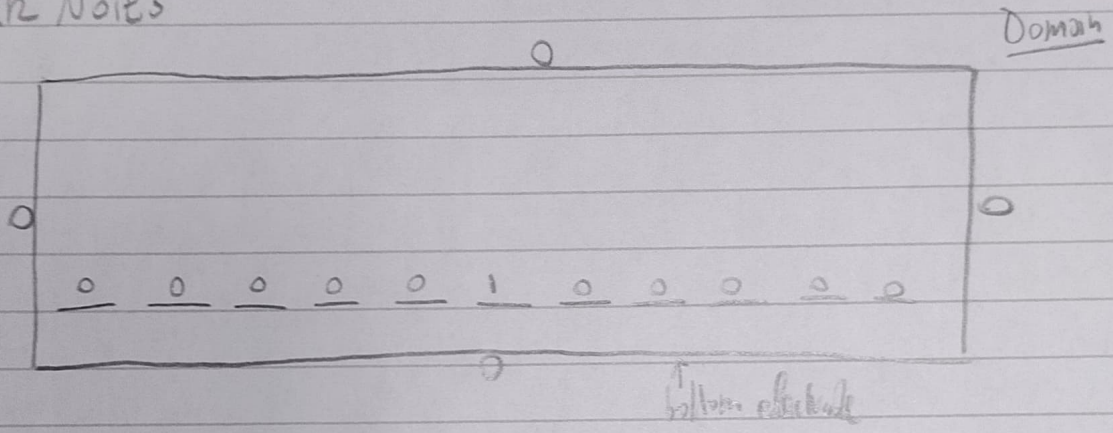
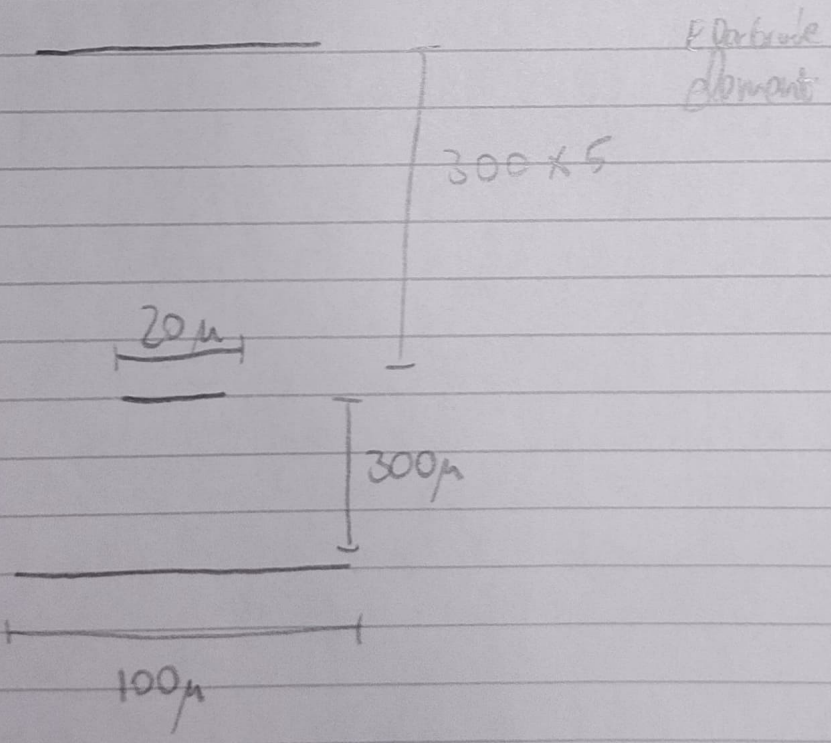
18/01/2022 - Weighting fields Documentation

P1

WEIGHTING FIELD

PAPER NOTES





LAPLACES EQ FOR THE W.F.

