Code: Phy/ EM-1/EFnP/001

Electromagnetism: Electric Field and Potential – Typical Questions

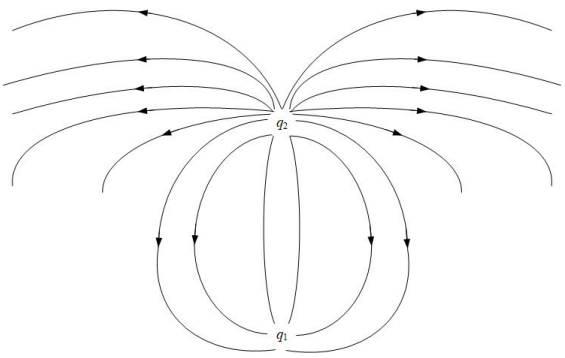
No of Questions: 80 **Time Allotted: 9 Hours (in 2 parts)**

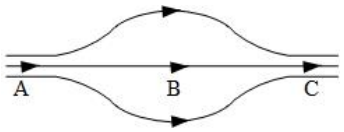
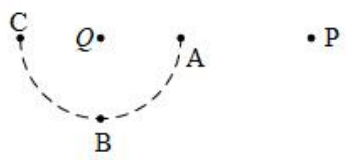
All questions are compulsory

[Note: a. Figures are conceptual only and not to the scale**]**

[b. Solutions may be taken up in Three parts as, Part I: 1 to 40 of Three Hours; Part II: 41 to 80 of

[c. It is advised to attempt question under examination conditions**]**

Q-1	Charge on a proton is $+1.6 \times 10^{-19}$ C and that on an electron is -1.6×10^{-19} C. Does it mean that electron has a charge 3.2×10^{-19} C less than the charge of a proton ?
Q-2	Is there any lower limit to the electric force between two particles placed at a separation of 1 cm?
Q-3	Consider two particles A and B having equal charges and placed at some distance. The particle A is slightly displaced towards B. (a) Does the force on B increase as soon as the particle A is displaced? (b) Does the force on the particle A increases as soon as it is displaced?
Q-4	Can a gravitational field be added vectorially to an electric field to get a total field?
Q-5	Why does a phonograph record attract dust particles just after it is cleaned?
Q-6	Does the force on a charge due to another charge depend on the charges present nearby?
Q-7	In some old texts it is mentioned that 4π lines of force originate from each unit positive charge. Comment on the statement in view of the fact that 4π is not an integer.
Q-8	Can two equipotential surfaces cut each other?
Q-9	If a charge is placed at rest in an electric field, will its path be along a line of force? Discuss the situation when the lines of force are straight and when they are curved.
Q-10	Consider the situation shown in the figure. What are signs of q_1 and q_2? If the lines are drawn in proportion to the charge, what is the ratio $\frac{q_1}{q_2}$? 
Q-11	A point charge is taken from a point A to a point B in an electric field. Does the work done by the electric field depend on the path of the charge?

Q-12	It is said that the separation between the two charges forming an electric dipole should be small. Small compared to what?
Q-13	The number of electrons in an insulator is of the same order as the number of electrons in a conductor. What is then the basic difference between a conductor and an insulator?
Q-14	When a charged comb is brought near a small piece of paper, it attracts the piece. Does the paper become charged when the comb is brought near it?
Q-15	Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that (a) $E_A > E_B > E_C$ (b) $E_A = E_B = E_C$ (c) $E_A = E_C > E_B$ (d) $E_A = E_C < E_B$ 
Q-16	When the separation between two charges is increased the potential energy of the charges (a) increase (b) decrease (c) remains the same (d) may increase or decrease
Q-17	If a positive charge is shifted from a low-potential region to a high-potential region, the electric potential energy (a) increase (b) decrease (c) remain the same (d) may increase or decrease
Q-18	Two equal positive charges are kept at points A and B. The electric potential at the points between A and B (excluding these points) is studied while moving it from A to B. The potential (a) continuously increase (b) continuously decrease (c) increase and then decrease (d) decrease and then increase
Q-19	The electric field at the origin is along the positive X-axis. A small circle is drawn with the center at the origin cutting the axes at points A, B, C and D having coordinates $(a, 0)$, $(0, a)$, $(-a, 0)$ and $(0, -a)$ respectively. Out of these points on the periphery of the circle, the potential is minimum at (a) A (b) B (c) C (d) D
Q-20	If a body is charged by rubbing it, its weight (a) remains precisely constant (b) increases slightly (c) decreases slightly (d) may increase slightly or decrease slightly
Q-21	An electric dipole is placed in a uniform electric field. Net electric force on dipole (a) always zero (b) depends on the orientation of the dipole (c) can never be zero (d) depends on the strength of the dipole
Q-22	Consider the situation of figure. The work done in taking a point charge from P to A is W_A, from P to B is W_B and from P to C is W_C. (a) $W_A < W_B < W_C$ (b) $W_A > W_B > W_C$ (c) $W_A = W_B = W_C$ (d) None of these 
Q-23	A point charge q is rotated along a circle in the electric field generated by another point charge Q. The work done by the electric field on the rotating charge in one complete revolution is - (a) Zero (b) Positive (c) Negative (d) Zero if charge Q is at the center and nonzero otherwise

