PHYSICS 486
Thermodynamics and Statistical Mechanics
Syllabus

Spring 2006

INSTRUCTOR: 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, Wednesday: 12:30 pm – 1:30 pm
Tuesday: 11:30 am – 12:30 pm
Thursday: 12:30 pm – 2:30 pm

These are my official office hours, but you should feel free to stop in at any time, or to make an appointment for a more convenient time.

CLASS HOURS:

Monday, Wednesday, and Friday: 11:30 am – 12:20 pm in Magruder Hall 3000.
Thursday: 11:30 am – 12:20 pm in Magruder Hall 1099.

CATALOG DESCRIPTION:

Advanced treatment of thermodynamic systems; thermodynamic cycles; absolute scales of temperatures; entropy; thermodynamic potentials; fundamentals of statistical mechanics; microcanonical, canonical, and grand canonical ensembles with applications to classical and quantum systems.
Prerequisites: grade of C or better in PHYS 251, PHYS 275, PHYS 382, and MATH 264.
NOTE: General Honors Course.

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, Carnot cycles and so on. 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.

TEXT:

This semester we will not have a required text. We will work mostly with class notes. However, any of the following three books are highly recommended for the thermodynamics part of the course:

- Zemansky and Dittman, *Heat and Thermodynamics* (7^{th} edition), McGraw-Hill (1997).
- G. Carrington, *Basic Thermodynamics* Oxford (1994).
- C.B.P. Finn, *Thermal Physics* (2^{nd} edition), Chapman & Hall (1993).

A more advanced thermodynamics text, but also highly recommended is:

- H.B. Callen. *Thermodynamics and an Introduction to Thermostatics* (2^{nd} edition), John Wiley & Sons (1985).

Two good introductions to statistical mechanics at the advanced undergraduate/first year graduate level are:

- K. Huang. *Statistical Mechanics* (2^{nd} edition), John Wiley & Sons (1987).
- Greiner, Neise and Stöker. *Thermodynamics and Statistical Mechanics*, Springer Verlag (1995).

A little bit more advanced, but an excellent reference is:

- L. E. Reichl. *A Modern Course in Statistical Physics* (2^{nd} edition), John Wiley & Sons (1998).

ACADEMIC DISHONESTY:

Academic dishonesty of any form will not be tolerated in this class. Anyone caught cheating on a test or homework will automatically receive a grade of zero on that test or homework. Further disciplinary action consistent with University policy will be considered, including failing the course. Homework, unless instructed otherwise, must be done individually. For more information about the University policy on academic dishonesty consult the appropriate sections of the Student Conduct Code (see the code at `http://conduct.truman.edu/conduct_code.htm`).

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 material covered in previous exams. In addition to these exams there will be occasional quizzes. All exams and quizzes must be done individually.

HOMEWORK POLICY:

There will be several homework assignments during the course. Unless otherwise indicated, **homework should be done individually**. I will consider academic dishonesty homework done in group or copied from any unauthorized source. You must turn in your homework assignments **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. Homework handed in after the class has started will be considered late homework. **No late homework will be admitted without a valid excuse**.

MISSING A TEST, QUIZ OR CLASS:

If you have a valid conflict that does not allow you to take an exam or quiz at the scheduled time **contact me as soon as possible**, preferably before the test takes place. In any case you should see me in person as soon as possible. Missing a test 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, like serious medical problems, will be considered valid excuses. In general,

having other exams in the same day is not a valid excuse. You are also responsible for showing on time to exams or class. If you are late to a class you will not be able to turn in your homework. Alarm clock malfunctions and similar events are NOT considered valid excuses. Field trips and sport events are not usually considered valid excuses unless previously arranged personally with me. The exact date of a quiz will be announced in a previous class, some times the day before the quiz. It is your responsibility to know that date. 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 or homework. Adjustments to make up missed exams, homework or quizzes, if any, will be made at my discretion and only in very rare situations.

GRADING POLICY:

The grade for this class will be obtained from 4 exams and from homework assignments and quizzes. Each exam will count 17.5% towards the final grade, homework and quizzes the remaining 30%. Unless indicated otherwise, each homework problem will have a value of 10 points and each quiz will have the same value as a homework problem (10 points).

Homework and quizzes	30.0%
Exam #1	17.5%
Exam #2	17.5%
Exam #3	17.5%
Exam #4	17.5%
Total :	100%

The minimum guaranteed grading scale is as follows:

Final Percentage	Final Letter Grade
90 to 100	A
80 to 90	B
70 to 80	C
60 to 70	D
below 60	F

Final letter grades are normally assigned according to the table above. However, depending on class performance or to reward class participation, at the end of the semester I may curve grades upward. If this curving is done and, for example, I add 1% to the final grade, a person with a final percentage of 79% may receive a B as a 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 with 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.
- Foundations of statistical mechanics. Phase space. Liouville theorem.
- Microcanonical ensemble. Entropy.
- Canonical ensemble. Free energy. Fluctuations.
- Grand Canonical ensemble. Quantum statistical mechanics.
- Independent particle approximation. Ideal quantum gases.
- Ideal Bose gas and Bose-Einstein condensation. Ideal Fermi gas.

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: Monday, February 13 in class.
Exam #2: Thursday, March 9 in class.
Exam #3: Monday, April 10 in class.
Exam #4: Monday, May 8, 11:30 a.m.– 1:20 p.m. (Finals week).

This schedule may change during the semester.