$$\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} = 0$$

$$\frac{f_{i,j+1} - 2f_{i,j} + f_{i,j-1}}{\delta x^2} + \frac{f_{i+1,j} - 2f_{i,j} + f_{i-1,j}}{\delta y^2}$$

$$= p_{i,j}$$

Using a cube mesh and considering free space only, using $p = 0$ since we are considering free space only

$$f_{i,j+1} + f_{i,j-1} - 4f_{i,j} + f_{i+1,j} + f_{i-1,j}$$

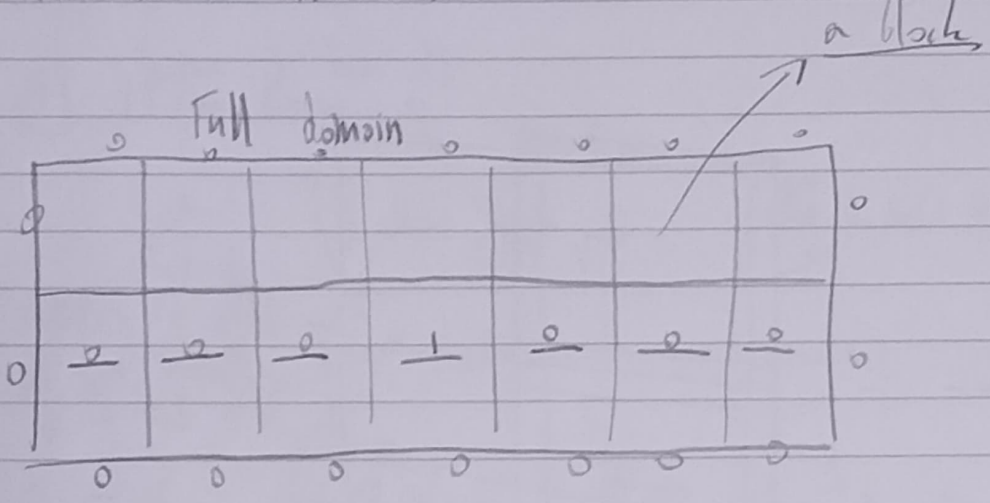
$$= 0$$

In terms of potentials:

$$V_S + V_W - 4V_P + V_E + V_N = 0$$

P3

STRUCTURING THE MESH



The mesh is divided into two types of blocks

BLOCK NAMING

Naming convention for the blocks and for the boundary calls

B-left-t	l-4-t	l-3-t	l-2-t	l-1-t	central-t	right-1-t	r-2-t	r-3-t	r-4-t	B-right-t
B-left	l-4	l-3	l-2	left-1	central	right-1	right-2	right-3	right-4	B-right

