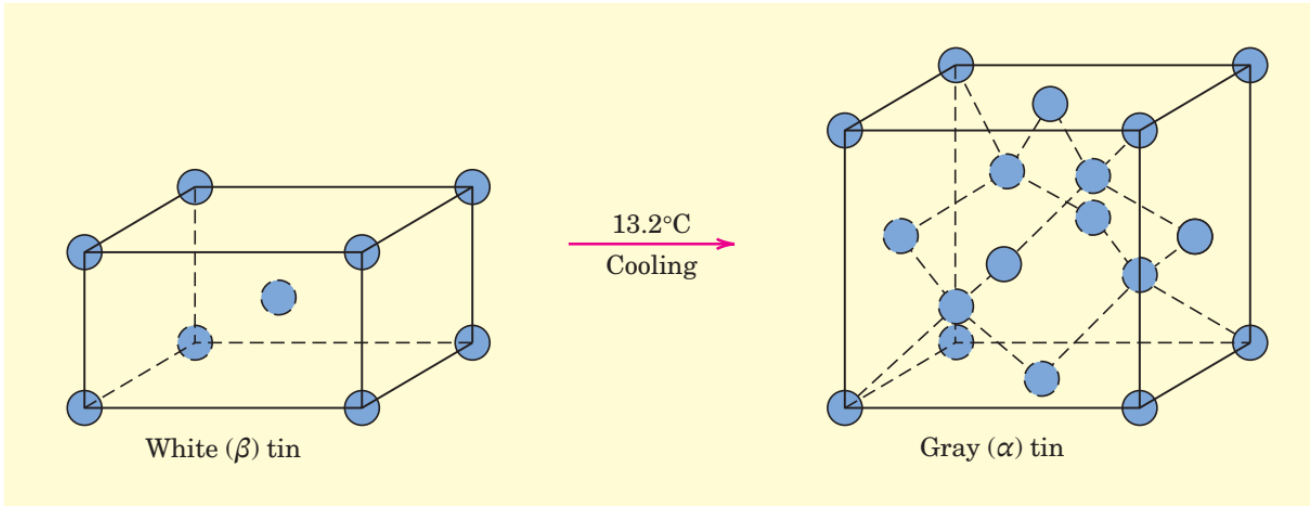
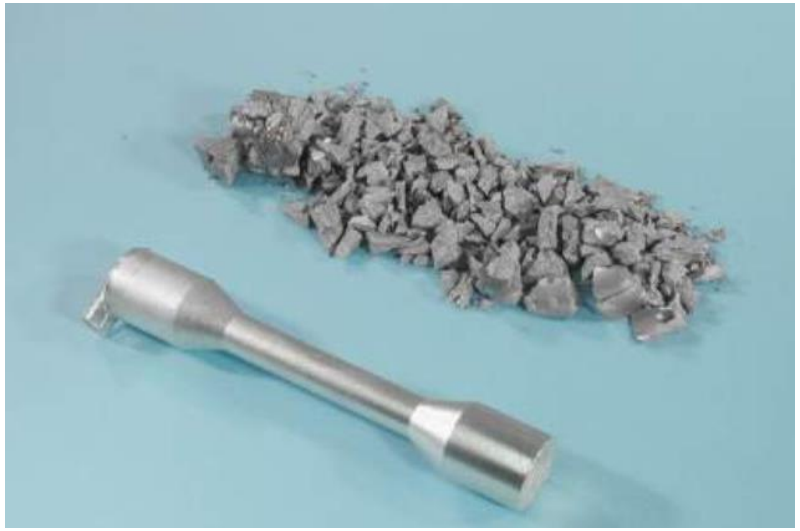
Tin (Allotropic Transformation)

- Tin experiences an allotropic change with temperature.
- White (or β) tin, having a body-centered tetragonal crystal structure at room temperature, transforms, at 13.2°C (55.8°F), to gray (or α) tin, which has a crystal structure similar to that of diamond (i.e., the diamond cubic crystal structure).





