CAE 464/517: HVAC Systems Design **Spring 2023**
Illinois Institute of Technology 3 credit hours
Department of Civil, Architectural and Environmental Engineering

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Course Unique Number(s)
CAE 464 Section 01: 24202 (undergraduate) – In Person
CAE 464 Section 02: 24203 (undergraduate) – Online
CAE 517 Section 01: 51444 (graduate) – In Person
CAE 517 Section 01: 51446 (graduate) – Online

Classroom and Meeting Time
SB-111, Tuesdays and Thursdays, 8:35 AM – 9:50 AM

Course Website
All content will be provided on Blackboard

For those who are interested to see last year's lecture, the Spring 2021 lecture notes are uploaded here:
http://built-envi.com/courses/cae-464-517-hvac-systems-design-spring-2021/

Prerequisites
[(CAE 331 or CAE 513 with min. grade of C) OR (MMAE 313 or MMAE 320 with min. grade of C)] or with some flexibility for different disciplines with prior background in thermodynamics, fluid mechanics, and/or heat transfer

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

Teaching Assistant
Mingyu Wang
Time: Thursdays 4-5 pm and Fridays 2-4 pm
Office: Alumni Memorial Hall Room 217
Email: mwang88@hawk.iit.edu

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
Study of the fundamental principles and engineering procedures for the design of heating, ventilating, and air conditioning systems; HVAC system characteristics; system and equipment selection; duct design and layout. Attention is given to energy conservation techniques and computer applications.

Instructor's Course Objectives and Learning Outcomes
To introduce students to both theory and applied design procedures for HVAC equipment and systems. By taking this course students will be able to:

1. Understand fundamentals of fluid and energy flows for HVAC equipment and systems
2. Design and size air distribution systems, hydronic systems, and refrigeration systems
3. Design, draw, and read mechanical drawings
4. Design, review, and assess different HVAC designs
5. Propose recommendations to revise HVAC designs and retrofit existing HVAC systems
6. Utilize both hand calculations and computer modeling (graduate students) for sizing air distribution systems, hydronic systems, and refrigeration systems

Textbook
You should already have a copy of the 2021 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals (IP unit version) from your CAE 331/513 course. You should have a copy of this reference 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 463/524 Building Enclosure Design, CAE 465/526 Energy Conservation Technologies, CAE 495 Capstone Senior Design, and several others.

The ASHRAE Handbook of Fundamentals costs $209 to the general public, but costs only $52 to ASHRAE student members. And ASHRAE student membership is only $25 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 $77). You can purchase the handbook and a student membership (if you aren't already a member) online here:

Note that ASHRAE publishes several different types of "handbooks." You should purchase the "Fundamentals" handbook from 2021. You can purchase a hard copy 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. Or you can purchase soft copies only from the site, as you wish.

Also, the 2017 version of the Handbook of Fundamentals (IP unit version) is acceptable.

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.

Amende, K.L., Keen, J.A., Catlin, L.E., Tosh, M., Sneed, A.M., Howell, R.H., Principles of Heating Ventilating, and Air Conditioning, 9th Edition, ASHRAE, 2021.
Behls, H., Duct Systems Design Guide, ASHRAE, 2021.
Engineer's HVAC Handbook, Edition 1.1, Price Industries
McDowall, R., *Fundamentals of HVAC*, ASHRAE, 2006.

McQuiston, F.C., Parker, J.D., Spitler, J.D., *Heating, Ventilation, and Air-Conditioning Analysis and Design*, John Wiley & Sons, Inc., 6th Edition, 2005.
Reddy, T.A., Kreider, J.F., Curtiss, P.S., Rabl, A., *Heating and Cooling of Buildings: Principles and Practices of Energy Efficient Design*, CRC Press, 3rd Edition, 2017.
Sugarman, S.C., *HVAC Fundamentals*, CRC Press, 3rd Edition, 2016.
2018 ASHRAE Handbook: Refrigeration, ASHRAE, 2018.
2019 ASHRAE Handbook: HVAC Applications, 2019.
2020 ASHRAE Handbook: HVAC Systems and Equipment, 2020.

Homework Assignments
There will be a total of 5 homework assignments. The best of 4 homework grades will be used for the final grade. Homework sets will be assigned based on lecture coverage. The homework will involve hand calculations, development of spreadsheets, modeling, and/or learning the fundamentals and data analysis. Each homework will be assigned at least a week before the homework due date. Graduate students may need to submit more problems per a homework assignment. You must work on the homework assignments individually.

Course Project
The course project focuses on the air distribution, hydronics, and refrigeration system designs. The first four parts are designed to assess student's ability to design air distribution, hydronic distribution, and refrigeration systems stand alone. The final project submission is an integrated design focusing on integration of air distribution designs with the refrigeration and hydronic systems. Group of two to three students can work on the group assignments and submit one submission per group. Graduate students will be required to complete additional sections of assignments focused on the use of computer software packages to size air distribution systems, hydronic systems, and refrigeration systems.

