# ME 301: Fundamentals of Thermodynamics

*Course description:* Thermodynamic properties of matter, ideal and real gases, work and heat, first and second laws and their application to engineering systems

*Number of credits:* 3

*Course Coordinator:* R.F. Richards

*Prerequisites by course:* Phys 201 with a grade of C or better; rec Math 315

*Prerequisites by topic:*

1. Differentiation
2. Integration
3. Conservation of Mass
4. Conservation of Energy

*Postrequisites:* ME 402; ME 303 (recommended)

*Textbooks/other required materials:*

1. Cengel, Y. *Property Tables Booklet/Thermodynamics*. McGraw-Hill, 2010, 7/e.
2. Cengel, Y.A. and Boles, *M.A. Thermodynamics: An Engineering Approach*. McGraw-Hill, 2010, 7/e.

*Course objectives:*

1. Determine the properties of pure substances using thermodynamic tables.
2. Use the ideal gas law.
3. Calculate changes in internal energy and enthalpy using specific heats.
4. Calculate the work done by a closed system via integration.
5. Apply the first law of thermodynamics to a closed system.
6. Apply the first law of thermodynamics to an open system.
7. Analyze the Carnot, Otto, and Rankine thermodynamic cycles.
8. Apply the second law of thermodynamics.
9. Calculate changes in entropy using thermodynamic tables.
10. Calculate changes in entropy for ideal gases.

*Topics covered:*

1. Basic concepts of Properties in pure substance.
2. First law of thermodynamics for closed systems.
3. First law of thermodynamics for control volumes.
4. Second law of thermodynamics; Carnot Cycle; thermodynamic temperature scale.
5. Concept and calculation of entropy.
6. Gas power cycles; Vapor cycles.
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.
2. Ability to analyze the performance of an engine, a power plant, or a refrigerator by applying the first law of thermodynamics.
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

# ME 301: Fundamentals of Thermodynamics

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| *Contribution to meeting the professional component:* | Engineering Topics |
| *Relationship of course to program objectives:* | Meets:<br>1. School of MME ME educational objectives: 1,2<br>2. School of MME ME program outcomes: (a)<br>3. ABET EC2000, Criterion 3 program outcomes: (a) |
| *Prepared by:* | R.F. Richards *Date:* July 10, 2014 |

A. **Reasonable Accommodation** (the nature of the particular course determines which one applies):

Pullman Campus. 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.

WSU Online Course. Reasonable accommodations are available in online classes for students with a documented disability. All accommodations must be approved through your WSU Disability Services office. If you have a disability and need accommodations, we recommend you begin the process as soon as possible. For more information contact a Disability Specialist on your home campus: Pullman or WSU Online (http://accesscenter.wsu.edu), Spokane (http://spokane.wsu.edu/students/current/studentaffairs/disability/), Tri- Cities (http://www.tricity.wsu.edu/disability), Vancouver (http://studentaffairs.vancouver.wsu.edu/student-resource-center/disability-services).

B. **Academic Integrity** WSU expects all students to behave in a manner consistent with its high standards of scholarship and conduct. Students are expected to uphold these standards both on and off campus and acknowledge the university's authority to take disciplinary action. The Standards of Conduct for Students can be found at http://conduct.wsu.edu.

C. **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.

D. **Classroom Safety**
Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the "Alert, Assess, Act" protocol for all types of emergencies. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way to assure your own safety (and the safety of others if you are able).
Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, visit the WSU safety portal (https://faculty.wsu.edu/classroom-safety/).

# ME 301: Fundamentals of Thermodynamics

**Specifics for Fall 2017 Section 1**

**MEETING TIME AND LOCATION: Section 1:** Goertzen Hall 21, M,W,F 2:10 - 3 PM

**INSTRUCTOR:** Dr. Jacob Leachman, Office: Sloan 217, Phone: 509-335-7711 (office), 208-816-0288 (cell) e-mail: jacob.leachman@wsu.edu ** I'm usually in meetings or my lab, seldom in my office, and receive more email than I can keep ahead of. Please call my cellphone if it's urgent.

**TEACHING ASSISTANT(s):** Jimmy Zheng, Lab: Phone: 509-715-9044, email: min.zheng@wsu.edu
Maryam Jamalian Phone: 509-335-8654, email: maryam.jamalian@wsu.edu

**ADDITIONAL COURSE RESOURCES:**

- ✓Recommended 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.
- ✓Software: Engineering Equation Solver (EES), available at: http://cougs.mme.wsu.edu/ees/unique.html
- ✓Website: All course materials will be posted on Blackboard, including Lesson Specific Forums: https://learn.wsu.edu
- ✓Recitation: Sloan 175, T,Th 4-7 pm. Exceptions are 9/21, 10/19, and 11/16 are in Wegner Hall G0001

**HOMEWORK:**

- Homework is due at the beginning of each class period.
- No credit is awarded for late assignments; your two lowest homework grades for the class will be dropped.
- 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, it is acceptable to discuss homework with friends. Your brain needs the tactile experience of entering the information yourself in order to increase the likelihood you know and remember the information. 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.
- If you spend "hours and hours" on your homework then you should get help – start the assignments early, consult the course Forums, go to recitation, and get help when you get stuck. You don't learn anything sitting in frustration.

