

Phys 425

Lecture 1

Crystal Structure

SYLLABUS

Pre-reqs:

- calculus, PDE, ODE, Linear Algebra, Fourier Transforms
- phys 211 (basic quantum mechanics)

free particle, particle in a box

Hydrogen solutions (quantum numbers)

- quantum statistical mechanics (212, 301, 302)

Homework = 30%

Quizzes = 10% > more conceptual

Exams = 40% > more skill testing (math)

Final Exam = 20%

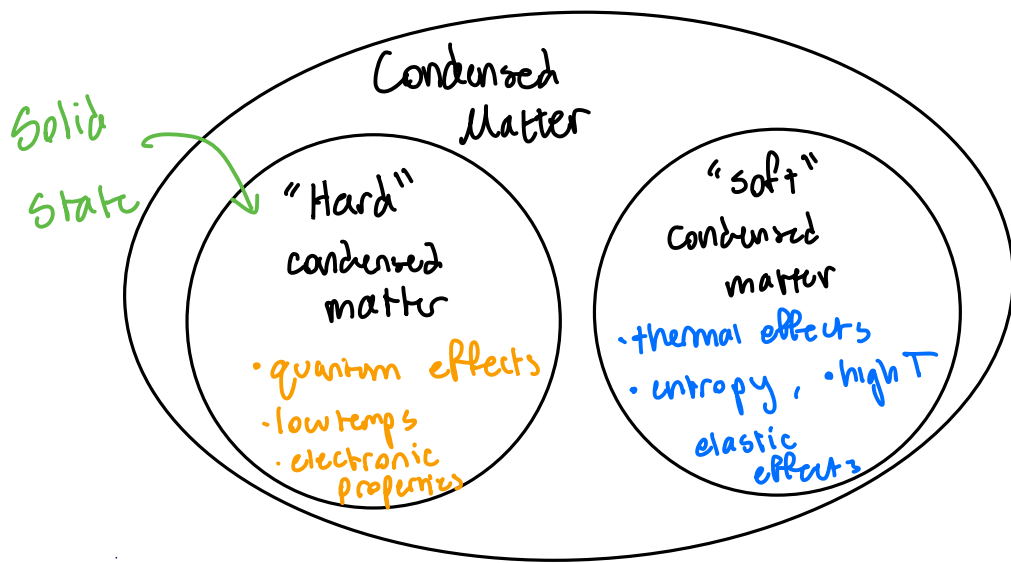
MT 1 = 10/17

MT 2 = 11/14

Final = 12/12

Book: Solid State Physics - Hoffman

Quantum Refreshers: Modern Physics - Harris



our goal: Take everything you know about physics so far, and apply it to solids.

Historically, start with

Newtonian physics

waves & oscillations

optics

~~E & M~~ (all in advanced solid state physics)

Statistical Mech.

crystal structures
are glorified diffraction gratings

→ apply these to solids.

Theme:

microscopic properties of atoms

macroscopic properties of solids

Crystal Structures

Solids tend to have a periodic structure in space

→ crystal lattice

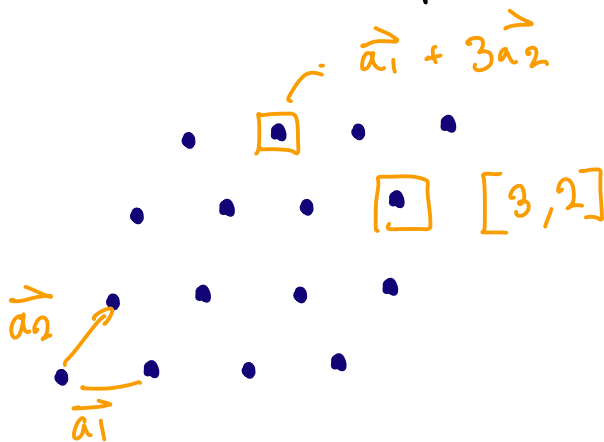
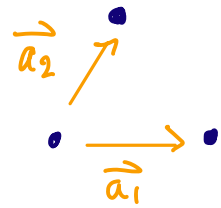
→ ABSTRACT ⇒ to mathematically describe the underlying structure

Bravais Lattice

↳ set of points, in space that are multiples of a set of linearly independent vectors called "the primitive lattice vectors"

Bravais Lattice:

primitive lattice vectors



19 total Bravais Lattices

- 5 exist in 2D
- 14 exist in 3D

* note: honeycomb lattice is not a Bravais lattice, we can't describe it with primitive lattice vectors

