Name of the Program: B.Sc. Engg. (EE)
Semester: 4th

Date: May 21, 2024
Time: 10:00AM – 1:00PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination
Course No.: EEE 4409
Course Title: Semiconductor Physics

Summer Semester, A.Y. 2022-2023
Full Marks: 150
Time: 3 Hours

There are **05 (five)** questions. Answer **all 05 (five)** questions. Marks for parts of the questions and corresponding CO and PO are indicated in the right margin. Programmable calculators are not allowed. Do not write on this question paper. Symbols carry their usual meanings.

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1. a) Formulate the continuity equations for excess electron and hole concentrations in semiconductor using suitable diagram and necessary justifications. From those equations, formulate the diffusion equations. — 11+4 (CO1) (PO1)

   b) i. Define storage delay time in a p-n junction.
   ii. Derive the equation of junction capacitance of a p-n junction.
   iii. An abrupt Si p-n junction has cross-sectional area, $A = 5\times10^{-4}$ cm^2. Doping on p-side, $N_a = 10^{17}$ cm^{-3} and on n-side, $N_d = 10^{17}$ cm^{-3}. Relative permittivity of Si is 11.8. Find out the junction capacitance, C_j at a reverse-bias voltage of –5 V. — 4+6+5 (CO2) (PO2)

2. a) A metal-semiconductor junction has been formed with $\Phi_m > \Phi_s$. The semiconductor is p-type. Draw the energy band diagram as the function of distance from the junction. Explain why the junction is rectifying or ohmic using suitable diagram(s) with different voltage polarities. — 15 (CO2) (PO2)

   b) Using energy band diagram as a function of distance in an ideal MOS structure ($\Phi_m = \Phi_s$) with p-type semiconductor under strong inversion, explain different components of minimum gate voltage required for strong inversion. Also draw the charge density, electric field and electrostatic potential as functions of distance in the MOS structure at inversion. — 11+4 (CO3) (PO2)

3. a) Explain the ways of controlling the threshold voltage of a MOSFET during fabrication. Using suitable diagram and without using any equation, explain how substrate bias can be used in n-channel enhancement mode MOSFET to modify its threshold voltage. — 9+6 (CO3) (PO2)

   b) For generalized biasing of emitter-base and collector-base junctions in a p-n-p BJT, deduce the equation for minority carrier distribution in the base. Using the equation, draw the minority carrier profile in emitter, base and collector under normal biasing (E-B forward and C-B reverse biased) condition. — 9+6 (CO3) (PO2)

4. a) Starting from the general equations of terminal currents of a p-n-p BJT, deduce the Ebers-Moll equations and using that construct the equivalent circuit (coupled diode model) of the BJT under general biasing condition. — 15 (CO3) (PO2)

   b) Describe the considerations required for designing solar cells. — 15 (CO4) (PO2)

5. a) Explain the compromise to be made in designing photodetectors. Also, describe the basic operation and necessary considerations (for optimizing efficiency) of a light emitting diode. — 15 (CO4) (PO2)

   b) Describe the conditions for successful laser operation. Explain how population inversion can be achieved in semiconductor LASER. — 15 (CO4) (PO2)