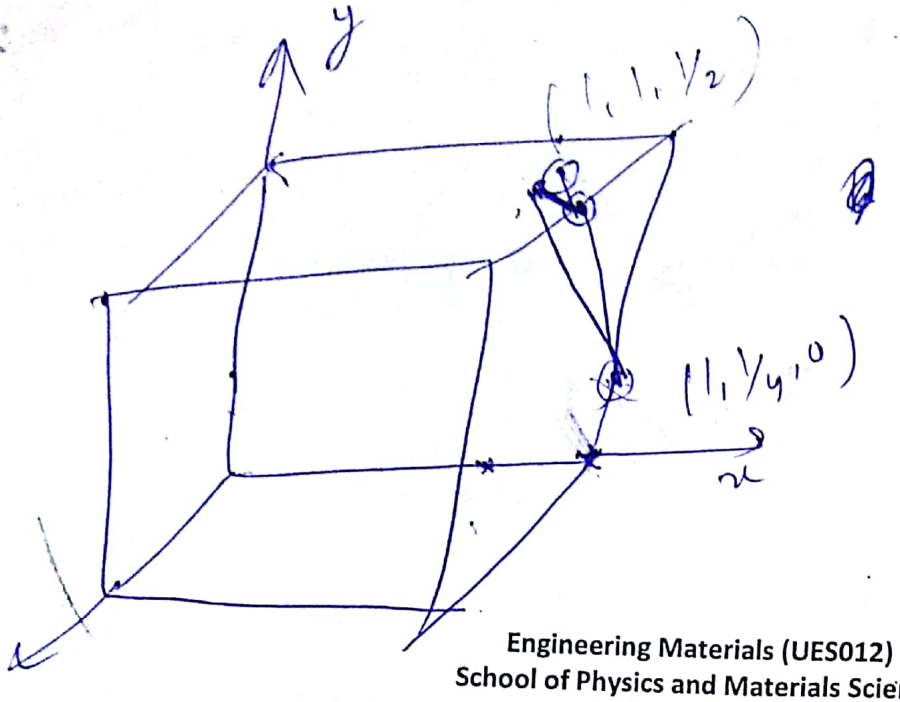


Engineering Materials (UES012)
School of Physics and Materials Science
Tutorial Sheet No 3-4

1. Draw the following crystallographic planes in cubic unit cell:
   (a) (101) (b) $(1\bar{1}0)$ (c) (221) (d) (210) (e) $(0\bar{1}2)$
2. Draw the following crystallographic planes in HCP; Check whether the symmetry exists.
   (a) $(01\bar{1}0)$ (b) $(\bar{1}0\bar{1}0)$ (c) $(\bar{1}2\bar{1}0)$ (d) $(10\bar{1}2)$ (e) $(01\bar{1}\bar{1})$
3. Draw cubic unit cell and show the following planes in it
   (a) $(21\bar{2})$ (b) $(1\bar{2}0)$ (c) $(12\bar{2})$ (d) $(20\bar{3})$ (e) $(\bar{3}1\bar{2})$ (f) $(2\bar{2}3)$
4. Draw the following directions in cubic unit cell
   (a) $[1\bar{1}\bar{1}]$ (b) $[\bar{1}\bar{1}3]$ (c) $[1\bar{1}0]$ (d) [110] (e) [101] (f) [102]
5. Draw the hexagonal unit cell and show the following planes in it:
   (a) $(1\bar{2}12)$ (b) $(\bar{1}100)$ (c) $(1\bar{1}01)$ (d) $(\bar{2}111)$ (e) $(12\bar{1}0)$
6. Compute and compare the linear densities for [100], [110] and [111] for copper. Given a = 0.3615 nm.
7. Calculate the linear atomic density in the [110] direction in the copper crystal lattice in atoms per square millimeter. The lattice constant of copper is 0.361 nm.
8. A metal crystalizes in the FCC structure. Calculate the linear atomic density along [110] and [111] direction. Assume lattice constant a = 0.3923 nm.
9. Compute the planar density for the BCC (100), (111) and (110) planes in terms of atomic radius r.
10. Calculate the planar density for (110) plane of BCC iron lattice in atoms per square millimeter. The lattice constant of iron is 0.287 nm.
11. From an X-Ray powder diffraction of a pure element, peaks at the following 2θ values in degrees were obtained 38.7, 45.4, 65.7, 78.8, 83.0, 99.6, 112.5, 117.0, 138.1, and 164.2. Copper K_α radiation was used. Find the lattice parameter and the crystal structure.
12. A BCC crystal is used to measure the wavelength of some X-rays. The Bragg angle for reflection from (110) plane is 20.2°. What is the wavelength? The lattice parameter of the crystal is 3.15 Å.
13. Determine the Miller indices of cubic crystal plane that intersects the position coordinates (1,1/4, 0), (1,1,1/2), and (3/4,1,1/4).
14. NaCl has the FCC lattice with a = 5.63 Å. What is the spacing of {100} plane?
15. Gold has atomic weight 197 and the density 19.3 gm/cc. What is the spacing between atoms in solid gold?

16. Compare packing fraction for SC and FCC lattice.

17. In powder diffraction pattern for lead with radiation of $\lambda = 1.54$ Å the (220) Bragg reflection angle is $\theta = 32^{\circ}$. What is the radius of atom?

