Division of Engineering and Mathematics
School of Science, Technology, Engineering, and Mathematics
University of Washington Bothell

B ME 435 Introduction to Heating, Ventilation, and Air Conditioning

Spring 2020

Time and Location: MW 8:45 - 10:45 am online (Canvas)
Canvas Homepage: https://canvas.uw.edu/courses/1386054

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Office Hours: MW 10:45 - noon on Zoom and by appointment

Course Description

This course covers fundamentals of heating, ventilation, and air conditioning (HVAC) to keep buildings comfortable and healthy for their occupants while minimizing environmental impact. Topics include properties of air-water mixtures, refrigeration cycles, heating and cooling load calculations, HVAC equipment, and design of HVAC systems for sustainable buildings.

Learning Outcomes

1. Use the psychrometric chart and thermodynamic principles to analyze moist air and air conditioning processes.
2. Apply standards for human comfort and indoor air quality in code-compliant HVAC system design.
3. Determine heating and cooling loads for buildings.
4. Describe the components of HVAC systems.
5. Analyze refrigeration systems and their components.
6. Size ducts, pipes, fans, and pumps required for transporting air and water in HVAC systems.
7. Describe characteristics and requirements of green and high-performance building design.

Course Materials

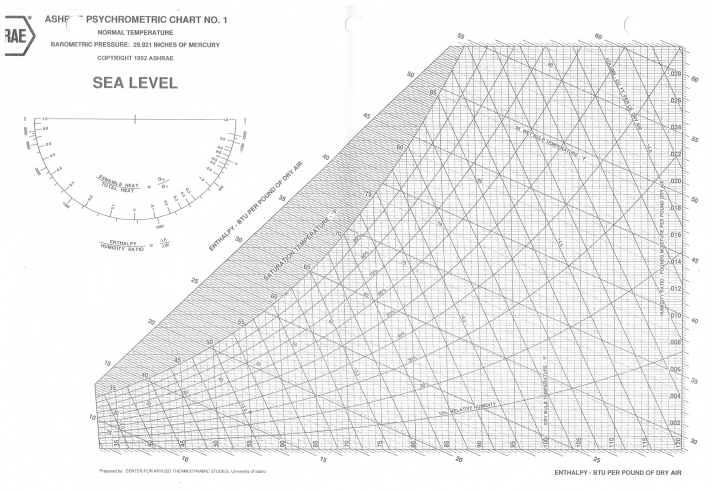
The following textbooks and supplies are required and should be ordered from the UW Bookstore (which promises free delivery to your home):

1. *Trane Air Conditioning Manual* (also known as the "blue book"), Ingersoll Rand, 1996

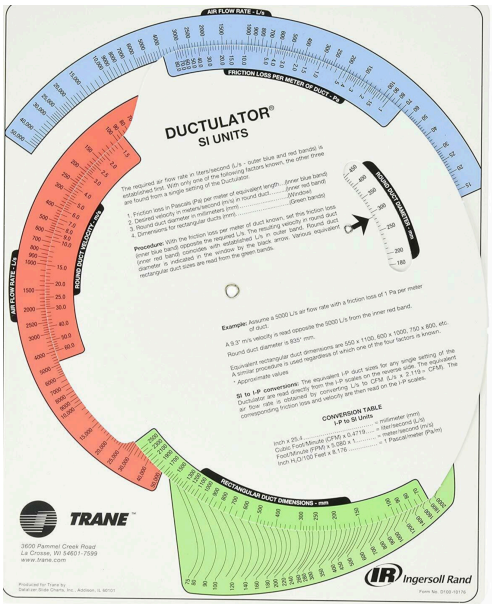
2. Psychrometric Chart, standard altitude, 11" x 17" pad of 25 sheets, I-P units

3. Ductulator (I-P/SI units)

We use a lot of psychrometric charts in HVAC. I was intending for you to use these 11" x 17" charts for the homework and exams in class, as they are easier to read and work with than smaller charts. Since you'll be submitting all your work online, the size won't matter as much. However, I still recommend these charts so that we're all using a common standard. ASHRAE also produces good charts (they're what I use). Whatever you use, be sure the chart is for normal temperature at sea level and in English (inch-pound) units.



The "ductulator" is a device for calculating the size of ducts and estimating friction losses in air handling systems. HVAC engineers often use it for quick estimates of quantities that can be tedious to calculate by hand.



Though not required, the *ASHRAE Handbook: Fundamentals* is a good resource to have on hand if you want to hit the ground running as an HVAC engineer. The Fundamentals is one of four volumes in the Handbook series. The others are *Refrigeration*, *HVAC Systems and Equipment*, and *HVAC Applications*. Each volume is revised every four years. The books are expensive, even with the ASHRAE member discount. I'd therefore recommend accessing it in UW Libraries, which allows download of individual chapters. Chances are, if you end up working for an HVAC engineering firm, the company will have copies you can use. If you're planning to take the PE Exam in Mechanical-HVAC, you'll need to study the entire series (especially the *Equipment and Systems* volume).

The textbook from B ME 331 (*Thermodynamics: An Engineering Approach*, by Yunus Cengel) may also be useful as a reference, especially chapter 11 on refrigeration cycles, 13 on gas mixtures, and 14 on gas-vapor mixtures.

