Q1.

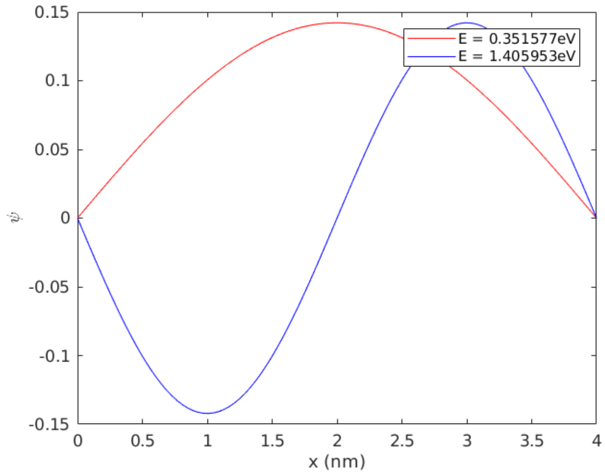

Figure 1: wavefunction for $x = 4nm$

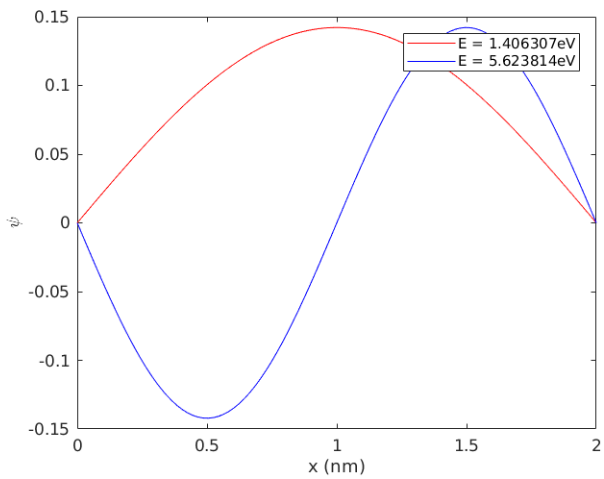

Figure 2: Wave function for $x = 2nm$

For a infinite potential well problem the Schrodinger equation can be written as

$$\frac{-\hbar^2}{2m^8}\frac{\partial^2\psi}{\partial x^2} = E\psi \tag{1}$$

Solution to Eq . 1 are of the form

$$\psi(x) = Asin(kx) + Bcos(kx), \text{ where } k = \frac{2m^*E}{\hbar^2} \tag{2}$$

Applying boundary conditions, $\psi(0/l) = 0$, in Eq. 2 we get

$$\psi(x) = Asin(\frac{n\pi x}{l}) \tag{3}$$

where l is the width of the well and A can be found by normalizing ψ. Comparing Eq3 and Fig. 1 we see that simulation results match with the analytical solution From Eq. 3 we got $k = n\pi/l$ therefore we can write

$$E(n) = \frac{\hbar^2 k^2}{2m^*} = \frac{n^2\hbar^2\pi^2}{2m^*l^2} \tag{4}$$

width	E(1) calculated	E(1) simulated	E(2) calculated	E(2) simulated
4 nm	0.3516eV	0.3516eV	1.406eV	1.4064eV
2 nm	1.4064eV	1.4064eV	5.6257eV	5.6257eV

Q2.

a.

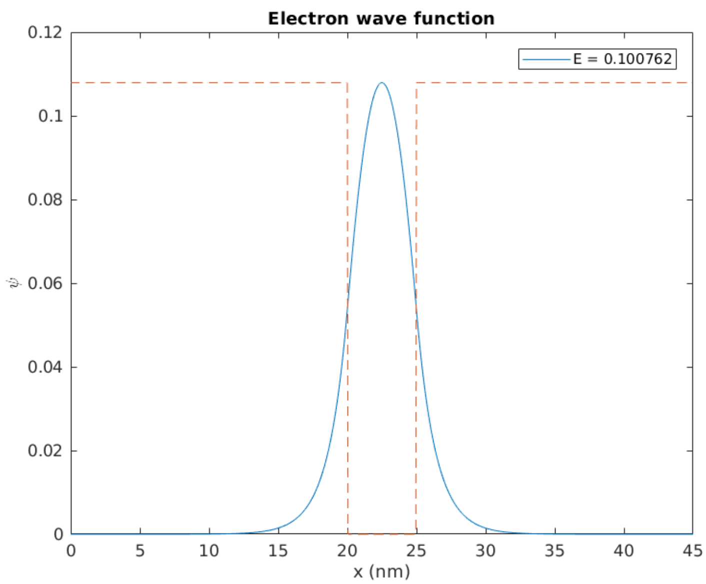

Figure 3: Electron Wave function for 1st bound state

b.