Napolean's buttons (Russian campaign 1812

Density Computations—Metals

- A knowledge of the crystal structure of a metallic solid permits computation of its theoretical density ρ through the relationship

$$\rho = \frac{nA}{V_C N_A}$$

where

n = number of atoms associated with each unit cell

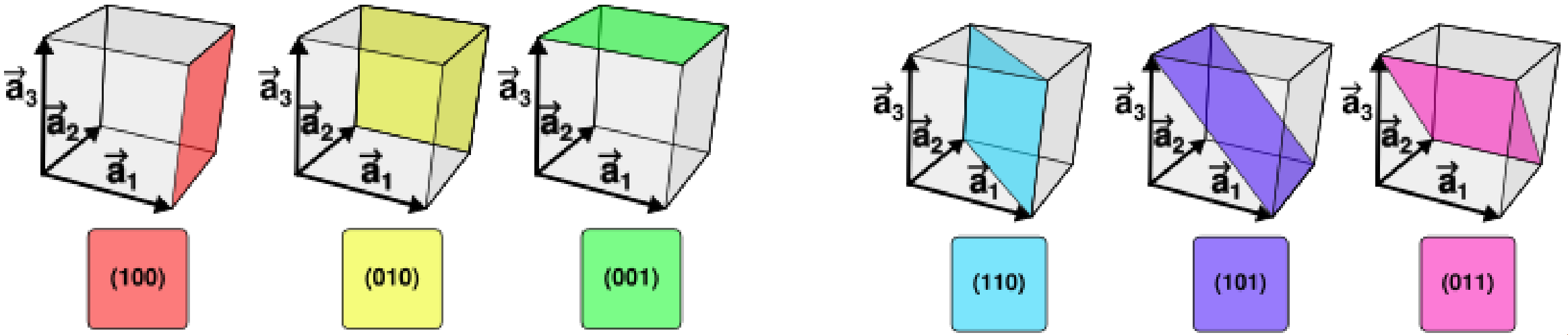
A = atomic weight

V_C = volume of the unit cell

N_A = Avogadro's number (6.023×10^{23} atoms/mol)

Miller Indices

- Miller indices form a notation system in crystallography for planes in crystal lattices.
- It is denoted by (hkl).
- Any two planes parallel to each other are equivalent and have identical indices.



Miller Indices

The procedure employed in determination of the h, k, and l index numbers is as follows:

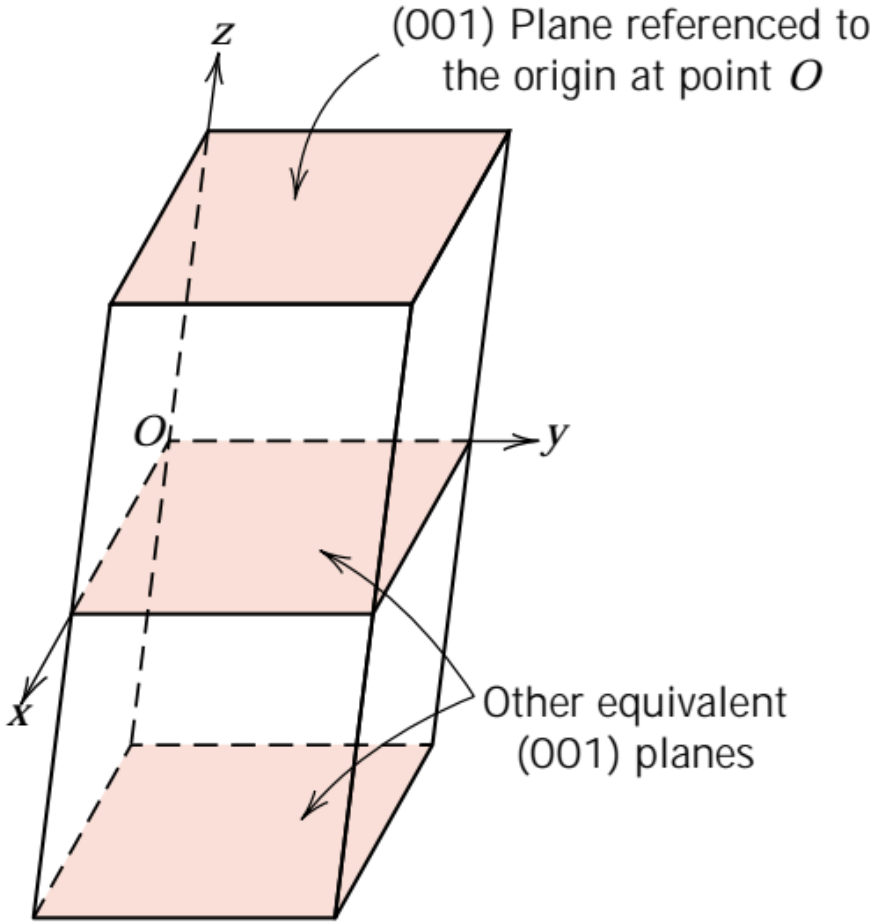
1) If the plane passes through the selected origin, either another parallel plane must be constructed within the unit cell by an appropriate translation, or a new origin must be established at the corner of another unit cell.
2) At this point the crystallographic plane either intersects or parallels each of the three axes; the length of the planar intercept for each axis is determined in terms of the lattice parameters *a*, *b*, and *c*.

