ME254: Materials Engineering Homework 3 Due: Wednesday, October 15, 2014

1st semester 1435-1436 H Instructor: Dr. Hamad F. Alharbi

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1. Tantalum has a BCC crystal structure with an atomic weight of 180.948 g/mol. If the density of Tantalum is 16.6826 g/cm^3, calculate the radius of its atom in nanometer?

Solution:

>> density=n*A/(Vc*Na)
➔ Vc=n*A/(density*Na)

>> n=2;
>> density=16.6826 g/cm^3;
>> A=180.948 g/mol;
>> Na=6.023e23;

Vc=n*A/(density*Na) = 3.6017e-23 cm^3

The lattice parameter is a=Vc$^{(1/3)}$ = 3.3024e-08 cm

For BCC, a=4R/sqrt(3)
➔ The radius of V is R=a*sqrt(3)/4 = 1.43e-08 cm = <u>0.1430 nm</u>

2. Determine whether Rhodium has an FCC or BCC crystal structure if it has an atomic radius of 0.1345 nm, a density of 12.41 g/cm^3, and an atomic weight of 102.9055 g/mol.

Solution:
Let us assume that Rhodium has a BCC crystal structure, then
n=2 & a=4R/sqrt(3) ➔ density=n*A/(Vc*Na)= 11.4023 g/ cm^3
which is not equal to the value given in the problem.

Thus, <u>Rhodium should have an FCC crystal structure</u>. To check that, for FCC:
n=4 & a=4R/sqrt(2) ➔ density=n*A/(Vc*Na)= 12.4132g/ cm^3
which is the value given in the problem.

3. Sketch the following directions within a cubic unit cell (you can draw more than one unit cell to indicate the directions):

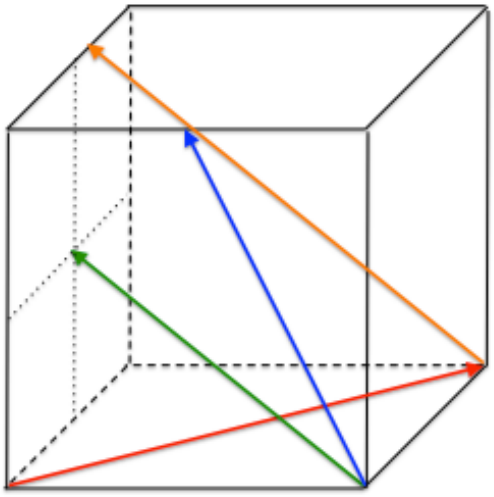
(a) $[\bar{1}10]$, (e) $[\bar{1}\bar{1}1]$,

(b) $[\bar{1}\bar{2}1]$, (f) $[\bar{1}22]$,

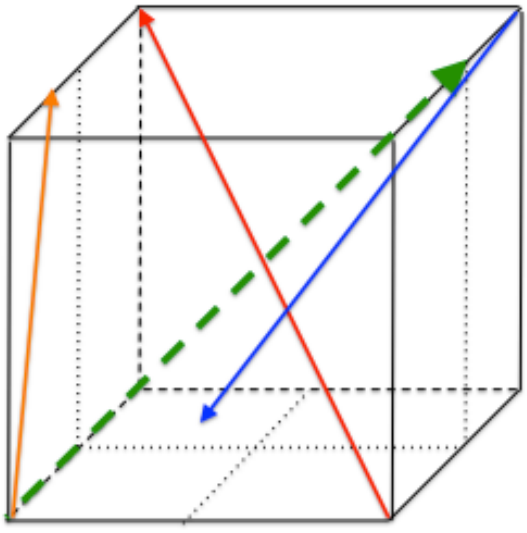
(c) $[0\bar{1}2]$, (g) $[1\bar{2}\bar{3}]$,

(d) $[1\bar{3}3]$, (h) $[\bar{1}03]$

Solution:

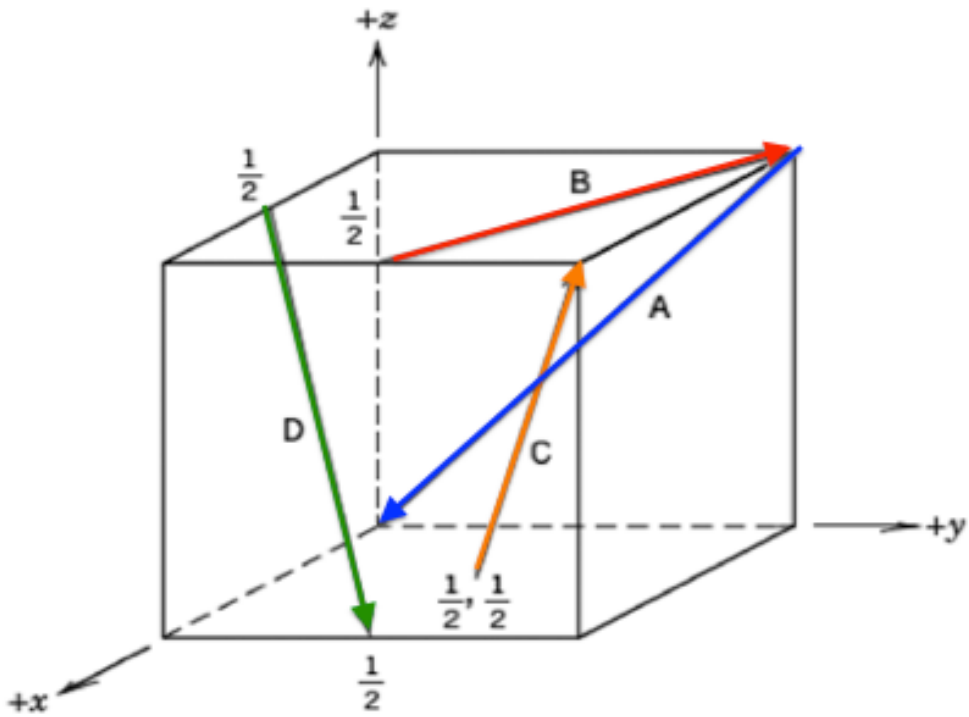


(a)[-1 1 0] Red
(b)[-1 -2 1] Green
(c)[0 -1 2] Blue
(d)[1 -3 3] Orange



e) [-1 -1 1] Red
f) [-1 2 2] Green
g) [1 -2 -3] Blue
h) [-1 0 3] Orange

4. Determine the indices for the following directions shown in the cubic unit cell:



Solution:

A.	B.	C.	D.
$[0\bar{1}\,\bar{1}]$	$[\bar{2}10]$	$[112]$	$[11\bar{2}]$

5. Sketch within a cubic unit cell the following planes:

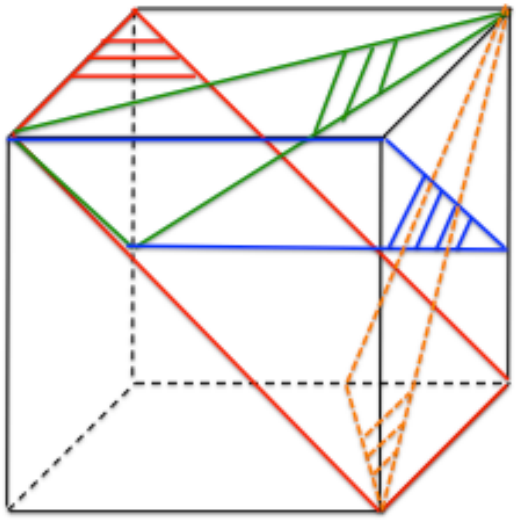
(a) $(0\bar{1}\bar{1})$, (e) $(\bar{1}1\bar{1})$,

(b) $(11\bar{2})$, (f) $(1\bar{2}\bar{2})$,

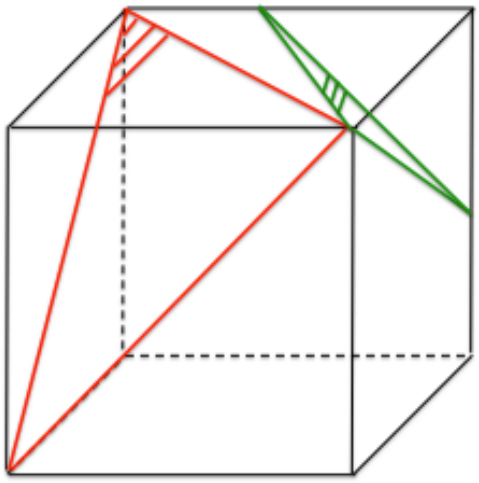
(c) $(10\bar{2})$, (g) $(\bar{1}2\bar{3})$,

(d) $(1\bar{3}1)$, (h) $(0\bar{1}\bar{3})$

Solution:

