

Problem 1:

$$\begin{aligned}
 a) 2 \ 1 \ 2 &\Rightarrow \frac{1}{2} \ 1 \ \frac{1}{2} \Rightarrow \left(\frac{1}{2}, 1, \frac{1}{2}\right) \Rightarrow (1, 2, 1) & b) \infty \ 1 \ 1 &\Rightarrow \frac{1}{\infty} \ 1 \ 1 \Rightarrow (0, 1, 1) \\
 5c) \frac{1}{2} \ 3 \ 2 &\Rightarrow 2 \ \frac{1}{3} \ \frac{1}{2} \Rightarrow \left(2, \frac{1}{3}, \frac{1}{2}\right) \Rightarrow (12, 2, 3) & 5d) 1 \ \bar{1} \ 1 &\Rightarrow 1 \ \bar{1} \ 1 \Rightarrow (1, \bar{1}, 1)
 \end{aligned}$$

Problem 2:

I will be using this Mathematica code I wrote to solve this problem:

```

h = 1; k = 0; l = 1;
Graphics3D[Arrow[{{0, 0, 0}, {h, k, l}}], Axes → True, AxesOrigin → {0, 0, 0},
  Boxed → False, AxesLabel → {x, y, z}]

h = 2; k = 0; l = 3;
Plot3D[z /. Solve[x h + y k + z l == 1, z], {x, 0, 2}, {y, 0, 2}, Mesh → None,
  PlotStyle → Cyan, PlotRange → {0, 1}, AxesOrigin → {0, 0, 0}, AxesLabel → {x, y, z},
  Boxed → False, ClippingStyle → None]

```

Figure 1: Mathematica code used for Problem 2

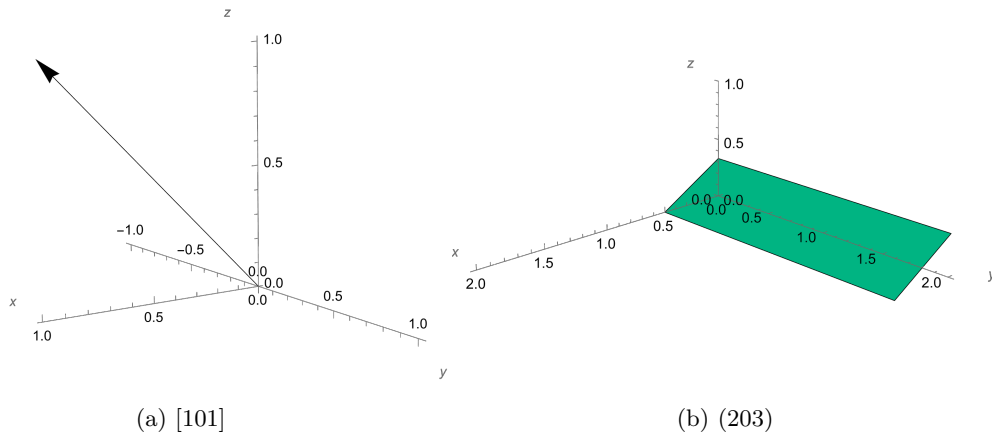


Figure 2: Problem 2

Problem 3:

We will need to calculate the volume of the unit cell V_{Cell} , and the volume of 8 Si atoms V_{Si} . However, we first need to compute the nearest neighbor (NN) distance r_{NN} :

$$\begin{aligned}
 r_{NN} &= \text{Distance between } \langle 0, 0, 0 \rangle \text{ \& } \langle \frac{1}{4}, \frac{1}{4}, \frac{1}{4} \rangle \\
 &= \sqrt{\left(0 - \frac{1}{4}\right)^2 + \left(0 - \frac{1}{4}\right)^2 + \left(0 - \frac{1}{4}\right)^2} * a \\
 &= \frac{\sqrt{3}}{4} a \\
 V_{Si} &= 8 \times \frac{4}{3} \pi \left(\frac{\sqrt{3}}{8} a\right)^3 = 0.34 a^3 \\
 V_{Cell} &= a^3 \\
 \frac{V_{Si}}{V_{Cell}} &= \frac{0.34 a^3}{a^3} = 34\%
 \end{aligned}$$

We can notice that as long as it is a diamond structure, this ratio is independent from the lattice constant.

Problem 4:

a) For diamond silicon structure:

(100): We will have $\frac{2}{5.43^2} \text{ atoms}/\text{\AA}^2$

(110): We will have $\frac{4}{\sqrt{2} \cdot 5.43^2} \text{ atoms}/\text{\AA}^2$

(111): We will have $\frac{2}{\frac{\sqrt{3}}{4} \cdot 5.43^2} \text{ atoms}/\text{\AA}^2$

We can see that $(111) > (110) > (100)$. Hence, (111) will be the best plane.

b) It will be $[1, 1, 1]$. Because it is the direction with the highest atomic density.

Problem 5:

a) The net charge is +1 for region A

b) The net charge is -1 for region B

c) a) The net charge is -1 for region A

b) The net charge is +1 for region B

Problem 6:

To answer this question we must know how many valence electron in each atom:

$$As : 6 \quad Si : 5 \quad Ga : 3$$

So, if we exclusively replaced *Ga* with *Si*, we will have more *mobile electrons*. Thus, we will have an *n-type* material.

The opposite goes when we replace *As* with *Si*, we will have more *holes*. Thus, a *p-type* material.