Thermodynamics and Statistical Mechanics (PHY 531)

Revised Schedule

Lecture #1, Monday, August 28th Syllabus – **Course Overview** (**Hard copy syllabus**)
Introductory lecture: syllabus.
Introduction in thermodynamics. General advise and hints.

Lecture #2, Wednesday, August 30th **(pp. 1-11)**
1. The first law of thermodynamics
1.1. Fundamental definitions
1.2. Thermometers
1.3. Different aspects of equilibrium
1.4. Functions of state

Lecture #3, Friday, September 1st (**pp. 13-21**)
1.5. Internal energy
1.6. Reversible changes
1.7. Enthalpy
1.8. Heat capacities

Monday, September 4th, Labor Day - No Classes

Lecture #4, Wednesday, September 6th (**pp. 20-23 and 25-33**)
1.8. Heat capacity. Continuation – Examples for an ideal gas
1.9. Reversible adiabatic changes in an ideal gas
2. Entropy and the second law of thermodynamics
2.1. A first look at the entropy

Lecture #5, Friday, September 8th (**pp. 33-42**)
2.2. The second law of thermodynamics
2.3. The Carnot cycle
2.4. The equivalence of the absolute and the perfect gas scale of temperature

Lecture #6, Monday, September 11th (**pp.34-42**)
2.5. Definition of entropy
2.6. Measuring the entropy. Thermodynamic potentials
E1. E2. E3. Maxwell relations derived from thermodynamic potentials (pp. 302-305)

Lecture #7, Wednesday, September 13th
Problems of thermodynamics – Thermodynamic transformations. Part I

Lecture #8, Friday, September 15th (**pp. 42-46**)
2.7. The law of increase of entropy. Clausius inequality (pp. 42-48)
2.8. Calculations of the increase in the entropy in irreversible processes.

Problems of thermodynamics: thermodynamic transformations. Part II

Lecture #9, Monday, September 18th, (**pp. 46-48**)
2.9. The approach to equilibrium. Examples

Lecture #10, Wednesday, September 20th (**pp. 52-64**)
3. Probability and Statistics

Lecture #11, Friday, September 22nd (**pp. 67-70**)
The ideas of statistical mechanics. Introduction
Definition of entropy

Lecture #12, Monday, September 25th (**pp. 81-86**)
The second law of thermodynamics derived from statistical mechanics

14. Wednesday, September 27th, Exam #1

Lecture #13th, Friday, September 29th, Problems of thermodynamics from Exam #1.
Analysis of exam #1 – Problems and their solutions

16. Monday, October 2nd, Yom Kippur - No classes

Lecture #14th, Wednesday, October 4th, **The canonical ensemble** (**pp. 91-97**)
5.1 A system in contact with a heat bath
5.2. The partition function
5.3. Definition of the entropy in the canonical ensamble
5.4. The bridge to thermodynamics through Z

Lecture #15th, Friday, October 6th, **The canonical ensemble**. **Thermodynamic properties** (**pp. 97-101**)
derived from microscopic principles
5.5. The condition for thermal equilibrium
5.6. Thermodynamic quantities from partition function
5.7. Example for two-level system

Lecture #16th, Monday, October 9th, **The canonical ensemble** (**pp. 101-106**)
5.8. Single-particle in one-dimensional box
5.9. Single-particle in a three-dimensional box

Lecture 17th, Wednesday, October 11th, **The canonical ensemble** (**116-123**)
5.14. Equipartition theorem
5.15. Minimizing the free energy
5.15.1. Minimizing the Helmholtz free energy
5.15.2. Minimizing the Gibbs free energy

Lecture 18th, Friday, October 13th, **Statistical Mechanics of Identical particles (pp. 128-134)**

6.1. Identical particles
6.2. Symmetric and antisymmetric wave functions
6.3. Bose particles or bosons
6.4. Fermi particles or fermions
6.5. Calculating the partition function for identical particles