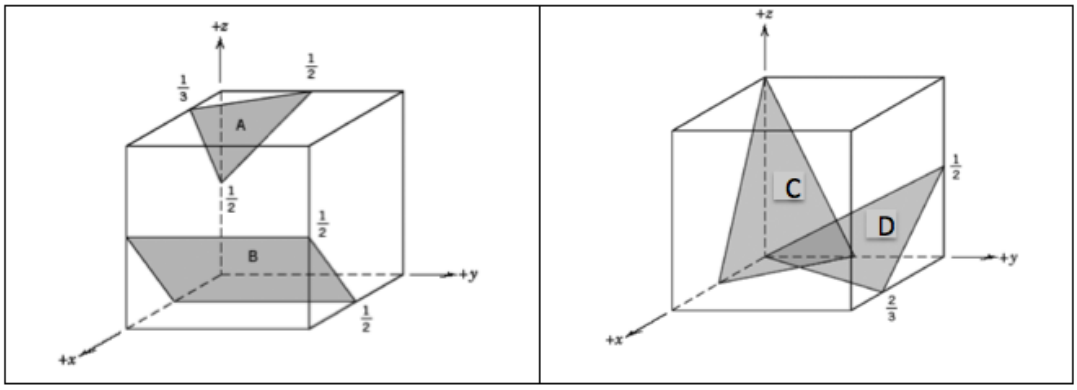


(a) (0 -1 -1) Red
(b) (1 1 -2) Green
(c) (1 0 -2) Blue
(d) (1 -3 1) Orange



e) (-1 1 -1) Red
f) (1 -2 -2) Green
g) (-1 2 -3) Not shown
h) (0 -1 -3) Not shown

6. Determine the Miller indices for the planes shown in the following unit cell:

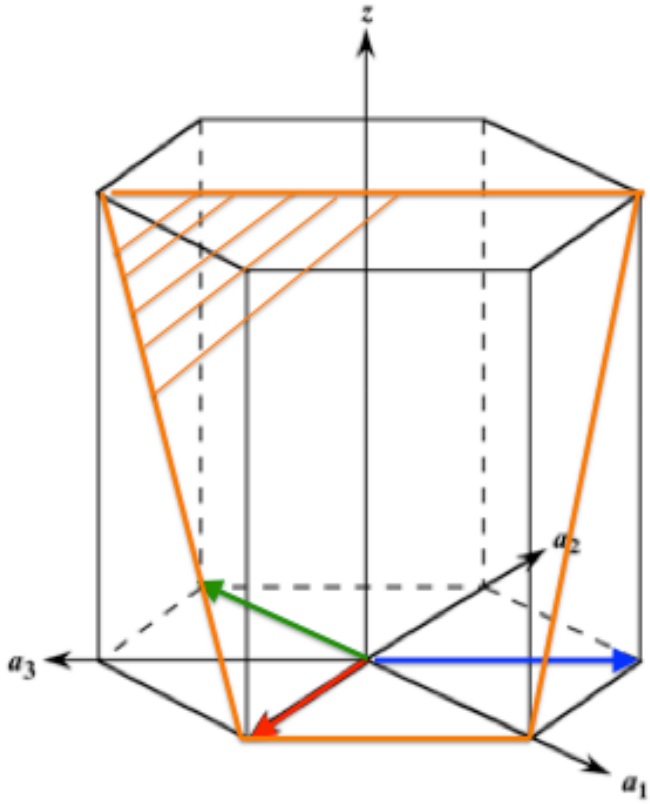


Solution:

A.	B.	C.	D.
$(32\bar{2})$	$(\bar{1}01)$	(221)	$(3\bar{2}4)$

7. Sketch the following planes and directions in HCP unit cell:
$(1\bar{1}01), [11\bar{2}0], (0001), [\bar{2}110], and\ [1\bar{2}10]$.

Solution:



- [1 -2 1 0] Red
- [1 1 -2 0] Blue
- [-2 1 1 0] Green
- (1 -1 0 1) Orange
- (0001) Basal plane

8. Calculate the atomic radius for aluminum given that Al has an FCC crystal structure and a planar density of $1.412\ x\ 10^{17}\ m^{-2}$ for the (111) plane. What are the values of the linear density for the [100], [110], and [111] directions.

The planar density for the (111) plane in FCC crystal is given by

$PD_{(111)FCC}$ = 4 / (sqrt(3) * a^2) (See Ch.3)
➔ a = sqrt (4 / (sqrt(3) * $PD_{(111)FCC}$))
= sqrt (4 / (sqrt(3) * $1.412\ x\ 10^{17}$))
= 4.0442e-09 m = 0.404 nm

For FCC, the relation between a and R:
Sqrt(2) a = 4 R
➔ R= Sqrt(2) * 0.404/ 4
= <u>1.4298 nm</u>

The values of the linear density for the [100], [110], and [111] directions are:

$LD_{[100]FCC}$ = 1/ a = 2.4727 X 10^8 atom/m
$LD_{[110]FCC}$ = 2 / (sqrt(2) * a) = **3.4969 X 10^8** atom/m
$LD_{[111]FCC}$ = 1 / (sqrt(3) * a) = 1.4276 X 10^8 atom/m

Please note that the highest linear density in FCC is along [110], which is the closed-packed direction.