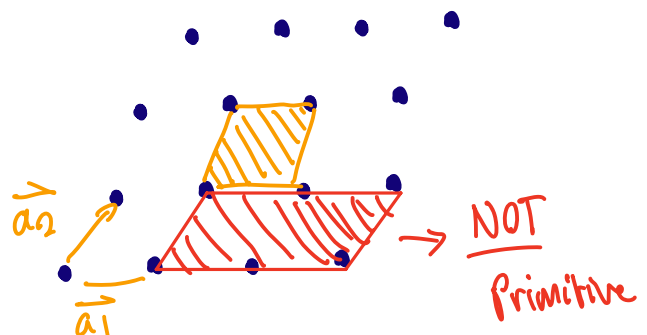
Any point can be written by
 $\vec{R} [n_1, n_2] = n_1 \vec{a}_1 + n_2 \vec{a}_2$
 in 2D

$$\vec{R} [n_1, n_2, n_3] = n_1 \vec{a}_1 + n_2 \vec{a}_2 + n_3 \vec{a}_3$$

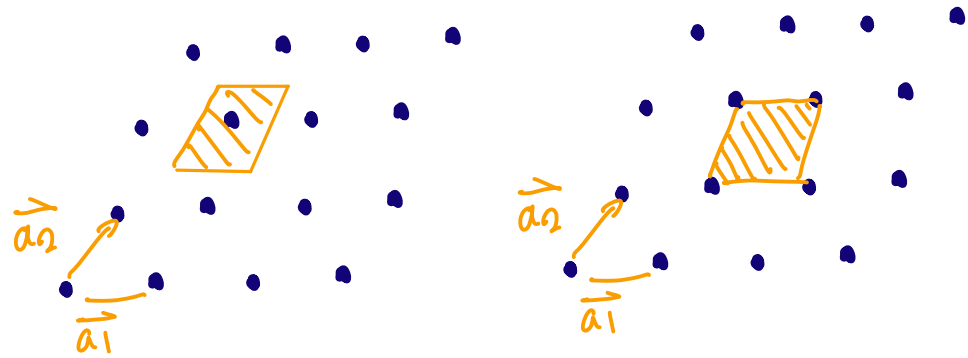
Any region of space that "fills" space when repeated is called a unit cell

↳ translated by lattice vectors

Unit cells



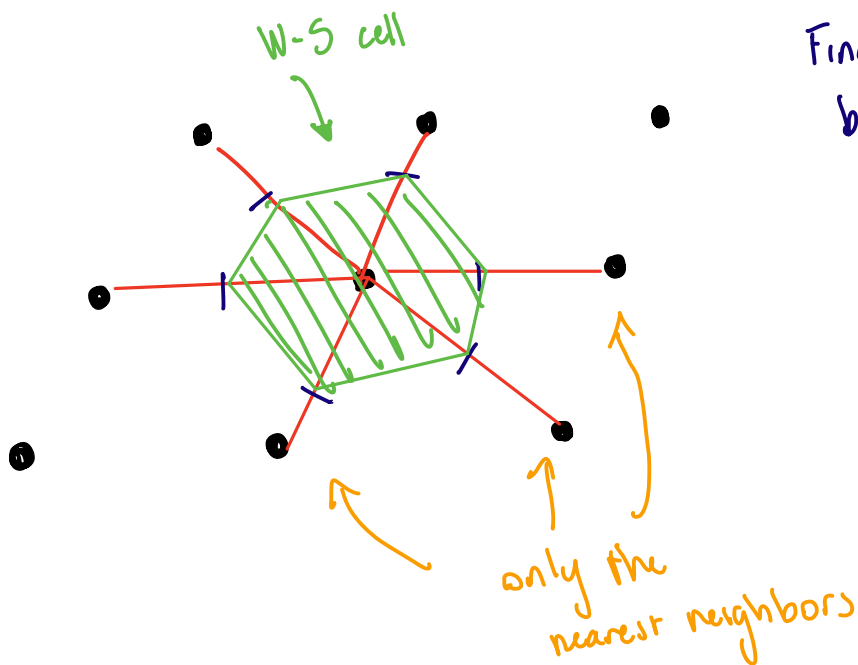
Unit cells that contain only one point are called primitive cells



Wigner - Seitz Cell (a choice of primitive cell)

Set of all points that are closer to a given lattice point than to any other point

(Smallest volume / area unit cell)



Find perpendicular bisectors, connect them

only the nearest neighbors