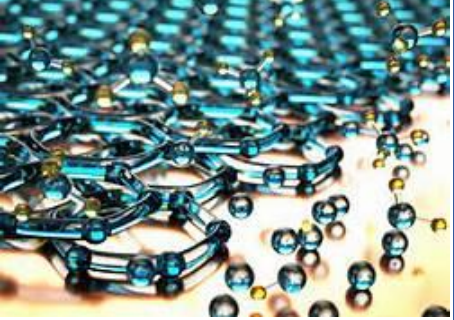


Materials Science

Lecture 7

Lebanese University - Faculty of Engineering – Branch 3

Fall 2022

Dr. Ali HARKOUS

Contents

Lecture 7:

Chap3: Crystalline Structure — Perfection

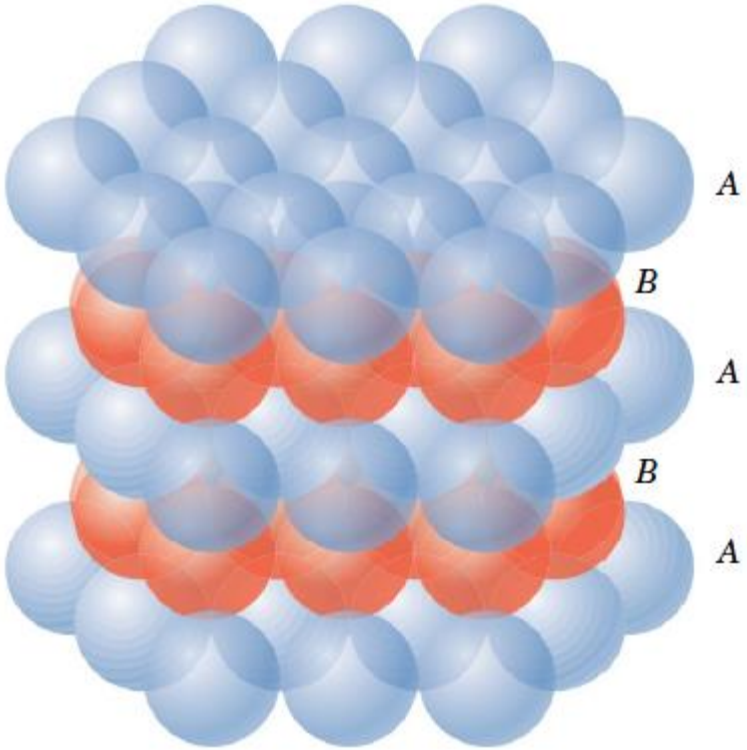
3.5. Close-packed crystal structures

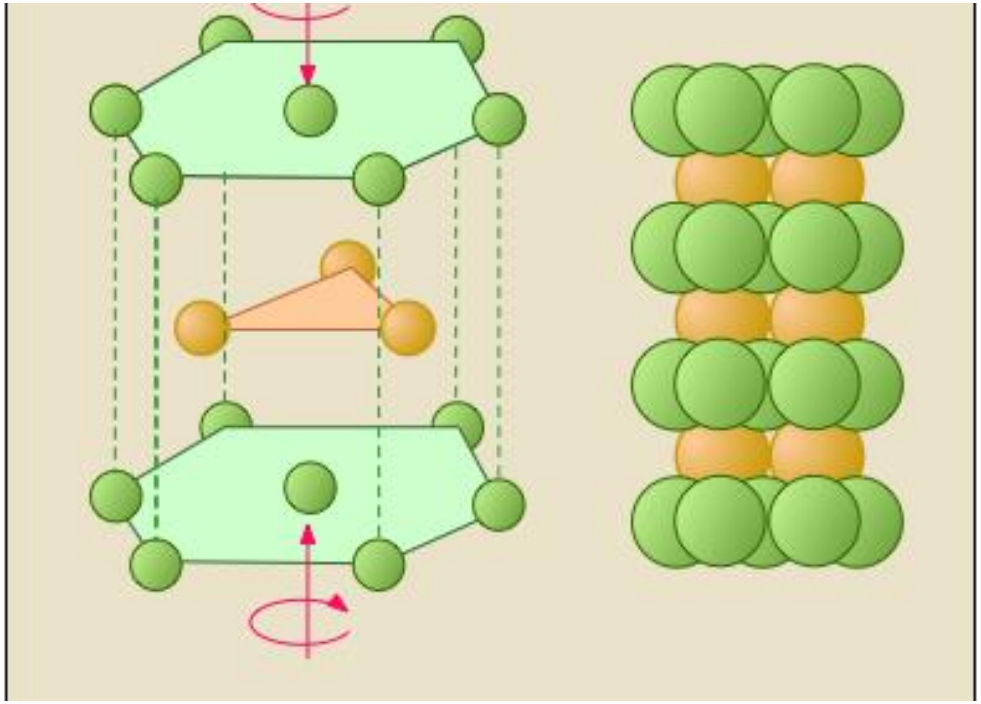
- You may remember from the discussion on metallic crystal structures that both face-centered cubic and hexagonal close-packed crystal structures have **atomic packing factors of 0.74**, which is the most efficient packing of equal-size spheres or atoms.