**EXAMS:**

- There will be three, class-long, cumulative examinations. The topics in this class naturally build off each other; therefore each exam will likely include material from previous examinations.
- You may use your own original notes on the exams, no machine copying of information is allowed. You may also use the textbook and a SCIENTIFIC calculator, no graphing/programmable calcs.

**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).

# ME 301: Fundamentals of Thermodynamics

**SCHEDULE:**
*the class schedule topics may change during the semester

| Date | | Day | Topics | Readings |
|---|---|---|---|---|
| 8/21 | **1st Law of Thermodynamics** | *Mon* | 1. Class Organization, Introduction to Thermodynamics | |
| 8/23 | | *Wed* | 2. Systems and balances | Chapter 1 |
| 8/25 | | *Fri* | 3. The forms of energy, heat, and work | Chapter 2 |
| 8/28 | | *Mon* | 4. Properties of pure substances: Real fluid | Chapter 3 |
| 8/30 | | *Wed* | 5. Properties of pure substances: Incompressible and Ideal | Chapter 3 |
| 9/1 | | *Fri* | 6. Closed system energy balance and internal energy | Chapter 4 |
| 9/4 | | *Mon* | **Labor Day – No Class** | |
| 9/6 | | *Wed* | 7. Analysis of closed energy systems | Chapter 4 |
| 9/8 | | *Fri* | 8. Open system energy balance and enthalpy | Chapter 4,5 |
| 9/11 | | *Mon* | 9. Open, un-steady system energy balance | Chapter 5 |
| 9/13 | | *Wed* | 10. Analysis of open systems: Pumps, Compressors, Diffusers | Chapter 5 |
| 9/15 | | *Fri* | 11. Analysis of open systems: Nozzles, Throttles, Turbines | Chapter 5 |
| 9/18 | | *Mon* | 12. Analysis of open systems: HEX's, Mixers, Pipe Flow | Chapter 5 |
| 9/20 | | *Wed* | 13. Class Demonstrations and 1st Law Review | |
| 9/22 | | *Fri* | **Exam #1** | |
| 9/25 | **2nd Law of Thermodynamics** | *Mon* | 14. The concept of Irreversibility and the 2nd Law | Chapter 6 |
| 9/27 | | *Wed* | 15. Maximum Efficiencies of Thermodynamic Cycles | Chapter 6 |
| 9/29 | | *Fri* | 16. Closed system entropy balance: Real fluid | Chapter 7 |
| 10/2 | | *Mon* | 17. Closed system entropy balance: Incompressible and Ideal | Chapter 7 |
| 10/4 | | *Wed* | 18. Open system entropy balance | Chapter 7 |
| 10/6 | | *Fri* | 19. Open, un-steady system entropy balance | Chapter 7 |
| 10/9 | | *Mon* | 20. Isentropic efficiency: Pumps, Compressors, Diffusers | Chapter 7 |
| 10/11 | | *Wed* | 21. Isentropic efficiency: Nozzles, Throttles, Turbines | Chapter 7 |
| 10/13 | | *Fri* | 22. Availability/Exergy of an energy resource | Chapter 8 |
| 10/16 | | *Mon* | 23. Availability/Exergy analysis of closed systems | Chapter 8 |
| 10/18 | | *Wed* | 24. Availability/Exergy analysis of open systems | Chapter 8 |
| 10/20 | | *Fri* | 25. Understanding Entropy | |
| 10/23 | | *Mon* | 26. Thermodynamic temperature scales | |
| 10/25 | | *Wed* | 27. Class Demonstrations and 2nd Law Review | |
| 10/27 | | *Fri* | **Exam #2** | |
| 10/30 | **Thermodynamic Cycles** | *Mon* | 28. Power Cycles: Concepts and Carnot | Chapters 9,10 |
| 11/1 | | *Wed* | 29. Power Cycles: Rankine cycle | Chapters 9,10 |
| 11/3 | | *Fri* | 30. Power Cycles: Rankine cycle modifications | Chapters 9,10 |
| 11/6 | | *Mon* | 31. Power Cycles: Brayton for power & propulsion | Chapters 9,10 |
| 11/8 | | *Wed* | 32. Power Cycles: Brayton for propulsion | Chapters 9,10 |
| 11/10 | | *Fri* | **Veteran's Day – No Class** | |
| 11/13 | | *Mon* | 33. Power Cycles: Otto & Diesel cycles | Chapters 9,10 |
| 11/15 | | *Wed* | 34. Power Cycles: Stirling cycles | Chapters 9,10 |
| 11/17 | | *Fri* | 35. Refrigeration Cycles: Concepts and Carnot | Chapter 11 |
| | | | **Thanksgiving Vacation** | |
| 11/27 | | *Mon* | 36. Refrigeration Cycles: Standard vapor compression | Chapter 11 |
| 11/29 | | *Wed* | 37. Refrigeration Cycles: Heat pump systems | Chapter 11 |
| 12/1 | | *Fri* | 38. Refrigeration Cycles: Advanced and combination cycles | Chapter 11 |
| 12/4 | | *Mon* | 39. Refrigeration Cycles: Refrigerant properties and selection | Chapter 11 |
| 12/6 | | *Wed* | 40. Class Demonstrations and Cycles Review | |
| 12/8 | | *Fri* | 41. Course feedback | |
| 12/12 | | *Tues* | **Exam #3 8:00-10:00 am in Goertzen 21** | |