

**CAE 438/538:** Control of Building Environmental Systems

**Fall 2021**  
3 credit hours

### **Control of Building Environmental Systems**

Illinois Institute of Technology

Department of Civil, Architectural and Environmental Engineering

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#### **Course Unique Number(s)**

CAE 438 Section 01: 13939 (undergraduate) – In class

CAE 438 Section 02: 13940 (undergraduate) - Online

CAE 538 Section 01: 13941 (graduate) – In class

CAE 538 Section 02: 13944 (graduate) - Online

#### **Classroom, Meeting Time, and Instructional Method**

Stuart Building 225, Tuesdays, 2:05 PM – 4:50 PM

#### **Course Website**

All content will be provided on Blackboard

#### **Prerequisites**

CAE 331 OR CAE 513 OR MMAE 322

#### **Instructor**

Mohammad Heidarinejad, Ph.D., P.E. Assistant Professor, Architectural Engineering

Office: Alumni Memorial Hall Room 204,

Phone: (312) 567-3426

Email: [muh182@iit.edu](mailto:muh182@iit.edu)

#### **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. I have an open door policy. If you would like to schedule a virtual meeting, please email me to schedule a time for a virtual meeting.

#### **Course Catalog Description**

Introduction to automatic control systems. Control issues related to energy conservation, indoor air quality and thermal comfort in buildings. Classification of HVAC control systems. Control systems hardware: selection & sizing of sensors, actuators & controllers. Practical HVAC control systems; elementary local loop and complete control systems. Case studies. Computer applications.

#### **Instructor's Course Objectives and Learning Outcomes**

To introduce students to both theory and hands-on applications of building control systems to design and operate buildings. By taking this course, students will be able to:

1. Prepare engineers to understand building controls (mostly HVAC systems)
2. Design control sequence for various building systems
3. Equip students to effectively communicate design intent
4. Select and size sensors, actuators, and controllers

## References (optional; will be given handouts when necessary)

I will rely on several 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, *Standard 135-2016: BACnet: A Data Communication Protocol for Building Automation and Control Networks*, 2016.
- 2020 ASHRAE Handbook HVAC Systems and Equipment
- ASHRAE, *2019 ASHRAE Handbook HVAC Application*.
- ASHRAE, *2018 ASHRAE Handbook Refrigeration*.
- ASHRAE, *Specifying Building Automation Systems*, 2015.
- ASHRAE, *Guideline 36 High-Performance Sequences of Operation for HVAC Systems*, 2018.
- Auvil, R.J., *HVAC control systems* (4<sup>th</sup> Edition), American Technical Publishers, Orland Park, Illinois, 2017.
- Brackney, L., Parker, A., Macumber, D., and Benne, K., *Building energy modeling with OpenStudio: a practical guide for students and professionals*, Springer, 2018.
- Building Automation System Integration with Open Protocols*, 2009. National Joint Apprenticeship & Testing Committee for the Electrical Industry and American Technical Publishers, Inc.
- Building Automation Control Devices and Applications*, 2008. National Joint Apprenticeship & Testing Committee for the Electrical Industry and American Technical Publishers, Inc.
- Coffin, M.J., *Direct Digital Control for Building HVAC Systems* (2<sup>nd</sup> Edition), 1998. Springer
- DiLaura, D., Houser, K., Mistrick, R., Steffy G.R., *The Lighting Handbook: Reference and Application*, 10<sup>th</sup> Edition, Illuminating Engineering Society
- EnergyPlus™ Documentation Engineering Reference: *The Reference to EnergyPlus Calculations*
- Hartman, T.B., *Direct Digital Controls for HVAC Systems*, 1993, McGraw-Hill.
- Haines, R.W. and Hittle, D.C., *Control Systems for Heating, Ventilating, and Air Conditioning*. 2003, Springer.
- 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.
- Merz, H., Hansemann, T., Hubner, C., *Building Automation Communication Systems with EIB/KNX, LON and BACnet* (2<sup>nd</sup> Edition), Springer, 2018.
- 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.
- Nardone, M.S., *Direct Digital Control Systems Application/Commissioning*, 1999. Springer
- Newman, M.H. *BACnet: The Global Standards for Building Automation and Control Networks*, Momentum Press, 2013.
- Newman, M.H. and Morris, M.D., *Direct Digital Control of Building Systems: Theory and Practice*, 1994.
- Reddy, T.A., Kreider, J.F., Curtiss, P.S., and Rabl, A. *Heating and Cooling of Buildings: Principles and Practice of Energy Efficient Design* (3<sup>rd</sup> Edition), CRC Press, Taylor & Francis Group. ISBN: 978-1439899892.
- Rinaldi, J.S., *Modbus: The Everyman's Guide to Modbus*, John Rinaldi, 2015.
- Shadpour, F., *The Fundamentals of HVAC Direct Digital Control* (3<sup>rd</sup> Edition). 2012, Hacienda Blue Publishing.
- Tiersch, F. and Kuhles, C., *BACnet and BACnet/IP*, Desotron Verlag Erfurt, 2010.

