AME 20231–Thermodynamics
Spring 2024

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Instructor Zoom office hours: 7:00-9:00 PM, M, Tu   stop by 366 Fitz as needed

https://notredame.zoom.us/j/99473328715?pwd=blpOVmcxL2RuUGpSR2JKdytjNnUyUT09

Course web site: https://www3.nd.edu/∼powers/ame.20231

Listserver address: sp24-ame-20231-01-group@nd.edu. When e-mail is sent to this address, the entire class will receive a copy of the mail.

Lecture time and location: Tu-Th, 9:30 AM-10:45 AM, 101 DeBartolo Hall
TA Zoom and in person office hours: Su-M-Tu-W, 311 DeBartolo, 4:00 PM-6:00 PM

Prerequisites: Calculus III. Though not required, Mechanics I will be useful.

Catalog description: "Basic concepts of thermodynamics. The first law of thermodynamics. Work, heat, properties of substances and state equations. The second law of thermodynamics. Applications to engineering systems."

Comments: The course will consider the fundamental science of classical thermodynamics and its practical applications. Problem solving will be emphasized, including problem formulation, analytic, and computational solutions.

Topics:

1. Introduction: some semantics, some history, some philosophy, relevance of thermodynamics to engineering applications, property, state, system, process, temperature, pressure, density, volume, energy, units, zeroth law of thermodynamics,

2. Properties of a pure substance: vapor/liquid/solid phase equilibrium, independent properties, thermal equation of state, tables of properties, ideal gas limit, some non-ideal state equations, interpolation,

3. The first law of thermodynamics: some mathematics, simple compressible systems, work, heat, classical formulation of the first law, internal, kinetic, and potential energy, enthalpy, constant pressure and constant volume specific heats, tables of energy and enthalpy, constant and temperature-dependent specific heats for ideal gases, time-dependency,

4. First law analysis for a control volume: detailed derivations, control volume mass conservation, first law formulation for control volume, steady-state processes, transient processes, devices, introduction to the Rankine cycle,

5. The second law of thermodynamics: statements of the second law, heat engines and refrigerators, reversible processes, absolute temperature scale, Carnot cycles,

6. Entropy: theoretical development, second law in terms of entropy, the Gibbs equation, entropy for ideal gases, entropy change for reversible and irreversible processes, tabulation of entropy, adiabatic reversible processes for ideal gases, entropy of mixing, probabilistic approach,

7. Second law analysis for a control volume: irreversible entropy production, Bernoulli's principle, efficiency of components,

8. Cycles: Rankine, Brayton, refrigeration,

9. Mathematical foundations: Maxwell relations, Legendre transformations, heat capacity, real gas behavior and non-ideal equations of state, adiabatic sound speed, introduction to compressible flow.

Course notes

J. M. Powers, 2023, *Lecture Notes on Thermodynamics*, `https://www3.nd.edu/~powers/ame.20231/notes.pdf`.

We will go through these notes in lecture. The notes roughly parallel the main text and uses similar notation. The pace will vary through the term, but will be somewhere between 10 and 20 pages per 75 minute lecture. Students may wish to print out the notes and annotate them during lecture. Students are also encouraged to read ahead before lecture and bring questions to lecture.

Required texts available in Hammes bookstore

C. Borgnakke and R. E. Sonntag, 2017, *Fundamentals of Thermodynamics*, Ninth Edition, John Wiley.

Useful non-required texts

H. C. von Baeyer, 1998, *Warmth Disperses and Time Passes: The History of Heat*, Modern Library.

M. M. Abbott and H. C. van Ness, 1989, *Thermodynamics with Chemical Applications*, Second Edition, Schaum's Outline Series in Engineering, McGraw-Hill.

S. Paolucci, 2019, *Undergraduate Lectures on Thermodynamics*, BreviLiber.

E. Fermi, 1936, *Thermodynamics*, Dover.

Required work and grading

Exams will be open book, closed notes and held in class. The final exam will be comprehensive.

Homework will be assigned weekly, generally to be submitted in scanned `.pdf` form on `CANVAS` by 9:00 AM most Thursdays. *A no-late homework policy will be strictly enforced.* All homework will be graded. Homework must be done on *one side only* of 8 1/2" by 11" *engineering* paper with no frayed edges. You should briefly restate the problem, give a sketch if helpful, give all necessary analysis, and place a box around your final answer. All plots must be computer generated. Label all axes. Neatness and effective communication are considered in grading as well as the final answer itself.

Two short (one page maximum) critical reviews of works from the literature will be required. The first will consider a historical and important article found in links in the course notes. The second review must consider an article on thermodynamics from the AIAA technical journal *Journal of Propulsion and Power* and consider some aspect of thermodynamics. The reviews are required to be written in a LaTeX format and will be checked primarily for style, format, grammar, and content.

An Office of Student Affairs-approved written excuse will be required in order for any consideration to be given for any required work (for example, examinations, or homework) which is not completed at the expected time.

Grades will be assigned based on students' performance on examinations, homework, and papers. Pertinent information is as follows:

Exam I	25	Thursday, 15 February 2024,
Exam II	25	Thursday, 4 April 2024,
Final Exam	35	Tuesday, 7 May 2024, 8:00 AM-10:00 AM, 101 DeBartolo
Homework	13	generally on Thursdays
Reviews	2	Thursday, 29 February 2024, Thursday, 11 April 2024.
Total	**100**	

Honesty policy

Academic honesty is expected. When confronted with an apparent violation, I will enforce the appropriate University regulations to the best of my ability. I will also try to make my expectations clear. By and large, though, these issues are out of my control and as such I do not seek out violations. Instead, I depend upon your basic integrity to prevent any problems.

In brief my expectations are as follows. I encourage you to freely discuss the homework amongst one another as you formulate your solutions *individually*. *Your* written work should represent *your* understanding of the problem. In practice this means copying (in whole or in part) another student's homework, exam, computer program, or paper is *not* permitted. Review papers must be the product of the student's mind and not artificial intelligence software. Copying homework from web-based answer keys is also considered to be an honor code violation. If you choose to discuss your work with a colleague, it should be a discussion in which one teaches another or both work to a mutual understanding. As a counter-example, it is not acceptable to give a friend your homework five minutes before class so that friend can copy your work. I also consider it unacceptable to copy work from a student who was in the class in a previous year. In your written reports, be careful to correctly use quotation marks for words that did not originate with you. Paraphrasing should be held to a minimum, but if used, the paraphrased section should be specifically identified and unambiguously cited. It is not sufficient to simply list a reference but not indicate where a specific quotation or paraphrase was employed. In addition all sources used should be fully cited. As is done in the scientific literature, you should *briefly* acknowledge in writing any significant discussions or interactions you had regarding the work you submit. As a general principle, I do not accept the justification that you were not sure of my intentions. If you feel you may be in an ethical grey area, then you should consult with me *before* acting.