Watch the attached videos

3.5. Close-packed crystal structures

- For HCP, the **centers of the third layer (the second A) are aligned directly above the original A positions**. This stacking sequence, ABABAB . . . , is repeated over and over.
- These close-packed planes for HCP are (0001)-type planes.





Close-packed plane stacking sequence for the hexagonal close-packed structure.

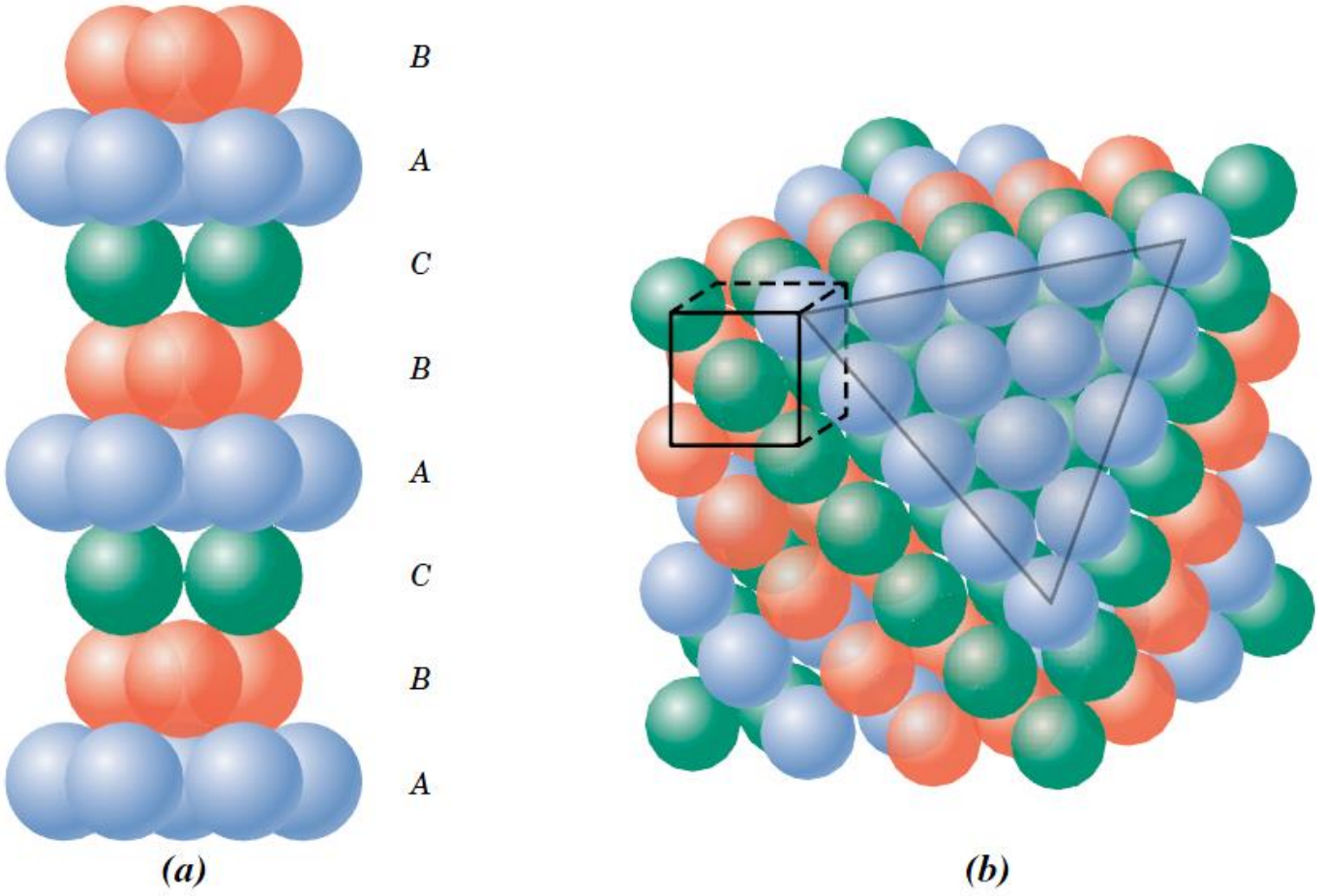
3.5. Close-packed crystal structures