Q-24	Mark out the correct options (a) Total charge of the universe is constant (b) Total positive charge of the universe is constant (c) Total negative charge of the universe is constant (d) Total number of charged particles in the universe is constant
Q-25	A point charge is brought in an electric field. The electric field at a nearby point (a) Will increase if the charge is positive (b) Will increase if the charge is negative (c) May increase if charge is positive (d) May decrease if charge is negative
Q-26	The electric field and the electric potential at a point are E and V respectively (a) If $E = 0, V$ must be zero (b) If $V = 0, E$ must be zero (c) If $E \neq 0, V$ cannot be zero (d) If $V \neq 0, E$ cannot be zero
Q-27	The electric potential decreases uniformly from 120 V to 80 V as one moves on the X-axis from $x = -1$ cm to $x = +1$ cm. The electric field at the origin. (a) Must be equal to 20 V-cm^{-1} (b) May be equal to 20 V-cm^{-1} (c) May be greater than 20 V-cm^{-1} (d) May less than 20 V-cm^{-1}
Q-28	Which of the following quantities do not depend on the choice of zero potential or zero potential energy? (a) Potential at a point (b) Potential difference between two points (c) Potential energy of two charges (d) Change in potential energy of a two-charge system
Q-29	An electric dipole is placed in an electric field generated by a point charge. (a) The net electric force on the dipole must be zero. (b) The net electric force on the dipole may be zero. (c) The torque on the dipole due to electric field must be zero (d) The torque on the dipole due to electric field may be zero
Q-30	A proton and an electron are placed in a uniform electric field. (a) The electric forces acting on them will be equal (b) The magnitude of the forces acting on them will be equal (c) Their acceleration will be equal (d) The magnitude of their acceleration will be equal
Q-31	The electric field in a region is directed outward and is proportional to the distance r from the origin. Taking electric potential at the origin to be zero (a) It is uniform region (b) It is proportional to r (c) It is proportional to r^2 (d) It increases as one goes away from the origin
Q-32	Find the dimensional formula of ε_0

Q-33	A charge of 1.0 C is placed at the top of your college building and another equal charge at the top if your house. Take separation between the two charges to be 2.0 km. Find the force between the charges on each other. How many times of your weight is this force?
Q-34	At what separation should two equal charges 1.0 C each be placed so that force between them must be equal to the weight of a 50 kg person?
Q-35	Two equal charges are placed at a separation of 1.0 m. What should be the magnitude of the charges so that the force between them equals weight of a 50 kg person?
Q-36	Find the electric force between two protons separated by a distance of 1 fermi (1 fermi = 1.0×10^{-15}m). The protons on a nucleus remain at a separation of this order.
Q-37	Two charges 2.0×10^{-6} C and 1.0×10^{-6} C are placed at a separation of 10 cm. Where should a third charge be placed such that it experiences no net force due to these charges?
Q-38	Two charges 2.0×10^{-6} C and -1.0×10^{-6} C are placed at a separation of 10 cm. Where should a third charge be placed such that it experiences no net force due to these charges?
Q-39	Two charged particles are placed at a distance 1.0 cm apart. What is the minimum possible magnitude of the electric force acting on each charge?
Q-40	Estimate the number of electrons in 100 g of water. How much is the total negative charge on these electrons?
Q-41	Suppose all electrons of 100 g of water are lumped together to form a negatively charged particle and all nuclei are lumped to form a positively charged particle. If these two charged particles are placed 10.0 cm away from each other, find the force of attraction between them. Compare it to your weight.
Q-42	Consider a gold nucleus to be a sphere of radius 6.9 fermi in which protons and neutrons are distributed, Find the force of repulsion between two protons situated at largest separation. Why do protons not fly apart under this separation?
Q-43	Two insulating small spheres are rubbed against each other and placed 1 cm apart. If they attract each other with a force of 0.1 N, how many electrons transferred from one sphere to the other during rubbing?
Q-44	NaCl molecule is bound due to the electric force between the sodium and the chlorine ions when one electron of sodium is transferred to chlorine. Taking the separation between the ions to be 2.75×10^{-8}cm , find the force of attraction between them. State assumption, if any, that you made.
Q-45	Find the ratio of electric and gravitational force between two protons.
Q-46	Suppose an attractive nuclear force acts between two protons which may be written as $F = \frac{Ce^{-kr}}{r^2}$. (a) Write down the dimensional formula and appropriate SI unit of *C* and *k* (b) Suppose that $k = 1$ fermi^{-1} and that repulsive electric force between the protons is just balanced by the attractive nuclear force when separation is 5 fermi, find the value of C.
Q-47	Three equal charges 2.0×10^{-6} C each are held fixed at the three corners of an equilateral triangle of side 5 cm. Fuind the coulomb force experienced by one of the charge due to the rest of the three.

