# PHY 6500 Thermal and Statistical Physics - Fall 2017

**Time: M, F 12:30 PM – 2:10 PM. From 08/30/17 to 12/19/17**

**Place: Room 185 Physics Research Building**

**Lecturer: Boris Nadgorny**

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**Office: 389 Physics, Phone: 577-2757**

**Office hours: Monday 2:30 PM – 4 PM or by appointment**

**Final Exam: Wednesday, December 13 at 12:30 pm**

**TEXTBOOK:**

**"Thermal Physics1st Edition: Thermodynamics and Statistical Mechanics for Scientists and Engineers"**

**Robert Floyd Sekerka**

Paperback ISBN: 978012803304

3eBook ISBN: 978012803337

Book is available from the publisher, see:

https://www.elsevier.com/books/thermal-physics/sekerka/978-0-12-803304-3?start_rank=1&producttype=books&sortby=sortByRelevance&q=thermal%20physics%20sekerka

**Supplementary textbook:** Enrico Fermi, Thermodynamics, Dover, New York.

**Additional References: Undergraduate Texts:**

H.C. van Ness, Understanding Thermodynamics: discussion of some basic ideas.

Callen – Thermodynamics and Statistical Physics: good thermodynamics reference.

A. Carter, Classical and Statistical Thermodynamics: concise and clear discussion of thermodynamics; less so of statistical physics.

Kittel and Kroemer – Thermal Physics: a nice book, consistent statistical approach, but is not easy to read.

**Additional References: Graduate Texts:**

L. D. Landau and E. M. Lifshitz, Statistical Physics: an original approach, some useful topics (e.g. changes of variables, fluctuations).

R. K. Pathria, Statistical Mechanics: a popular graduate textbook

K. Huang, Statistical Mechanics: another common graduate textbook**.**

## LIST OF TOPICS (*Indicates optional topics).

**Part I: Thermodynamics**

1: Introduction

- 1.1 Temperature
- 1.2 Thermodynamics Versus Statistical Mechanics
- 1.3 Classification of State Variables
- 1.4 Energy in Mechanics
- 1.5 Elementary Kinetic Theory

2: First Law of Thermodynamics

- 2.1 Statement of the First Law
- 2.2 Quasistatic Work
- 2.3 Heat Capacities
- 2.4 Work Due to Expansion of an Ideal Gas
- 2.5 Enthalpy

3: Second Law of Thermodynamics

- 3.1 Statement of the Second Law
- 3.2 Carnot Cycle and Engines
- 3.3 Calculation of the Entropy Change
- 3.4 Combined First and Second Laws

21: Grand Canonical Ensemble

21.1 Derivation from Microcanonical Ensemble

21.2 Ideal Systems: Orbitals and Factorization

21.2.1 Factorization for Independent States

21.2.2 Fermi-Dirac Distribution

*24: Bose Condensation

*24.1 Bosons at Low Temperatures

25: Degenerate Fermi Gas

25.1 Ideal Fermi Gas at Low Temperatures

**Homework**

There will be about 8-10 homework assignments during the semester. To receive full credit, the solutions should be clearly written and explain all the important steps. It is acceptable (and can be useful) to discuss homework problems with each other and compare different solutions. However, you are not allowed to copy the work of others or use problem solutions obtained from any other source. If two identical papers are submitted, each student, after receiving a warning, will only be credited 50% of the total score; no score will be given the second time. Late homework will be accepted (until the solutions are posted), but the score will be reduced by 25 %.

**Exams:**

There will be two midterm exams and one an all-encompassing final exam at the end of the semester.

**Bonus Problems:**

A few bonus problems (typically conceptual problems) will be given in class. Students will be able to discuss them with each other, while the lecturer will moderate the discussion. By the end of the class students will briefly answer the question based on their assessment of the arguments. In addition to scores given for these questions, the students will be able to get participation points during this discussion. Participation will be factored in your final grade. Participation may take different forms: asking questions,

making comments, being able to answer questions, and taking part in discussions of bonus questions.

**Score:**

Your total score will be calculated as follows:

Homework 20%

Two Midterm exams 40%

Final exam 40%

Bonus problems 10%

Total Possible Score: 110

**Grading:**

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|---|---|---|---|---|---|
| **90-100 A** | **85 – 89 A-** | **80 – 84 B+** | **75-79 B** | **70-74 B-** | **65-69 C+** |
| **60-64 C** | **55-59 C-** | **50-54 D+** | **45-49 D** | **40-44 D-** | **0-39 F** |

**Test policy**

You must notify the instructor as soon as possible if you expect to miss or have missed an exam for valid reasons (illness, family emergency, etc). If a student misses a final exam due to these reasons a make-up exam will be administered. For the midterm no make-up exam will be given. However, if a student misses the midterm exam for legitimate reasons, 50% of their score for the final can be used to make up for the missed exam.

**Students with Disabilities**

Students with disabilities are provided with full and equal participation in the services and activities of Wayne State University. Reasonable and effective accommodations, academic adjustments and /or auxiliary aids as determined on a case-by-case basis. More information is available at http://studentdisability.wayne.edu/rights.php.

**Course Description**

PHY 6500 course is devoted to the study of basic principles of thermal physics and statistical physics, governing systems made of a large number of particles. Some of the examples include transformations of heat into mechanical work, ideal and non-ideal gases, phase transitions, properties of gases and solids, and many other fundamental phenomena. Statistical physics is one of a few indispensable subjects widely used in chemistry, biology, geology, environmental science, cosmology, low-temperature physics, solid state physics, atomic physics, and engineering. Students are expected to develop the problem-solving skills in the area of thermal and statistical physics. Sufficient knowledge of calculus of many variables is required.

**Learning Objectives:**

Upon completing the requirements of this course, students will have the knowledge and skills to:

1. Use the tools of statistical physics to solve problems in a number of physical systems, such as Maxwell relations between derivatives of thermodynamic variables, partition function, Boltzmann distribution, Gibbs distribution, Legendre transformation.
2. Understand equations of state, ideal and non-ideal (e.g. van der Waals) gasses, laws of thermodynamics, properties of quantum and classical systems ant the systems close to absolute zero. Be able to apply laws of thermodynamics and identify conditions of thermodynamic equilibrium. Describe the statistical nature of concepts and laws, in particular: entropy, temperature, chemical potential, microcanonical, canonical and grand canonical ensembles
3. Understand statistical mechanics of quantum gases (bosons or fermions), including Fermi gases and Bose-Einstein condensates. Fermi-Dirac and Bose-Einstein distributions, black-body radiation.