- For the face-centered crystal structure **FCC**, the centers of the third plane are situated over the **C** sites of the first plane (**Figure**).

- This yields an ABCABCABC . . . stacking sequence; that is, the atomic alignment repeats every third plane.

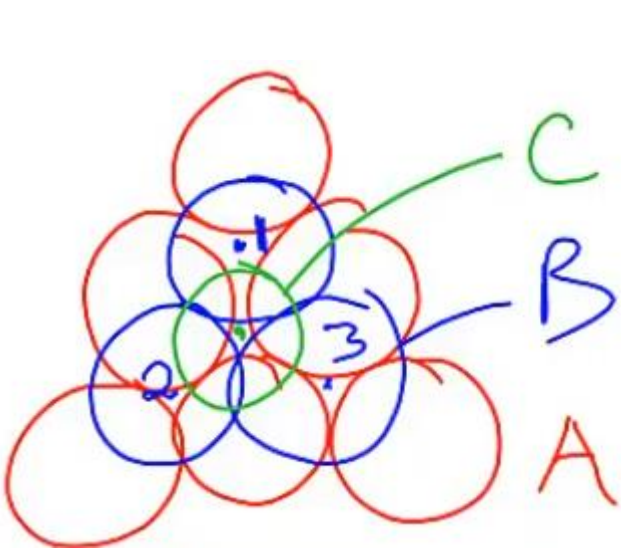
- It is more difficult to correlate the stacking of close-packed planes to the FCC unit cell. However, this relationship is demonstrated in the **next Figure**. These planes are of the (111) type.