cells

The boundaries are named as

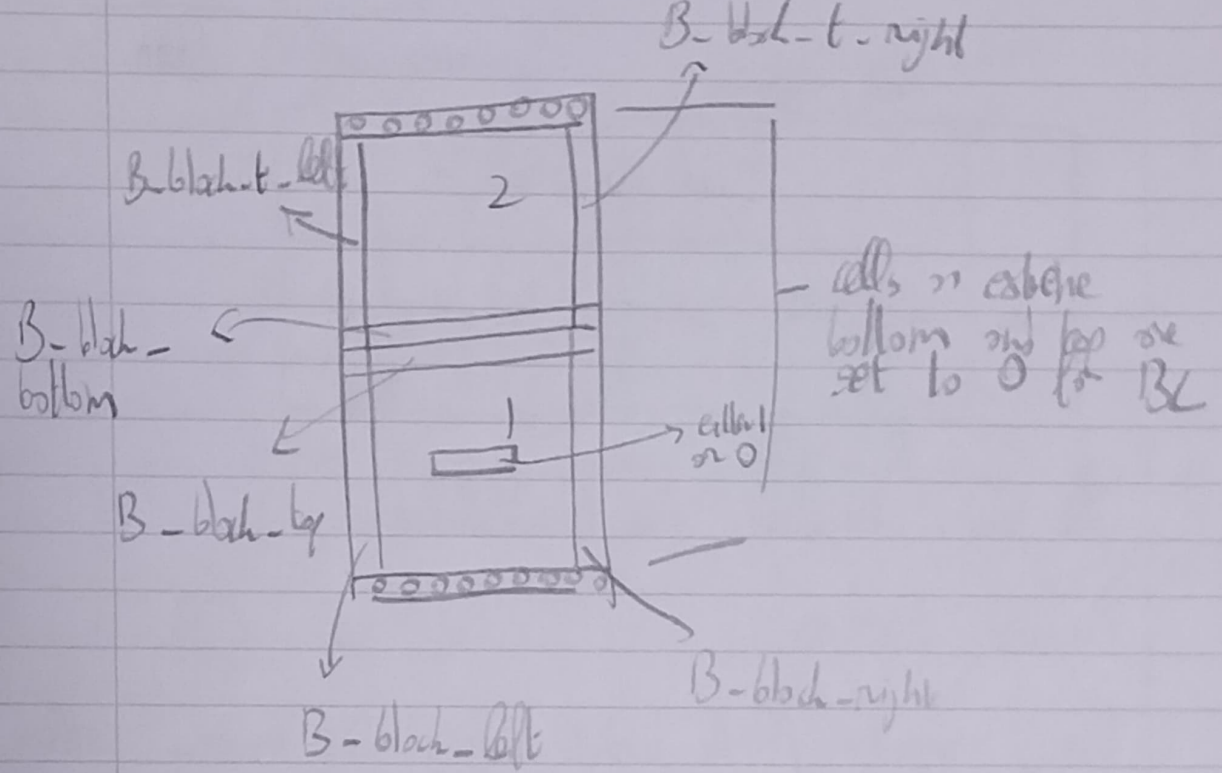
B-block name - boundary location

i.e B-left-1-t - left

(The mesh as divided in blocks) (Block structure mesh)

P4

TRANSITION CELLS



Note that B_blah_l. in 2 are $N_y - 1$

like wise

B_blah_t_l. in 1 are $N_y - 1$

true only when in field to B

B_blah_top N_x

blah_t_bottom

P5

FLOW DIAGRAM

1 Define dimensions

N_x_1
N_y_1 } bottom blocks

N_x_2
N_y_2 } top blocks

Define electrode location for bottom blocks $\frac{N\_y}{3} * N\_x + \frac{2}{5} N\_x$ [5]
$+ \frac{3}{5} N\_x$ [E]

2 Use fn.s

block_with_electrode
block_without_electrode } to define the position of coefficients (coeff. of eq. in boundary eq.) and matrix b positions