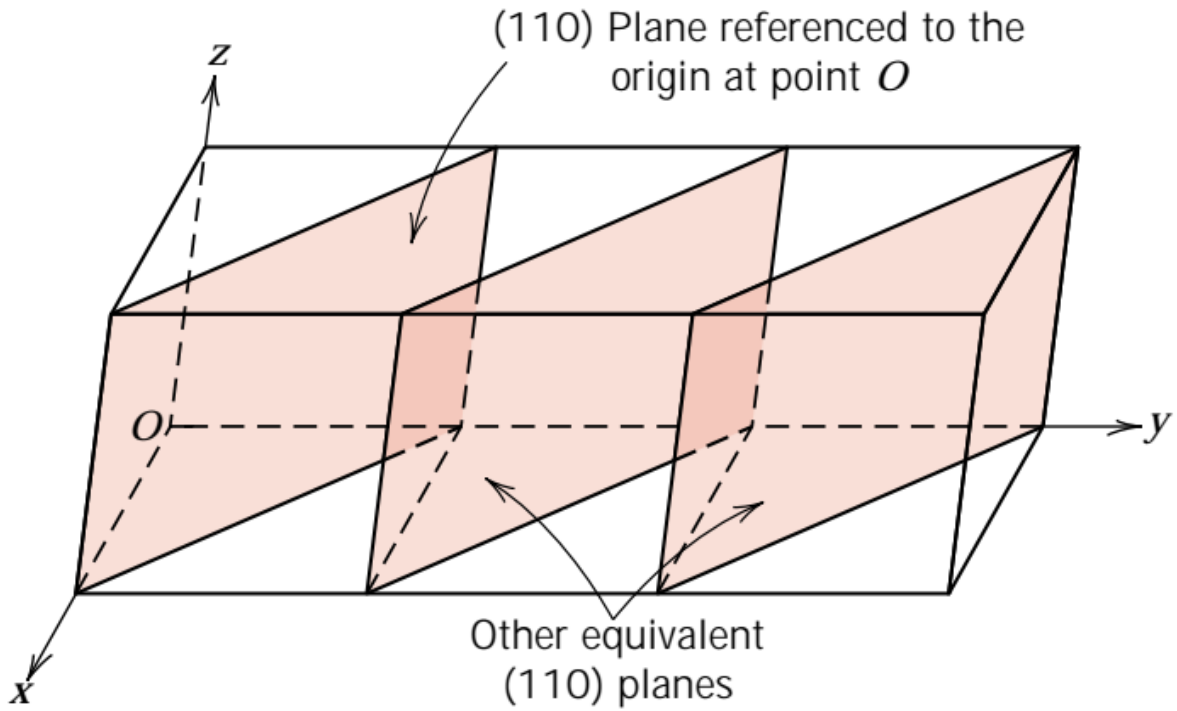
Miller Indices

3) The reciprocals of these numbers are taken. A plane that parallels an axis may be considered to have an infinite intercept, and, therefore, a zero index.
4) If necessary, these three numbers are changed to the set of smallest integers by multiplication or division by a common factor.
5) Finally, the integer indices, not separated by commas, are enclosed within parentheses, thus (hkl).