$\frac{1}{3}, \frac{2}{3}, 1$

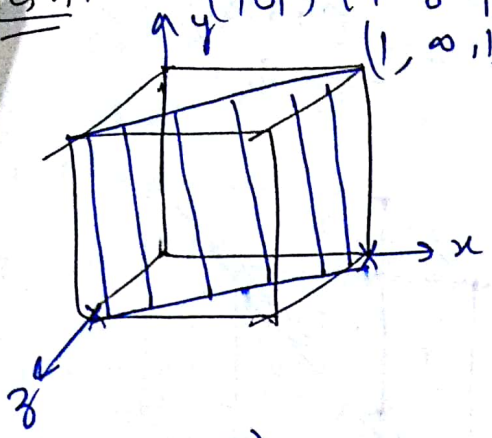
$3, \frac{3}{2}, 1$

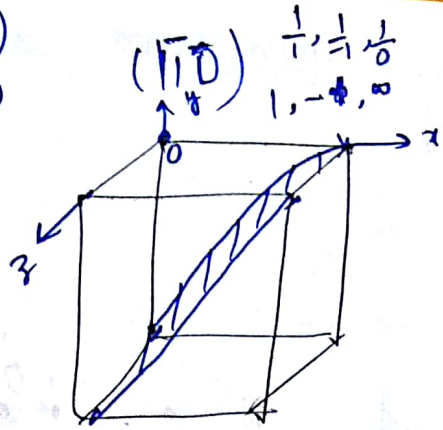
(6, 3, 2) multiplied

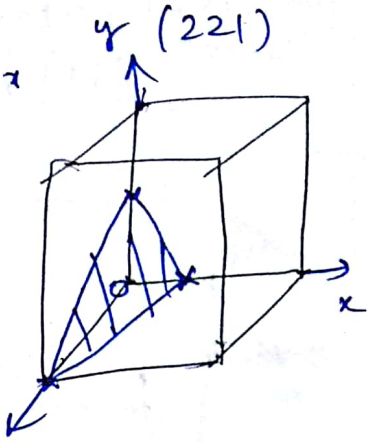
$2\pi\left(\frac{1}{6}, \frac{1}{3}, \frac{1}{2}\right)$

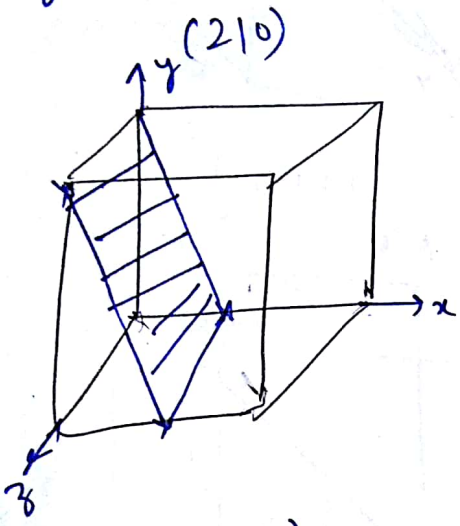
$\left(\frac{1}{3}, \frac{2}{3}, 1\right)$

