B.Sc. Eng.ME/IPE/1st Sem. Date:17 April 2025

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF NATURAL SCIENCES

Semester Final Examination **Winter Semester**: 2023-2024
Course Number: PHY 4113 **Full Marks**: 120
Course Title: Structure of Matter, Electricity, Magnetism and Modern Physics **Time**: 2 Hours

Please answer according to the order of the questions. Answer all the **4 (FOUR)** questions. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in the brackets.

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1. a) State Faraday's first and second laws of electromagnetic induction. (6) (CO1) (PO1)

b) Describe Kirchhoff's current and voltage law and discuss how to employ them in circuit analysis. (6) (CO1) (PO1)

c) Draw the M-H hysteresis curve for ferromagnetic materials and label the following terms with definition: (6) (CO1) (PO1)

i. Saturation magnetization
ii. Remanence
iii. Coercive field

2. a) i) Justify that the inductance of a long solenoid depends on its geometry. (6+14) (CO2) (PO2)
ii) For an LR circuit discuss the growth of current. Relate the value of current i at any time t with maximum or steady state current i_0 along with graphical representation.

b) From the concept of Compton scattering explain that the change in the wavelength of a photon scattered by an electron at rest can be shown by the expression (20) (CO2) (PO2)

$$\lambda' - \lambda = \frac{h}{m_0 - c}(1 - \cos\varphi)$$

Where the terms have their usual meanings.

c) i) Explain the type of force experienced by a moving charge when placed in a magnetic field. Extend your answer to illustrate the force on a current carrying wire in an uniform magnetic field. (17+3) (CO2) (PO2)
ii) Discuss the formula for finding the direction of magnetic force.

3. a) Determine the relationship between current and voltage in a capacitor that has a time varying voltage supply. (7) (CO3) (PO2)

b) Apply Biot-Savart's law to derive the mathematical expression for magnetic flux density at a point, due to a nearby current-carrying conductor. (7) (CO3) (PO2)

c) i) Calculate the electric current that flows in the circuit in figure 1. (4+3) (CO3) (PO2)

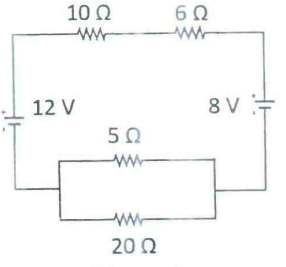

Figure: 1

ii) The magnetic flux associated with a coil changes from zero to 6×10^{-2} Wb in 0.6 s. Determine the average e.m.f. induced in the coil.

4. a) i) Calculate the threshold frequency and the corresponding wavelength of radiation incident on a certain metal whose work function is 3.31×10^{-19} joules. (3.5+3.5) (CO3) (PO2)
ii) Compute the wavelength of the X-rays scattered at 180 degree, when the initial wavelength of X ray was 140 pm.

b) i) A long straight wire in the horizontal plane carries a current of 50 A in the north to south direction. Calculate the magnitude and direction of magnetic field B at a point 2.5 m east to the wire. (3.5+3.5) (CO3) (PO2)
ii) A 3.0 cm wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27 T. Calculate is the magnitude of magnetic force on the wire and mention the direction.

c) i) Calculate the velocity and de-Broglie wavelength of an α-particle of energy 1 keV. Mass of the α-particle is 6.68×10^{-27}kg. (3+4) (CO3) (PO2)
ii) For a radioactive disintegration process, use the radioactive decay law to demonstrate a relation between the number of atoms present at any time t with the number of atoms initially present.