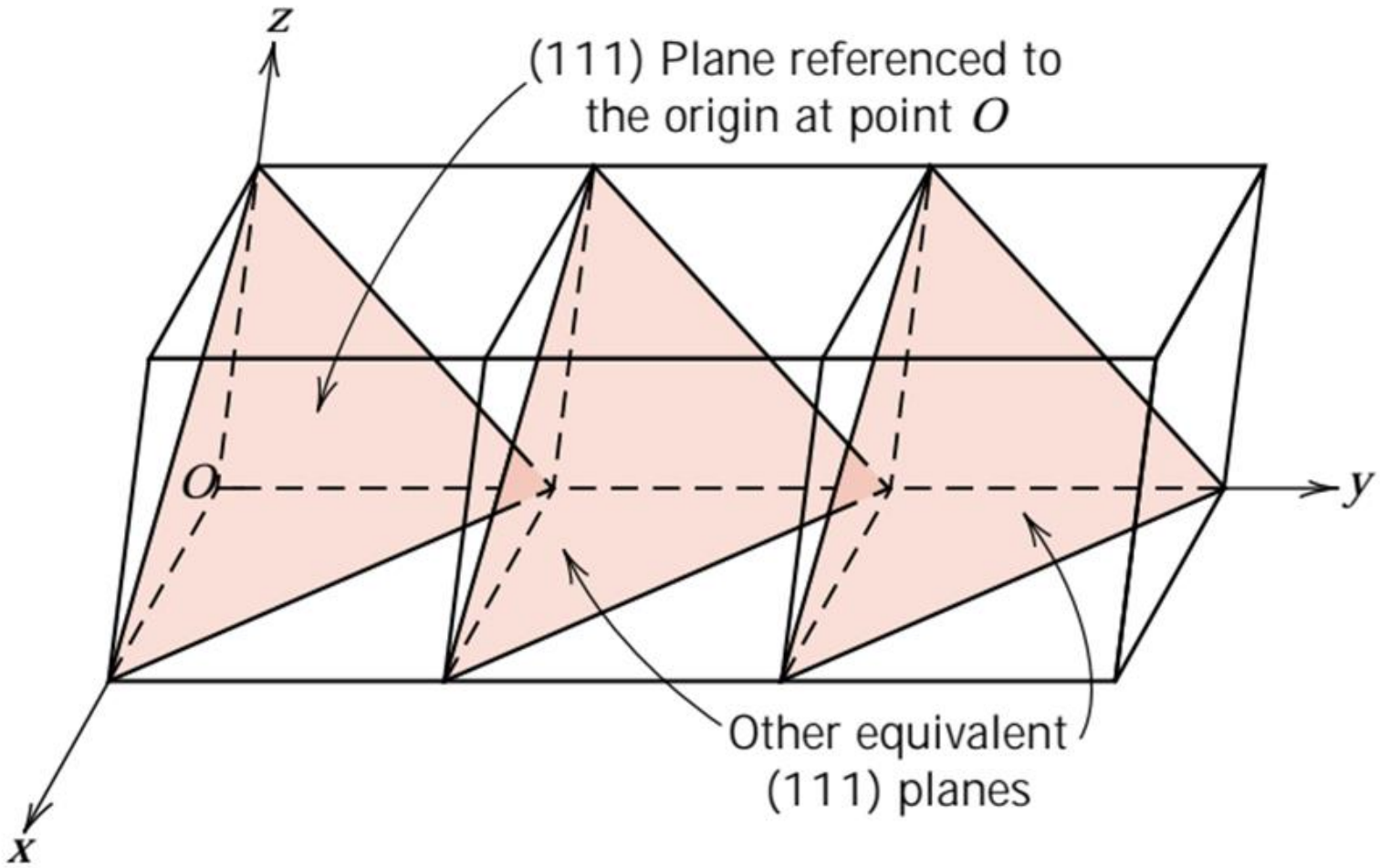
- **An intercept on the negative side of the origin is indicated by a bar or minus sign positioned over the appropriate index.**

