Habib University

School of Science & Engineering

Course	EE/CE – 211 – Basic Electronics
Semester	Spring 2024
Assignment	1
Due Date	Feb 12th, 2024
Instructor	Ahmad Usman
Total Marks	100

Name: ____Student ID: __________________

Note:

- Take a print of the assignment and solve on the space provided after every question. You can use extra sheets for your answers. Attach them properly.
- No assignment shall be graded if submitted late and don't comply the guidelines as mentioned above.

Course Learning Outcomes
After the completion of the course the student should be able to

CLOs	Description	Learning-domain level
CLO - 1	Explain and understand the working and behavior of semiconductor diodes, BJTs and MOSFETs in the modern electronic systems.	**Cog – 3**
CLO - 2	Ability to analyze DC and AC the behavior of the semiconductor diodes, BJTs, and MOSFETs in the modern electronic systems.	**Cog – 4**
CLO - 3	Develop an ability to design DC power supplies, DC biasing circuits and single stage amplifier circuits based on the concepts learned pertaining to semiconductor diodes, BJTs, and MOSFETs, for various modern electronic applications.	**Cog – 3**

Question # 1 (CLO – 1, Points: 10, 2.5 + 2.5 + 5)

The surface of a Silicon (Si) wafer is (100) plane.

(a) Sketch the placement of Si atoms on the surface of the wafer.

(b) Determine the number of atoms per cm^2 at the surface of the wafer.

(c) Repeat parts (a) and (b) for a surface of Si wafer to be (110) plane.

Question # 2 (CLO – 1, Point: 10, 2.5 + 2.5 + 2.5 + 2.5)

The Figure 1(a) below shows a crystalline plane. It has intercepts of 1a, 3a, and 1a on the x, y, z axes, respectively. The side length of a cubic cell is “a”.

(a) What is the Miller index notation for the plane?

(b) What is the Miller index notation for the direction normal to plane?

(c) Assuming the crystal structure to be cubic, determine the Miller indices for

  i) The plane shown in the Figure 1(b)

  ii) The vector shown in the Figure 1(b)

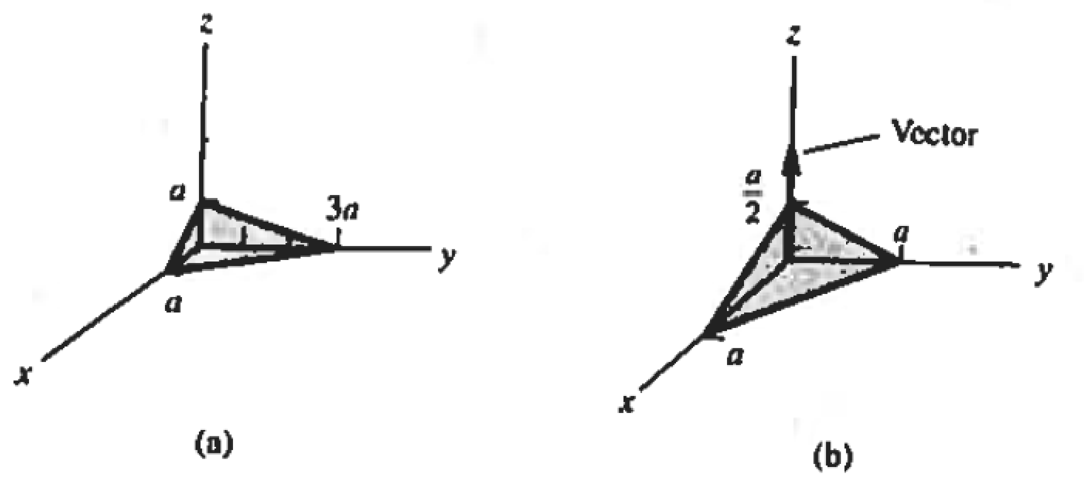


Figure: 1

Question # 3 (CLO – 1, Points: 10, 2 + 3 + 3 + 2)

A crystalline lattice is characterized by the cubic cell as shown in the Figure 2. The single cell has a single atom positioned at the center of the cube.