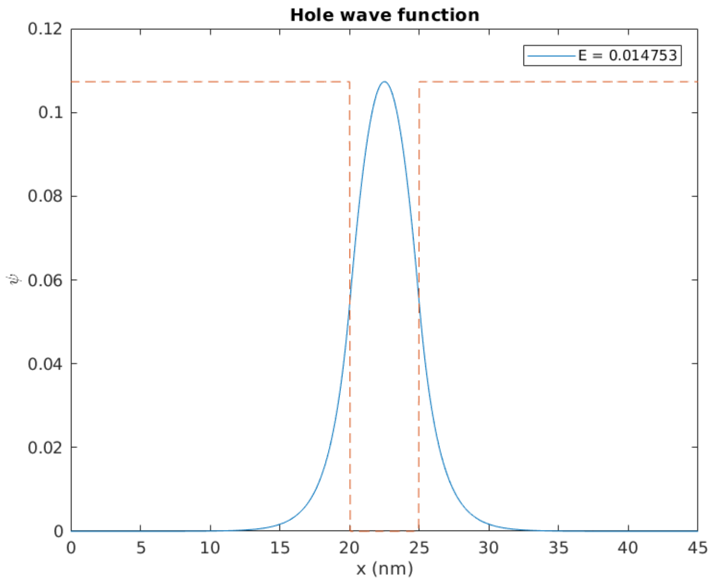

Figure 4: Hole Wave function for 1st bound state

As expected the electron and hole wave function in a finite potential well have a shape similar to the wave function in an infinite well within the well while decreasing exponentially in the barrier region

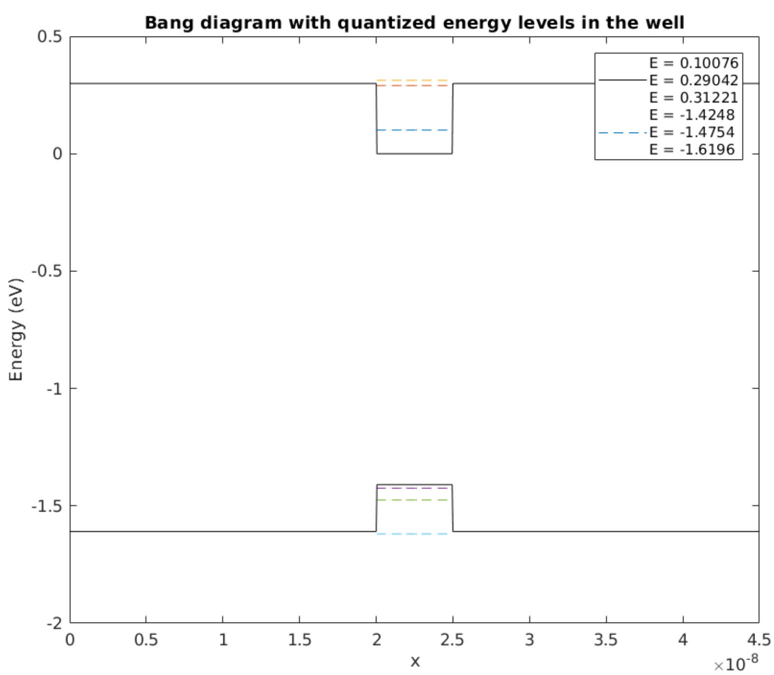

Figure 5: Energy Band Diagram with quantized Energy levels in the well

c.