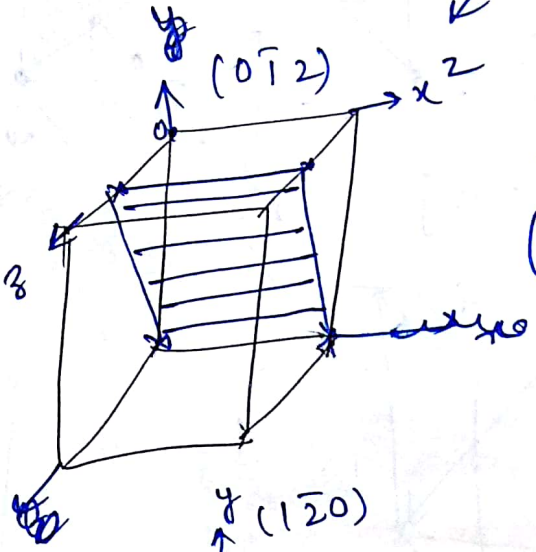
Q.1:-







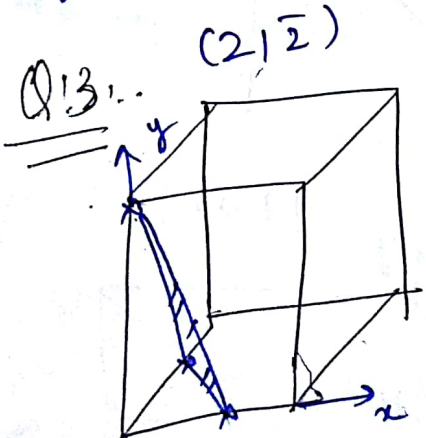


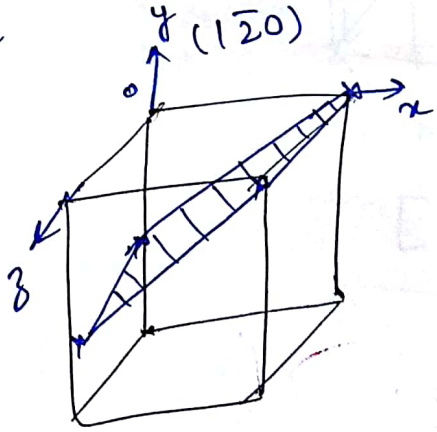


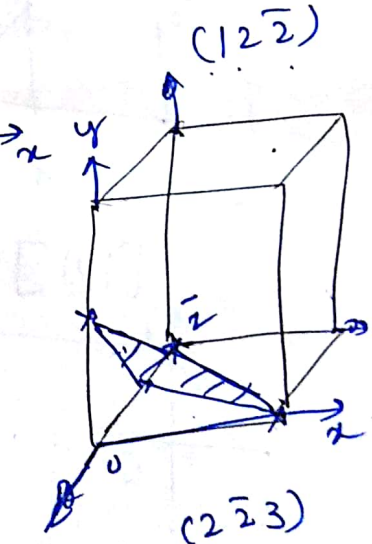
$\frac{1}{0}, \frac{1}{-1}, \frac{1}{2}$

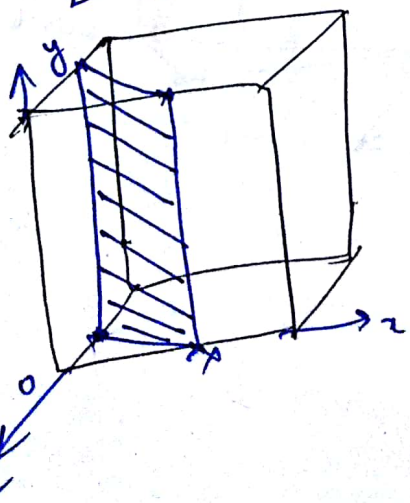
$(\infty, -1, \frac{1}{2})$

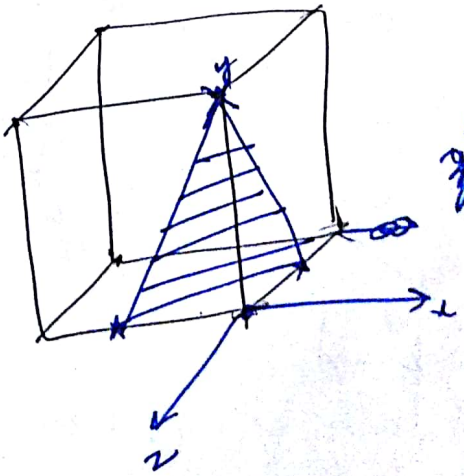
Q.3:-

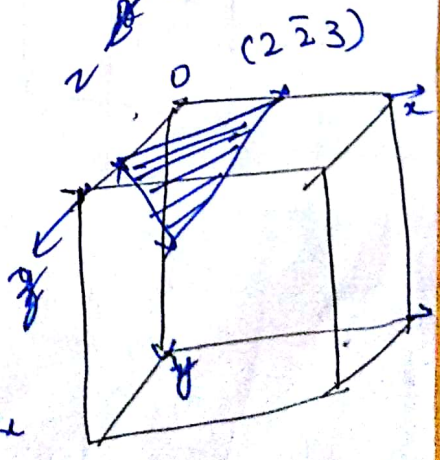






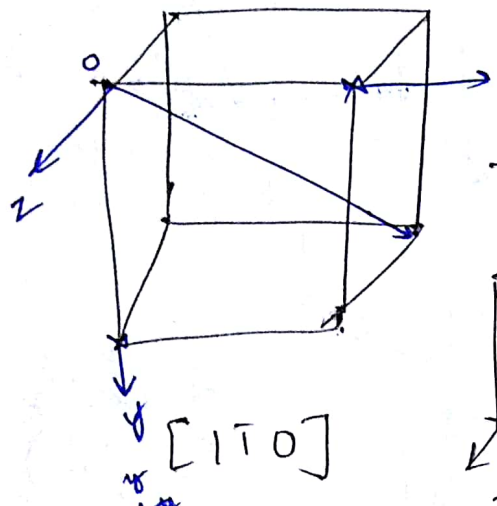






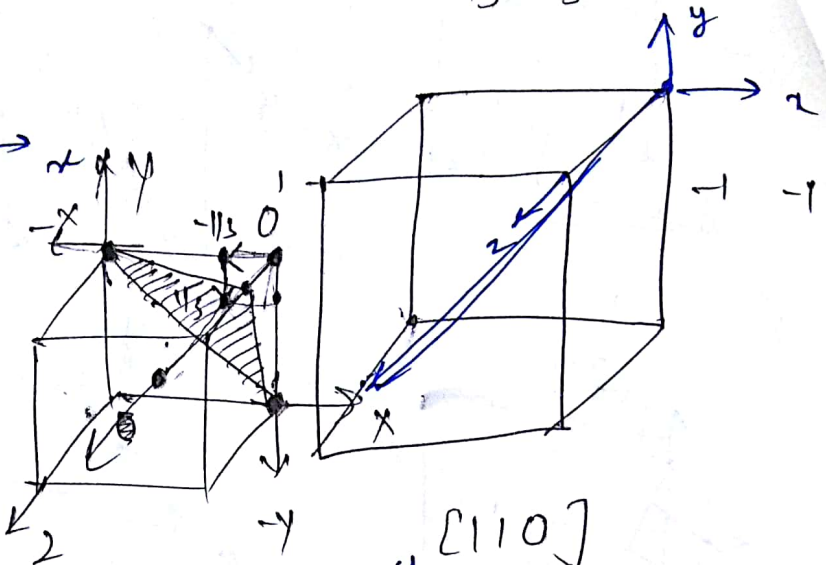
Q!4!- Cubic directions

[1 1 $\bar{1}$]

