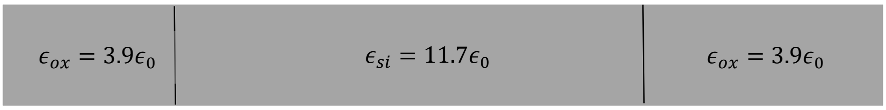
HW6

20202051 Nuripark

The workfunction of the gate metal is the energy difference bet the vacuum level and Fermi level. In our convention, the fermi level is 0eV, and V=4.3eV.

The energy difference bet the vacuum level and the intrinsic fermi level of silicon is 4.63eV. The intrinsic fermi level of silicon is at -0.33eV.



The difference with the previous homework is : $\phi(0) = \phi(a) = 0.33374V$. These values could be different by the gate voltage. We change the gate voltage 0 to 1.

$$\phi = 0.32V \rightarrow E_i = -0.32eV, E_c = 0.24eV \ldots E_c - E_f = 0.24eV$$

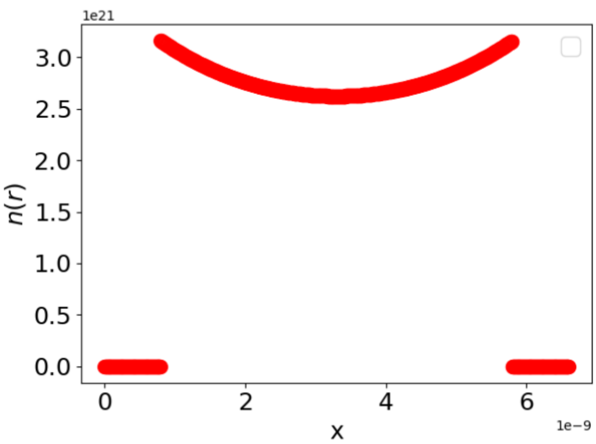
$$\phi = 1.32V \rightarrow E_i = -1.32eV, E_c = -0.76eV \ldots E_c - E_f = -0.76eV$$

If we apply large gate volatege, our electrostatic potential getting larger and also the electron density. That is contradicted with our depletion approximation. Thus we have to consider self-consistence solution.

Effective DOS of the conduction band, at 300K, $N_c = 2.86 * 10^{19} cm^{-3}$. At eqb, the electron density is $n(r) = N_C \exp\left(\frac{E_f - E_c}{k_B T}\right)$. However, we set E_f to zero. And the $E_c = -q\phi + E_c - E_i$.

$$n(r) = N_C \exp\left(\frac{q\phi - E_c + E_i}{k_B T}\right) = n_i \exp\left(\frac{\phi}{V_T}\right), p(r) = n_i \exp\left(-\frac{\phi}{V_T}\right)$$

We make the figure of electron density where the gate voltage is 0.



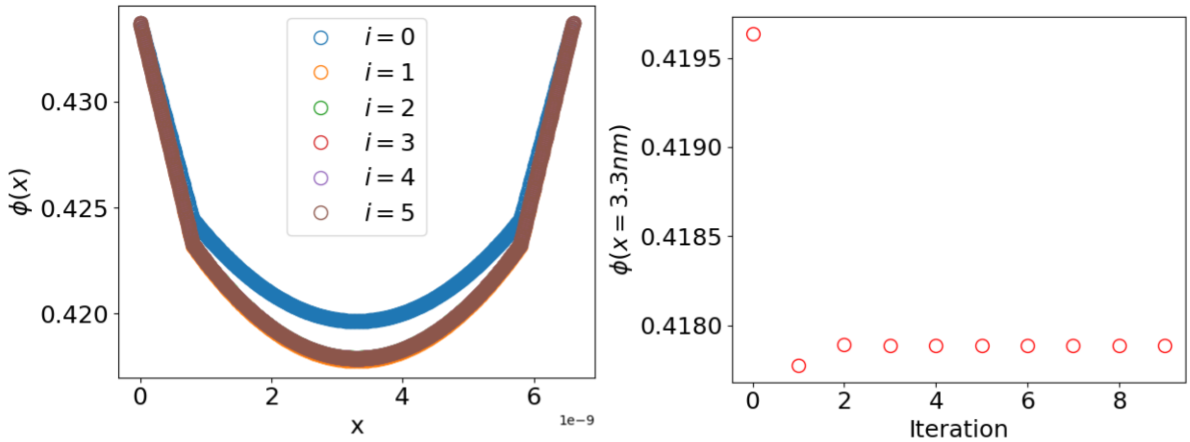
Now, lets go back to the posisson equation :

$$\frac{d}{dx}\left[\epsilon(x)\frac{d}{dx}\phi(x)\right] = -\rho(x), \qquad \rho(x) = q(p(x) - n(x) - N_{acc})$$

We can now consider electron & hole density. By using those densities, we now can earn ϕ again.