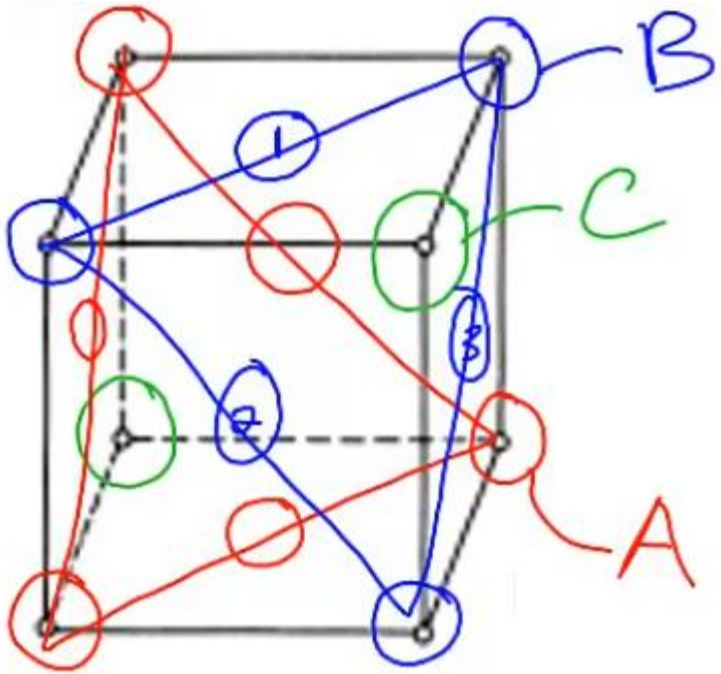
3.5. Close-packed crystal structures



(a) Close-packed stacking sequence for the face-centered cubic structure.
(b) A corner has been removed to show the relation between the stacking of close-packed planes of atoms and the FCC crystal structure; the heavy triangle outlines a (111) plane.

3.5. Close-packed crystal structures





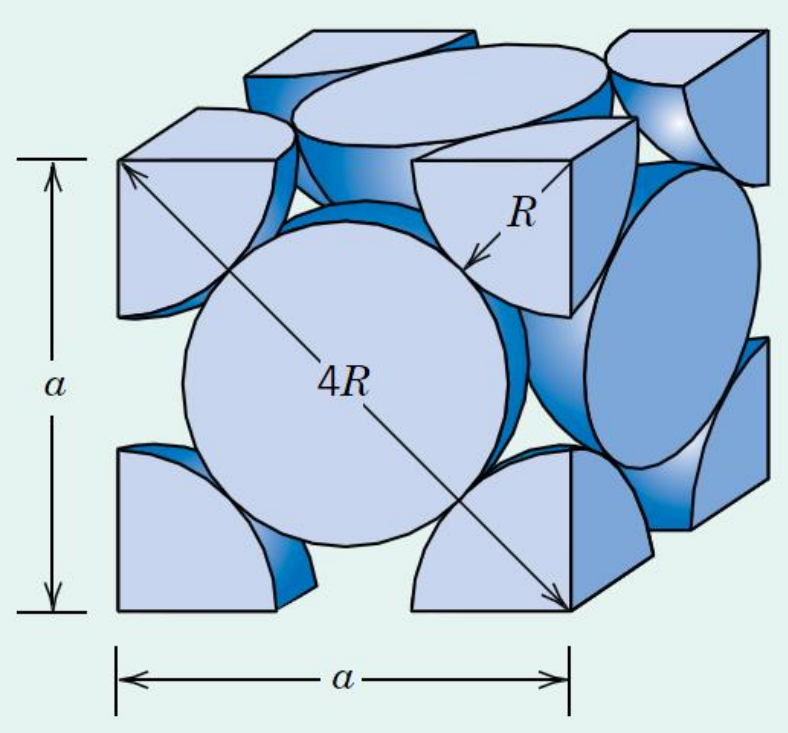
Close-packed stacking sequence for the face-centered cubic structure FCC.