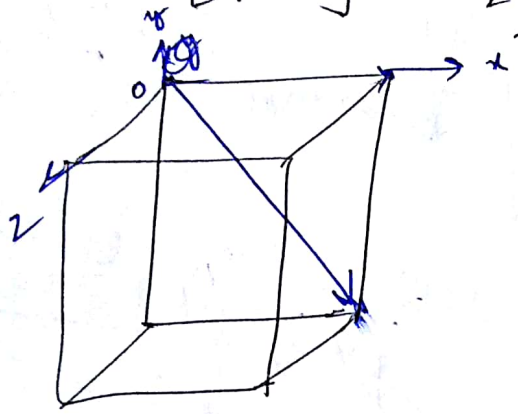


[$\bar{1}$ $\bar{1}$ 3]

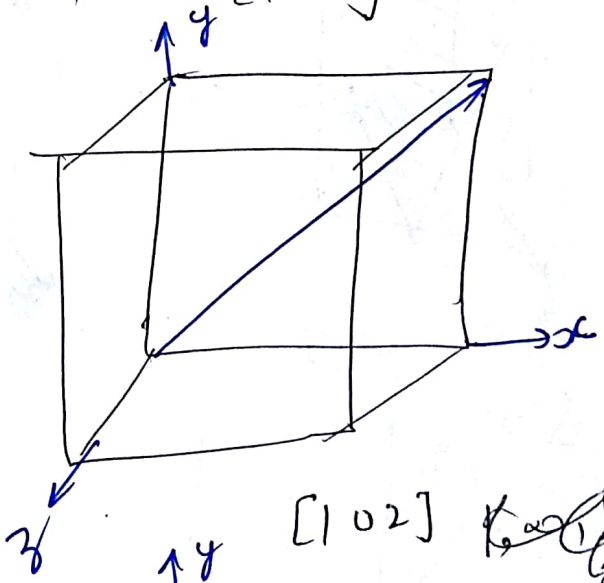
$-\frac{1}{3}$ $-\frac{1}{3}$ 1



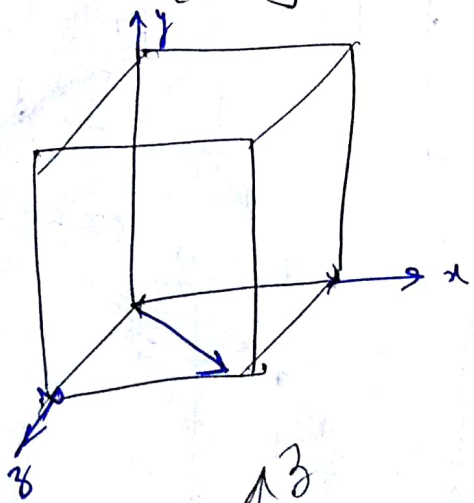
[1 $\bar{1}$ 0]



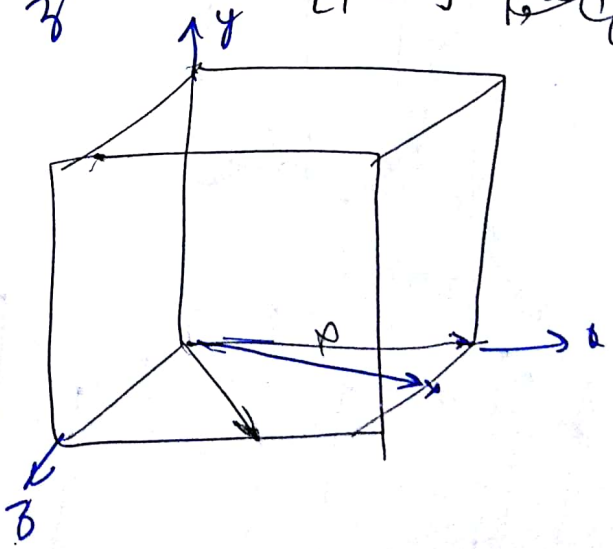
[1 1 0]

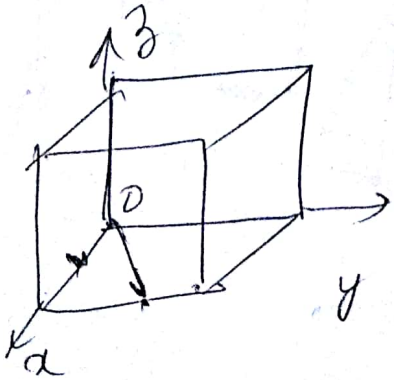


[1 0 1]