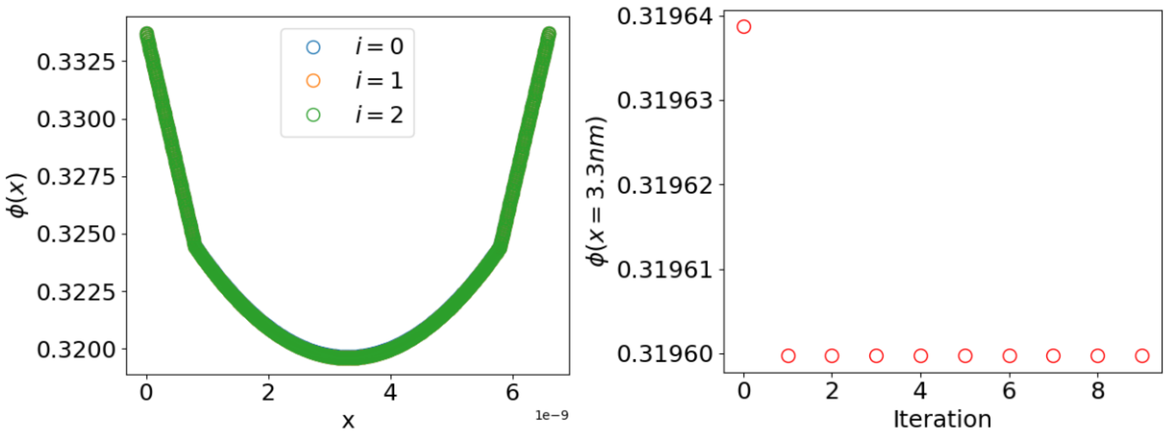
1. $V_{gate} = 0.1V$

Here is the result of $\phi(x)$ by the routine of density & voltage 'i' times iteratively.



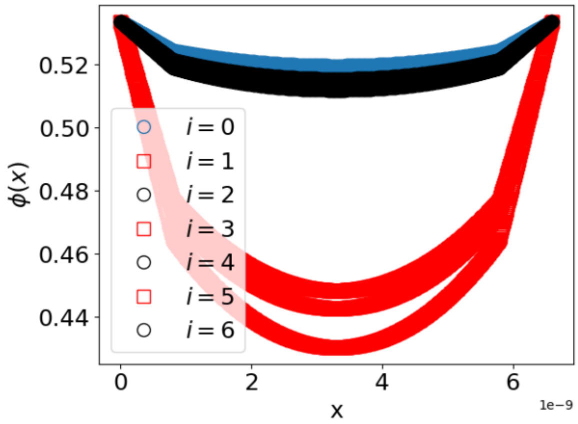
We can find that as the iteration goes, ϕ converge to some values. Since the center of voltage, $\phi(x = 3.3nm)$, changes most dramatically, lets see the behavior of $\phi(x = 3.3nm)$.

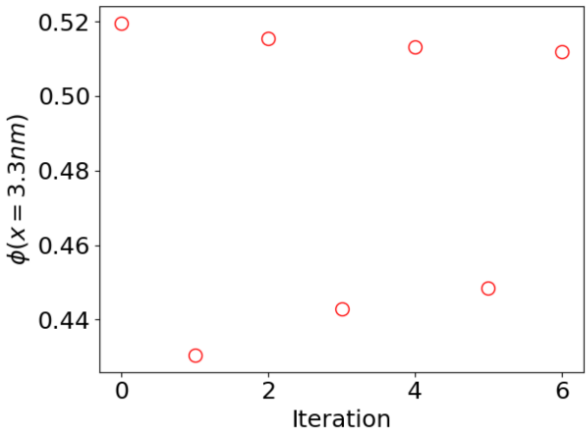
2. $V_{gate} = 0V$



This left figure tells us the reason why $V_{gate} = 0.1V$ is shown first. When $V_{gate} = 0V$, ϕ just look similar even though the density of electron & hole calculated iteratively.