All bottom blocks will have block_with_electrode (some eq.) save position

All top blocks

3 Define initial potential guess.

all 0 except for anode electrode set to 1
this is also BC

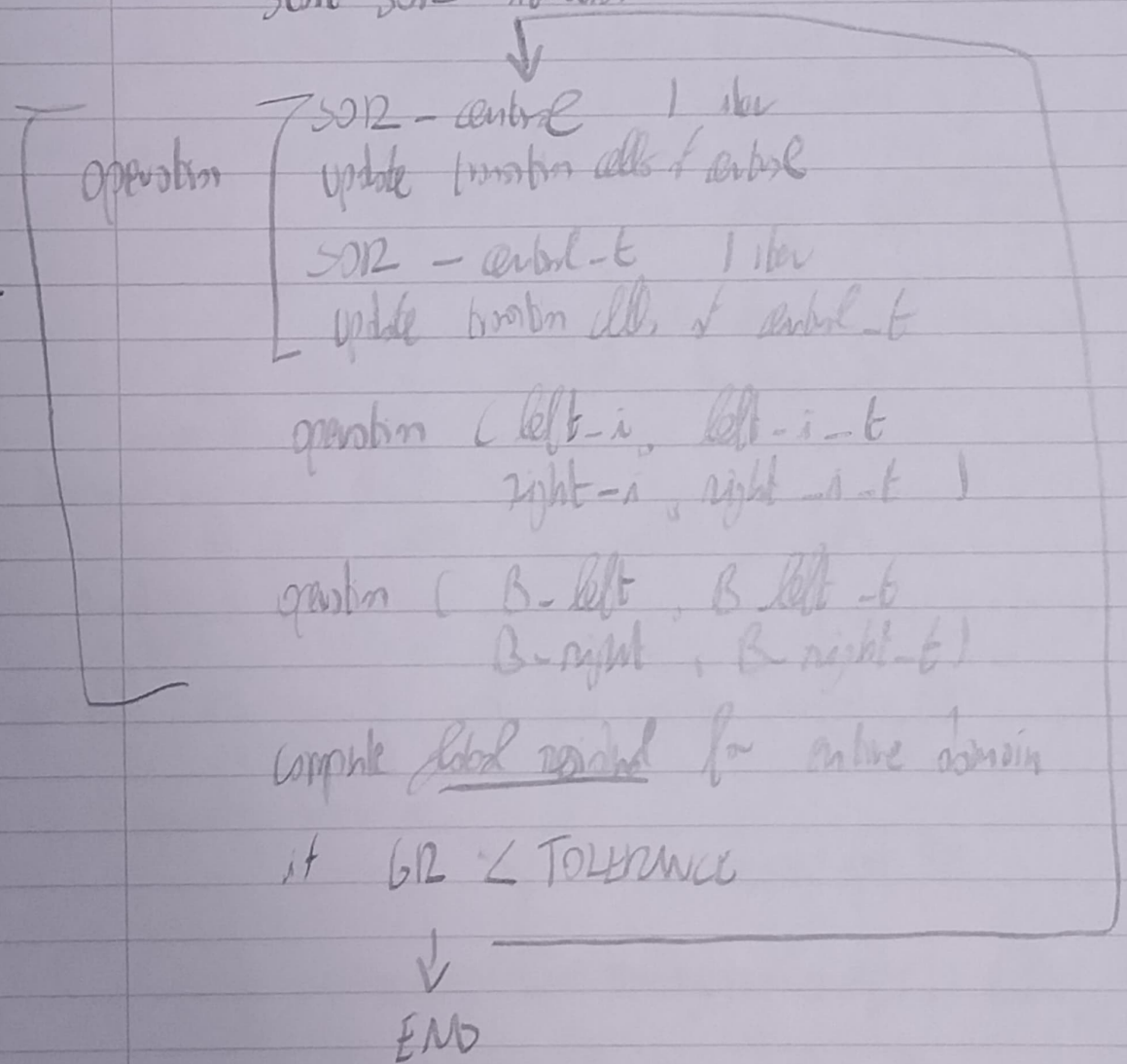
P6

4 Define all transition cells (initially set to 0)

Notice that the transition cells for B-right (B_t) (right)
left (B-t) (left)

are set to 0 and left to 0 since they are a BC

5 define some fn and block
start SOR iteration



* At every operation step we must define the source since the transition cells are constantly updated.

P7

Solving The System of Discretised Equations

System:

$$A\vec{V} = \vec{b}$$

- A: matrix of coefficients
- $\vec{V}$: potential vector
- $\vec{b}$: source vector

6.5. SOR:

$$x_i^{(n+1)} = (1-w)\, x_i^{(n)} + \frac{w}{a_{ii}} \left(-\sum_{j<i} a_{ij} x_j^{(n+1)} - \sum_{j>i} a_{ij} x_j^{(n)} + b_i \right)$$

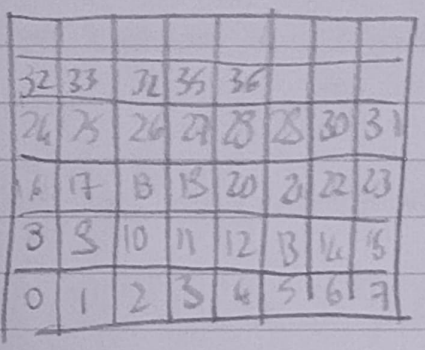
(updated values)

For the specific case of the weighting field:

$$V_P^{(n+1)} = (1-w)\, V_P^{(n)} + \frac{w}{(-4)} \left(-V_S^{(n+1)} - V_W^{(n+1)} - V_E^{(n)} - V_N^{(n)} + b_{SM} \right)$$

b_{SM} : source at the boundary cells only

P3



$2N_x \longrightarrow 3N_x - 1$

$N_x \longrightarrow 2N_x - 1$

$0 \longrightarrow N_x - 1$

Cell positions:

S W P E N

$P - N_x$ $P-1$ cube cell $P+1$ $P + N_x$] mapping to initial vector V_{12}

$V_E = V[E]$ and so on.

CREATING THE SOURCES FOR A BLOCK

two functions block_with_electrode_source
block_without_electrode_source

create the source terms

GLOBAL RESIDUAL

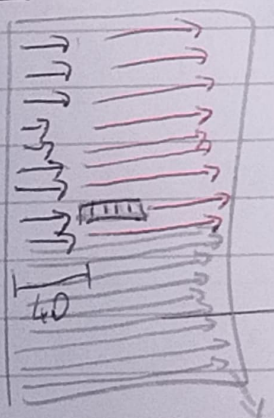
$$A\vec{V} = \vec{b}$$

$$\sum_i (A_{ij}V_j - b_i)^2 = R - b$$

How far away we are from satisfying the system of linear eq. with our iterative solution.

NOTE ON THE DIFFUSION OF THE BC

0th iteration



Block with electrode

→ updates nothing so far

sweep of the domain

In order for the BC to diffuse to the left you require 40 iterations at least

The solution will diffuse much more quickly to the right than the left

In order to reach Left -2 at least 240 iterations are needed.