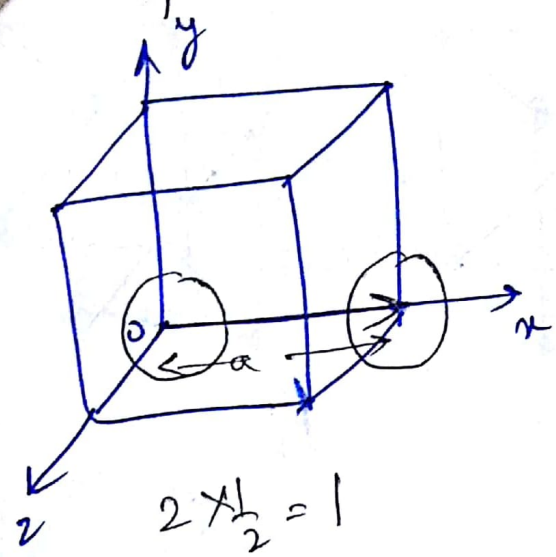
[1 0 2]





y (2 1 0)

01:- Linear atomic density in [100] [110] [111] of Cu.

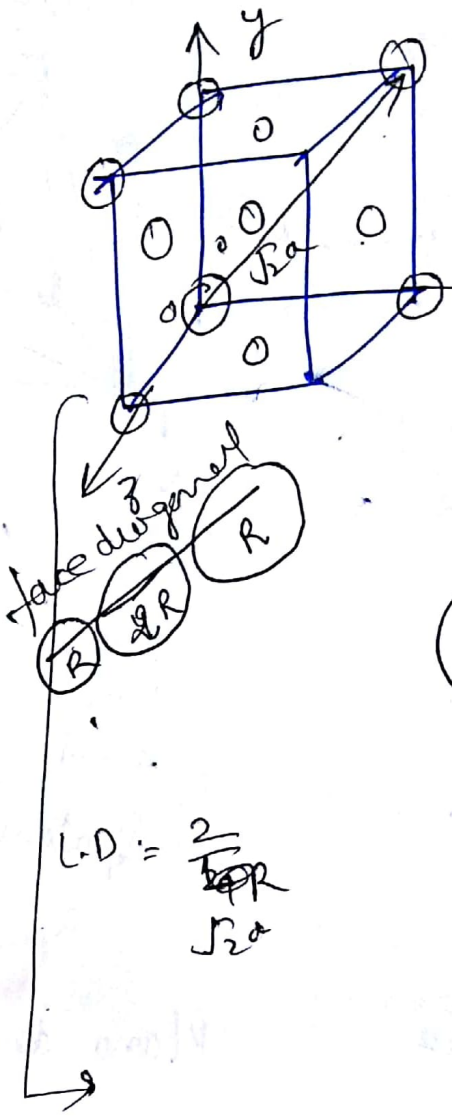


$2 \times \frac{1}{2} = 1$

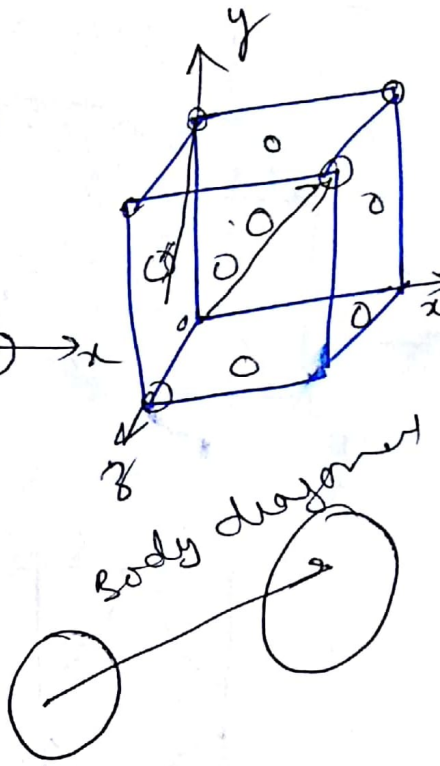
Cu → fcc

L.D. =

L.D = $\frac{1}{a}$



L.D = $\frac{2}{\sqrt{2}a}$

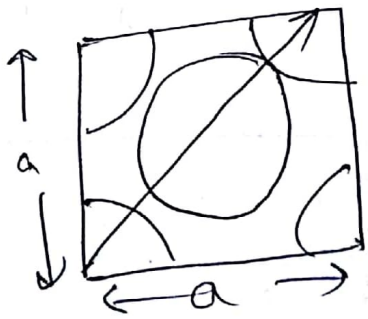


L.D = $\frac{1}{\sqrt{3}a}$

(7)

