B.Sc. 2nd Semester (Honours) Examination, 2022 (CBCS)
Subject: Physics
Paper: CC-3
Electricity and Magnetism

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own word as far as practicable.
Symbols have their usual meanings.

Group-A

1. Answer any five questions **2x5= 10**

a. What is electrical susceptibility of a dielectric medium? What is its unit?

b. Express the Gauss's law for dielectric in both integral and differential form, explaining each symbol.

c. Define electric displacement vector $\vec{D}$.

d. Three resistances R_1, R_2 and R_3 are connected in parallel between two points A and B. If we connect a cell (of negligible internal resistance) with emf E between A and B, then what will be the equivalent resistance of the circuit between A and B?

e. Show that the electrostatic energy of a charged capacitor (charge= Q and capacitance=C) is given by $U= 0.5Q^2/C$.

f. Show that the force experienced by the plates carrying the charge +q of an isolated air-filled parallel plate capacitor is $-q^2/2\varepsilon_0 A$, where A is the plate area.

g. What is the origin of magnetostatic field $\vec{B}$? What is the significance of the equation $\nabla.\vec{B} =0$?

h. State the difference between ballistic and deadbeat galvanometers.

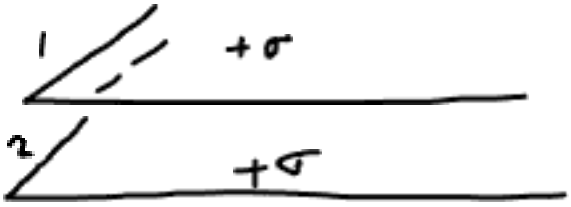
Group-B

Answer any two questions **5x2= 10**

2. State and prove the maximum power transfer theorem. 2+3

3. Two large non conducting (parallel to each other) sheets with identical positive charge distribution σ are placed close to each other as shown in the figure alongside. a) draw the

direction of electric field on both side of each surface, b) calculate the electric field above the sheet, between the sheets and below the sheet. 2+1+1+1



4. State Lenz's law. For a circuit having self-inductance L and carrying current I, show that the magnetic energy U stored in the system is $U = \frac{1}{2} LI^2$. 2+3

5. A small ball of mass $4x10^{-9}$ kg is kept suspended over a very large horizontal sheet of surface charge density, $\sigma = 5 \times 10^{-6}$ C/m^2. How much charge needs to be induced to the ball so that it remains suspended at its place without any physical support and does not fall down? What would be the force due to the electric field on the ball, if the charge density of the horizontal sheet is doubled? 3+2

Group-C

Answer any two questions **10x2= 20**

6.i) State Amperes circuital law. Using Amperes circuital law, calculate the magnetic field, both inside and outside of a toroid. 2+ (2+1)

ii) Define magnetic vector potential. Show that $\nabla^2 \vec{A} = -\mu_0 \vec{J}$, 2+3

7. i) Calculate the force between two equal parallel circular coaxial coils (radius r) which are at a small distance (d) apart in free space and carrying currents I_1 and I_2 respectively. Assume each of the coil has a single turn. When will the force be attractive and repulsive? 3+2

ii) A long cylinder carries a charge density that is proportional to the distance from the central axis: $\rho = ks$, for some constant k. Find the electric field inside the cylinder.

8. i) In a ballistic galvanometer circuit, a tapping key is often utilized to stop the oscillations of the galvanometer. How does it work?

ii) What is critical damping resistance? What is its significance?

iii) What is the relationship between charge sensitivity and current sensitivity of the moving coil galvanometer? 3+(3+2)+2

9. A Wheatstone bridge consists of four resistances R_1, R_2, R_3 and R_4 connected externally to a battery with emf E and internal resistance r_i. A galvanometer G (interal resistance r_g) is connected across at the junctions of resistors R_1, R_2 and R_3 and R_4. What is the balanced condition of the Wheatstone bridge? Show that under balanced condition $R_1/ R_2 = R_3/ R_4$

2+8