Chap 3

Exercises

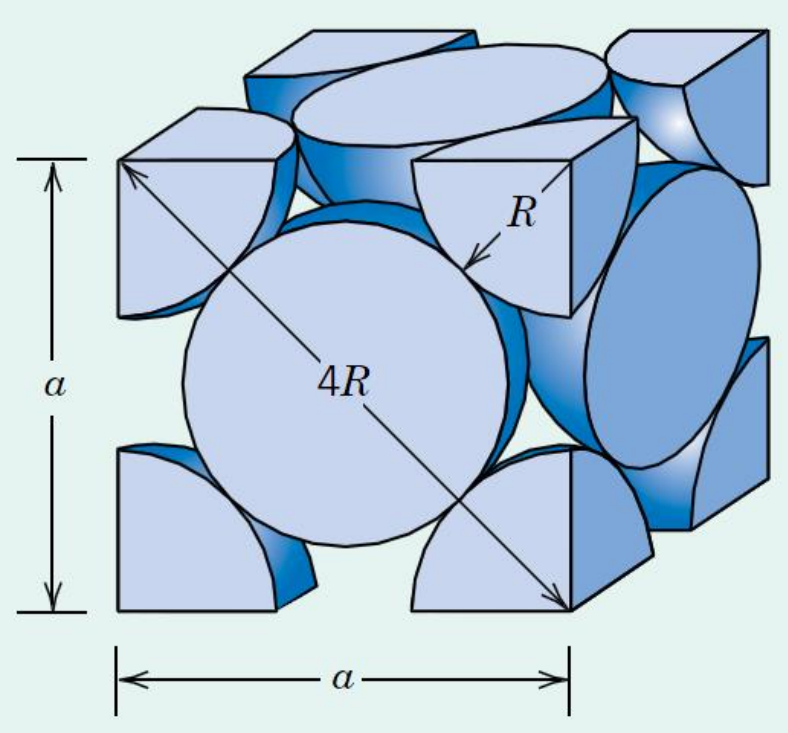
Exercise 1

Calculate the volume of an FCC unit cell in terms of the atomic radius R.



Exercise 2

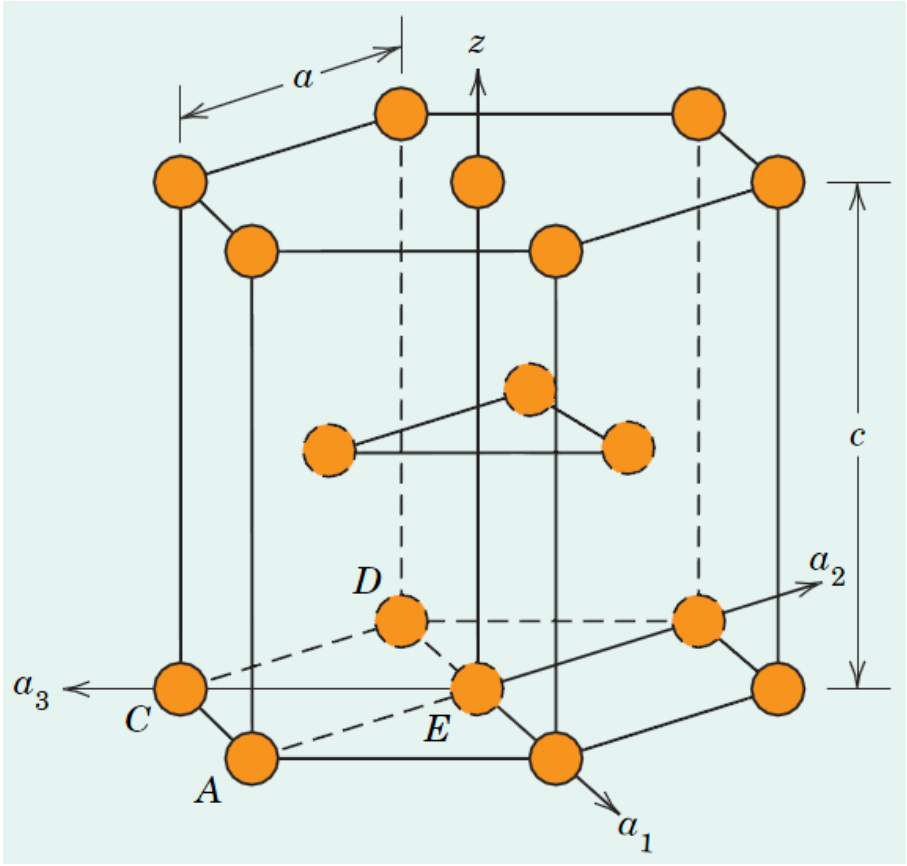
Using volumes, Show that the atomic packing factor for the FCC crystal structure is 0.74.