Atomic density

Linear Atomic density = $\frac{\text{No. of atoms}}{\text{Area of plane}}$



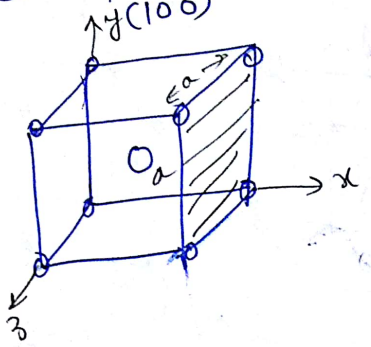
$4 \times \frac{1}{4} + 1$

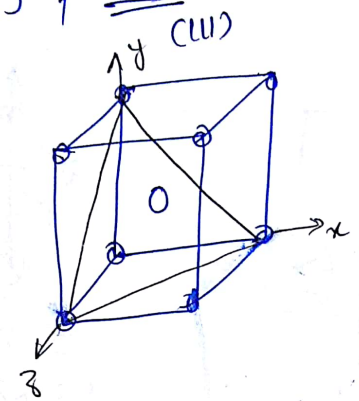
$= 2$

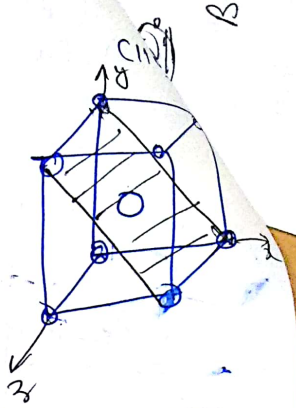
$= \frac{2}{\sqrt{2}a^2}$

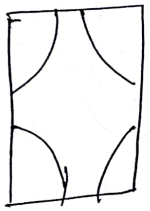
$= \frac{2}{a^2}$

(1) Planar density of BCC



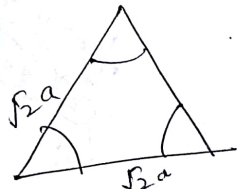






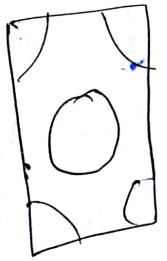
No. of atoms = $4 \times \frac{1}{4}$
= 1

Planar density = $\frac{1}{a^2}$



No of atoms = $3 \times \frac{1}{6}$
= $\frac{1}{2}$

Planar density = $\frac{1/2}{\text{Area of triangle}}$ → $\frac{\sqrt{3}}{4}(\sqrt{2}a)^2$



No. of atoms = $4 \times \frac{1}{4}$
= 1+1

Planar d = $\frac{2}{a \times \sqrt{2}a}$
= $\frac{2}{\sqrt{2}\,a^2}$

$a = \frac{4r}{\sqrt{3}}$

Q:13: Equation of plane $ax + by + cz = d$

A $(1, 1/4, 0)$ $\quad a + \frac{b}{4} = d$ — (1)

B $(1, 1, 1/2)$ $\quad a + b + \frac{c}{2} = d$ — (2)

C $(3/4, 1, 1/4)$ $\quad \frac{3a}{4} + b + \frac{c}{4} = d$

$2d \sin\theta = n\lambda$

Bragg angle $= \theta = 20.2°$

$2 d \sin\theta = 1.\lambda$

$2 \times \frac{3.15}{\sqrt{2}} \sin 20.2° = \lambda$

$\lambda = 1.\ 5\ 3\ A°$

$a = 3.15\ A°$

plane $= (110)$

$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$

$= \frac{3.15}{\sqrt{1+1+0}} = \frac{3.15}{\sqrt{2}}$

$= 2.22 A°$

(17) Pb $= ?$

$2d \sin\theta = n\lambda$

$2 \times \frac{a}{\sqrt{8}} \sin 32° = 1.54 A°$

$a = \frac{1.54 \times \sqrt{8}}{2 \times \sin 32°}$

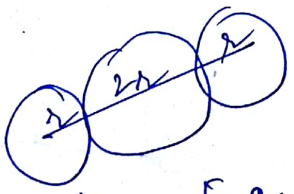
(220)

$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$

$= \frac{a}{\sqrt{4+4+0}} = \frac{a}{\sqrt{8}}$

FCC.

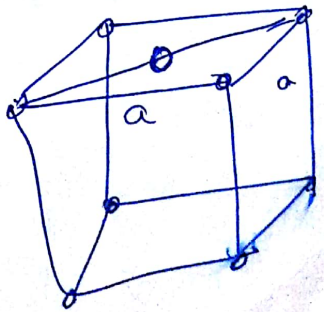
Radius $= ?$



$4r = \sqrt{2}a$

$r = \frac{\sqrt{2}a}{4}$

$= \ .$



14. $a = 5.63 A^\circ$ {100} plane

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}} = \frac{5.63}{\sqrt{1+0+0}} = 5.63 A^\circ$$

15.

$Z = 197$ $\rho = 19.3$ gm/cc Gold: FCC.

$n = 4$

$$\rho = \frac{n M}{N_a a^3}$$

N_a = Avogadro no. $= 6.022 \times 10^{23}$

n = no. of atoms per unit cell

a = lattice parameter

Spacing b/w atoms = ? $= 2r$

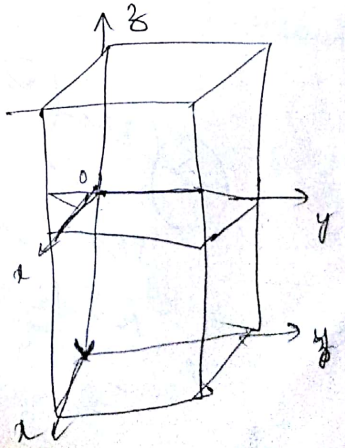
$$19.3 = \frac{4 \times 197}{6.022 \times 10^{23} \times a^3}$$

$$a = \sqrt[3]{\frac{4 \times 197}{19.3 \times 6.022 \times 10^{23}}}$$

Nd in FC. $4r = \sqrt{2}\, a$

$$a = \frac{4r}{\sqrt{2}}$$

Then $2r = ?$



	θ	$\sin^2\theta$
38.7	19.35	0.109
45.4	22.7	0.1489
65.7	32.85	0.2942
78.8	39.4	0.40288
83	41.5	0.439
99.6	49.8	0.5838
112.5	56.25	0.69134
117.0	58.5	0.72699
138.1	69.05	0.8721
164.2	82.1	0.9811

