PHL556: STATISTICAL MECHANICS

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1 TENTATIVE TOPICS

- Introduction: The macroscopic and microscopic state; Kinetic Theory of Gases: Kinetic energy and temperature; Boltzman Law; The districution of molecular speeds
- The random walk problem; Probability and distribution. Central limit theorem and its significance;
- Elements of Ensemble Theory: Phase space of a classical system. Liouvilles theorem and the postulates of statistical mechanics; Quantum states and the phase space;
- The microcanonical ensemble: The canonical ensemble and the concept of temperature; partition fucntion technique; The Grand canonical ensemble
- Example from statistical Mehanics of non-interacting systems;
  (a) Paramagnet; first law of thermodynamics in magnetic variables; microscopic states and avearges, isolated paramagent, Temperature and Entropy ; paramagent at a given temperature (canonical ensemble)
  (b) Ideal gas: Derivation of equation of state from the partition function; ideal gas in a grand canonical ensemble, chemical potential;
  (c) Oscillators in contact with heat bath; microscopic state and partition fucntion; Einstein solid and its specific hear. Phonons and Debye model
- Examples from the interacting systems: Cluster expansion; Van der Waals equation of state; Ising model

- Quantum mechanical ensemble theory; The density matrix, statistics of various ensembles; examples.
- Bose and Fermi statistics: The statistical mechanics of an ideal Bose gas; Statistical mechanics of photons and black body radiation; Bose Einstein condensation and superfluidity; Degenerate Fermi gas, white dwarf star; A general introduction to fermionic condensation and BEC-BCS cross-over

2 Optional

- Phase transition; critical exponent; Landau's phenomenological theory: A qualitatiove discussion on scaling and renormalization group; Fluctuation;
- Fractional statistics and anyons;

3 Text Books

Lecture notes will be provided which will appear on my url from time to time.

- STATISTICAL MECHANICS (SECOND EDITION): R. K. PATHRIA (ELSEVIER)
- STATISTICAL PHYSICS : J. K. BHATTACHARJEE (ALLIED PUBLISHERS)
- STATISTCIAL PHYSICS : AMIT AND VERBIN (WORLD SCIENTIFIC) (PARTICULARLY FOR PROBLEMS)

4 Reference books

- THERMAL AND STATISTICAL PHYSICS - H. GOULD AND J. TOBOCHNIK (E-BOOK; COPYRIGHTED) $http://stp.clarku.edu/notes$
- Lecture Notes by Finn Ravndal (available at $http://www.fys.uio.no/\ finnr/$)

- STATISTICAL MECHANICS : K. HUANG (2ND EDITION) JOHN WILEY
- FUNDAMENTALS OF STATISTICAL AND THERMAL PHYSICS ; F. REIF (McGRAW HILL)

5 GRADING

Minor I - 20
Minor II- 20
Tutorials + Quiz + self study project- 20
Major - 40
Pass marks - 40

6 Suggested project topics

Before the minor I students are requested to submit an abstract that will tell what they intend to study and what are the materials they want to study. The reports has to be typed (no handwritten report will be accepted). The presentation also has to be in the ppt format). The references are provided in order to guide and they are not mandatory. Students are very much encouraged to choose the subtopics under the project title and to independently search the literature relevant to their subtopics. The group of students assigned a given topic can also do the work jointly, but the presentation and report has to be independent.

1. Statistical Physics of Vehicular traffic.
   $http://physics.ucsd.edu/students/courses/winter2005/physics200b/$
   Homepage of Prof. Dan Arovas

2. Black Hole Thermodynamics
   $hep-th-0502195$ available at $xxx.lanl.gov$ Lecture Notes by Ted Jacobson at university of Utrecht (first two sections)

3. Vortices in superfluid and Superconductor (E)
   Many more articles both of pedagogical and popular nature are available on the web.

4. Glass phase of matter.
   $http://hypertextbook.com/physics/matter/glass/$
   Americal Journal of Physics, Volume **67**,1145(1999)
   Americal Journal of Physics , Vol **22**,page 45, 1954. There is a series of four articcles by the same author in this journal

5. XY model- vortices, vortex unbinding and Kosterliz thouless transition
   Principle of Condensed matter physics by Chaikin and Lubensky (section 6 and 9)

6. Entropy and Information. The paper by *Shanon* available on the web.
   Lecture Notes by Ravndall (already mentioned) available on theweb.

7. Bose Einstein condensation in interating system.
   Les Houches lecture notes by Prof. Y. Castin (available on $xxx.lanl.gov$)
   or the lectures notes by Prof. A. Fetter. (available on the $xxx.lanl.gov$)

8. The problem of random flight(Reading project mostly based on the first section of Chandrasekhar's RMP article)(M)

9. The theory of Brownian motion (E) . Text book and Chadra Sekhar's paper

10. Numerical project 1; Monte carlo simulation of two-dimensional Ising model. A good amount of material is available on the web. if the students use some code they must make it sure that they refer to it in the presentation.

11. Numerical project 2: Simulaion of the random walk problem in two and three dimension. Again web based materials are available. Some theoretical material available in the website of online courses in MIT (in the mathematics section)