# ME 301: Fundamentals of Thermodynamics

*This is a cooperative course taught jointly by WSU and the University of Idaho*

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| *Course description:* | Thermodynamic properties of matter, ideal gas, real fluids, and incompressible substances, work and heat, first and second laws and application to engineering systems |
| *Number of credits:* | 3. This course is required. |
| *Course Coordinator:* | J. Leachman |
| *Prerequisites by course:* | Phys 201 with a grade of C or better, or PHYS 201 and 211, both with C or better. |
| *Prerequisites by topic:* | 1. Differentiation<br>2. Integration<br>3. Conservation of Mass<br>4. Conservation of Energy |
| *Postrequisites:* | ME 405; ME 303 (recommended) |
| *Textbooks/other required materials:* | 1. Cengel, Y. *Property Tables Booklet/Thermodynamics*. McGraw-Hill, 2024, 10/e.<br>2. Cengel, Y.A. and Boles, *M.A. Thermodynamics: An Engineering Approach*. McGraw-Hill, 2024, 10/e. |
| *Course objectives:* | 1. Calculate changes in internal energy and enthalpy using real fluid, ideal gas, and incompressible property models.<br>2. Apply the first law of thermodynamics to closed and open systems.<br>3. Calculate changes in entropy using real fluid, ideal gas, and incompressible property models.<br>4. Apply the second law of thermodynamics to closed and open systems.<br>5. Analyze Carnot, power, and refrigeration cycles using state-diagrams. |
| *Topics covered:* | 1. Basic concepts of properties in pure substance.<br>2. First law of thermodynamics for closed systems.<br>3. First law of thermodynamics for control volumes.<br>4. Second law of thermodynamics; Carnot Cycle; thermodynamic temperature scale.<br>5. Concept and calculation of entropy.<br>6. Gas power cycles; Vapor cycles.<br>7. Refrigeration cycles. |
| *Expected student outcomes:* | 1. An understanding of how an automobile engine runs, how a utility plant generates electricity, and how a refrigerator keeps the icebox cold.<br>2. Ability to analyze the performance of an engine, a power plant, or a refrigerator by applying the first law of thermodynamics.<br>3. Ability to determine the fundamental limits on the operation of these devices using the second law of thermodynamics. |
| *Class schedule:* | Three 50-minute lecture sessions per week, for one semester. |
| *Laboratory schedule:* | None |
| *Contribution to meeting the professional component:* | Engineering Topics |
| *Relationship to student outcomes:* | Strongly Supports Outcome 1 |
| *Prepared by:* | Chris Doman and J. Leachman *Date:* January 3, 2023 |

A. **Reasonable Accommodation:** Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center.

B. **WSU Safety:** WSU is committed to maintaining a safe environment for its faculty, staff, and students. Safety is the responsibility of every member of the campus community and individuals should know the appropriate actions to take when an emergency arises. In support of our commitment to the safety of the campus community the University has developed a Campus Safety Plan (http://safetyplan.wsu.edu). It is highly recommended that you visit this web site as well as the University emergency management web site at http://oem.wsu.edu/ to become familiar with the information provided.

C. **Academic Integrity:** Academic Integrity is the cornerstone of higher education. As such, all members of the University community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Academic integrity will be strongly enforced in this course. Students who violate WSU's Academic Integrity Policy (identified in Washington Administrative Code (WAC) 504-26-010(4) will receive [insert academic sanction (e.g., fail the course, fail the assignment, etc.)], will not have the option to withdraw from the course pending an appeal, and will be reported to the Center for Community Standards. Cheating includes, but is not limited to, plagiarism and unauthorized collaboration as defined in the Standards of Conduct for Students, WAC 504-26-010(3). You need to read and understand all of the definitions of cheating. If you have any questions about what is and is not allowed in this course, you should ask course instructors before proceeding.

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**Specifics for Spring 2024 Section 1**

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**MEETING TIME AND LOCATION:**
**Lecture:** Goertzen 21, MWF 2:10-3:00.

**Recitation:** Spark 339, F 3:10-5:00. **Note that recitation functions as office hours for this class and is intended as a group work time. If you have a private matter to discuss with me, please send me an email or call my cellphone.

**INSTRUCTOR:** Dr. Jacob Leachman, Office: HYPER Lab 230 Dairy Road, Phone: 208-816-0288 (cell) e-mail: jacob.leachman@wsu.edu ** I'm usually in meetings or in my office across campus. Please call my cellphone if it's urgent.

**TEACHING ASSISTANT(s):** Parsa Akbari, Office: ETRL 207, Phone: 509-338-8384, parsa.akbari@wsu.edu.

**ADDITIONAL COURSE RESOURCES:**
- ✓ Alternative Text: S.A. Klein and G.F. Nellis, *Thermodynamics*, Cambridge University Press, 1st ed. (2011). Also can be viewed as an e-book via the WSU library.
- ✓ Website: All course materials will be posted on Canvas.

**HOMEWORK:**
- Homework is due every Friday at 8 pm.
- No credit is awarded for late assignments; your two lowest homework grades for the class will be replaced with perfect scores. Extenuating circumstances will be evaluated on a case-by-case basis when I am notified in advance.
- Given the large volume of homework that will be graded, it is in your best interest to make your work as neat as possible, credit may be deducted for solutions that are not clearly identified and/or difficult to follow.
- Students must complete all parts of the homework on their own; however, I encourage you to work with friends to teach each other solution strategies as this still allows for differentiation of original solutions. Copying, pasting, reusing code, or handing in the same work with different names will result in immediate submission to the student conduct board, potentially without warning.

