**REQUIRED TEXT**


RECOMMENDED BOOKS on reserve in Grainger Engineering Library


Abbreviations for books are employed in the suggested reading for each topic in the course outline given below.

OUTLINE (2011)

The estimated number of lectures for each topic is indicated. Relevant reference material is indicated using the abbreviations for books defined above.

References in ITALICS are the best to read.

KD2= new 2nd edition of the Ken Dill book
KD1= old 1st edition of the Ken Dill book
KD1+2 means same place in both books

PART I: Fundamentals and Elementary Applications (15)

I. Introduction to Probability and Statistics (2)

KD1+2, Ch.1; PM, Ch.11

**MATH TOOL: SELF-STUDY, KD1 Ch. 4 & 5, Appendix**
II. Thermodynamics, Entropy, First & Second Laws (6)
   A. Extremum Principles
      *KD1+2, Ch.2*
   B. Heat, Work, Energy and the First Law
      *KD1+2, Ch.3* ; *DC, Ch. 1.1*
   C. Boltzmann Entropy
      *KD1, Ch.6, p.81-88* OR *KD2, Ch.5*
   D. Free Energies, Temperature, Equilibrium and Ideal Gas
      *KD1+2, Ch. 7, Ch.8* ; *DC, Ch. 1.2,1-1.4* ; *PM, Ch.17*

III. Statistical Mechanics and Elementary Applications (7)
   A. Boltzmann Distribution Law, Partition Function, Ensembles
      Canonical vs. Microcanonical ensembles, Heat Capacity, Energy Fluctuations
      *KD1+2, Ch.10 ; Ch.12, p.230-232; DC, Ch.3.1-3.4 ; PM, Ch.18,19*
   B. Discrete Systems: conformationally flexible molecules, paramagnetism via Boltzmann and “order parameter” approaches
      *KD1+2, Ch.10, p.184-188*
   C. Continuum Systems
      Ideal atomic gas, Classical vs. Quantum, Particle-in-a-Box model
      Vibrations, Harmonic Oscillators, Einstein model of solids
      Molecules, degrees of freedom, and Partition function factorization
      *KD1+2, Ch.11 and Ch. 12, p228-232 ; PM, Ch.18,21,22*

PART II: Liquids, Mixtures, Phase Behavior & Surfaces (12)

IV. Phase Equilibria & Thermodynamics of 1-Component Fluids (6)
   A. Intermolecular Interactions & Generic Phase Equilibria considerations
      *KD1, Ch.24, p.449-456* OR *KD2, Ch.24, p.471-479*
      *KD1+2, Ch. 14, 1st two sections; Ch.25*
   B. Classic Van der Waals Model
      Equation-of-State, Virial expansion, Liquid-Vapor Phase transition, Isothermal compressibility, Law of Corresponding states
      *KD1+2, Ch.24, p.479-483*
      *NG, Ch 4.1-4.4*
   C. Microscopic Lattice Fluid Model
      Grand Canonical Ensemble, Partition function, athermal limit, mean Field approximation, Attractions, connection to van der Waals model
      *DC, Ch.5.2 ; KD1, Ch.24, p.462-463* OR *KD2, Ch.24, p.485-486*

V. Continuum Fluids: Thermodynamics, Structure and Freezing (3)
   (*Note: Dill book has virtually nothing for this Section*)
A. **Hard Sphere Fluids** (relevant to atoms, molecules, colloids)
   - 1-dimensional Tonks model, comparison to lattice fluid model

B. **Correlation functions, Radial Distribution function g(r)**
   - *DC*, Ch. 7.2, 7.3, 7.5; *McQ*, Ch. 13.1-13.3
   - *KD1* Ch.24, p.460-463 OR *KD2*, Ch.24, p.483-485

C. **Thermodynamic properties, Structure and Crystallization**
   - 3-dimensional packing effects, repulsive vs. attractive forces
     - *DC*, Ch. 7.4; *McQ*, Ch.2.1-12.3, 13.9, 14.3

VI. **Two Component Liquid Solutions and Solid Alloys (3)**
   - Phase Diagrams & mean field theory for Liquid-Liquid phase separation
     - *KD1+2*, Ch. 15 and 25; *TLH*, Ch.14.4, 20.1

VII. **Surfaces (1)**
   - Physical Adsorption, Monolayers and Langmuir Isotherm
     - *KD1*, Ch.27, p.515-519 OR *KD2*, Ch.27, p.541-546
     - *TLH*, Ch 7.1+14.1

PART III: **Solids, Magnets, Biopolymers and Quantum (12)**

VIII. **Thermal Properties of Crystals (1)**
   - Collective phonons, vibrational properties, heat capacity, Debye model, comparison of Debye and Einstein models, characteristic temperatures
     - *McQ* Ch. 11.1-11.3 + 11.6
     - *DC*, Ch.4.3; *PM*, Ch.20

IX. **Cooperative Phenomena (8)**
   - **A. Order Parameters, Critical Phenomena, Broken Symmetry**
     - General concepts, Landau approach
       - *KD1+2*, Ch 26
   - **B. Spatial Correlations and Susceptibility**
     - Spin correlation functions, density fluctuations, Correlation length
   - **C. Ising Model, Spins, Magnets**
     - 1-d Ising model, Curie-Weiss Mean Field theory, Fluctuation effects and energy-entropy competition; Effect of dimension; external fields
       - *DC*, 5.1, 5.3,5.4; *NG*, Ch. 3.7, 4.5
       - *KD1*, p.508-509 OR *KD2*, p.525-527
   - **D. Order-Disorder Phase Transitions in Solids**
     - Description of ordered state (e.g. Cu-Zn alloy), Mean Field theory
       - *Handout*
E. Helix-Coil Conformational Transition in Biopolymers
Polypeptides, Conformation, Hydrogen-bonding, Entropy vs. Energy
KD1, Ch26, p.499-508 OR KD2, Ch.26, p.527-535

X. Quantum Electronic Phenomena (3).....if time allows
**Topics in this section of topics not covered at all in the Dill book**

A. Quantum Statistics
Non-interacting systems, Fermi-Dirac statistics, State filling, Fermi level
DC, Ch. 4.3, 4.4 ; McQ, Ch.4.2 ; PM, Ch 24

B. Electron Gas and Metals
Weakly and strongly degenerate Fermi gas, Electronic heat capacity
DC, Ch.4.5 ; McQ , Ch. 10.1,10.2 ; PM, Ch.26