Miller Indices



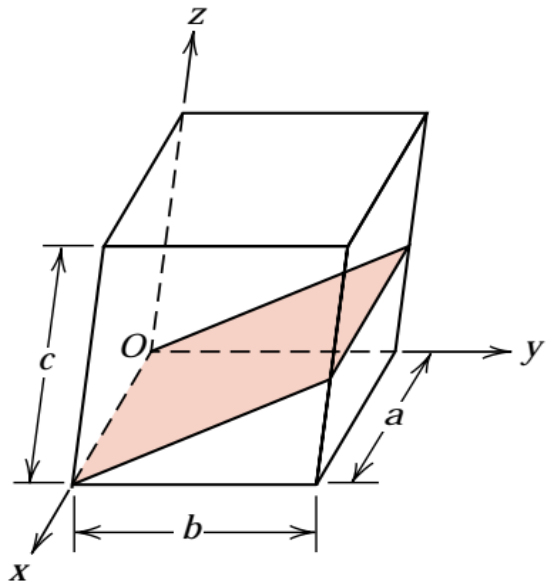


Miller Indices

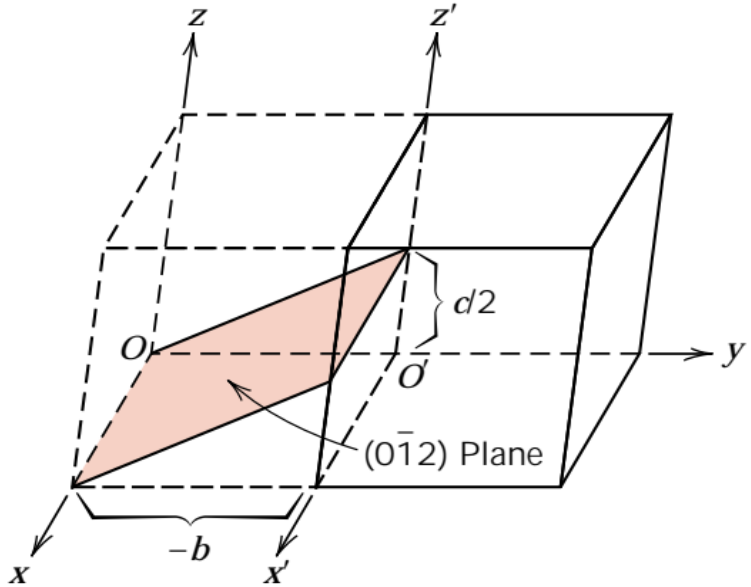


An Example

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



(a)

