END SEMESTER EXAMINATION, JULY-2023
University Physics: Electricity & Magnetism (PHY 2001)

Programme: B.Tech **Semester: 2nd**
Full Marks: 60 **Time: 3 Hours**

Subject/Course Learning Outcome	*Taxonomy Level	Ques. Nos.	Marks
CO-1: Able to comprehend Laws of electricity and magnetism Electromagnetic waves, active components of dc and ac circuits.	L_1, L_2	1(a),2(a),3(a), 4(a),5(a),6(a), 7 (a), 8 (a)	16
CO-2: Able to apply theoretical concepts and laws of electricity & magnetism to solve problems related to circuits analysis, electromagnetic theory and relevant engineering applications.	L_2, L_3	1(b), 2(b), 3(b), 4(b),5(b),6 (c), 7(b)	14
CO-3: Able to apply the fundamental laws of electromagnetism to give appropriate solutions to complex problems, design experiments and circuits, design small electrical equipments related to day to day life.	L_2, L_3	1(c), 2(c), 3(c), 4(c),5(c), 6 (b),7 (c),	14
CO-4: Able to apply the concepts of electromagnetism to conduct the experiments, acquire data in order to explore physical principles, effectively communicate the results and critically analyze & interpret the observed data related to scientific/engineering studies.	L_2, L_3, L_4	9 (a),10 (a)	4
CO-5: Able to apply the concepts of electromagnetic force, electromagnetic wave to select and apply appropriate technique to design small engineering tools.	L_2, L_3, L_4	8 (b), 8 (c),9 (b), 9(c)	8
CO-6: Able to apply the concepts of use of circuit elements in dc and ac electrical circuits analyze their effects and response to various electromagnetic fields and can assess the safety measures.	L_2, L_3, L_4	10 (b), 10 (c)	4

Bloom's taxonomy levels:** ***Remembering (L1), Understanding (L2), Applying (L3), Analysing (L4), Evaluating (L5), Creating (L6)

Answer all questions. Each question carries equal mark.

1. (a) Evaluate the potential energy of an electric dipole in a uniform external electric field. 2
   (b) An electric dipole is in a uniform electric field of magnitude $5x10^5 N/C$. The charges are $\pm$ 1.6×10^{-19} C each and are separated by 0.125 nm. Find the magnitude of the potential energy of the dipole if it makes an angle 145^0 with the direction of electric field. 2
   (c) An electric dipole is placed in a region of uniform electric field E, with the electric dipole moment p, pointing in the direction opposite to E. Is the dipole (i) in stable equilibrium (ii) in unstable equilibrium (iii) neither? Justify. 2
2. (a) A charged non-conducting sphere of radius R has a total positive charge q. Find the electric field at any point inside the sphere. 2
   (b) A solid non-conducting sphere with radius 0.45 m carries a net charge of 0.25nC. Find the magnitude of the electric field at a point 0.1 m inside and outside the surface of the sphere. 2
   (c) An amount of charge 'Q' is placed on an irregularly shaped conductor. Can it be possible to calculate the electric field at an arbitrary position outside the conductor applying the Gauss law if the shape and size of the conductor is known? Justify your answer. 2
3. (a) Derive an expression for electric field in terms of potential gradient. 2
   (b) A small particle has charge – 5 μC and mass 2 x 10^{-4}kg. It moves from point 'A' where the electric potential is V_A = + 200V, to point 'B' where the electric potential is V_B = + 800V. The electric force is the only force acting on the particle. The particle has speed 5m/s at point 'A'. What is its speed at point 'B'? Is it moving faster or slower at 'B' than at 'A'? Explain. 2
   (c) If the electric potential at a certain point is zero, does the electric field at that point have to be zero? 2
4. (a) Derive an expression for energy density of a capacitor having Capacitance 'C', Cross sectional Area of each plate 'A' and Separation between each plate 'd'. 2
   (b) Consider a parallel plate capacitor, in which each plate has an area of 0.2 m^2 and are 0.01m apart. We connect the capacitor to a power supply, charge it to a potential difference V_0 = 3 kV and disconnect the power supply. We then insert a sheet of insulating plastic material between the plates, completely filling the space between them. We find that the potential difference decreases to 1.00 kV while the charge on each capacitor plate remains constant. Find the energy density, both before and after the dielectric sheet is inserted. 2

   (c) A capacitor has vacuum in the space between the conductors. If you double the amount of charge on each conductor, what happens to the capacitance? Justify your answer. 2
5. (a) Derive the expression for current in a conducting wire in terms of drift velocity. 2
   (b) A copper wire of diameter 1mm carries a current of 1.75 A to a 200-W lamp. The free electron density in the wire is 8.5 × 10^{28} per cubic meter. Find (i) the current density; and (ii) the drift velocity. 2
   (c) Suppose you replace the copper wire as in Q.5 (b) to another copper wire having twice diameter. If the current remains same, what will be the magnitude of drift velocity? 2
6. (a) A charged capacitor of capacitance C is discharged through a resistor of resistance R. Obtain the expression for instantaneous charge on the capacitor during discharging. 2
   (b) A 1.50-μF capacitor is charging through a 12.0-Ω resistor using a 10.0-V battery. What will be the current when the capacitor has acquired ¼ of its maximum charge? Will it be ¼ of the maximum current? 2
   (c) Show graphically the variation of charge q and current i with time when the charged capacitor is being discharged in RC circuit. 2
7. (a) Evaluate the force on a current carrying conductor in a magnetic field. 2
   (b) A straight horizontal copper rod carries a current of 50A from west to east in a region between the poles of a large electromagnet. In this region there is a horizontal magnetic field toward the northeast (that is, 45° north of east) with magnitude 1.20 T. Find the magnitude and direction of the force on a 1.00-m section of rod. 2
   (c) If you double the speed of the charged particle in a magnetic field while keeping the magnetic field, charge and mass constant, how does this affect the radius of the trajectory and time required to complete one circular orbit. 2
8. (a) State Ampere's circuital law and express its modified form with help of displacement current. 2
   (b) A cylindrical conductor with radius R carries a current I. The current is uniformly distributed over the cross-sectional area of the conductor. Find the magnetic field as a function of the distance r from the conductor axis for points both inside ($r < R$) and outside ($r > R$) the conductor. 2
   (c) A closed curve encircles several conductors. The close line integral of magnetic field around this curve is 3.83×10^{-4} Tm. (a) What is the current in the conductors? (b) If you were to integrate around the curve in the opposite direction, what would be the value of the line integral? 2

9. (a) Express the instantaneous current in an R-L circuit when there is growth of current. Explain it graphically. 2

(b) A 35.0-V battery with negligible internal resistance, a resistor of resistance 50.0Ω and a 1.25-mH inductor with negligible resistance are connected in series with an open switch. The switch is suddenly closed. How long after closing the switch will the current through the inductor reach one-half of its maximum value? 2

(c) Explain the charge oscillation in LC Circuit. 2

10 (a) Write the key features of electromagnetic wave. 2

(b) For an electromagnetic wave propagating through free space, calculate the frequency of a wave, with a wavelength of (a) 30 Å; (b) 300 Å; (c) 3000 Å and (d) 30 m. 2

(c) Express the Maxwell's electromagnetic equations which are not changed in the presence of charges and currents. 2

End of Questions