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

B ME 433 A - Advanced Thermal Fluids: HVAC Engineering
Spring 2018

Time and Location: TTh 3:30 - 5:30 in UW1 - 261

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Canvas Homepage: https://canvas.uw.edu/courses/1213212

Overview

Advanced Thermal Fluids provides an opportunity for Mechanical Engineering students with senior standing to dig deeper into a thermal fluids topic. This year's course introduces the processes and technologies—known collectively as heating, ventilation, and air conditioning (HVAC)—used to maintain buildings and other enclosed spaces at desired levels of temperature, humidity, and air quality. These spaces are subject to a variety of inputs from the external environment, as well as from activities occurring within them. Some of these inputs are predictable, others less so, resulting in a highly dynamic system. Choice of technology depends on many factors, including the purpose of the space, such as whether it will be a residence, hospital, university building, greenhouse, food preparation area, warehouse, or industrial facility.

The HVAC engineer must be able to model the energy flows into and out of the system, select equipment that will provide the required heating and cooling, and design processes that maintain the system at the desired equilibrium conditions—all while striving to optimize cost, performance, and environmental impacts.

Learning Outcomes

At the end of this course, students will be able to:

1. Apply thermodynamics and psychrometric principles to the analysis of indoor air properties and air conditioning processes.
2. Evaluate indoor and outdoor environmental conditions that govern design of HVAC systems.
3. Determine heating and cooling loads for sizing HVAC systems.
4. Size ducts and pipes for efficient transport of air and water in HVAC systems.

5. Size and assess performance of air and hydronic HVAC systems.
6. Describe the components of refrigeration, heat pump, and heating equipment, and evaluate their performance.
7. Identify design phases and delivery methods of HVAC engineering projects.
8. Design a basic HVAC system on paper or with energy modeling software.

ABET Learning Outcomes

The learning outcomes for this course map to ABET outcomes (f), (g), (h), and (i):

(a) Apply knowledge of mathematics, science and engineering.
(c) Design a system, component, or process to meet desired needs.
(e) Identify, formulate, and solve engineering problems.
(k) Use techniques, skills, and modern engineering tools necessary for engineering practice.

Course Materials

The following textbook is required and should be available in the bookstore:

Ronald H. Howell, *Principles of Heating Ventilating and Air Conditioning*, 8th Edition (Atlanta: ASHRAE, 2017).

Other required readings will be posted in Canvas as needed.

Most HVAC textbooks are based on the *ASHRAE Handbooks on HVAC* published every few years by the American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE). The two volumes relevant to this course may be accessed in UW Libraries at the following:

2017 ASHRAE Handbook - Fundamentals (I-P Edition). https://app-knovel-com.offcampus.lib.washington.edu/web/toc.v/cid:kpASHRAEP2/viewerType:toc

2016 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning Systems and Equipment (I-P Edition). https://app-knovel-com.offcampus.lib.washington.edu/web/toc.v/cid:kpASHRAEN1/viewerType:toc?sort_on=default

A third reference from ASHRAE is a guide to design and construction of sustainable buildings: *ASHRAE GreenGuide - Design, Construction, and Operation of Sustainable Buildings (5th Edition).* https://app-knovel-com.offcampus.lib.washington.edu/web/toc.v/cid:kpASHRAEO8/viewerType:toc

Energy Modeling Software

Energy modeling software for calculating loads and sizing HVAC systems can be obtained from various sources, some of which are free. Two tools that have long been used by HVAC engineers are EnergyPlus and eQuest. Both were developed by the Department of Energy, and both are free. A third tool, Trane Trace 700, is also widely used, though it will soon be phased out and replaced by the powerful Trane Trace 3D Plus. The Trane software isn't free but is steeply discounted for educational institutions. I am able to obtain licenses for any student who'd like to try it out, and even use it in a project (see below). 30-day free-trial versions are also available.