$h^2+k^2+l^2$

SC = 1 : 2 : 3

BCC = 2 : 4 : 6 : 8 :

FCC = 3 : 4 : 8 : 11 : 13

$2d\sin\theta = n\lambda \qquad d = \frac{a}{\sqrt{h^2+k^2+l^2}}$

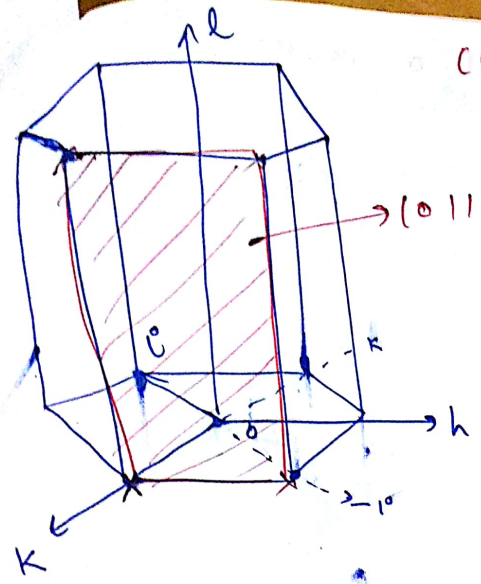
$\sin^2\theta = \frac{\lambda^2}{4a^2}(h^2+k^2+l^2)$

$\Rightarrow \sin^2\theta \propto h^2+k^2+l^2$

Lattice parameter $a = \frac{\lambda}{2d\sin\theta}\sqrt{h^2+k^2+l^2}$

$= \frac{1.54}{2\times 0.29}\sqrt{1+1+1}$

$\boxed{a = 4.598\ A^\circ}$



(0 1 $\bar{1}$ 0)

h+k+i = l.

h+k+i = 0

0+1-1 = 0

$\frac{1}{\infty}$, $\frac{1}{1}$, $\frac{1}{-1}$

0, 1, -1

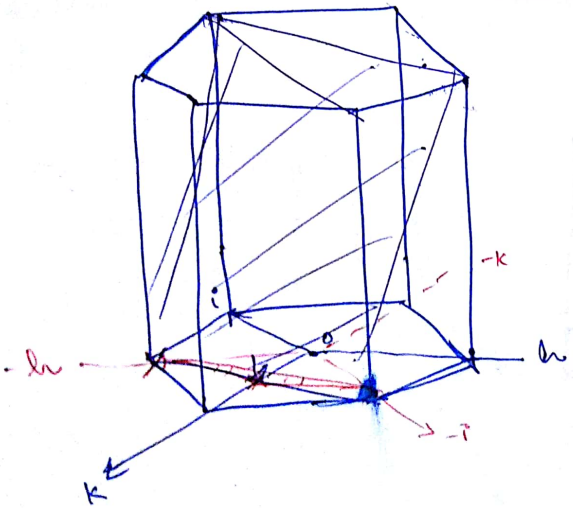
(0 1 1 $\bar{1}$ 0)

(3) ($\bar{1}$ 0 $\bar{1}$ 0)

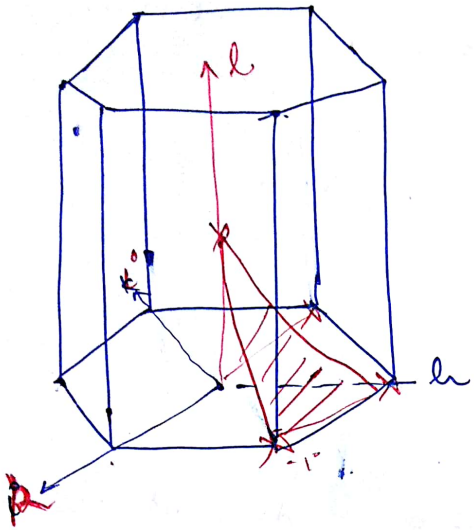
-1 + 0 - 1 = 0 does not exist

(4) ($\underset{h}{\bar{1}}$ $\underset{k}{2}$ $\underset{i}{\bar{1}}$, 0)