Lecture 19th, Monday, October 16th, **Statistical Mechanics of Identical particles (pp. 134-140)**

6.6. Spin
6.7. Identical particles localized on lattice sites

Lecture 20th, Wednesday, October 18th, **Maxwell distribution (pp. 144-146)**

7.1. The probability that a particle is in a quantum state
Homework Problems and their solutions

Lecture 21st, Friday, October, 20th, **Maxwell-Boltzmann distribution (pp. 146-154)**

7.2. Density of states in k space
7.3. Single-particle density of states in energy

Lecture 22nd, Monday, October 23rd, **Maxwell-Boltzmann distribution (pp. 146-154)**

7.4. The distribution of speeds of particles in a classical gas

Lecture 23rd, Wednesday, October 25th,

Homework problems and their solutions - Chapter 7

Lecture 24th, October 27th, Chapter 8 - **Plank's distribution**

8.1. Blackbody radiation (**pp. 160-166**)
8.3. Plank's distribution (**pp. 167-168**)

28. Monday, October 30th, Exam #2

Lecture 25th, Wednesday, November 1st, **Plank's distribution (pp. 172-176)**

8.5. Derivation of the Plank distribution
8.6. The free energy

Lecture 26th, Friday, November 3rd, **Chapter 9 - Systems with variable number of particles (pp. 188-193)**

9.1. Systems with variable number of particles
9.2. The condition for chemical equilibrium
9.3. The approach to chemical equilibrium

Lecture 27th, Monday, November 6th, **Chapter 9 - Systems with variable number of particles (pp. 193-197)**

9.4. The chemical potential

Lecture 28th, Wednesday, November 8th, **Chapter 9 - Systems with variable number of particles (pp. 202-207)**

9.7. The grand canonical ensemble
9.8. Absorption of atoms on surface sites
9.9. The grand potential

Lecture 29th, Friday, November 10th, **Chapter 10th – Fermi and Bose particles (pp. 210-215)**

10.1. Introduction
10.2. The statistical mechanics of identical particles

Lecture 30th, Monday, November 13th, **Chapter 10th – Fermi and Bose particles (pp. 215-222)**

10.3. The thermodynamic properties of a Fermi gas

Lecture 31st, Wednesday, November 15th, **Chapter 10th – Fermi and Bose particles (pp. 229-233)**

10.5. The thermodynamic properties of a non-interacting Bose gas

Lecture 32nd, Friday, November 17th, **Present Homework Problems of Chapter 9th**

Lecture 33rd, Monday, November 20th, **Chapter 11th, Phase transitions (pp. 236-239)**

11.1. Phases
11.2. Thermodynamic potential

38. Wednesday, November 22nd, Thanksgiving Holiday

39. Friday, November 24th, Thanksgiving Holiday

Lecture 34th, Monday, November 27th, **Chapter 11th, Phase transitions (pp. 239-244)**

11.3. Approximation
11.4. First-order phase transition
11.5. Clapeyron equation

Lecture 35th, Wednesday, November 29th, **Chapter 11th, Phase transitions (pp. 245-248)**

11.6. Phase separation

42. Friday, December 1st, Exam #3

Lecture 36th, Monday, December 4th, **Chapter 12th, Continuous phase transitions (pp. 255, 256, 258)**

12.1. Introduction
12.2. Ising model
12.2.1. Mean field theory

Lecture 37th, Wednesday, December 6th, **Surprise lecture: The unexpected quiz. Are we prepared for the final exam?**

Lecture 38th, Friday, December 8th,
Review Meeting for the final exam

Final exam, Friday, December 15th, 8:00 – 10:00 AM

There will be three parts that will follow "Bowley & Sanchez":
Part I. Thermodynamics (Chapters 1-3)
Part II. Statistical mechanics I (Chapters 4-8)
Part III. Statistical mechanics II (Chapters 9-12)