Q-48	Four equal charges 2.0×10^{-6} C each are fixed at four corners of a square of side 5 cm. Find the Coulomb force experienced one of the charges due to rest of the four.
Q-49	A hydrogen atom contains one proton and one electron. It may be assumed that electron revolves in a circle of radius 0.53 angstrom (1 angstrom = 10^{-10}m and is abbreviated as Å) with proton at the center. The hydrogen atom is said to be in the ground state in this case. Find the magnitude of the electric force between the proton and the electron of a hydrogen atom in its ground state.
Q-50	Find the speed of the electron in the ground state of hydrogen atom which contains one proton and one electron. It may be assumed that electron revolves in a circle of radius 0.53 angstrom (1 angstrom = 10^{-10}m and is abbreviated as Å) with proton at the center.
Q-51	Ten positively charged particles are kept fixed on the X-axis at points x=10 cm, 20 cm, 30 cm …. 100 cm. The first particle has a charge 1.0×10^{-8} C, the second charge 8×10^{-8} C, the third charge 27×10^{-8} C, and so on. The tenth particle has a charge 1000×10^{-8} C, Find the magnitude of the electric force acting on a 1C charge placed at the origin.
Q-52	Two charged particles having charge 2.0×10^{-8} C, each are joined by an insulating string of length 1 m and the system is kept on a smooth horizontal table. Find tension in the string.
Q-53	Two identical balls, each having a charge 2.00×10^{-7} C and a mass 100 g are suspended from a common point by two insulating strings each 50 cm long. The balls are held at separation 5.0 cm apart and then released. At the instant just after release of the balls find – (a) The electric force on one of the charged balls (b) The component of resultant force on it along and perpendicular to the string (c) The tension in the string (d) The acceleration of one of the balls.
Q-54	Two identical pith balls are charged by rubbing against each other. They are suspended from a horizontal rod through two strings of length 20 cm each, the separation between the suspension points being 5 cm. In equilibrium, the separation between the balls is 3 cm. Find the mass of each ball and tension in the strings. The charge on each ball has a magnitude 2.0×10^{-8} C.
Q-55	Two small spheres each having a mass of 20 g are suspended from a common point by two insulating strings of length 40 cm each. The spheres are identically charged and the separation between the balls at equilibrium is found to be 4 cm. Find charge on each sphere.
Q-56	Two identical pith balls, each carrying a charge Q, are suspended from a common point by two strings of equal length L . Find the mass of each ball if angle between the strings is 2θ in equilibrium.
Q-57	A particle having a charge 2.0×10^{-4} C is placed directly below and at a separation of 10 cm from the bob of a simple pendulum at rest. The mass of the bob is 100 gm. What charge should the bob be given so that the string becomes loose?
Q-58	Two particles A and B having charge Q and $2Q$ respectively are placed on a smooth table with a separation d. A third particle C is clamped on the table in such a way that the particles A and B remain at rest on the table under the electrical forces. What should be the charge on C and where should it be clamped?