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

Stoecker, W. *Microcomputer control of Thermal and Mechanical Systems*, 1989. Springer

### Homework Assignments

There will be a total of 6 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.

### Course Group Project

The course group project focuses on understanding building control systems. The project has three deliverables described in the project assignment document. 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 will complete additional sections of course group project.

### Course Individual Project

The course individual project focuses on understanding building control systems on a specific topic that the student will select in coordination with the instructor. This individual project has only one deliverable described in the project assignment document. Each student is required to present the individual report at the end of the semester during the assigned university exam week. Graduate students will complete additional sections of course individual project.

### 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.

### Exam

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	6	5	30
Exam	1	30	30
Group Project (Interim Reports)	2	7	14
Group Project (Final Report)	1	10	10
Group Project (Final Presentation)	1	6	6
Individual Project (Final Report)	1	5	5
Individual Project (Final Presentation)	1	5	5

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](mailto: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://web.iit.edu/student-affairs/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**

Sexual harassment, sexual misconduct, and gender discrimination by any member of the Illinois Tech community is prohibited. This includes harassment among students, staff, or faculty. Sexual harassment by a faculty member or teaching assistant of a student over whom they have authority or by a supervisor of a member of the faculty or staff 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 Title IX Office for information on the resolution process and support options.

You can file a complaint electronically at [iit.edu/incidentreport](http://iit.edu/incidentreport), which may be completed anonymously. You may also file a complaint in-person by contacting the Title IX Coordinator, Virginia Foster at 312.567.5725/ [foster@iit.edu](mailto:foster@iit.edu) or the Deputy Title IX Coordinator 312. 567.5726/ [eespeland@iit.edu](mailto:eespeland@iit.edu).

If you are not ready to file a formal complaint but wish to learn about your rights and options, you may contact Illinois Tech’s Confidential Advisor service at 773.907.1062. You can also contact a licensed practitioner in Illinois Tech’s Student Health and Wellness Center at 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 Title IX Office’s website at <https://web.iit.edu/hea/resources>.

## Course Topics and Tentative Schedule

Week	Date	Topics	Due Date
1	08/24/21	Introduction, overview, control theory, and terminology	
2	08/31/21	Instrumentation (1): Overview of sensors, inputs, and outputs, and temperature sensors	
3	09/7/21	Instrumentation (2): Flow, pressure, RH, and CO2 sensors	
4	09/14/21	Controlled devices (1): Introduction and dampers, valves, actuators	<b>Assignment #1</b>
5	09/21/21	Controlled devices (2): Dampers, valves, and actuators	
6	09/28/21	Controllers: Intro to building controllers	<b>Assignment #2</b>
7	10/05/21	Sequences of Operation (SOO) ASHRAE Guideline 36	<b>Assignment #3</b>
8	10/12/21	ASHRAE Guideline 13: Intro ASHRAE Guideline 13: BAS Device Network Design	<b>Assignment #4</b>
9	10/19/21	Control Modes Control of Building Systems: HVAC, Lighting, Fire Protection <b>Project Overview</b>	<b>Assignment #5</b>
10	10/26/21	Building Automation Communication Systems: Intro	<b>Assignment #6</b>
11	11/02/21	<b>Building Tour</b>	<b>Project Deliverable #1</b>
12	11/09/21	<b>Exam (Take Home)</b>	
13	11/16/21	Building Automation Communication Systems: Data Communication	
14	11/23/21	Building Automation Communication Systems: BACnet Objects and Services	<b>Project Deliverable #2</b>
15	11/30/21	Building Automation Communication Systems: BACnet Services	
16	12/09/21	<b>Student Project Presentations (During the Final Exam)</b>	<b>Final Presentation</b>
17	12/13/21	<b>Final Project Report</b>	<b>Project Deliverable #1</b>