THE GURUKUL INSTITUTE
PLOT 5C, 2ND FLOOR, COMPLEX, SEC-13, OPP. JAIPURIA SCHOOL,
VASUNDHARA,GHAZIABAD (U.P).CELL;9810780903

ELECTROSTATICS

Basic Properties Of Electric Charge

1. A polythene piece rubbed with wool is found to have negative charge of 3.2×10^{-7} C.
   (a) Estimate the number of electrons transferred from wool to polythene.
   (b) Is there a transfer of mass from wool to polythene? If yes, how much?

2. Two particles A and B having charges 8×10^{-6} C and -2×10^{-6} C, respectively, are held fixed with a separation of 20 cm. Where should a third charged particle be placed so that it does not experience a net electric force?

Principle Of Superposition

3. It is required to hold equal charges, q each in equilibrium at the corners of a square of side 'a'. What charge placed at the centre of the square can do this?

Electric Field

4. What is the electric field at any point on the axis of a uniformly charged rod of length 'L' and linear charge density 'λ'? The point is separated from the nearer end by a distance 'a'.
5. A ring shaped conductor with radius R carries a total charge q uniformly distributed around it. Find the electric field at a point P that lies on the axis of the ring at a distance x from its centre.

Problems

1. A charged cork ball of mass M is suspended on a light string in the presence of a uniform electric field as shown in the adjacent figure. When .... = (E_x.. + E_Y ..) N/C, the ball is in equilibrium at the angle θ. Find (a) the charge on the ball, and (b) the tension in the string.

2. Derive an expression for the electric field at the centre O of a hemispherical shell of radius R and constant surface charge density σ C/m^2 placed with its axis vertical as shown in the adjacent figure.
3. A small charged particle of mass m and charge q is suspended by an insulated thread in front of a very large sheet of charge density σ. The angle made by the thread with the vertical in equilibrium is

(A) $\tan^{-1}\left(\frac{\sigma q}{2\varepsilon_0 mg}\right)$ (B) $\tan^{-1}\left(\frac{\sigma q}{\varepsilon_0 mg}\right)$
(C) $\tan^{-1}\left(\frac{2\sigma q}{\varepsilon_0 mg}\right)$ (D) Zero

4. Four changed particles, each having a charge q, are placed at the four vertices of a regular pentagon. The sides of the pentagon have equal length 'a'. The magnetic of electric field at the centre of the pentagon is
(A) $\frac{q}{4\pi\epsilon_0 a}$ (B) $\frac{2q}{4\pi\epsilon_0 a^2}$
(C) $\frac{q}{4\pi\epsilon_0 a^2}$ (D) None of these

5. A block of mass m having charge q is hung by a spring of spring constant k in a vertical electrostatic field F. The string extension in equilibrium will be
(A) $\frac{mg}{k}$ (b)$\frac{qE}{k}$
(c)$\frac{mg+qE}{k}$ (d)$\frac{mg-qE}{k}$

EXERCISE-1

1. Two identical metallic spheres of exactly equal masses are taken, one is given a positive charge q and the other an equal negative charge. Their masses after charging are different. Comment on the statement.

2. (i) A negatively charged particle is placed exactly midway between two fixed particles having equal positive charge. What will happen to the charge

(a) If it displaced at right angle to the line joining the positive charges?

(b) If it is displaced along the line joining the positive charges?

(ii) Is the Coulomb force between two given charges affected in any way if other charges are brought in the neighbourhoods?

(iii) Is the Coulomb force between two given charges affected in any way if some foreign material (say dielectric or conductor) are inserted between them.

3. (i) Does an electric charge experience a force due to the field that the charge itself produces?

(ii) Two point charges q and –q are placed at a distance d apart. What are the points at which resultant electric field is parallel to the line joining the two charges?

(iii) Three equal and similar charges q are placed on corners of a square of side ‘a’. What is the electric field at the centre of the square?

4. Five point charges, each of magnitude +q are kept at the corners of a regular hexagon of side a at A,B,C,D and E. Find the electric field at the centre O of the hexagon.

