models to predict energy consumption patterns of building energy end-uses
4. Perform different building energy retrofit scenarios to provide opportunities to reduce energy and greenhouse gas emissions of buildings
5. Understand the impacts of influential parameters on energy end-uses of buildings
6. Visualize and analyze building performance data and applying statistical methods to compare the metered with the simulated results

References (optional; will be given handouts when necessary)

Lecture notes are sufficient for this course. 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.

You should have a copy of the 2017 or 2021 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals (IP unit version) for use from your CAE 331/513: Building Science or CAE 464/517: HVAC Systems Design courses. I may refer to this for some of the topic in this class

In addition to the ASHRAE Handbook of Fundamentals, I will also rely on several other materials in this course:

ASHRAE Advanced Energy Design Guides (AEDG), ASHRAE.

ASHRAE 90.1-2019. *Energy Standard for Buildings Except Low-Rise Residential Buildings.*

2020 ASHRAE Handbook HVAC Systems and Equipment

2019 ASHRAE Handbook HVAC Application.

2018 ASHRAE Handbook Refrigeration.

ASHRAE, *Procedures for Commercial Building Energy Audits.*

Brackney, L., Parker, A., Macumber, D., and Benne, K., *Building energy modeling with OpenStudio: a practical guide for students and professionals*, Springer, 2018.

Clarke, J., *Energy simulation in building design,* Routledge, 2001.

EnergyPlus™ Documentation Engineering Reference: *The Reference to EnergyPlus Calculations*

Heidarinejad, M., Laurent, J.G.C., Wentz, J., Rekstad, N., Spengler, J.D., and Srebric, J., *Actual building energy use patterns and their implications for predictive modeling*, Energy Conversion and Management 144,164-180, 2017.

Heidarinejad, M. and Srebric, J. *Building Energy Modeling*, Annual Review of Heat Transfer

Hensen, L.M. and Lamberts, R., *Building performance simulation for design and operation*, Spon Press, 2011.

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.

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.

US DOE Advanced Energy Retrofit Guides: *Practical ways to improve energy performance*

US EPA, *Energy Star: Building Upgrade Manual*

Homework Assignments

There will be a total of 5 homework assignments. Homework sets will be assigned based on lecture coverages. The homework will involve hand calculations, development of spreadsheets, and/or learning the fundamentals and data analysis. You must work on the homework assignments individually. Graduate students may need to submit more problems per a homework assignment, specifically some of the assignments will aim at getting students updated with how to use programming languages (e.g., R., Python, or MATLAB). Students who took CAE 523 should already know R.

Course Project

The course project focuses on retrofitting an existing building. The project has three deliverables described in the project assignment document. Each student is responsible for working on the first two deliverables of the course project individually. The third deliverable will be a group project submission. Each group will entail two students. Each group is required to present their report at the end of the semester during the assigned university exam week. Graduate students need to submit additional sections as well as using the programming language for some aspects.

Late Homework Assignment and Report Policy

Homework assignments and project reports are due at the midnight on the day that it is due. Homework assignments and project reports will receive an absolute 5-point deduction for every day that it is late.

Exams

There will be one take home exam during the semester of the fundamental concepts learned in the course. Each student is responsible for working on exam individually.

Grading

For all students, course grades will be determined by the total number of points accumulated through assignments, exams, and course project. The percentage of total points required for various letter grades is also given.

Grading	Quantity	% of Total for Each	% of Total
Assignments	5	5	25
Exam	1	30	30
Project Reports (Interim)	2	11	22
Final Report	1	15	15
Final Presentation	1	8	8

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 the instructors 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: https://www.iit.edu/student-affairs/student-handbook/fine-print/code-academic-honesty

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.

Illinois Tech's Sexual Harassment and Discrimination Information
Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community. This includes harassment among students, staff, or faculty. Sexual harassment of a student by a faculty member or sexual harassment of an employee by a supervisor is particularly serious. Such conduct may easily create an intimidating, hostile, or offensive environment.

Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Office of Title IX Compliance for information on support options and the resolution process.

You can report sexual harassment electronically at iit.edu/incidentreport, which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at foster@iit.edu or the Deputy Title IX Coordinator at eespeland@iit.edu.
For confidential support, you may reach Illinois Tech's Confidential Advisor at (773) 907-1062. You can also contact a licensed practitioner in Illinois Tech's Student Health and Wellness Center at student.health@iit.edu or (312)567-7550.

For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Office of Title IX Compliance website at https://www.iit.edu/title-ix/resources.

Course Topics and Tentative Schedule

Week	Date	Topics	Assignment Due
1	08/24/22	Introduction to (i) course objectives, (ii) CAE 331/513 and CAE 464 review, and (iii) energy consumption in the building sector	
2	08/31/22	Building energy consumption patterns and building performance analysis	
3	09/07/22	Introduction to building energy simulation and OpenStudio training	Assignment #1
4	09/14/22	Assignment 1 feedback and training to programming in R and Python	Assignment #2
5	09/21/22	OpenStudio and advanced HVAC systems	Assignment #3
6	09/28/22	Model calibration and uncertainty analysis **Project Assigned**	
7	10/05/22	Assignment feedback and building energy audits and commissioning	
8	10/12/22	OpenStudio training (Rhino/Grasshopper & Ladybug Tools) Building energy audits and commissioning	Assignment #4
9	10/19/22	Building retrofit and energy efficiency measures (EEMs) – Part 1	Project Deliverable #1
10	10/26/22	Intro to building performance metrics and life cycle analysis and GREET training	
11	11/02/22	**Exam (Take Home)**	
12	11/09/22	Building retrofit and energy efficiency measures (EEMs) – Part 2	
13	11/16/22	Life cycle analysis and measure installation	Project Deliverable #2
14	11/23/22	**Thanksgiving – No Class**	
15	11/30/22	Building to grid integration and utility programs	
16	12/7/22	Student Project Presentations (During the Final Exam)	Final Presentation
17	12/11/22	Final Project Report	Final Report