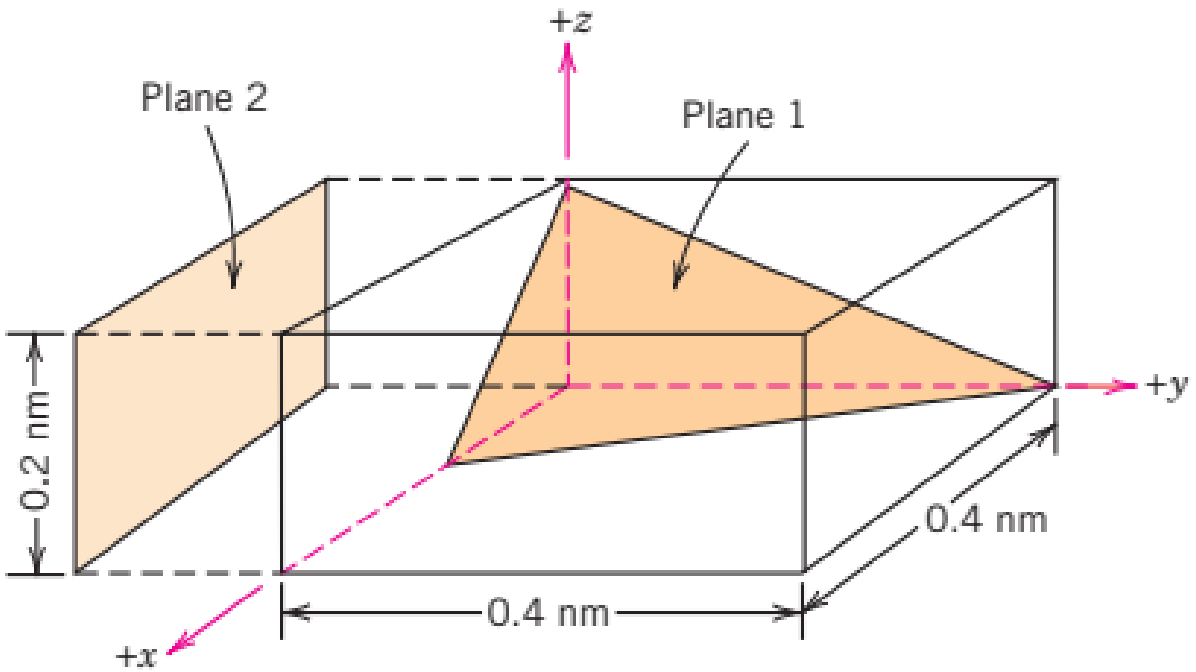


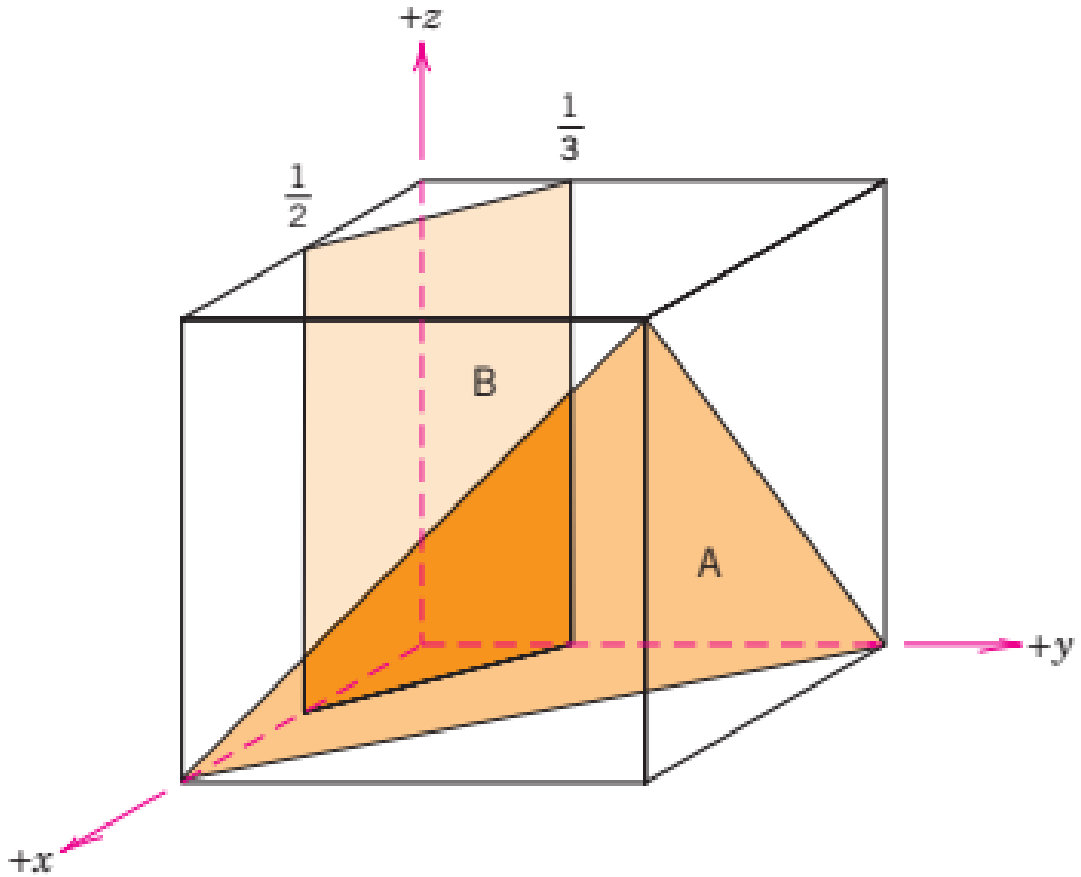
(b)

	x	*y*	*z*
Intercepts	∞a	$-b$	$c/2$
Intercepts (in terms of lattice parameters)	∞	-1	$\frac{1}{2}$
Reciprocals	0	-1	2
Reductions (unnecessary)			
Enclosure		$(0\bar{1}2)$	