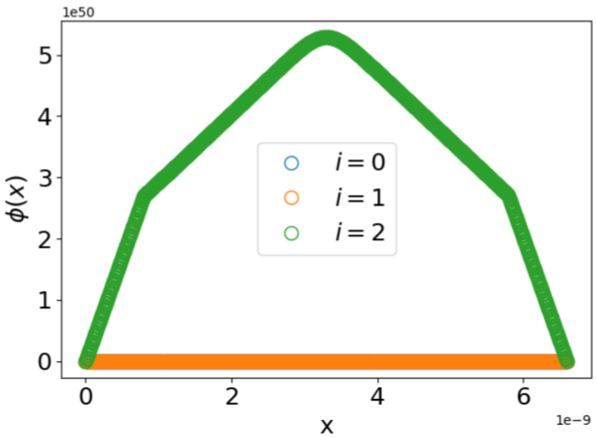
3. $V_{gate} = 0.2V$

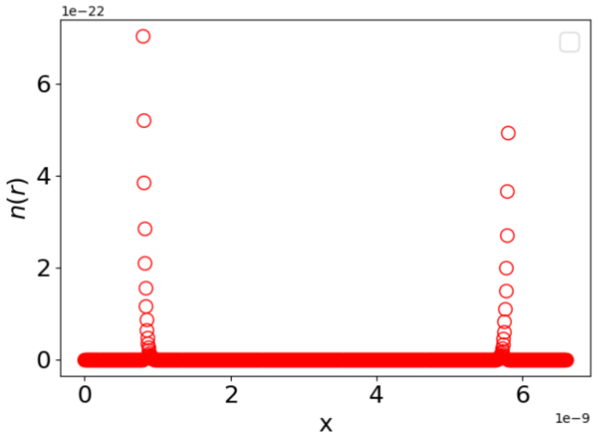




It shows another interesting behavior. Odd iterations are red. Even iterations are black. They show different behaviors. We also find the minimum value of $\phi(x = 3.3nm)$ in the right figure.

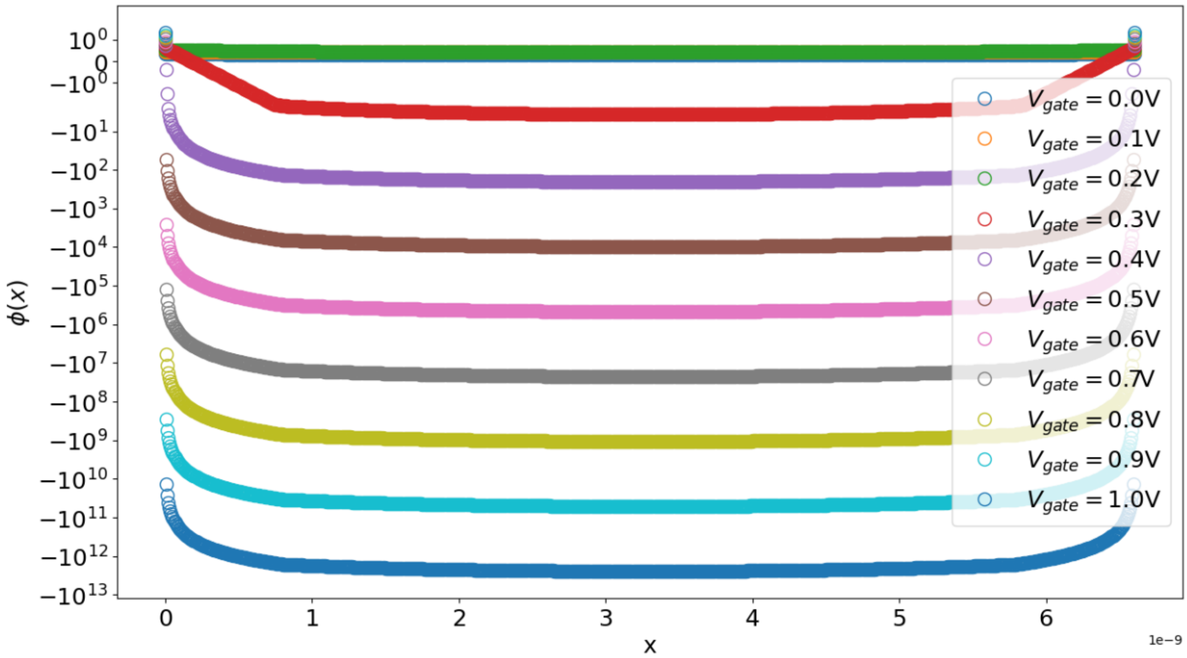
4. $V_{gate} \geq 0.3V$





Now it shows weird behavior. The density of electrons and holes diverges or converge to 0.

5. $V_{gate} = 0 \sim 1V$



Only one more steps are done to get the voltages.