1. Find out the first bound states for both electrons and holes for the following cases:

   (a) GaN / $In_{0.1}Ga_{0.9}N$ / GaN quantum well with 3 nm well thickness.

   (b) Repeat (a) with GaAs system. Find out the difference between electron and hole wavefunction separations ~~%~~ for both the cases.

   (c) GaAs / $In_{0.1}Ga_{0.9}As$ / GaAs / $In_{0.1}Ga_{0.7}As$ / GaAs – 100 nm / 3 nm / 10 nm / 3 nm / 100 nm. Find out the first bound state for electron. Repeat with the centre GaAs thickness at 1 nm. Comment on the difference betn. the first bound states for electrons.

   (d) Consider two quantum wells

   AlAs / GaAs / AlAs – 100 ~~nm~~ 3 / 100 nm

   $Al_xGa_{1-x}As$ / GaAs / $Al_xGa_{1-x}As$ – 100 nm / W / 100 nm

   Find out the value of W so that electrons have same bound state energy. Is there any difference in the bound state energy for the holes.

2. Design a GaAs based LED such that the peak emission occurs at 1.6 eV. You can choose a suitable barrier composition and thickness.

3. Define internal quantum efficiency and external quantum efficiency for LEDs.

Text

4. Show that for normal incidence the reflectance for both s and p polarization is given by

$$R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2$$

Text

5. What is the internal quantum efficiency for an ideal LED. The LED is made from GaAs. Find out the maximum external quantum efficiency.

6. The thickness of the p and n regions in a p-i-n LED should not be very large. Explain

if the p and n region will be large then there will be more series resistance

7. A quantum well LED always lead to some loss of energy due to carrier capture. Explain.

as there will always be loss wh e fall sin q well

8. Plot the ~~electron~~ following for 3D, 2D, 1D and 0D systems
   i) Density of states
   ii) Electrons distribution
   iii) Position of bound states