College of Liberal Arts and Sciences
VILLANOVA UNIVERSITY
Physics Department

Thermodynamics & Statistical Mechanics

Fall 2012

Instructor
Dr. Joe Schick
Mendel 365-B
610-519-7873
joseph.schick@villanova.edu

Office Hours
Monday & Wednesday 1:30 to 2:20
Tuesday 12:00 to 1:50
I am available at other times too. Call or email to set up an appointment.

Description
This course provides an introduction to statistical mechanics, which is an essential component of the study of physics. It is through application of statistical physics that we can make the connection between the interactions between individual particles and the behavior of bulk matter. Despite the use of the word *statistical*, the predictions obtained from this powerful approach are definitive.

Text
Thermal Physics, Daniel V. Schroeder, Addison Wesley Longman (2000).

Course format
This course will meet three times each week. It is essential that you be actively engaged in the work of any course, and this is no different. Therefore, there will be ample opportunities for in-class calculations and discussion. *Furthermore, details of course coverage will be based on* your *input through these discussions.*

Attendance
You should attend all classes and actively participate. More than a few absences can affect your final grade adversely.

Preparation
You should be reading the book ahead of each class and re-reading it in more detail after each class. Actively read by using a pencil to make comments and calculations in the margin. Bring your questions back to class for discussion.

Homework
I will be assigning regular problem sets for turning in at specific times. You should make every effort to turn in your solutions on time. *You must use* ***explanatory prose*** *in your solutions*. I encourage you to work the homework problems in groups but be sure you have thoroughly understood what is done. If a problem set is late, points will be deducted. Please note that you might not be able to do every problem on the first try. Please begin working on a new assignment early so you can ask for help. However, it is acceptable to submit partially worked solutions for partial credit. The average of the homework scores will make up 25% of your final grade.

Tests
There will be two exams during the semester and one final examination. Your score on each test constitutes 25% of your final grade. The final exam will count for 25% of your final grade.

Grading
Your grade will be determined from the formula described above. At mid-term, an estimate will be made from the graded materials available at that time.

Honesty
Villanova's academic integrity policy will be enforced in this course.

Learning support
If you need accommodations, please contact the Learning Support Office (9-5636).

Course goals & objectives

All students successfully completing this course will demonstrate:

Goal I. Knowledge of essential facts of thermodynamics and statistical mechanics

- **Objective A**. Ability to state definitions of *thermal equilibrium, temperature, energy, work, heat, entropy, reversible process, free energy, phase transformation, Boltzmann factor, equipartition, degree of freedom, partition function, Gibbs factor, boson, fermion, density of states,* and other terms
- **Objective B**. Ability to explain the laws of thermodynamics and discuss them in the context of specific processes performed on model systems
- **Objective C**. Ability to explain the basic assumptions of statistical mechanics and discuss how thermodynamic ideas emerge from the statistics

Goal II. Ability to compute results and make predictions based on the laws of thermodynamics

- **Objective A**. Ability to use the first law of thermodynamics, *PV* diagrams, and the ideal gas formula for computing the thermodynamic properties of an ideal gas undergoing various processes
- **Objective B**. Ability to use the dependence of internal energy upon entropy to compute the temperature of a system graphically, analytically, and numerically
- **Objective C**. Ability to compute thermodynamic properties of cyclic processes
- **Objective D**. Ability to show why the Carnot cycle is the most efficient possible cyclic process
- **Objective E**. Ability to compute properties of systems undergoing phase transformations

Goal III. Ability to compute results and make predictions in statistical mechanics

- **Objective A**. Ability to compute the thermodynamic properties of the ideal monatomic gas from a simple point-particle model of a gas
- **Objective B**. Ability to compute the multiplicity and entropy of a system of *N* harmonic oscillators, including the case of very large values of *N* through the use of *Stirling's approximation*
- **Objective C.** Ability to determine the Boltzmann factor for specific systems, to compute the partition function, and thermodynamic properties of the system
- **Objective D.** Ability to apply Maxwell-Boltzmann statistics to derive the thermodynamic properties of an ideal gas
- **Objective E.** Ability to apply Fermi-Dirac or Bose-Einstein statistics to specific systems such as a white dwarf star, electrons in a semiconductor, and blackbody radiation

Goal IV. Ability to write and explain principles learned in this course

- **Objective A**. Ability to use explanatory prose in solving problems
- **Objective B**. Ability to verbally present solutions of problems