Documentation [P1] 18/01/2022

POISSON EQ

$$\frac{f_{i,j+1} - 2f_{i,j} + f_{i,j-1}}{\delta x^2} + \frac{f_{i+1,j} - 2f_{i,j} + f_{i-1,j}}{\delta y^2}$$

$$= -\frac{\rho_{i,j}}{\varepsilon}$$

$$\vec{\nabla}^2 V = -\frac{\rho}{\varepsilon} \quad \text{since} \quad \vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon}$$

$$\vec{E} = -\vec{\nabla} V$$

$$\vec{\nabla}^2 V = -\frac{N_e}{\varepsilon} \quad \leftarrow \text{dopant concentration}$$

$$\vec{\nabla}^2 V = -\frac{Ne}{\varepsilon_R \varepsilon_0} \qquad \vec{\nabla}^2 \left(\frac{V_{\varepsilon_0}}{e}\right) = -\frac{N}{\varepsilon_R}$$

N_0 : reference concentration

$$\vec{\nabla}^2 \left(\frac{V_{\varepsilon_0}}{N_0 e}\right) = -\frac{N}{\varepsilon_R N_0} \rightarrow \text{Sovle}$$

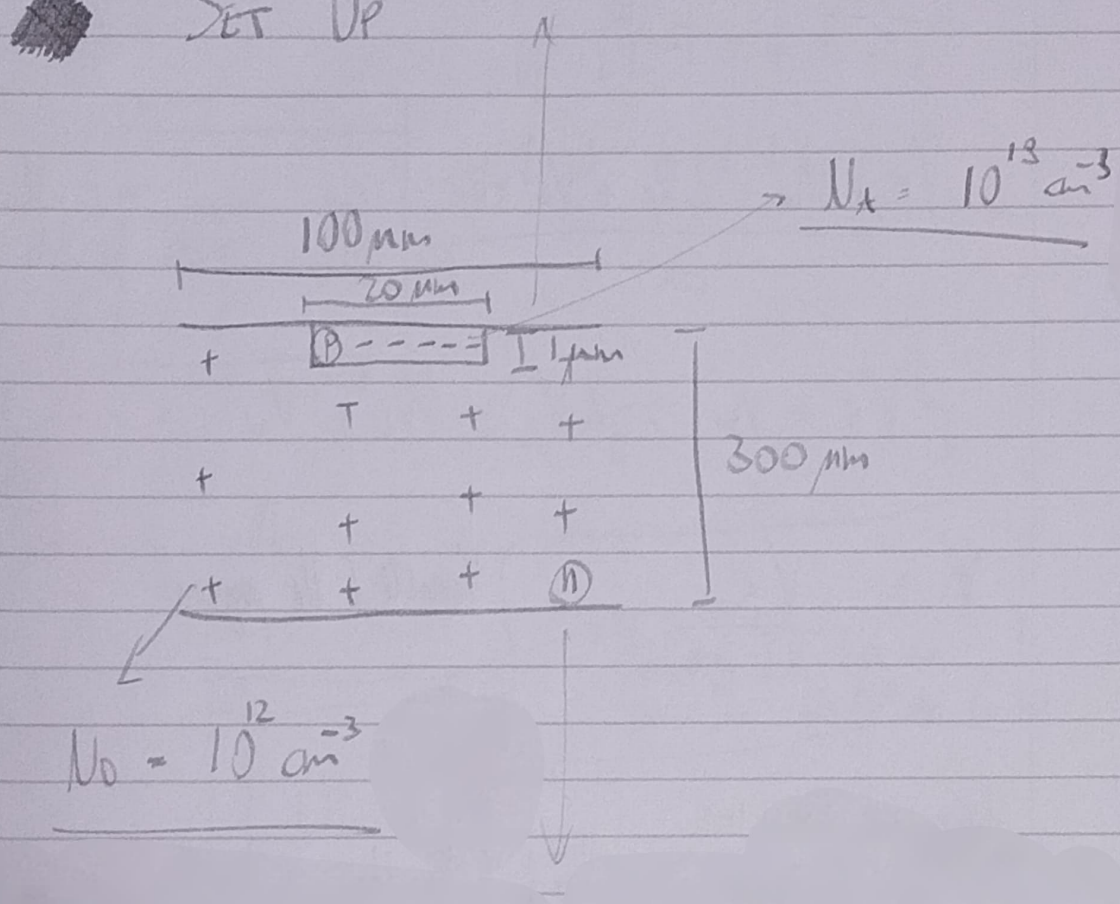
$\rightarrow$ solution

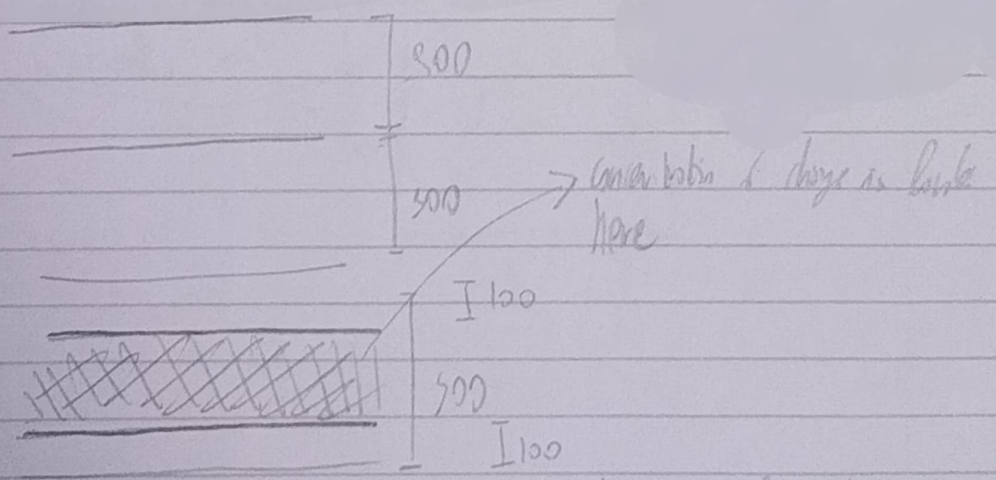
N_0 is dopant concentration of bulk Si, n Si