An Example

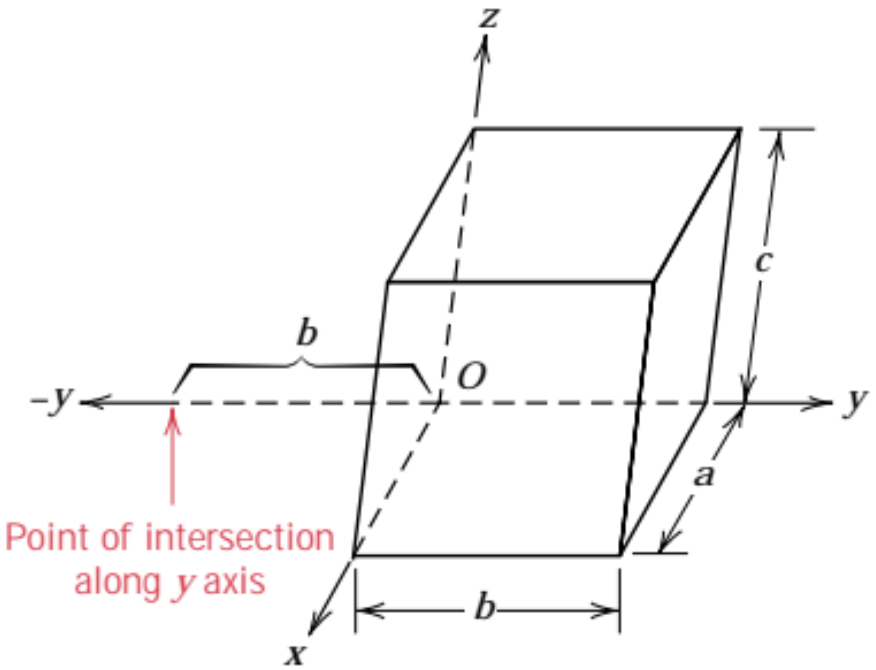
- **Determine the Miller indices of the planes as shown in the figures:**

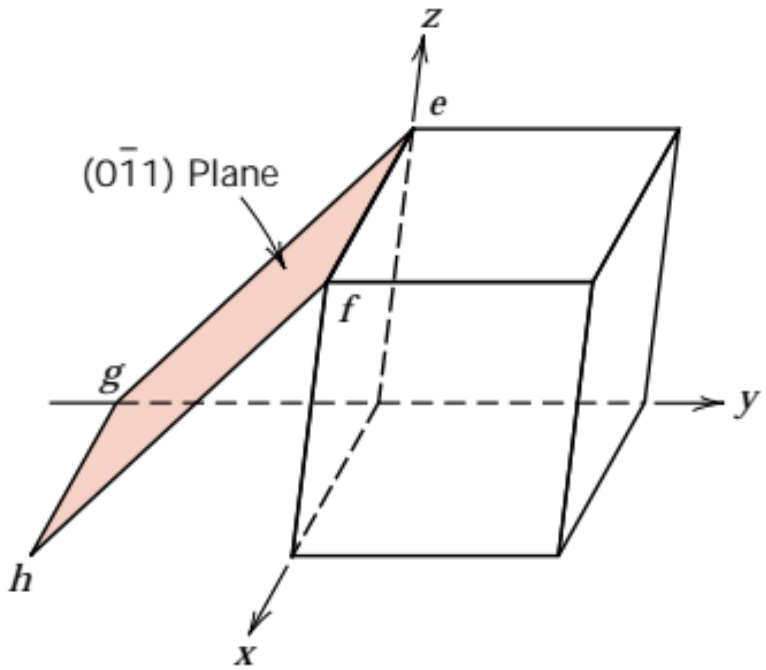




An Example

Construct a $(0\bar{1}1)$ plane within a cubic unit cell.





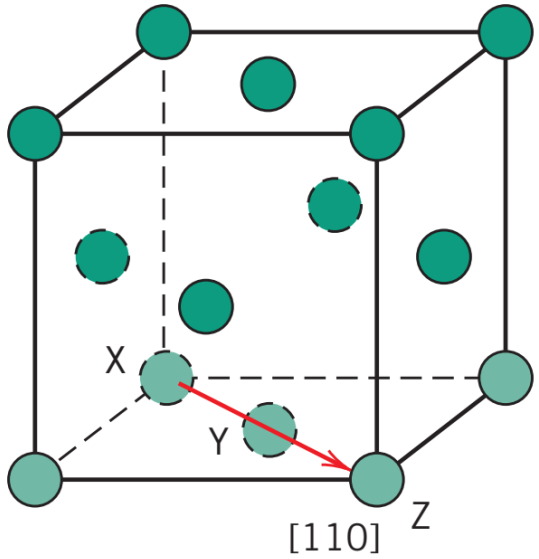
Linear Density

- Linear density (LD) is defined as the number of atoms per unit length whose centers lie on the direction vector for a specific crystallographic direction; that is,