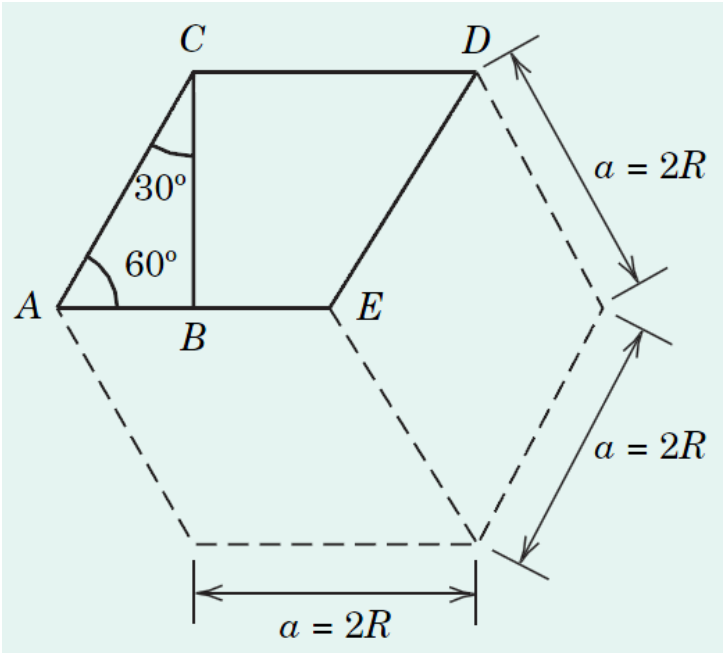


Exercise 3

(a) Calculate the volume of an HCP unit cell in terms of its a and c lattice parameters.

(b) Now provide an expression for this volume in terms of the atomic radius, R, and the c lattice parameter.





Exercise 4

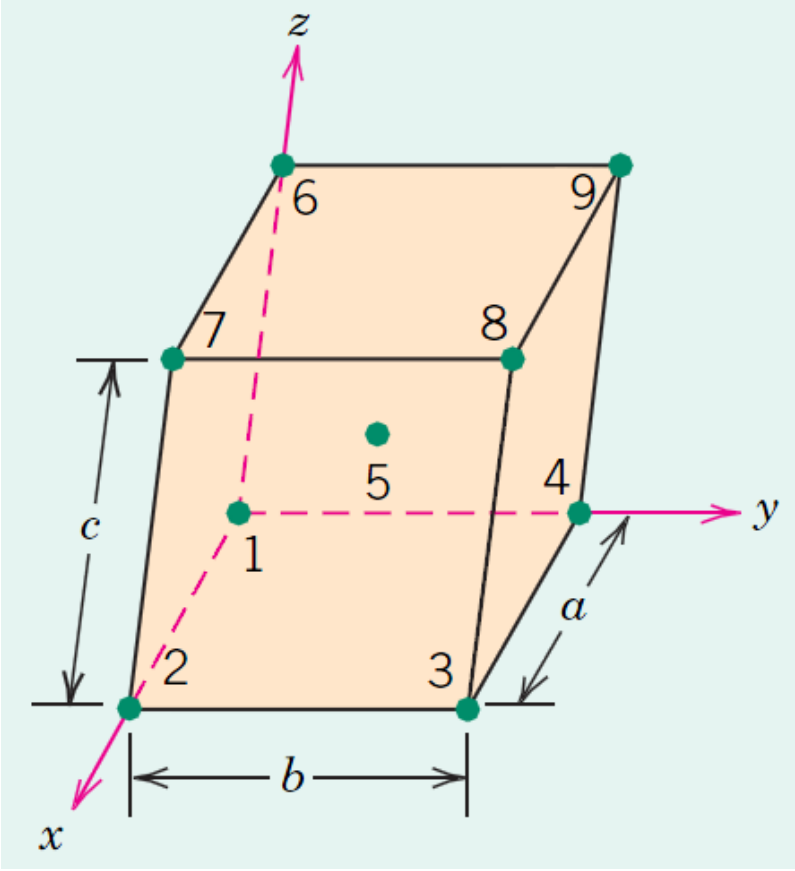
Theoretical Density Computation for Copper

Copper has an atomic radius of 0.128 nm, an FCC crystal structure, and an atomic weight of 63.5 g/mol. Compute its theoretical density, and compare the answer with its measured density.

