B.Sc. (Honours) Examination, 2019

Semester-II

Physics (Honours)

Course: BPC-21

(Electricity & Magnetism-I)

Time: Three Hours **Full Marks: 40**

Questions are of value as indicated in the margin.

Answer ***any four*** questions.

1. a) State and explain Gauss's theorem in electrostatics.
   b) Using Gauss's theorem obtain the electric field due to a uniformly charged solid sphere at points inside and outside the sphere. Show graphically the variation of electric field with distance starting from the centre of the sphere.
   c) Obtain Coulomb's law applying Gauss's theorem. 2+(4+1)+3=10

2. a) Define electric potential and equipotential surface.
   b) Deduce a relation between electric field and potential.
   c) Two long coaxial hollow cylinders of radii a and b, $(a < b)$ are charged to potentials V_a and V_b, respectively. Show that the potential at any point between the cylinders at a distance r from the axis is given by $V(r) = V_a - (V_a - V_b)\frac{\ln(\frac{r}{a})}{\ln(\frac{b}{a})}$.

   2+3+5=10

3. a) What are dielectric polarization and bound charge?
   b) Establish the following relations: (i) $\bar{D} = \epsilon_0\bar{E} + \bar{P}$ and (ii) $\bar{P} = \epsilon_0(K-1)\bar{E}$ where $\bar{D}, \bar{E}, \bar{P}, \epsilon_0$ and K have their usual meaning.
   c) A small cavity is made in a dielectric where the electric field $\bar{E}$ is uniform. If $\bar{P}$ be the uniform polarization in the dielectric, show that the electric field at the centre of the cavity is $\bar{E}_0 = \bar{E} + \frac{\bar{P}}{3\epsilon_0}$. 2+4+4=10

4. a) Define electric dipole and dipole moment.
   b) Find expressions for potential and electric field due to a dipole.
   c) What will be the potential energy of the dipole in an external electric field?

   2+5+3=10

5. a) Find the capacitance of a spherical capacitor. What will happen when the outer sphere is very large in comparison to the inner sphere?
   b) N identical spherical drops of liquid are charged to the same potential V. One large drop is formed by combining these. Show that the potential of the large drop is $N^{2/3}V$ and its capacity is $N^{1/3}$ times of that of the smaller drop.
   c) Two insulated spherical conductors having capacitances C_1 and C_2 are charged with Q_1 and Q_2, respectively. Now they are brought in contact through a conducting wire. Will the total energy of the system remain conserved under this condition? Justify your answer. (3+1)+2+4=10

P.T.O.

6. a) State Kirchoff's laws for network of conductors.
   b) What is the limitation of a Wheatstone bridge for determining very low resistances? By constructing a Kelvin's double bridge, explain how this limitation can be removed.
   c) Show that the electric field is a conservative field. 2+5+3=10

7. a) Let a point charge +q is placed in front of a conducting plane of infinite extent maintained at zero potential. Using the method images, calculate the induced surface charge density on the conducting plane and the image charge.
   b) Show that the energy required to build up a current i in a circuit of self-inductance L is $\frac{1}{2}Li^2$. Hence, establish that the co-efficient of self-inductance is numerically twice the work done in establishing a unit current in an inductor.
   c) Prove $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ where the symbols have their usual meaning. 5+(2+1)+2=10