**EXAMS:**
- There will be three, class-long, cumulative examinations.
- The TA and myself will take attendance and proctor the exams. You are allowed to use a SCIENTIFIC calculator as these are required for use on the Fundamentals of Engineering (FE) exam.

**GRADING:** Homework: 50%; 3 Exams: 50%. Distribution: 100–93 (A), 93–90 (A-), 90–87 (B+), 87–83 (B), 83–80 (B-), 80–77 (C+), 77–73 (C), 73–70 (C-), 70–60 (D), 60–0 (F), incomplete (I), integrity violation (X).

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**SCHEDULE:**

*the class schedule topics may change during the semester

| Date | | Day | Topics | Readings |
|---|---|---|---|---|
| 1/8 | 1st Law of Thermodynamics | *Mon* | 1. Class Organization, Introduction to Thermodynamics | |
| 1/10 | | *Wed* | 2. Systems and balances | Chapter 1 |
| 1/12 | | *Fri* | 3. The forms of energy, heat, and work | Chapter 2 |
| 1/15 | | *Mon* | **Martin Luther King Jr. Day – ALL UNIVERSITY HOLIDAY** | |
| 1/17 | | *Wed* | 4. Properties of pure substances: Ideal and Incompressible | Chapter 3 |
| 1/19 | | *Fri* | 5. Properties of pure substances: Real fluids | Chapter 3 |
| 1/22 | | *Mon* | 6. Closed system energy balance and internal energy | Chapter 4 |
| 1/24 | | *Wed* | 7. Analysis of closed energy systems | Chapter 4 |
| 1/26 | | *Fri* | 8. Open system energy balance and enthalpy | Chapter 4,5 |
| 1/29 | | *Mon* | 9. Open un-steady system energy balance | Chapter 5 |
| 1/31 | | *Wed* | 10. Analysis of un-steady systems | Chapter 5 |
| 2/2 | | *Fri* | 11. Analysis of open steady systems: Pumps, Compressors, Diffusers | Chapter 5 |
| 2/5 | | *Mon* | 12. Analysis of open steady systems: Nozzles, Throttles, Turbines | Chapter 5 |
| 2/7 | | *Wed* | 13. 1st Law Demo Day | Chapter 5 |
| 2/9 | | *Fri* | **Exam #1** | |
| 2/12 | 2nd Law of Thermodynamics | *Mon* | 14. The concept of Irreversibility and the 2nd Law | Chapter 6 |
| 2/14 | | *Wed* | 15. Maximum Efficiencies of Thermodynamic Cycles | Chapter 6 |
| 2/16 | | *Fri* | 16. Entropy and Thermodynamic Temperature Scales | Chapter 6 |
| 2/19 | | *Mon* | **President's Day – CLASS HOLIDAY** | |
| 2/21 | | *Wed* | 17. Closed system entropy balance: Real fluid | Chapter 7 |
| 2/23 | | *Fri* | 18. Closed system entropy balance: Incompressible and Ideal | Chapter 7 |
| 2/26 | | *Mon* | 19. Open system entropy balance | Chapter 7 |
| 2/28 | | *Wed* | 20. Open, un-steady system entropy balance | Chapter 7 |
| 3/1 | | *Fri* | 21. Isentropic efficiency: Pumps, Compressors, Diffusers | Chapter 8 |
| 3/4 | | *Mon* | 22. Isentropic efficiency: Nozzles, Throttles, Turbines | Chapter 8 |
| 3/6 | | *Wed* | 23. Availability/Exergy of an energy resource | |
| 3/8 | | *Fri* | 24. Availability/Exergy analysis of closed & open systems | |
| | | | **Spring Vacation** | |
| 3/18 | | *Mon* | 25. Entropy optimization of flow systems | |
| 3/20 | | *Wed* | 26. 2nd Law Demo Day | |
| 3/22 | | *Fri* | **Exam #2** | |
| 3/25 | Thermodynamic Cycles | *Mon* | 27. Power Cycles: Concepts and Carnot | Chapters 9,10 |
| 3/27 | | *Wed* | 28. Power Cycles: Rankine cycle | Chapters 9,10 |
| 3/29 | | *Fri* | 29. Power Cycles: Rankine cycle modifications | Chapters 9,10 |
| 4/1 | | *Mon* | 30. Power Cycles: Brayton for power | Chapters 9,10 |
| 4/3 | | *Wed* | 31. Power Cycles: Brayton for propulsion | Chapters 9,10 |
| 4/5 | | *Fri* | 32. Power Cycles: Otto & Diesel cycles | Chapters 9,10 |
| 4/8 | | *Mon* | 33. Power Cycles: Stirling cycles | Chapters 9,10 |
| 4/10 | | *Wed* | 34. Refrigeration Cycles: Concepts and Carnot | Chapter 11 |
| 4/12 | | *Fri* | 35. Refrigeration Cycles: Standard vapor compression | Chapter 11 |
| 4/15 | | *Mon* | 36. Refrigeration Cycles: Heat pump systems | Chapter 11 |
| 4/17 | | *Wed* | 37. Refrigeration Cycles: Advanced and combination cycles | Chapter 11 |
| 4/19 | | *Fri* | 38. Refrigeration Cycles: Refrigerant properties and selection | Chapter 11 |
| 4/22 | | *Mon* | 39. Cycles Review | |
| 4/24 | | *Wed* | 40. Thermodynamics and cryogenic hydrogen research | |
| 4/26 | | *Fri* | 41. FE Exam Prep | |
| 5/1 | | *Wed* | **Exam #3 1:30-3:30 pm** | |