Exercise 5

Specification of Point Coordinate Indices

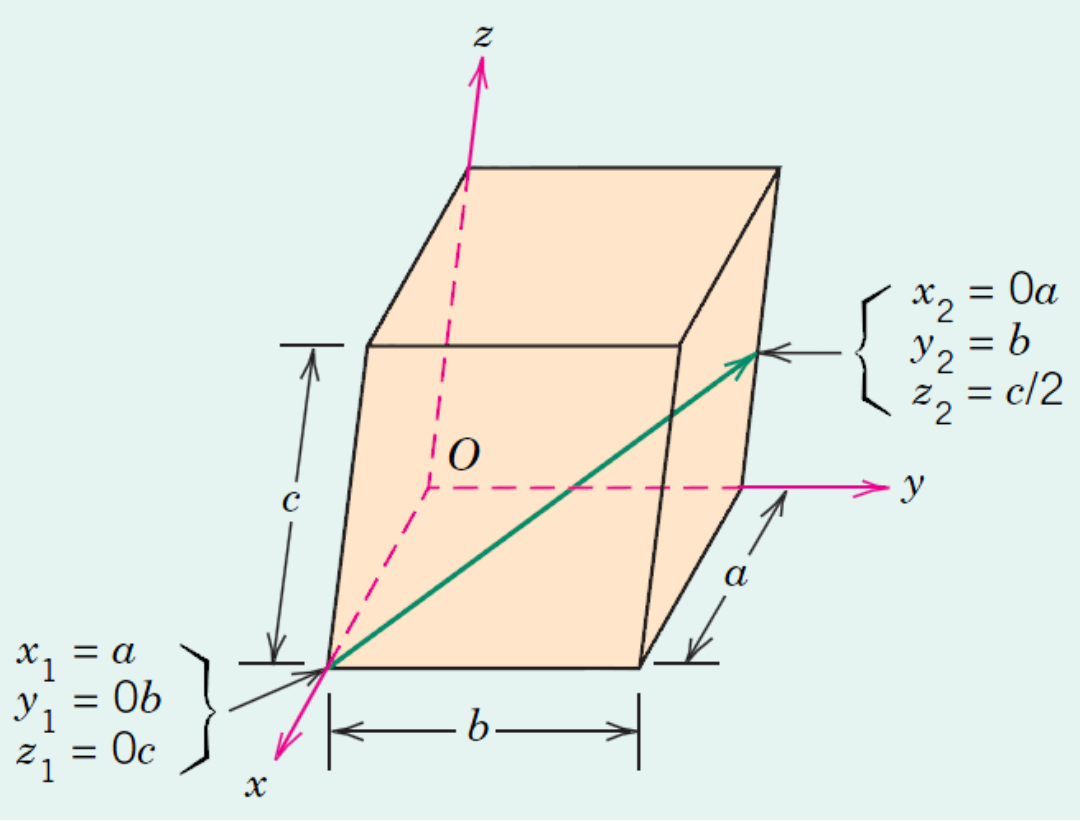
Specify coordinate indices for all numbered points of the unit cell in the illustration on the next page.



