B Sc in EEE, 1st Sem. Date: 09 January 2026

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF NATURAL SCIENCES

Mid Semester 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.

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1. a) Describe briefly the ionic, covalent, metallic, and van der Waals bonds. Give examples of materials for each of these bonding types. (7.5) (CO1) (PO1)

   b) (i) Demonstrate that the expression for the energy levels of the hydrogen atom using Bohr atomic model can be expressed by $E_n = -\left[\frac{m}{2\hbar^2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\right]\frac{1}{n^2}$ for $n = 1, 2, 3, 4, \ldots\ldots$, where m is the electron mass, e is the magnitude of the electronic charge, ε_0 is the permittivity of free space, $\hbar$ is the reduced Planck constant and the characteristic size of the atom is given by the Bohr radius $a \equiv \frac{4\pi\varepsilon_0\hbar^2}{me^2} \approx 0.5 \times 10^{-10} m$. (12+3) (CO2) (PO2)

   (ii) Discuss that the reciprocal wavelength for the transition in a hydrogen atom from a lower energy level to a higher energy level can be demonstrated as $\frac{1}{\lambda} = \frac{me^4}{8\varepsilon_0^2 ch^3}\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$, where the symbols have their usual meanings.

   c) The energy of the n^{th} state of hydrogen atom is expressed as $\frac{-13.6\ eV}{n^2}$. The energy associated with a transition between $n_2 = 3$ state and $n_1 = 2$ state is (7.5) (CO3) (PO2)

   $$E_{n_2} - E_{n_1} = \Delta E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) eV.$$

   Calculate the energy required for the transition from $n_2 = 3$ state to the $n_1 = 2$ state and determine the frequency of photon that causes an electron to make this transition.

2. a) State the postulates and success of the Drude and Lorentz classical free electron theory. (7.5) (CO1) (PO1)

   b) Demonstrate the expression for the current density J of a metal under the application of an electric field E using the classical free electron gas theory. Hence, estimate that the electrical conductivity σ of a metal can be expressed as (15) (CO2) (PO2)

   $$\sigma = \frac{ne^2\lambda}{\sqrt{3mk_BT}},$$

   where e is the electronic charge, n is the number of electrons per unit volume, λ is the mean free path of the electrons, m is the electron mass, k_B is the Boltzmann constant, and T is the absolute temperature.

c) (i) Determine the Miller indices of a plane that intercepts the x-axis at a, the y-axis at $3a$, and the z-axis at $4a$. (7.5) (CO3) (PO2)
(ii) Compute the charge carrier relaxation time, at room temperature, in n-type silicon specimen for which the electrical conductivity is $500\ \Omega^{-1}m^{-1}$ and the concentration of donor impurities is $1 \times 10^{22}\ m^{-3}$. You may assume the effective mass of an electron to be $0.5\ m_e$.

3. a) Describe the techniques of producing the coherent sources of light by the division of wavefront and division of amplitude. Give examples for both cases. (7.5) (CO1) (PO1)

b) Demonstrate Young's double slit interference experiment and express that the separation between two consecutive bright or dark fringes will be $\beta = \frac{\lambda D}{d}$, where the symbols have their usual meanings. (15) (CO2) (PO2)

c) Young's experiment is performed with blue-green light of wavelength 500 nm. The slits are 1.20 mm apart, and the viewing screen is 5.40 m from the slits. Determine the separation between the bright fringes near the center of the interference pattern. (7.5) (CO3) (PO2)

4. a) Describe the formation of circular fringes and, explain why the central spot is dark in Newton's rings interference experiment. (7.5) (CO1) (PO1)

b) Demonstrate Newton's ring interference experiment and explain with the relevant mathematical expressions, how the refractive index of a liquid can be determined using this experiment. (15) (CO2) (PO2)

c) A Newton's rings apparatus is arranged such that the radii of the n^{th} and $(n + 20)^{th}$ bright rings are found to be 0.162 and 0.368 cm, respectively, using 546 nm light. Calculate the radius of curvature of the lower surface of the lens. (7.5) (CO3) (PO2)