

## Syllabus for the Solid State course

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**Textbooks:** *Introduction to Solid State Physics*, 8<sup>th</sup> Ed. by Charles Kittel  
*Solid State Physics*, 2<sup>nd</sup> Ed. by J.R. Hook & H.E. Hall

**Office Hours:** Wednesdays from 2 to 4 PM at ISB-236

- **Crystallography:**

Translation vectors, primitive cell, Wigner-Seitz cell, types of lattices (Cubic, Tetragonal, Monoclinic, Triclinic,...)

Fourier theorem, Reciprocal space, G vectors, Brillouin zone X rays, and Bragg reflexion, structure and form factor

examples: SC,FCC,BCC,diamond, graphite, NaCl

- **Chemical bonding:**

$H_2^+$  and Covalent bonding, hybridization, hopping, bandwidth, population analysis asymmetric case H-Cl and ionic bonding, Madelung energy

more general case of overlap and eigenvalue equation TB Hamiltonian

Van der Waals bonding,

Hydrogen bonding,

Metallic bonding and screening,

Examples of crystals of different types, and their nature (metals, insulators)

Definition of cohesive energy

- **Phonons:**

Normal mode analysis in a cluster with a simple example of dimer and trimer, force constant matrix  $\rightarrow$  idea of diagonalization

Linear chain  $\rightarrow$  use of Fourier transform to take advantage of translational symmetry to separate modes, dynamical matrix

General treatment in 3D (acoustic and optic modes)

Derivation from eq. of motion and harmonic expansion of the potential, quantization of phonon modes DOS: definition and calculation, zero-point energy contribution in total energy

- **Thermal properties:**

Einstein model, Debye model ( $T^3$  dependence), heat conductivity, dilation and anharmonicity

- **Free-electron theory**

Particles in a box, quantization of levels, Fermi sea of non-interacting electrons (Pauli principle)

effect of finite temperature, Fermi-Dirac distribution, Jellium model, total energy

Heat capacity, Electrical conductivity  $\rightarrow$  defect scattering and Drude model, Hall effect

- **Electrons in a periodic potential**

Perturbation approach, Bloch theorem,

plane wave basis to solve the BS problem, bandgap opening at the FBZ boundary

Passage from molecules to solids and formation of bands DOS calculation, examples in 1,2, and 3D for free electrons