Building and Energy Modeling Software:
If we were taking the course on campus, you would be introduced to the Trane Trace 3D Plus HVAC design and analysis software. Trane Trace is widely used in industry to model heating and cooling loads, predict energy consumption and costs, and compare design alternatives. Although our academic license doesn't allow remote access, you can download a trial version and use it for one month on your own computer (Windows only). I recommend you try it out and familiarize yourself with its capabilities. You won't be required to use it in the course, though it may be included in one of the options for a small design project.

For more information, see
https://www.trane.com/commercial/north-america/us/en/products-systems/design-and-analysis-tools/analysis-tools/trace-3d-plus.html

A free, open-source alternative to Trane Trace is EnergyPlus. EnergyPlus has the added advantage of a version that runs on Mac OS. For more information, see
https://energyplus.net

Assignments and Grading

All assignments are submitted in Canvas and are open-book. Hand-written work should be done on green engineering paper, scanned at a reasonably high resolution (preferably in black and white, unless color is needed to distinguish parts of images, equations, or other content) and combined into a single pdf document.

Homework (25 %): Problem sets will be assigned regularly. Each set will be posted in Canvas approximately one week before it is due. You may hand-write or word-process solutions. Solutions will be posted after the homework has been collected. Homework is due before the start of class (8:45 am).

Canvas Quizzes and Discussions (10 %): Short quizzes in Canvas will be given during some class meetings. These quizzes will be based on material up to and including the reading assigned for that day. The purpose is to encourage you to keep up but also to serve as a basis for discussion and to highlight key concepts. These quizzes will open in Canvas at the start of class (8:45 am). Questions may be multiple choice, short answer, or short essay.

Two exams (25 % each): Open book and notes, given as Canvas quizzes. All questions will be multiple choice. The longer problems will require that you upload your calculations in a pdf file. Partial credit may be given for the longer problems for the portion of work that is correct, even if the answer is wrong; little or no credit is given to correct guesses with missing or incorrect supporting calculations. You are required to sign a document I'll prepare for you to affirm that you followed the rules strictly and did not cheat. Exams must be completed by 10:45 am; this means you will need to factor in time after answering the questions to scan your work, convert it to pdf, and upload it into Canvas. Late penalties will apply after 11 am, though these may be waived if technical difficulties delay submission and you explain the situation to me.

Design Project (15 %). Done in teams of 4, the project is an open-ended design problem. Several options will be provided, at least one of which will involve acquiring and learning to use one of the software applications described above. Your deliverable is a report, formally written,

that defines the problem, discusses relevant principles applicable to it, and presents a design solution. The report, to be submitted in Canvas by the team leader, should be typed in 12-point font, double-spaced, and include relevant drawings and calculations (drawings and calculations can be done by hand or in SolidWorks or other software). Length will vary depending on the problem, but 10-15 pages is typical when all materials are included. Project options will be made available and teams formed in the second week. I'm happy to solicit your ideas for projects during our first couple of class meetings.

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Grading: Exams, homework, and projects are graded on the 100-point scale. Canvas quizzes are scored based on the number of questions, with one point given for each correct answer. Grades are converted to the 4-point scale using the following linear conversion: ≥95=4.0, 94=3.9, 93=3.8, 92=3.7, 91=3.6, 90=3.5,…,85=3.0,…,80=2.5,…,65=1.0, 62=0.7 (lowest passing grade), ≤62=0.
In exceptional circumstances, grades may be curved using the appropriate statistical measure. More information on the UW grading system can be found here:
http://www.washington.edu/students/gencat/front/Grading_Sys.html

Late work: Ten points will deducted for each day a homework or project is late, though no credit will be given after three days. Submissions between 8:45 and 11:59 pm on the due date will be considered one day late; between 11:59 pm on the due date and 11:59 pm the following day two days late, and so on. Missed quizzes cannot be made up. Missed exams can be made up only in exceptional circumstances at the discretion of the instructor.

Schedule for Spring 2020

	Topic/ Activity	Reading	Assignment
3/31	Overview and Getting Used to Online Class		Ice-Breaking
4/1	HVAC Systems Overview and Some Thermo	HVAC Overview* Heat (Trane, Ch 1)*	
4/6	Atmospheric Air and Psychrometrics	Ch IV	
4/8	Thermal Comfort, Health, and Ventilation	Ch II Health*	PS 1
4/13	Air Conditioning Processes I	Ch V (pp. 87-106)	
4/15	Air Conditioning Processes II	Ch V(pp. 106-119)	PS 2
4/20	Load Calculations I	Load Calculations* Ch III (pp. 17-29)	
4/22	Load Calculations II	Ch III (pp. 29-49)	PS 3
4/27	**Exam 1**		Exam 1
4/29	Refrigeration and Heat Pumps	Chapter VI (pp. 120-140) Chapter VII (198-207)	
5/4	Air Conditioning Systems Air Processing and Humidity Control	"Systems" Ch VII (pp. 218-237)	PS 4
5/6	Air Handling and Distribution I	Ch IX	
5/11	Air Handling and Distribution II Water Handling and Distribution	Ch IX (finish) Water Distribution*	PS 5
5/13	Air Conditioning System Selection	System Selection*	PS 6
5/18	**Exam 2**		Exam 2
5/25	Memorial Day - No online meeting!		
5/27	Design Process and Codes	Design*	
6/1	Sustainable and High Performance Buildings	Buildings*	Project Report
6/3	Projects Discussion		Projects Due

Notes:
1. Readings in blue font are from the Trane Air Conditioning Manual.
2. Readings with an asterisk will be made available in Canvas.