(a) What is the name of the lattice generated by the given unit cell?

(b) Determine the number of atoms per unit volume in the crystal. Provide your answer in terms of the lattice constant, a.

(c) Assume the crystal has a (110) surface plane. Determine the number of atoms per unit area whose centers lie on the plane (110) plane.

(d) A direction vector is drawn through the center of the atom in the unit cell. Specify the Miller indices of the direction vector.

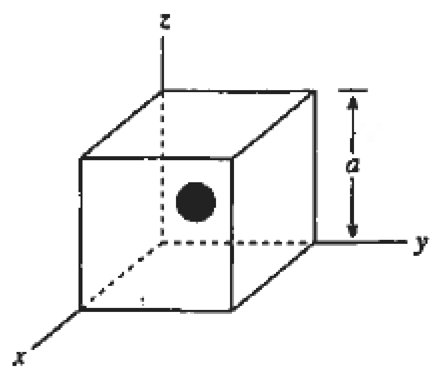


Figure: 2

Question # 4 (CLO – 2, Points: 10, 6 + 4)

The intrinsic carrier concentration of germanium (GE) is expressed as

$$n_i = 1.66 \times 10^{15} T^{3/2} \exp\frac{-Eg}{2kT} \text{ cm}^{-3}$$

where $E_g = 0.66$ eV.

(a) Calculate n_i at 300 K and 600 K and compare the results with those for Silicon.

(b) Determine the electron and hole concentrations if Ge is doped with Phosphorous (P) at a density of $5 \text{x} 10^{16}$ cm^{-3}.

Question # 5 (CLO – 1, Points: 10, 5 + 5)

An n-type piece of silicon experiences an electric field equal to 0.1 V/µm.

a) Calculate the velocity of electrons and holes in this material.
b) What doping level is necessary to provide a current density of 1 mA/µm under these conditions? Assume the hole current is negligible.

Question # 6 (CLO – 1, Points: 10, 5 + 5)

A n-type piece of silicon with a length of 0.1μm and a cross section area of 0.05μm × 0.05μm sustains a voltage difference of 1 V.

a) If the doping level is 10^{17} cm^{-3}, calculate the total current flowing through the device at T = 300 K.

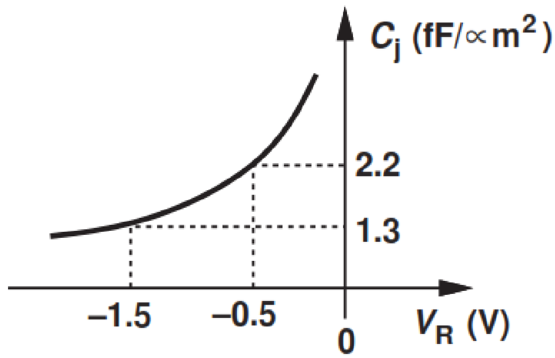
b) Repeat (a) for T = 400 K assuming for simplicity that mobility does not change with temperature. (This is not a good assumption.)

Question # 7 (CLO – 1, Points: 10)

Due to a manufacturing error, the p-side of a pn-junction has not been doped. If $N_D = 3 \times 10^{16}$ cm^{-3}, calculate the built-in potential at $T = 300$ K.

Question # 8 (CLO - 2, Points: 10, 5 + 5)

An oscillator application requires a variable capacitance with characteristics shown in figure below. Determine N_A and N_D.



Question # 9 (CLO – 2, Points: 10, 5 + 5)

Two identical pn junctions are placed in series.

a) Prove that this combination can be viewed as a single two-terminal device having an exponential characteristic.
b) For a tenfold change in the current, how much voltage change does such a device require?

Question # 10 (CLO – 2, Points: 10, 5 + 5)

Figure shows two diodes with reverse saturation currents of I_{S1} and I_{S2} placed in parallel.

a) Prove that the parallel combination operates as an exponential device.
b) If the total current is I_{TOT}, determine the current carried by each diode.