Q-59	Two identically charged particles are fastened to the two ends of a spring if spring constant 100 Nm^{-1} and natural length 10 cm. The system rests on a smooth horizontal table. If the charge on each particle is 2.0×10^{-8} C, find the extension in the length of the spring. Assume that the extension in the length of the spring is small as compared to its natural length. Justify the assumption after you solve the problem.
Q-60	A particle A having a charge of 2.0×10^{-6} C is held fixed on a horizontal table. A second charged particle of mass 80 g stays in equilibrium on the table at a distance of 10 cm from the charge. The coefficient of friction between the table and the second charge is $\mu = 0.2$. Find the range in which the second charged particle may lie.
Q-61	A particle A having a charge 2.0×10^{-6} C and a mass 100 g is placed at the bottom of a smooth inclined plane of inclination 30^0. Where should another particle B, having same charge and mass be placed on the incline so that it may remain in equilibrium?
Q-62	Two particles A and B, each having a charge Q are placed at a distance d apart. Where should a particle of charge q be placed on the perpendicular bisector of AB so that it experiences maximum force? What is the magnitude of the maximum force?
Q-63	Two particles A and B each having a charge Q are held fixed with a separation d between them. A particle C having a mass m and a charge q is kept at the middle point of the line joining A,B . (a) If it is displaced through a distance y, perpendicular to AB, what would be the electric force experienced by it. (b) Assuming $y \ll d$ show that this force is proportional to y. (c) Under what conditions will the particle C execute simple harmonic motion if it is released after such a small displacement as at (b)? (d) Find the time period of the oscillations under conditions stipulated at (c).
Q-64	Two particles A and B each having a charge Q are held fixed with a separation d between them. A particle C having a mass m and a charge q is kept at the middle point of the line joining A,B . (a) If it is displaced through a distance x, along the line AB, what would be the electric force experienced by it. (b) Assuming $x \ll d$ show that this force is proportional to x. (c) Under what conditions will the particle C execute simple harmonic motion if it is released after such a small displacement as at (b)? Find the time period of the oscillations under conditions stipulated at (c).
Q-65	The electric force experienced by a charge 1.0×10^{-6} C is 1.5×10^{-3} N. Find the magnitude of the electric field at the position of the charge
Q-66	Two particles A and B having charges $+2.00 \times 10^{-6}$ C and -4.00×10^{-6} C respectively are held fixed at a separation of 20.0 cm. Locate the points on the line AB where (a) The electric field is zero (b) The electric potential is zero.
Q-67	A point charge produces an electric field of magnitude 5.0 NC^{-1} at a distance of 40 cm from it. What is the magnitude of the charge ?

Q-68	A water particle of mass 10.0 mg and having a charge 1.50×10^{-6} C stays suspended in a room. What is the magnitude of electric field in the room? What is its direction.
Q-69	Three identical charges, each having a value 1.0×10^{-8} C are placed at corners of an equilateral triangle of side 20 cm. Find the electric field and potential center of the triangle.
Q-70	Positive charge Q is distributed uniformly over a circular ring of radius R. A particle having a mass m and a negative charge q, is placed on its axis at a distance x from the center. Find the force on the particle. Assume $x \ll R$, find the time period of oscillation of particle if it is released from there.
Q-71	A rod of length L has a total charge Q distributed uniformly along its length. It is bent in the shape of a semicircle. Find the magnitude of the electric field at the center of curvature of the semicircle.
Q-72	A 10 cm long rod varies a charge +50 μC is distributed uniformly along its length. Find the magnitude of the electric field at a point 10 cm from both ends of the rod.
Q-73	Consider a uniformly charged ring of radius R. Find the point on the axis where electric field is maximum.
Q-74	A wire is bent on the form of a regular hexagon of side a. A total charge q is distributed uniformly on it. What is the electric field at the center.
Q-75	A circular wire-loop of radius a carries a total charge Q distributed uniformly over its length. A small length of wire is cut off. Find electric field at the center due to the remaining wire.
Q-76	A positive charge q is placed in front of a conducting cube at a distance d from its center. Find electric field at the center of the cube due to charge appearing on its surface.
Q-77	A pendulum bob of mass 80 mg and carrying a charge of 2×10^{-8}C is at rest in a uniform horizontal electric field of 20 kVm^{-1}. Find the tension in the thread.
Q-78	A particle of mass m and charge q is thrown at a horizontal speed u against a uniform horizontal electric field E. How much distance will it travel along the field before coming to momentary rest?
Q-79	A particle of mass 1g an charge 2.5×10^{-4}C is released from rest in an electric field 1.2×10^{4} NC^{-1}. (a) Find electric force and the force of gravity acting on the particle. (b) Can one of these forces be neglected in comparison with the other for appropriate analysis? (c) How long will it take for the particle to travel a distance of 40 cm along the field? (d) What will be the speed of the particle along the field after travelling 40 cm? (e) How much is the work done by the electric force on the particle during this period?
Q-80	A ball of mass 100 g and having a charge 4.9×10^{-5}C is released from rest in a region where horizontal electric field of 2.0×10^{4} NC^{-1} exists. (a) Find the resultant force acting on the ball. (b) What will be the path of the ball? (c) Where will the ball be at the end of 2s?

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