IP2

$N_0 = 10^{12}\ cm^{-3}$

SET UP





Assume a thickness of 0.5 μm ⇒ In order to get surface charge density all concentrations have been multiplied by this value

P3

DISCRETISED EQ.

$$\frac{V_S + V_W - 4V_P + V_E + V_N}{\delta x^2} = -\frac{N e}{\varepsilon_r \varepsilon_0}$$

$$\frac{V_S + V_W - 4V_P + V_E + V_N}{\delta x^2} \frac{\varepsilon_0}{e N_0} = -\frac{N}{N_0 \varepsilon_r}$$

$$V'_S + V_W' - 4V_P' + V_E' + V_N' = -\frac{N}{N_0 \varepsilon_r}$$

$$\boxed{V' = \frac{V \varepsilon_0}{N_0 e \delta x^2}}$$ Variable of the program

Here we can use

$$\boxed{\frac{N_A}{N_0} = 10^{-7} \qquad \frac{N_D}{N_0} = 1}$$

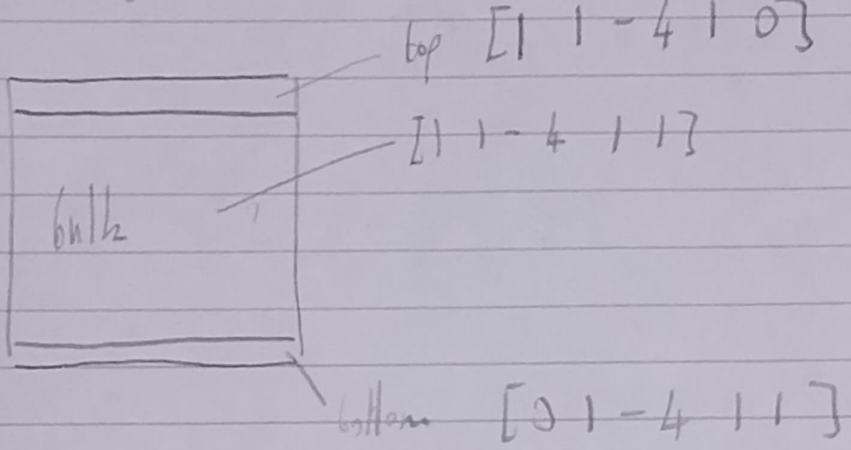
[redacted]

* the P implant is almost fully ionized, so we can just say that all of it is - charge

P4

Coefficients in The Discretised Equations

Sphere/rectangular duct periodic B.C.



Neighbouring cells