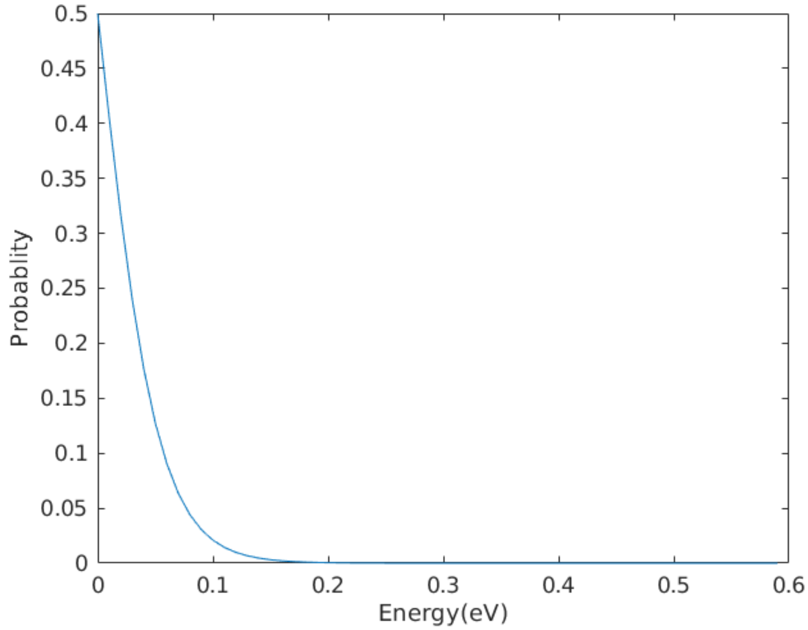

Figure 6: Electron probability

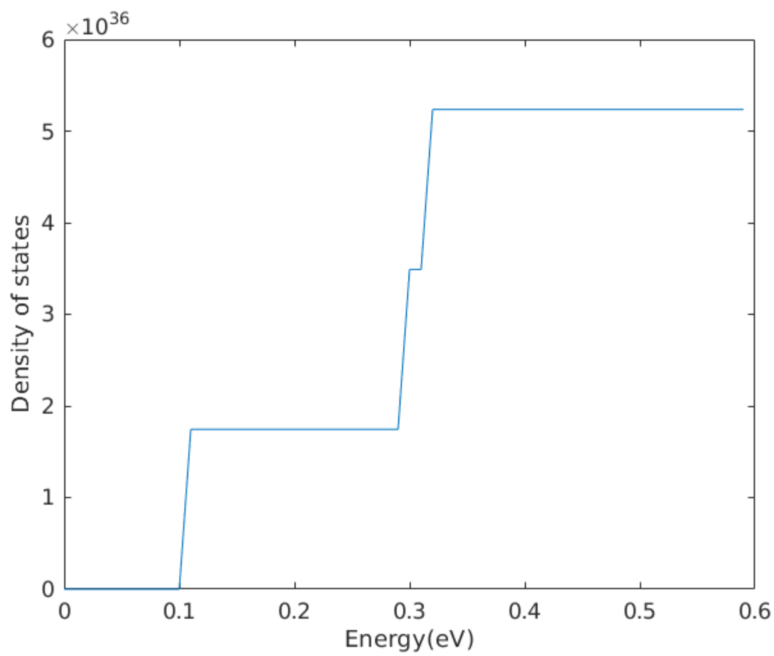

Figure 7: Density of states Beyond Ec

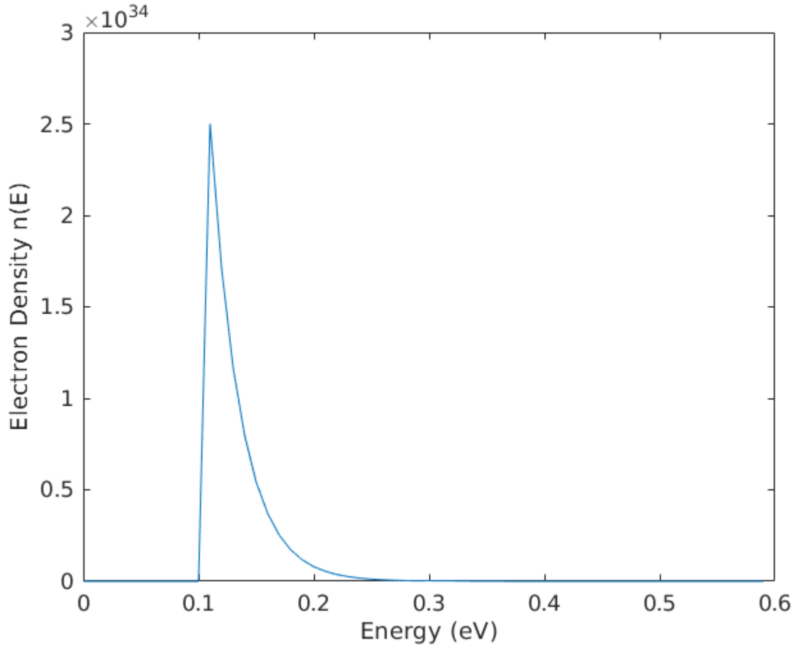

Figure 8: Electron density vs Energy

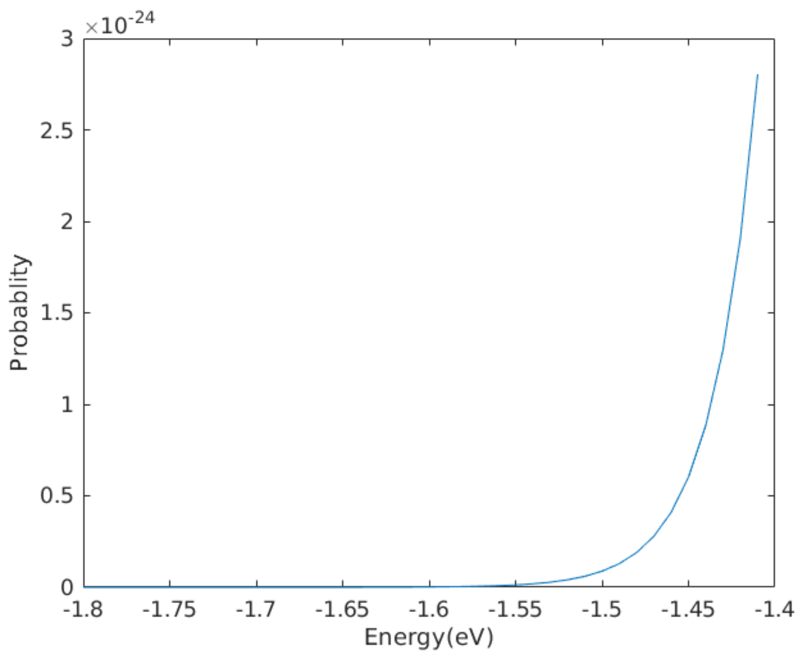

Figure 9: Hole probability

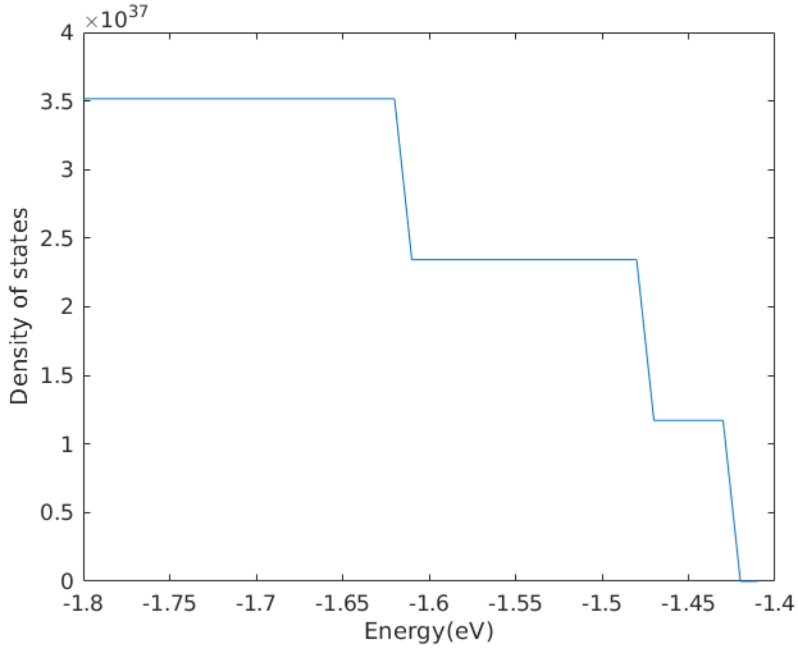

Figure 10: Density of states Beneath Ev

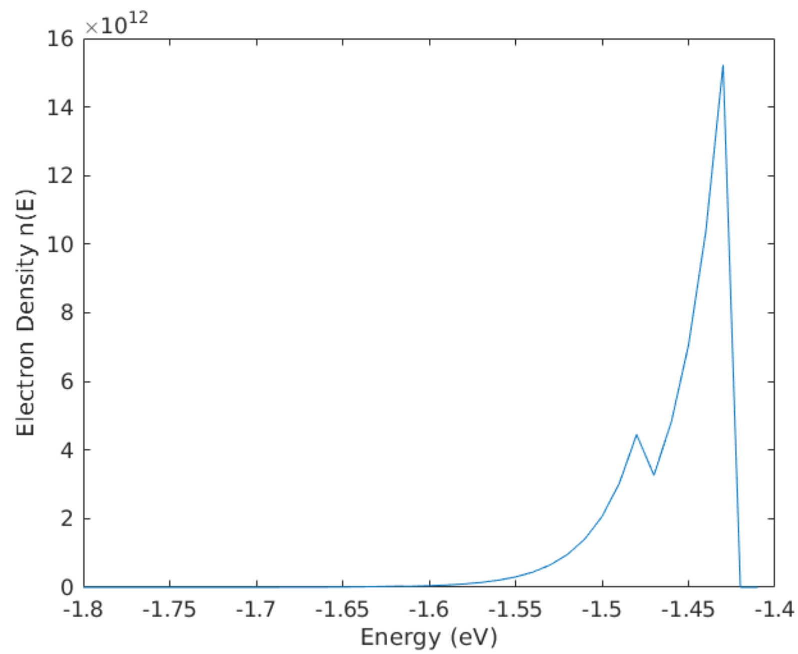

Figure 11: Hole density vs Energy