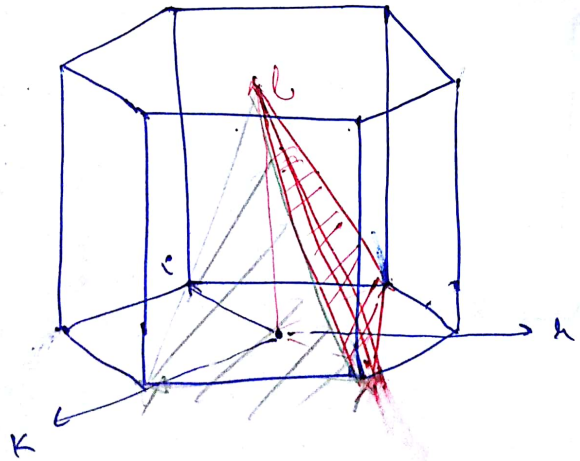
-1 + 2 - 1 = 0 exists

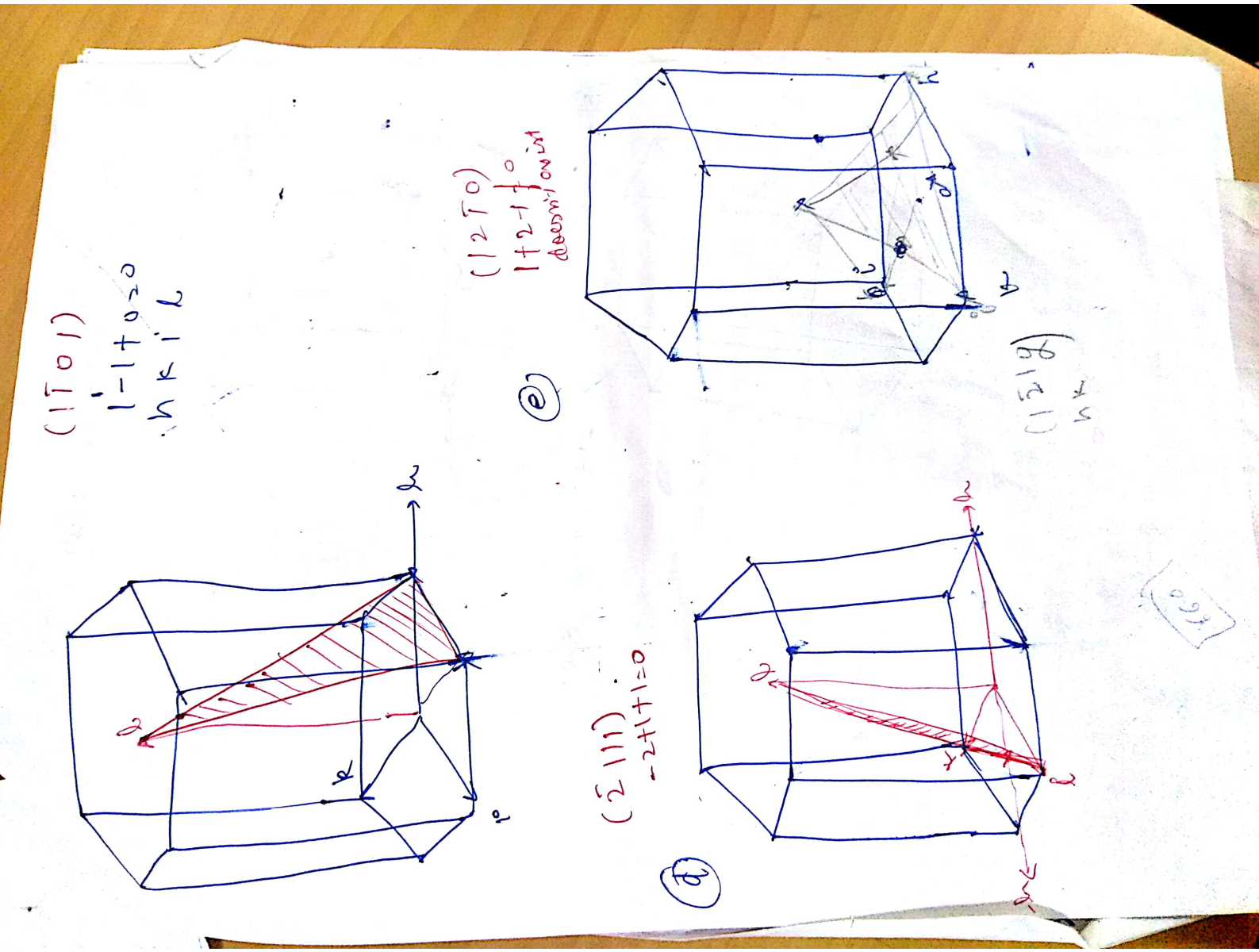


d. $(1\,0\,\bar{1}\,2)$ hkil $1+0-1=0$ ✓



e. $(0\,1\,\bar{1}\,1)$ hkil $0+1-1=0$ ✓





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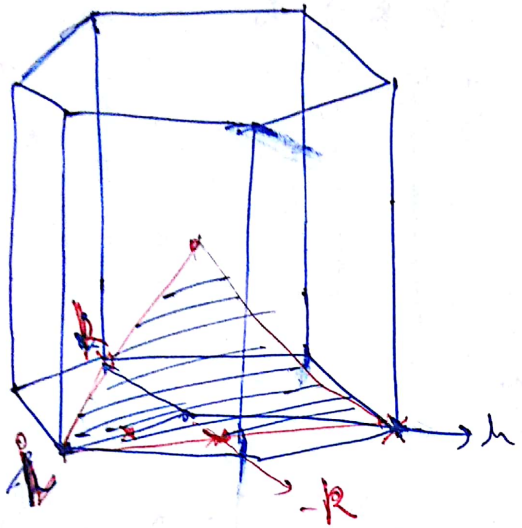
(4)

(a) $(1\bar{2}\,12)$ $\quad 1-2+1=0$ exists



(5) $(\bar{1}100)$ $\quad -1+1+0=0$ exists