Students are required to present the group assignments as an integrated design project and submit the design documents, including mechanical drawings on the final exam day scheduled by the university. ***Online students*** are required to ***present in class or record their presentation***.

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 a 5-point deduction for every day that it is late before the solution is posted on Blackboard. After the solution is posted or the assignments are graded, the blackboard submission page is closed for that particular homework.

Midterm Exams
There will be two in-person mid-term exams (open book and open lecture notes) focused on the fundamental concepts learned in the course. The midterm exam is during the class time. Graduate students may need to answer more questions. ***Online students*** are required to coordinate with the instructor to take the exam.

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
Homework	5 (Best of 4)	4	16
Midterm Exams	2	22.5	45
Project Reports (Interim)	3	8	24
Project Report (Final)	1	9	9
Project Presentation (Final)	1	6	6

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	Reading	Assignment Due
1	01/10/23	**Course Overview & Introduction:** Grading, expected skills, and knowledge outcomes **Introduction to HVAC:** Intro to the course and review of HVAC system drawings	F38, F39	
	01/12/23	**Review HVAC Thermodynamics:** Installation in real buildings and intro to moist air properties, Psychrometric chart, sensible and latent heat	F1	
2	01/17/23	**Review HVAC Thermodynamics:** Psychrometric processes	F1	
	01/19/23	**Building Loads:** Space conditioning and intro indoor and outdoor design conditions	F14	
3	01/24/23	**Building Loads:** Building heating and cooling load calculations (I)	F17, F18	HW 1
	01/26/23	**Building Loads:** OpenStudio training (heating and cooling loads) – Recordings will be provided		
4	01/31/23	**Building Loads:** Building heating and cooling load calculations (II)	F17, F18	
	02/02/23	**Building Loads:** Load calculation examples	F17, F18	HW 2
5	02/07/23	**Revit Training**		
	02/09/23	**Review of Fluid Flows:** Intro to fluid flow and ASHRAE 62.1	F3	
6	02/14/23	**Air Distribution Systems:** Principles and air jet patterns	F20, F21	HW 3
	02/16/22	**Air Distribution Systems:** Classification of air diffusion		
7	02/21/23	**Air Distribution Systems:** Diffuser selection	F20	
	02/23/23	**Air Distribution Systems:** Diffuser selection examples and intro to pressure loss in ducts **Project Assigned**	F20, F21	
8	02/28/23	**Air Distribution Systems:** Pressure loss in ducts and fittings	F20, F21	
	03/02/23	**Air Distribution Systems:** Duct design methods		
9	03/07/23	**Midterm Exam (1)**		
	03/09/23	**Air Distribution Systems:** Fan selection and affinity laws		Project Part 1
10	03/14/23	**Spring Break**		
	03/16/23	**Spring Break**		

Course Topics and Tentative Schedule (Continued)

Week	Date	Topics	Reading	Assignment Due
11	03/21/23	**Air Distribution Systems:** Fan selection example and air handling unit		
	03/23/23	**Hydronic Systems:** An overview of HVAC hydronic systems (e.g., boilers, chillers, cooling powers)	F22, S13, S32	
12	03/28/23	**Hydronic Systems:** System characteristics and fluid flow, steam system design, system operation and sizing system components	F22, S36	HW 4
	03/30/23	**Hydronic Systems:** Centrifugal pumps, operating characteristics, selection parameters influencing performance, affinity laws, combining pump and characteristic curves in system design	F22	
13	04/04/23	**Midterm Exam (2)**		
	04/06/23	**Hydronic Systems:** Pipe system fundamentals fitting coefficients, and equivalent length estimations of ΔP- system	F22	
14	04/11/23	**Hydronic Systems:** control strategies, technology for hydronic systems, 2-way & 3-way valves	F22	Project Part 2
	04/13/23	**Refrigeration:** Introduction to vapor compression and T-s and P-h diagrams	F2	
15	04/18/23	**Refrigeration:** Vapor compression cycles and applications	F2, F30	
	04/20/23	**Refrigeration:** Potential environmental impacts of refrigerants (global warming, ozone depletion), Cooling towers	F2, R18, S40	Project Part 3
16	04/25/23	**Refrigeration:** Absorption cooling (Principles of operation and cycle analysis)	F2	
	04/27/23	**HVAC Systems Design:** Integrated Design and Applications (Chilled Beams, Ground Source Heat Pumps, VRF, and Water Source Heat Pumps) air flow strategies (e.g., Constant Air Volume (CAV), Variable Air Volume (VAV), and Dedicated Outdoor Air Systems (DOAS))	S5 S20, S21, S51	
17	TBD (Exam Date)	**Final Project Presentation (Integrated Design)**		Final Presentation (HW 5 Extra)
	TBD	**Final Project Report (Integrated Design)**		Final Report

A = 2019 ASHRAE Handbook: HVAC Applications
F = 2021 ASHRAE Handbook of Fundamentals
R = 2018 ASHRAE Handbook: Refrigeration, ASHRAE
S = 2020 ASHRAE Handbook: HVAC Systems and Equipment