B Sc in EEE, 1st Sem. Date: 03 April 2026 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF NATURAL SCIENCES

Semester Final Examination | Winter Semester: A.Y. 2024 - 2025
Course Number: PHY 4121 | Full Marks: 120
Course Title: Engineering Physics I | Time: 2 hours

Please answer according to the order of the questions. There are 4 **(four)** questions. Answer all 4 **(four)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding CO and PO are written in the brackets at right side.

1. a) State clearly the differences between the metal, insulator and semiconductor in terms of conductivity and energy band. (7.5) (CO1) (PO1)

   b) Demonstrate an expression for equilibrium concentration of electrons in the conduction band of an intrinsic semiconductor using Fermi-Dirac distribution probability function and density of states. (12+3) (CO2) (PO2)

   c) In an intrinsic semiconductor, the concentrations of electrons in the conduction band and of holes in the valence band are expressed as: $n = 2\left(\frac{2\pi m_e^* k_B T}{h^2}\right)^{3/2} e^{-(E_C - E_F)/k_B T}$, and $p = 2\left(\frac{2\pi m_h^* k_B T}{h^2}\right)^{3/2} e^{-(E_F - E_V)/k_B T}$, where the symbols have their usual meanings. (7.5) (CO3) (PO2)

      (i) Determine the Fermi energy using the equations given above for an intrinsic semiconductor in terms of the effective masses of the electrons and holes.

      (ii) Compute the Fermi energy at $T = 300\ K$ of an intrinsic semiconductor with conduction band minimum $E_C = 1.2\ eV$, valence band maximum $E_V = 0\ eV$, electron effective mass $m_e^* = 0.1m_e$, and hole effective mass $m_h^* = 0.5m_e$.

2. a) Describe briefly the fundamental characteristics of the diamagnetic, paramagnetic, and ferromagnetic materials. (7.5) (CO1) (PO1)

   b) (i) Depict the B-H hysteresis loop for a ferromagnetic material suitable for permanent magnets. Identify the saturation flux density, residual flux density, and coercive field intensity. (15) (CO2) (PO2)
   (ii) Demonstrate that the area enclosed by the B-H hysteresis loop represents the energy dissipated per unit volume of the material during each cycle of magnetization.

   c) The area of the hysteresis loop of a 1200 cm^3 ferromagnetic material is 0.9 cm^2 with B_{max} = 1.5 Tesla. The scale factors are 1 cm = 10 Amp/m along x-axis and 1 cm = 0.8 Tesla along y-axis. Calculate the power loss in Watts due to hysteresis if this material is subjected to an 50 Hz alternating flux density with a peak value 1.5 Tesla. (7.5) (CO3) (PO2)

3. a) State the differences between Fresnel diffraction and Fraunhofer diffraction. Describe the changes in the diffraction pattern when (i) the wavelength of light increases, and (ii) the slit width increases. (7.5) (CO1) (PO1)

b) Depict the intensity distribution of light due to a single slit diffraction, given by $I \approx A^2 = A_0^2 \frac{(\sin\beta)^2}{\beta^2}$, and hence find the positions and intensities of secondary maxima relative to the principal maximum. The symbols in the equation have their usual meaning. (15) (CO2) (PO2)

c) In an experiment with single slit diffraction of 532 nm light, the angular width of the central maximum is observed to be $\pi/3$. Determine the width of the slit. (7.5) (CO3) (PO2)

4. a) State Brewster's law for the polarization of light. An unpolarized light of intensity I_0 is incident on a set of polarizer and analyzer. The intensity of light transmitted through the analyzer is $\frac{1}{2} I_0$. Describe it in terms of Malus's law. (7.5) (CO1) (PO1)

b) Describe the photoelectric effect phenomenon and find the expression of Einstein's photoelectric equation. Explain the importance of metals to observe the photoelectric effect. (15) (CO2) (PO2)

c) The work function of Calcium is $2.7\ eV$. An electromagnetic radiation of frequency $8\times10^{14}\ Hz$ is applied to Calcium. Calculate the kinetic energy of the photoelectrons leaving the Calcium. (7.5) (CO3) (PO2)