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

Date: May 16, 2023
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. 2021-2022
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) Explain how Fermi function varies with electron energy for T = 0 K and T > 0 K in intrinsic semiconductors and for T > 0 K in extrinsic semiconductors. — 15 (CO1) (PO1, PO2, PO5)

   b) Derive the equations of injected minority carrier concentrations in the neutral regions of a forward-biased p-n junction as functions of distance from the transition region. Using the equations, derive the equation of diode current. — 15 (CO2) (PO1, PO2, PO5)

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) for forward-biased and reverse-biased conditions. — 15 (CO2) (PO1, PO2, PO5)

   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. — 15 (CO3) (PO1, PO2, PO5)

3. a) Draw the capacitance-voltage (C-V) characteristics of an ideal MOS structure and explain why capacitance varies with gate voltage in different regions of the characteristics. Also, explain two 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 p-channel enhancement mode MOSFET to modify its threshold voltage. — 15 (CO3) (PO1, PO2, PO5)

   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 and using that equation draw the minority carrier profile in emitter, base and collector under normal biasing (E-B forward and C-B reverse biased) condition. Also, deduce the general equations of terminal currents from the minority carrier profile. — 15 (CO3) (PO1, PO2, PO5)

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. Also, show the coupled diode model of the BJT under normal biasing condition (E-B forward and C-B reverse biased). — 15 (CO3) (PO1, PO2, PO5)

   b) Using current equation, I-V characteristics and circuit diagrams, explain how the same photodiode can be used either as a photodetector or as a solar cell. Describe the considerations required for designing solar cells. — 15 (CO4) (PO1, PO2)

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

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