Syllabus:

- Crystal lattices
- Miller indices
- Miller-Bravais indices
- Structures of metallic, ionic and polymer crystals
- Reciprocal lattice
- X-ray diffraction techniques
- Geometric structure factor
- Numerical problems related to these topics

Introduction Slide:

- Bonds:
    - Primary: *Ionic, Metallic, Covalent*
    - Secondary: *Fluctuating Induced Dipole Bond, Polar Molecule-Induced Dipole Bonds*
- Lattice + Basis = Crystalline Structure
- **Crystallographic Structures:**
    - Cubic
    - Tetragonal
    - Orthorhombic
    - Monoclinic
    - Triclinic
    - Rhombohedral
    - Hexagonal
- Space Lattice
- 2D Lattices:
    - Square Lattice
    - Rectangular Lattice (*Rect. unit cell, centered unit cell*)
    - Hexagonal Lattice
    - Parallelogram Lattice
- **Crystallographic Restriction Theorem**
- **Unit Cells:**
    - Primitive
    - Face Centered
    - Body Centered
    - Side Centered

- Combination of unit cells and crystallographic structures: Bravais Lattices

Book: Chapters 1-3:

- Unit Cell
- Coordination Number (CN)
- Atomic Packing Factor (APF)
- **Face Centered Cubic (FCC)**
    - Eq. atoms : 4
    - a : $2\sqrt{2}$ R
    - CN : 12
    - APF : 0.74
- **Body Centered Cubic (BCC)**
    - Eq. atoms : 2
    - a : $4R/\sqrt{3}$
    - CN: 8
    - APF: 0.68
- **Hexagonal Close Packed (HCP)**
    - Eq. atoms : 6
    - c/a : 1.633
    - CN : 12
    - APF : 0.74
- Cation/Anion ratios : (r_c/r_a)
    - CN 2 : < 0.155
    - CN 3 : 0.155 - 0.225
    - CN 4: 0.225 - 0.414
    - CN 6 : 0.414 - 732
    - CN 8 : 0.732 - 1
    - CN 12 : > 1
- NaCl
    - FCC - CN : 6
- CsCl
    - BCC - CN : 8
- ZnS
    - Tetrahedral - CN : 4
- **Density computation formula**
- Diamond
- Graphite

- Polymorphism
- Allotropy
- **Crystallographic Directions**
    - What, why
    - Notation
    - Drawing
    - Family of Directions
- **Miller-Bravais Coordination System**
    - What, why
    - Notation
    - Drawing
- Conversion from 3 to 4 indices, vice versa
    - [u'v'w'] = [uvwt]
      U = n (2u' - v') /3
      V = n (2v' - u') /3
      W = nw'
      T = - (u+v)
- **Crystallographic Planes**
- **Miller Indices [hkl]**
- **Miller Bravais Indices [hkil]**
    - Conversion
    - i = - (h + k)
- Polycrystalline Materials
- Anisotropy
- Isotropy

Reciprocal Lattice PDF:

- Definition, basics
- Mathematical Definition --> $e^{iK.R} = 1$, for R of Bravais Lattice and periodicity K
- Reciprocal vectors from original vectors
- Proof that reciprocal of reciprocal lattice is original lattice
- **Reciprocal Lattice of FCC**
    - BCC
    - $b_1 = 4\pi/a\ (y + z - x)$ *... and so on.*
- **Vice versa for Reciprocal of BCC**
- Reciprocal of Reciprocal Lattice
- Volume of RL : $(2\pi)^3/v$

- Lattice Plane definition
- Family of Lattice Planes definition
- **Reciprocal Lattice Plane Theorem -- + -- Proof**
- Reciprocal Vectors as Miller Indices of Lattice Plane
- **Intercepts with crystal axes of a Lattice Plane are reciprocals of miller indices -- Proof**

X-Ray Diffraction:

- Bragg's Equation
  - $n*\lambda = 2d\sin\theta$
  - Order of reflection = n
  - Assumptions
- Von Laue Approach
  - How is it different from Bragg's
  - Condition for constructive interference
  - $K = |k - k'|$
- Equivalence of Bragg's and Von Laue Condition
- **Ewald's Construction**
  - Laue's method
  - Rotating Crystal Method
  - Powder or Debye Scherrer Method
- Geometric Structure Factor
  - Mathematical Definition
  - BCC Even | Odd Proof
- https://www.researchgate.net/post/How_can_I_find_the_structure_FCC_or_BCC_etc_when_it_is_not_available_in_JCPDS
- http://physics.usask.ca/~bzulkosk/modphyslab/phys381manual/xray_diffraction_2004.pdf