CAE 464/517: HVAC Systems Design **Spring 2021**
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)
CAE 517 Section 01: 51444 (graduate)

Classroom and Meeting Time
Herman Hall Mezzanine, Tuesdays and Thursdays, 3:35 PM – 4:50 PM

COVID-19 Update, January 18, 2021: This class is listed under the new classroom delivery methods for Spring 2021 as a Hybrid (S) course, meaning that there is a classroom reserved on the day and time it is scheduled to meet, and lectures have the ability to be streamed live and also recorded and made available for remote viewing after each class period. Thus, Hybrid (S) can accommodate in-person activities if instructors and/or students choose to do so, as well as fully remote with a live stream occurring at the same day/time as class (with the live stream recording also available for asynchronous viewing).

Out of an abundance of caution, at least the first 2 weeks of the semester will be held entirely online (more info for the university's COVID related policy is accessible here: https://www.iit.edu/COVID-19/fall2020. In this course, I will reassess the situation after these first two weeks to determine exactly how the course will be delivered and how frequent (if at all) I will be in person. And regardless of which section you're enrolled in for this course, this course can be taken entirely remotely (online) if you wish. There is no need to change your registration to do so. If you wish to be in-person, there is a classroom scheduled and you're welcome to use it, whether not I am there each time (still TBD). We will assess everyone's preferences in the first week, and further plan from there.

For the online lectures, please remind me to click on the **RECORD** button if I forget!

Course Website
All content will be provided on Blackboard

Prerequisites
[(CAE 331 or CAE 513 with min. grade of C) OR (MMAE 313 or MMAE 320 with min. grade of C)]

Instructor
Mohammad Heidarinejad, Ph.D., P.E. Assistant Professor, Architectural Engineering
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Teaching Assistant
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Office Hours
As always, I'm available via email. If you would like to schedule a virtual meeting, I'm accessible via Google Hangout (my id is mheidarinejad@iit.edu or muh182@iit.edu). Just send me a text on these handles. If I am available, we can meet virtually. You're more than welcome to email me to schedule a time for a virtual meeting.

Teaching Assistant: TBD (Virtual Meeting Only)

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 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 463/524 Building Enclosure Design, CAE 465/526 Energy Conservation Technologies, CAE 495 Capstone Senior Design, and several others. Some of you have bought the book for CAE 331 Building Science course.

The ASHRAE Handbook of Fundamentals costs $209 to the general public, but costs only $54 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 $79). You can purchase the handbook and a student membership (if you aren't already a member) online: https://www.ashrae.org/communities/student-zone/membership-and-meetings/student-membership-benefits.

Note that ASHRAE publishes several different types of "handbooks." You should purchase the "Fundamentals" handbook from 2017. 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.

For this semester, Dr. Stephens 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.

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.

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.
Engineer's HVAC Handbook, Edition 1.1, Price Industries
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 8 homework assignments. 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 three 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. All students will present their work virtually during the final exam.

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.

Exam
There will be one mid-term exam focused on the fundamental concepts learned in the course. The exam is a take home exam. Graduate students may need to answer more questions. All the submissions will be online.

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	8	3.5	28
Midterm Exam	1	32	32
Project Report 1	1	7	7
Project Report 2	1	7	7
Project Report 3	1	7	7
Final Project Report	1	12	12
Final Project Presentation	1	7	7

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:
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.

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	01/19/21	**Course Overview & Introduction:** Grading (exams, homework, projects), expected skills, and knowledge outcomes		
	01/21/21	**Introduction to HVAC:** Review of HVAC system drawings and installation in real buildings	F38, F39	
2	01/26/21	**Review HVAC Thermodynamics:** Moist air properties, Psychrometric chart, sensible and latent heat	F1	
	01/28/21	**Review of Fluid Flows:** Fluid flow basics and conservation of energy applied to flows (CAE 208 & CAE 209)	F3	HW 1
3	02/02/21	**Building Loads:** Building heating and cooling load calculations	F14, F17, F18	
	02/04/21	**Building Loads:** Building cooling load calculations	F14, F17, F18	
4	02/09/21	**No Class (COVID Study Day)**		HW 2
	02/11/21	**Building Loads:** OpenStudio Training	F14, F17, F18	
5	02/16/21	**Air Distribution Systems:** Diffuser design and selection, diffuser operational principles, zone location selection criteria, device selection	F20, F21	HW 3
	02/18/21	**Air Distribution Systems:** Fan selection, system effects on performance, affinity laws	F20, F21	
6	02/23/21	**Air Distribution Systems:** Fan output controls and energy utilization, pressure loss in ducts and fittings	F20, F21	HW 4
	02/25/21	**Air Distribution Systems:** REVIT Training		
7	03/02/21	**Air Distribution Systems:** Duct system design, equal friction method, comparison of different design solutions	S20, S21	HW 5
	03/04/21	**Air Distribution Systems:** Constant Air Volume (CAV), Variable Air Volume (VAV), and Dedicated Outdoor Air Systems (DOAS)	S20, S21, S51	
8	03/09/21	**Hydronic Systems:** An overview of HVAC hydronic systems (e.g., boilers, chillers, cooling powers)	F22, S13, S32	Project Part 1
	03/11/21	**Midterm Exam**		
9	03/16/21	**Hydronic Systems:** System characteristics and fluid flow, steam system design, system operation and sizing system components	F22, S36	
	03/18/21	**Hydronic Systems:** Centrifugal pumps, operating characteristics, selection parameters influencing performance, affinity laws, combining pump and characteristic curves in system design	F22	

Course Topics and Tentative Schedule (Continued)

Week	Date	Topics	Reading	Assignment Due
10	03/23/21	**Hydronic Systems:** REVIT Training		
	03/25/21	**Hydronic Systems:** Pipe system fundamentals fitting coefficients, and equivalent length estimations of ΔP- system,	F22	HW 6
11	03/30/21	**Hydronic Systems:** control strategies, technology for hydronic systems, 2-way & 3-way valves	F22	
	04/01/21	**Refrigeration:** T-s and P-h diagrams, and space conditioning (CAE 331)	F2	Project Part 2
12	04/06/21	**Refrigeration:** Introduction to vapor compression cycles and examples	F2	
	04/08/21	**No Class (COVID Study Day)**		
13	04/13/21	**Refrigeration:** Vapor compression cycle applications	F2, F30	
	04/15/21	**Refrigeration:** Potential environmental impacts of refrigerants (global warming, ozone depletion)	F2, R18	HW 7
14	04/20/21	**Refrigeration:** Cooling Towers	S40	
	04/22/21	**Refrigeration:** Absorption cooling (Principles of operation and cycle analysis)	F2	
15	04/27/21	**HVAC Systems Design:** Integrated Design		Project Part 3
	04/29/21	**HVAC Systems Design:** Integrated Design		
16	05/04/21	**HVAC Systems Design:** Applications (VRF and Chilled Beams)	S5	HW 8
	05/04/21	**HVAC Systems Design:** Applications (Water Source and Ground Source Heat Pumps)		
17	TBD	**Final Project Presentation (Integrated Design)**		Final Presentation
	05/15/21	**Final Project Report (Integrated Design)**		Final Report

A = 2019 ASHRAE Handbook: HVAC Applications
F = 2017 ASHRAE Handbook of Fundamentals
R = 2018 ASHRAE Handbook: Refrigeration, ASHRAE
S = 2020 ASHRAE Handbook: HVAC Systems and Equipment