Physics 404 Syllabus

Introduction to Thermodynamics and Statistical Mechanics

Course instructor: Dr. Vladimir Manucharyan, Assistant Professor of Physics. PSC 2156.
Teaching assistant: Mr. Nitish Mehta; nitishm.90@gmail.com; Office hours by appointment.
Course meets: Toll 1410, Tu Th 12:30 – 13:45.

Course Goal
To learn the foundations of thermodynamics and statistical description of physical systems containing macroscopically large number of microscopic degrees of freedom. Both classical and quantum systems will be covered.

Prerequisites
- Phys 273 (required)
- Phys 401 (recommended for best performance)

Recommended textbooks
- D. Schroeder, An introduction to thermal physics. Chapters 1-7.
- R. Feynman's lectures on physics. Chapters 6, 39-47,
available online @ http://www.feynmanlectures.caltech.edu/I_toc.html
- H. Callen, Thermodynamics and introduction to thermostatistics, 2nd edition.
Chapters 1-4, 6, 8-9, 13, 15-18.

Homework
Homework is provided as a study aid and is not graded. For best results it is strongly recommended that you work on the homework prior to solutions posting and discuss it with your peers and TA.

Exams
There will be 3 midterm exams (take-home/in-class/take-home) and 1 take-home cumulative final exam.

Exam rules
All exams are of the "open book/notes/internet but I would not count too much on that"- style.

Grading policy
The 4 exam grades are weighted in the proportion 20%/30%/20%/30% to define your course grade. Example: if your exam grades are B/B+/A-/A, your final grade G is given by
G = 0.2*3+0.3*3.3+0.2*3.7+0.3*4 = 3.53 ---> 3.7 ---> A-.

Grade appeal policy
All disputes regarding the details of grading is to be submitted in writing to the instructor. Note that a thorough re-evaluation of your exam might result in a *lower* grade as well.

Tentative course schedule

Week 0. Deterministic/Random motion of a complex system. The problem of initial conditions.
Week 1. Random Walk. Probability. Probability distribution. Fluctuations. Diffusion.
Week 2. Ideal gas. Pressure. Work/Heat. Equipartition of energy. Temperature.
Week 3. The 1rst law. Adiabatic/isothermal processes. Sound propagation. Heat capacity.

Midterm 1 (take-home)

Week 4. Irreversibility. Maxwell's demon. Einstein's model of a solid. Microcanonical formalism.
Week 5. Entropy and thermal equilibrium. Two-state paramagnet. Entropic force in a polymer.
Week 6. Entropy and heat. Reversible processes. Efficiency of heat engines (polymer and gas).
Week 7. Refrigerators. Adiabatic demagnetization. Laser cooling.

Midterm 2 (in-class)

Week 8. Formal structure of thermodynamics. Entropy of an ideal gas. Entropy of mixing.
Week 9. Equilibrium of an open system. Helmholtz and Gibbs free energies. Phase transitions.
Week 10. Van der Waals model of a steam-water phase transition. Dilute mixtures/solutions.
Week 11. Canonical formalism. Partition function. Equipartition. Maxwell's distribution.

Midterm 3 (take-home)

Week 12. Ideal gas revisited. Grand canonical formalism. Bosons & fermions
Week 13. Black body radiation. Plank's spectrum. Radiation pressure. Nuclear winter.
Week 14. Degenerate Fermi gas. Neutron stars. White dwarfs.

Final exam (take-home)

How to succeed in this course?

Unfortunately, there is no recipe to guarantee success. However, there is a recipe to fail, which is described below.

- Don't pay attention during lectures.
- Don't thoroughly study the recommended literature.
- Don't do the homework.
- Don't analyze your mistakes in midterm exams.
- Don't contact your excellent TA for help throughout the course.
- Don't form study groups to tackle the material together.

You are thus strongly advised to apply a negation to these practices. This is a hard course. Expect to feel a slight discomfort at all times. It's normal to any true learning experience.