

PHYSICS 486
Thermodynamics and Statistical Mechanics
Syllabus, Spring 2017

Dr. Eduardo Sánchez Velasco

OFFICE

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Note: Do **not** use the phone or e-mail for grade related questions.

OFFICE HOURS

Monday: 10:30 a.m. - 11:30 a.m.

Wednesday: 10:30 a.m. - 11:30 a.m. *and* 12:30 p.m. - 1:30

Friday: 10:30 a.m. - 11:30 a.m. *and* 12:30 p.m. - 1:30 p.m.

CLASS HOURS

Monday, Wednesday, Thursday, Friday: 11:30 a.m. - 12:20 p.m. in Magruder Hall 1099.

CATALOG DESCRIPTION

The fundamental ideas of thermodynamics and of statistical mechanics are introduced and applied to classical and quantum systems. Topics include the meaning of temperature, work in thermodynamic systems, the Second Law of thermodynamics and its consequences, thermodynamic cycles, thermodynamic potentials, and the fundamentals of statistical mechanics using microcanonical, canonical, and grand canonical ensembles. *Credit: 3 hours.* Prerequisites: grades of C or higher in PHYS 251, PHYS 275, PHYS 382, and MATH 264. Pre- or co-requisite: STAT 290.

NOTE: Honors Scholar Course. This course counts toward the 63-credit Liberal Arts and Sciences (LAS) graduation requirement.

COURSE OBJECTIVES

This is an introductory course to the basic concepts in Thermodynamics and Statistical Mechanics, and it serves as the foundation for more advanced courses. The course is divided in two main parts; in the first one we will examine the theoretical framework and basic laws of Thermodynamics with emphasis in thermodynamic potentials. We will use a classical approach to the subject, introducing first basic concepts such as temperature, work, heat, thermodynamic cycles, entropy, and thermodynamic potentials. In the last part of the course we will focus on the Gibbs ensemble formulation of equilibrium Statistical Mechanics and how to obtain in the different ensembles thermodynamic potentials and other important statistical quantities. Using all these tools we will analyze some simple systems, and prepare the ground for further study in this area.

- ☞ The main emphasis of the course is theoretical; therefore proofs and derivations, not just problem solving, are of fundamental importance. **Knowing and understanding them will be expected from the students.**

TEXTBOOK

The required text for this course is:

- *Fundamentals of Thermodynamics and Statistical Mechanics, Lecture Notes*, Second Edition, by E. Sánchez Velasco. CreateSpace, 2010.

ACADEMIC DISHONESTY

Academic dishonesty of any form will not be tolerated in this class. Anyone caught cheating on a test, homework or quiz will automatically receive a grade of zero on that test, homework or quiz. Further disciplinary action consistent with University policy will be considered, including failing the course. Homework, quizzes and exams, unless instructed otherwise, must be done individually without any outside help. For more information about the University policy on academic dishonesty, consult the appropriate sections of the Student Conduct Code (see the code and related information at <http://conduct.truman.edu>).

STUDENTS WITH DISABILITIES

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and the [Disability Services](#) office (x4478) as soon as possible.

EXAMS

There will be four closed book exams in this class. The tentative exam dates are listed at the end of this syllabus. All exams, **including the final** (exam #4), will be on the material covered since the preceding test. That is, **they are not “comprehensive.”** However, you may have to use as background for one exam some material covered in previous exams. In exams it will be expected a deep knowledge of the material. Having only a general understanding of the material without knowledge and full understanding of the relevant details will not be enough. All exams, unless instructed otherwise, are without books or notes, and must be done individually. Being late to an exam may disqualify you from taking that exam, so **don't be late!**

- 👉 **IMPORTANT:** Under normal situations, once an exam starts, you will NOT be allowed to leave the room until you finish the exam. Plan accordingly.

HOMEWORK POLICY

There will be homework assignments during the course. Unless otherwise indicated, homework should be done individually. **homework assignments MUST be done individually without any external help; I will consider academic dishonesty homework done in group or copied from any unauthorized source** You must turn in your homework **in person** at the **beginning** of the class session in which they are due unless you have a valid reason not to attend the class. **No late homework will be admitted without a valid excuse.** Homework handed in after the class has started will be considered late homework. I will consider academic dishonesty to have some one turn in your homework assignment for you without my approval. If you have a valid reason not to attend a class, and a homework assignment is due that day, you should turn in your homework personally to me, preferably BEFORE the class. You will have to justify to me in person the reason for your absence. Remember that homework will be due BEFORE the class begins. Any missed homework will be counted as zero. I will give guidelines on homework presentation. Failure to follow these guidelines will be penalized.