Fermi level (which is close to Ec of GaAs) is taken as the reference energy level to calculate probability and Density of states. As seen from in the above figures the discontinuities in the electron and whole distribution is expected in a quantum well system due to discritization of Energy levels in the well. 2D density of states relation is $g(E) = m^*/\hbar^2\pi$ for each discrete energy level which will add up to give unit step like figure as shown in Figs. 7, 10

Q3.

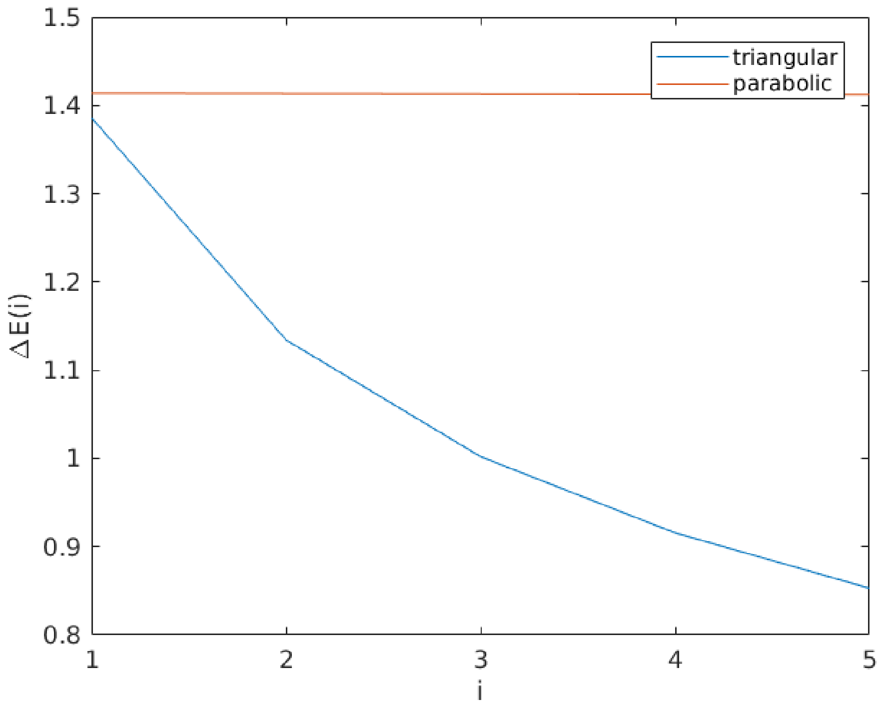

Figure 12: $\Delta E(i)$

Analytically, discrete energy level spacing decreases as we go up in a triangular well while in the case of parabolic well discrete energy level spacing remains same. We get a similar result from simulation

File name	Description
q1.m	Q1 code
q2.m	Q2 code
q3.m	Q3 code
173079020_Assignment04.pdf	this document

Table 1: Contents of zip file