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

B ME 331 A Thermal Fluids I (SLN 11173)
Autumn 2017

Time and Location: MW 8:45 - 10:45 am in UW2-240

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Canvas Homepage: https://canvas.uw.edu/courses/1114741

Course Description

This course, the first in the three-quarter Thermal Fluid Systems series, introduces the subject of *thermodynamics*, the study of energy and energy transfer as heat and work. Topics include mass and energy conservation, energy transfer as heat and work, thermodynamic properties of substances, and analysis of devices based on principles of thermodynamics, such as heaters and air conditioners, automobile and jet engines, pumps and compressors, refrigeration systems and thermal power generation plants. Assignments consist of weekly homework, two one-hour exams, an essay on energy and society, and a two-hour final exam.

Thermodynamics is the starting point for more detailed study of energy processes. The other subjects of Thermal Fluid Systems, fluid mechanics and heat transfer, delve more deeply, and with greater mathematical rigor, into energy conversion and transfer processes. *Fluid mechanics*, the subject of next quarter's Thermal Fluids II, deals with the natural and forced motion of gases and liquids, such as flow of liquids in pipes and flow of air around aircraft wings in flight. *Heat transfer*, the main subject in Thermal Fluids III, is the study conduction, convection, and radiation, the three mechanisms by which thermal energy flows as heat from a warmer to a cooler space. While the driving force for fluid flow is difference in pressure between two points in a system, in heat transfer it is difference in temperature.

In a refrigerator or internal combustion engine, mechanical work, fluid flow, and heat transfer are all occurring at the same time. Hence methods from each of the three disciplines are often applied together in the design and analysis of real-world systems.

Learning Outcomes

At the end of this course, students will be able to:
1. Determine thermodynamic properties of solids, liquids, and gases, and report them in English and SI units.
2. State the first law of thermodynamics, and use it to solve energy balance problems for closed (control mass) systems.
3. Apply the first law to open (control volume) systems under steady flow, as well as to common steady-flow devices, including turbines, nozzles, pumps, valves, heat exchangers, and compressors.
4. State the second law of thermodynamics, and apply it, together with the first law, in the analysis of cycles (Carnot) and cyclic devices (heat engines, refrigerators, etc).
5. Define entropy, calculate entropy changes in processes, and use entropy to determine isentropic efficiencies for various steady-flow devices.
6. Describe and analyze gas, vapor power, and refrigeration cycles.
7. Describe and analyze ideal gas mixtures and mixtures of air and water vapor.
8. Identify and analyze ethical and societal implications of energy technologies.

ABET Learning Outcomes

The learning outcomes for this course correspond to ABET outcomes (a), (e), and (h):

(a) An ability to apply knowledge of mathematics, science, and engineering.
(e) An ability to identify, formulate and solve engineering problems.
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Assignments and Grading Criteria

Homework (15 %): A total of 9 problem sets will be assigned in Canvas, about one per week. Usually, each homework will include, in addition to the problems you must do, some practice problems you are encouraged to do on your own but not required to turn in. Homework must be done by hand, in pencil, on green engineering paper, using the departmental template. To receive full credit, homework must be submitted <u>at the beginning of the class at which it is due</u>. No homework will be accepted after the solutions are posted in Canvas. The lowest homework grade will be dropped.

Classwork (5 %): Occasionally, you will be asked to answer questions or complete a worksheet in class. Included here are exercises related to equipment demonstrations.

Two in-class midterm exams (20 % each, 40 % total). Each exam consists of a closed book part and open book part. You will first do the closed book part, which will consist of some combination of multiple choice, short answer, and true-false questions. After submitting the closed-book part, you will pick up the open-book part to complete in the remaining time. The open-book part will consist of problems similar to those on the homework, and you may use your textbook, class notes, and any other materials *except* for a computer. If you do not have the textbook, it is your responsibility to print out or copy the parts you think you will need.

Final exam (25 %): Two hours, given in class Wednesday, December 15 at 8:45 am. The final exam is similar to the midterm exams in format but is longer and focused on the material covered since the second midterm exam.

Essay on energy and society (15 %): In this assignment, you will write an essay of about 1000 words on a topic drawn from one of the three prompts below:

1. University of Washington Seattle operates a power plant that provides steam and electricity used on campus. We will have an opportunity to visit the plant Friday, October 13, at 10 am. After the tour, do some research on this plant; talk with the plant manager Mark Kirschenbaum (markki@uw.edu) about its history and its relationship with UW and the larger community. In your essay, describe the plant in terms of what it does and how it works. But the larger part should describe ways the plant is reducing its environmental footprint and aligning with UW's sustainability goals. What conclusions can you draw about the plant's prospects?

2. Despite the serous environmental harm done by burning coal, natural gas, and other fossil fuels, we in the US remain addicted to them. Why is it proving so difficult to transition away from fossil fuels? Look up the work of Mark Z. Jacobson, an engineering professor who believes we can shift to an energy system that is 100% powered by sun, wind, and other renewable sources. For a more skeptical take, look up Christopher Clack, a scientist who thinks Jacobson analysis is misleading and the goal impossible to achieve. Where do you stand? Should we be doing more to hasten the shift to renewable energy sources? What would you propose that we do?

3. Does the internal combustion engine have a future? Just this summer, Volvo announced that it will be phasing out cars powered by internal combustion engines over the next two years; starting in 2019, all its cars will be powered by electric motors. A few weeks later, the government in the UK announced that Britain would ban the sale of gasoline and diesel cars starting in 2040. Just a few days ago, the Chinese government said it was working on a plan to ban all fossil fuel vehicles, though no timeline was announced. California may be about to do the same. Is the internal combustion engine on the way out? If so, should we be celebrating? Have electric motors and batteries developed to a point where they are ready to replace combustion engines on a large scale? Do some research on this topic and report your findings.