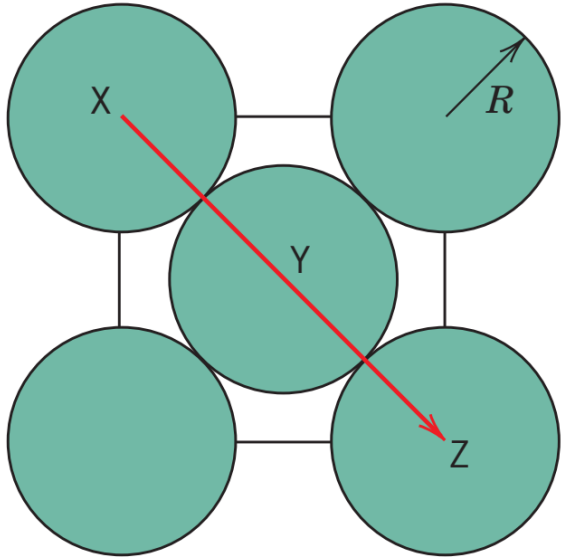
$$LD = \frac{\text{number of atoms centered on direction vector}}{\text{length of direction vector}}$$

- Unit of LD is reciprocal length (e.g. m^{-1}).
- Let us determine the linear density of the [110] direction for the FCC crystal structure.

Linear Density



(a)



(b)

$$\mathrm{LD}_{110} = \frac{2 \text{ atoms}}{4R} = \frac{1}{2R}$$

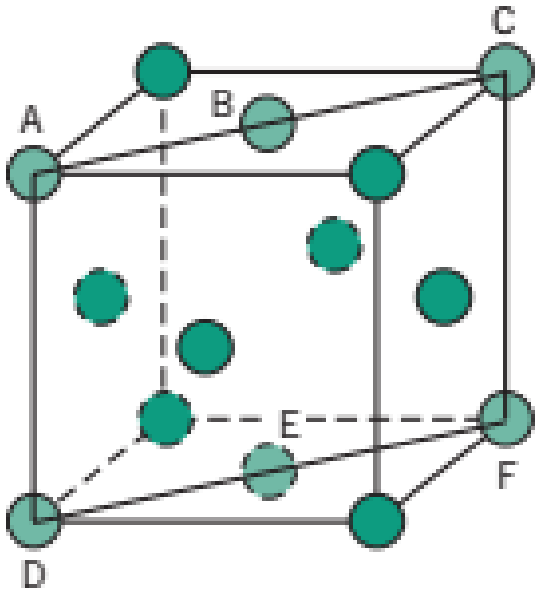
Planar Density

- Planar density (PD) is taken as the number of atoms per unit area that are centered on a particular crystallographic plane, or

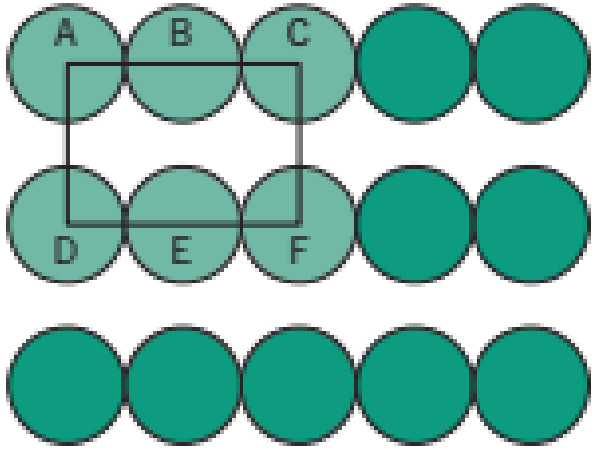
$$PD = \frac{\text{number of atoms centered on a plane}}{\text{area of plane}}$$

- Unit of PD is reciprocal area (e.g. m^{-2}).
- Let us determine the PD of the [110] direction for the FCC crystal structure.

Planar Density



(a)



(b)

$$PD_{110} = \frac{2 \text{ atoms}}{8R^2\sqrt{2}} = \frac{1}{4R^2\sqrt{2}}$$