Exercise 6

Determination of Directional Indices

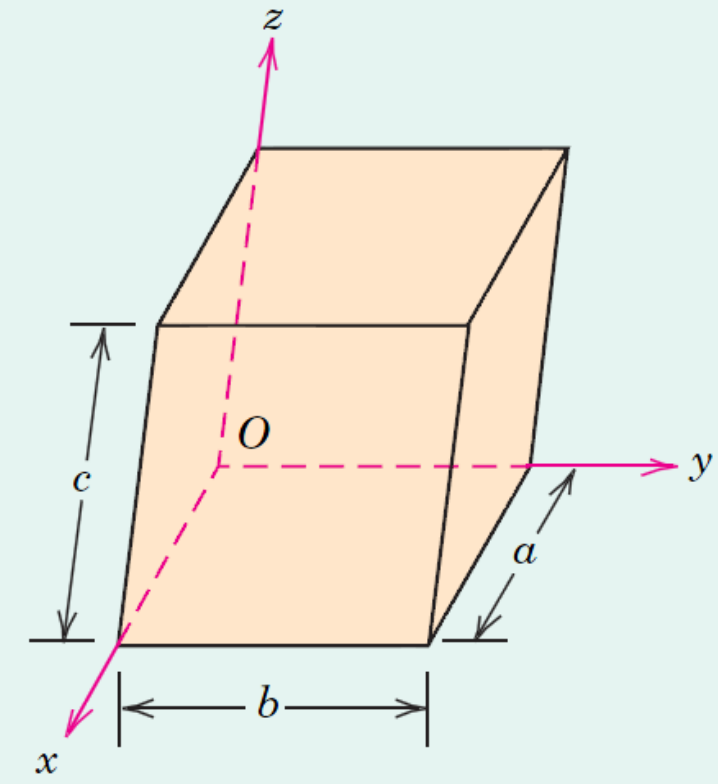
Determine the indices for the direction shown in the accompanying figure.



Exercise 7

Construction of a Specified Crystallographic Direction

Within the following unit cell draw a $[1\bar{1}0]$ direction with its tail located at the origin of the coordinate system, point O.



Exercise 8

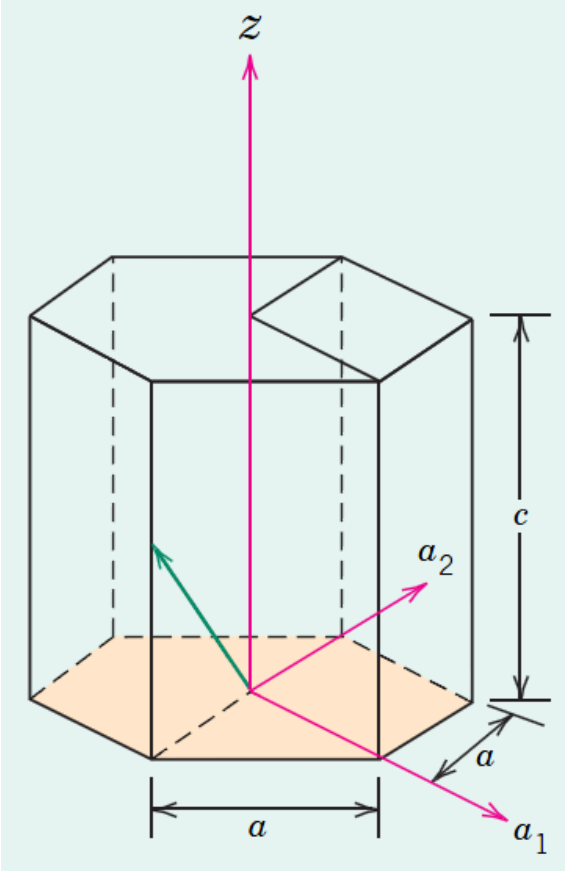
Conversion and Construction of Directional Indices for a Hexagonal Unit Cell

(a) Convert the [111] direction into the four-index system for hexagonal crystals.
(b) Draw this direction within a ruled-net coordinate system (per Figure 3.10).
(c) Now draw the [111] direction within a hexagonal unit cell that utilizes a three-axis (a_1, a_2, z) coordinate scheme.

Exercise 9

Determination of Directional Indices for a Hexagonal Unit Cell

Determine the indices (four-index system) for the direction shown in the accompanying figure.



Exercise 10

Determination of Planar (Miller) Indices

Determine the Miller indices for the plane shown in the accompanying sketch (*a*).