Upload your essay to Canvas by 11:59 pm November 29. Use no fewer than three written sources (not including the textbook) from reputable magazines, newspapers, and scholarly journals; cite them, and list them in a References section at the end. Articles found in general internet searches will have a high chance of not being reputable. Try searching the UW Libraries data bases or Google Scholar. Trusted sources include magazines like Mechanical Engineering Magazine from ASME, IEEE Spectrum, New York Times, Wall Street Journal, The Economist, Science Magazine, Scientific American, and Nature. Note that the higher quality sources are usually hidden behind pay walls; best to access them through UW Libraries. The US Department of Energy web site (**https://energy.gov**) has a lot of interesting and authoritative information. In power generation, Utility Dive and Power Magazine are authoritative news sources read by professionals in the field. Other good internet sources are Bloomberg New Energy Finance, Renewable Energy World, and Greentech Media.

Take care not to plagiarize. Your essay will be processed by a plagiarism detection system in Canvas. Learn to spot and to avoid plagiarism. For more information, see **http://guides.lib.uw.edu/c.php?g=345664&p=2329452**
Resources on writing and properly citing sources can be found here: **http://guides.lib.uw.edu/bothell/ai**

Required Materials

Yunus A. Cengel and Michael A. Boles, *Thermodynamics: An Engineering Approach*, 8th Edition, McGraw-Hill, 2014. Other editions may be used, but keep in mind that organization and end-of-chapter problems may differ among the editions.

Calculator: You may use any calculator for homework and regular classwork. However, for exams, you may use only calculators designated by the National Council of Examiners for Engineering and Surveying as acceptable for use on engineering licensing exams. A list of these calculators can be found here: **https://ncees.org/exams/calculator/**

Engineering Paper, Pencils, and Neatness: Unless an assignment specifies otherwise, all work is to be done on green engineering paper, in pencil, on one side only. Pencils must be number 2 or HB lead. Legibility is important—work I struggle to decipher will be returned ungraded.

Canvas: Canvas is our online course management system. For help using it, see **http://www.uwb.edu/learningtech/elearning/canvas/canvas-for-students.**
I organize course materials in the Modules section of Canvas. Each module corresponds to a date on the syllabus schedule. The modules build as the course progresses, with the most recent module at the top of the page.

Policies and Campus Resources

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

Grading: Exams will be graded on a 100-point scale. At the end of the course, the grades will be averaged and then 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.
Homework and essays are graded directly on the 4-point scale. More information on the UW grading system can be found here: **http://www.washington.edu/students/gencat/front/Grading_Sys.html**

Absences and missed assignments: One or two absences will probably not hurt your grade, unless you happen to miss an exam. If you must miss an exam, notify me as far as possible in advance so we can arrange a make-up time, which will most likely be *before* the exam is scheduled 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.

B ME 331 Thermal Fluids I Schedule for Autumn 2017

Date	Topic	Reading*	Assignment Due
Sept 27	Intro; definitions; units	1-1 to 1-10	
Oct 2	Forms of energy; heat, work; First Law	2-1 to 2-4, 2-6	Homework 1
Oct 4	Properties of pure substances	3-1 to 3-4	
Oct 9	Property tables; enthalpy; gas laws	3-5 to 3-8	Homework 2
Oct 11	Energy analysis of closed systems	4-1 to 4-5	
Oct 16	Energy analysis of open systems	5-1 to 5-3	Homework 3
Oct 18	1st hour: Exam 1 on chapters 1-4 2nd hour: Steady-flow devices	 5-4	**Exam 1**
Oct 23	Second Law and thermodynamic cycles	6-1 to 6-4	
Oct 25	Reversible processes and the Carnot cycle	6-5 to 6-11	Homework 4
Oct 30	Entropy	7-1 to 7-6	
Nov 1	Tds relations and entropy change	7-7 to 7-12	Homework 5
Nov 6	Otto and Diesel cycle engines	9-1 to 9-6	
Nov 8	Brayton cycle power plants	9-8 to 9-10	Homework 6
Nov 13	1st hour: Exam 2 on chapters 5-7 2nd hour: Jet propulsion power cycles	 9-11	**Exam 2**
Nov 15	Rankine cycle power plants	10-1 to 10-6	
Nov 20	Cogen and combined cycle power plants	10-8 to 10-9	Homework 7
Nov 22	Refrigeration cycles	11-1 to 11-4, 11-6	
Nov 27	Gas-vapor mixtures; psychrometrics	13-1, 14-1 to 14-6	Homework 8
Nov 29	Heating and air conditioning processes	14-7	**Essay due**
Dec 4	Lab activity and/or in-class practice		Homework 9
Dec 6	Tie up loose ends, review, and practice		
Dec 13	Final Exam (2 hours)		**Final Exam**

* Readings are sections in Cengel, 8th Edition. For example, “1-1 to 1-10” refers to chapter 1, sections 1-1 through the end of 1-10. For most readings, notes will be posted in Canvas. After the first day, readings should be completed before the class in which they are assigned.

Optional Power Plant Tour! Are you interested in seeing thermodynamics come to life in a power plant? Plan to meet at 10 am Friday, October 13, at UW Seattle for a guided tour of the campus’s own steam/electric power generation plant. Details to follow.