Links to the software mentioned above:
EnergyPlus (free): https://energyplus.net
eQuest (free): https://energydesignresources.com/resources/software-tools/equest.aspx
Trane Trace 700: http://www.trane.com/commercial/north-america/us/en/products-systems/design-and-analysis-tools/analysis-tools/trace-700.html
Trane Trace 3D Plus: http://www.trane.com/commercial/north-america/us/en/products-systems/design-and-analysis-tools/analysis-tools/trace-3d-plus.html

ASHRAE: The local Puget Sound Chapter is quite active, due in part to the relatively large number of HVAC professionals in the area and booming construction of new buildings. Going to meetings is a great way to network and learn about the latest trends and technologies. Student membership is just $21/year ($206 for regular membership), and that holds for the first year after graduation. If anybody is interested in forming a UWB student chapter of ASHRAE, I'd be happy to serve as the faculty advisor. Just let me know. At least 10 student members would be needed to become eligible for a student chapter. For more information:
https://www.ashrae.org/membership/join
https://www.ashrae.org/communities/student-zone/student-branches

Assignments

The assignments, due dates, and weightings are as follows:

1. **Two in-class, exams, April 24 and May 22 (30 % each, total of 60%):**
   The exams consist of questions and problems similar to those in the homework, classwork, and practice. The first part of the exam, focusing on concepts, is closed book. The second part, consisting of problems, is open book. Students have the full 2 hours for each exam.

2. **Homework, spread over the quarter (15 %):**
   Homework assignments will be posted in Canvas at least one week before the due date. The problems will consist of end-of-chapter problems and questions of my own design.

3. **Project (15 %):**
   You will work in teams of three, on an open-ended problem. You may choose one of the following two options:
   Option 1: Provide a solution to one of the following "System Design Problems" in Appendix B of the textbook: B.1, B.2, or B.3. Your solution should consist of drawings, calculations, list of assumptions you had to make, and a memo briefly (in 2 pages or so) describing what you did and why you did it. Staple everything together or place in a 3-ring binder.
   Option 2: Create a tutorial on how to use one of the energy modeling programs described above. Use whatever means—writing, screenshots, diagrams, etc.—helps you to make a clear, easily understandable lesson. Assume your "student" is a

mechanical engineer who understands HVAC processes and is able to do the basic calculations by hand but just needs help with the software. Show in your tutorial how the software can be used to model energy loads in an actual or hypothetical building.

Groups will share their results with the class in an informal discussion during the last two weeks of the quarter. Project reports are due in class. Project reports are due

4. **Classwork (10%):** Includes exercises and practice done during class time.

Policies

A list of STEM School policies and resources can be found here: http://www.uwb.edu/getattachment/stem/about/stem-policies/classroom-policies-stem-fc-1-12-17.pdf

Grading: All assignments will be graded on a 100-point scale. At the end of the course, an overall weighted average grade will be calculated and converted to the 4-point grade 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.
Grades on exams and other major assignments may be curved within Canvas to maintain consistency of grade distributions. More information on the UW grading system can be found here: http://www.washington.edu/students/gencat/front/Grading_Sys.html

Absences, late and missed assignments: If you must miss an exam, notify me as far as possible in advance; at my discretion, a make-up exam may be scheduled, most likely *before* the exam is given in class. Unless you can furnish proof that an emergency has occurred, missing an exam without informing me in advance will result in a grade of zero. Missed classwork may not be turned in late. Late homework will receive a 10-point deduction for each late day.

Schedule *

Date	Topic	Reading	Activity
Mar 27	Introduction		
Mar 29	Thermodynamics and psychrometrics	Ch 2	
April 3	Refrigeration and heat pump equipment	Chs 16, 18	
April 5	Psychrometrics and HVAC processes	Ch 3	Homework 1
April 10	Thermal comfort	Ch 4	Guest from Trane (date tentative)
April 12	Heating equipment	Ch 19	Homework 2
April 17	Heating and cooling load determination 1	Ch 5	Guest from Berona Engineers
April 19	Heating and cooling load determination 2	Ch 5	Homework 3
April 24	**Exam 1**		**Exam 1**
April 26	Residential cooling and heating loads	Ch 6	Guest from Trane (date tentative)
May 1	Nonresidential load estimation	Ch 7	Homework 4
May 3	Energy consumption of HVAC systems	Ch 8	
May 8	Duct and pipe sizing	Ch 9	
May 10	Air conditioning system design	Ch 11	Homework 5
May 15	Hydronic systems	Ch 13	
May 17	Air washing and dehumidification	Ch 17	Homework 6
May 22	**Exam 2**		**Exam 2**
May 24	HVAC project design & delivery	TBA	Guest from FSi Consulting Engineers (date tentative)
May 29	Sustainability Project discussions	TBA	
May 31	Project discussions		

* Schedule subject to change to accommodate availability of guest presenters.