MISSING A TEST, QUIZ OR CLASS

Students are expected to attend all class sessions. If you have a valid conflict that does not allow you to take an exam or quiz, or to handle your homework, you must **contact me as soon as possible**, preferably before the event takes place. In any case you should see me **in person** as soon as possible. Missing a test, quiz or homework requires a valid excuse, otherwise a grade of zero will be assigned. I reserve the right to determine what is, and is not, a valid excuse. As a rule only extreme situations, such as serious medical problems, will be considered valid excuses. Field trips and sport events are not usually considered valid excuses unless previously arranged personally with me. In general, having other exams in the same day is not a valid excuse. Adjustments to make up missed exams, homework, or quizzes, if any, will be made at my discretion, and only in extreme situations.

It is your responsibility to be on time for all classes, exams and quizzes. Alarm clock malfunctions and similar events are NOT considered valid excuses for being late or absent. If you are late to a class, you will not be able to turn in your homework or take a quiz, which usually are done at the beginning of the class. Being late to an exam or quiz may disqualify you from taking that exam or quiz. The exact date and content of a quiz will be announced in a previous class; it is your responsibility to know that date and content. If you miss a class, make sure to ask if a quiz was announced in it. "I did not know there was a quiz today" is NOT a valid excuse for missing a quiz. The same applies to changes of date, time or content of exams, and homework.

GRADING POLICY

The grade for this class will be obtained from 4 exams and from homework assignments and quizzes. Each exam will count 20% towards the final grade, homework and quizzes the remaining 20%.

Homework and quizzes	20%
Exam #1	20%
Exam #2	20%
Exam #3	20%
Exam #4	20%
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Total :	100%

The minimum guaranteed grading scale is as follows:

Final Percentage	Letter Grade
85% to 100%	A
70% to 85%	B
60% to 70%	C
50% to 60%	D
below 50%	F

Final letter grades are normally assigned according to the table above. However, at the end of the semester I may curve grades upward. If this curving is done and, for example, I add 1% to all the final grades, a person with a final percentage of 69% may receive a B as the final letter grade, even though the above table indicates that a C would normally be assigned. However, **curving is not**

guaranteed, and you should not count on it. I will never curve downward. As a rule, only the grades in the above table (A, B, C, D or F) will be given. Any other grade, like incomplete (IC), will be given at my discretion, and only under **very unusual and extreme circumstances**, like a serious medical problem. Poor performance will not qualify you for a grade other than A, B, C, D, or F.

TENTATIVE COURSE OUTLINE

Some of the topics I intend to cover in the lectures, in their approximate order, are indicated below.

- Basic concepts. Equilibrium. Temperature. Macroscopic variables.
- Quasi-static processes. Heat and work. Cyclic processes. First law.
- Thermodynamic engines. Second law of thermodynamics. Carnot theorem.
- Clausius theorem. Entropy. Irreversible processes. Third law.
- Some thermodynamic identities. Euler and Gibbs–Duhem relations.
- Thermodynamic potentials. Legendre transforms.
- Free energy, enthalpy, Gibbs free energy, grand potential.
- Maxwell’s relations. Reduction of derivatives.
- Some notions of thermodynamic stability.
- First order phase transitions. Clausius–Clapeyron relation.
- Continuous phase transitions. Critical phenomena.
- Foundations of statistical mechanics. Microstates. Quantum and classical systems. Phase space.
- Microcanonical ensemble. Entropy. Classical ideal gas. Spins systems.
- Canonical ensemble. Free energy. Equipartition and virial theorems. Fluctuations.
- Applications to simple systems. Oscillator model of solids. 1D Ising model.
- Grand Canonical ensemble.
- Independent particle approximation. Occupation number. Fermi and Bose Statistics.

Note that this is only a tentative schedule. I may change it to adapt to the needs of the class as we go along. The purpose of the class is for you to learn, not to follow a rigid class schedule. Your feedback in this matter will be very helpful. Please let me know if you think I am going too fast or too slow, or if there are topics in which you would like a more detailed explanation.

TENTATIVE EXAM DATES

Exam #1: Thursday, February 9 in class.

Exam #2: Monday, March 6 in class.

Exam #3: Thursday, April 6 in class.

Exam #4: Monday, May 8, 11:30 a.m. - 1:20 p.m. ([finals week](#)).

 This syllabus may change during the semester.

Updated versions of this syllabus will be posted at <http://www2.truman.edu/~velasco>.