5. A semi infinite line charge of linear charge density λ has the shape as shown in the figure. Portion ABC forms three-fourth of a circle of radius R while the straight portion from C to infinity is parallel to BOA. The field at the centre of circle (O) is

(A) $\frac{\lambda}{2\sqrt{2}\pi\varepsilon_0 R}$ (B) $\frac{\lambda}{2\pi\varepsilon_0 R}$

(C) Zero (D) None Of These

6. The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will Be

(A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$

(C) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{2\sqrt{2}R^2}$

7. Charge q is uniformly distributed over a thin half ring of radius R. The electric field at the centre of the ring is

(A) $\frac{1}{4\pi\epsilon_0 R^2}$ (B) $\frac{q}{2\pi^2\epsilon_0 R^2}$

(C) $\frac{q^2}{2\pi\epsilon_0 R^2}$ (D) $\frac{q^2}{4\pi\epsilon_0 R^2}$

Gauss’ Law

1. (a) Show that the normal component of electrostatic field hsa discontinuity from one side of a charged surface to another given by

$E_2 – E_1 . n = \sigma/\epsilon_0$

Where n is a unit vector normal to the surface at a point and σ is the surface charge density at that point (the direction of n is from side 1 to side 2). Hence show that just outside a conductor, the electric field id $\sigma/$ n

(b) Find the electrostatic pressure on the conductor.

2. Determine the electric field due to a plane sheet of charge.

3. determine the electric field near a charged conduction surface.
4. figure shows a section of an infinite rod of charge having linear charge density λ which is constant for all points on the line. Find electric field E at a distance r from the line.
5. Figure shows a spherical symmetric distribution of charge (q) of radius R. Find electric field .... For points A and B Which are lying outside and inside the charge distribution, respectively.

Problems

1. The electric field in a particular space is E= (x + 2)i with x measured in meters.
   Consider a cylinder of radius = 20 cm that is coaxial with the x-axis. One end of the cylinder is positioned at x = 0 and the other end at x = 2.0 m.
   (a) what is the magnitude of the electric flux through the end of the cylinder at x = 2.0 m.
   (b) What net charge is enclosed within the cylinder?

2. if the constant electric field in the figure has a magnitude E_0 , calculate the total electric flux through the parabolidal surface.

Objective

1. Charge is distributed uniformly throughout the volume of an infinitely long cylinder of radius R. The electric field at a distance r from the cylinder axis (for r < R) is

(A) $\frac{\rho r}{\varepsilon_0}$ (B) $\frac{\rho r}{2\varepsilon_0}$ (C) $\frac{\rho r}{3\varepsilon_0}$ (D) $\frac{\rho r}{4\varepsilon_0}$

2. a uniformly charged and infinitely long line having a linear charge density 'λ' is placed at a normal distance y from a point O. Consider a imaginary sphere of radius R with O as centre and R > y. Electric flux through the surface of the sphere is

(A) Zero (B) $\frac{2\lambda R}{\varepsilon_0}$

(C) $\frac{2\lambda\sqrt{R^2-y^2}}{\varepsilon_0}$ (D) $\frac{\lambda\sqrt{R^2+y^2}}{\varepsilon_0}$

Exercise – 2

1. Electric lines of force never cross. Why?
2. If a charged particle is placed at rest in an electric field, will its path be along line of force? Discuss the situation when the lines of force are straight and when they are curved.
3. explain whether Gauss' law is useful in calculating the electric field due to three equal charges located at the corners of an equilateral triangle?
4. Four closed surfaces S_1, S_2, S_3 and S_4 together with the charges -2Q, Q and –Q are shown in the figure. Find the electric flux through each surface.
5. A plane surface of area S is inclined at an angle θ with a uniform field ....as shown in the figure. Find the magnitude of flux of ... over S.

6. the electric field vector is given by .. = a$\sqrt{x}$ ... . Find
   (a) the flux of ... through a cube bounded by surfaces
   x= ℓ , x = 2ℓ , y = ℓ , z = 0 and z = ℓ
   (b) the charge within the cube.

7. A Point charge Q is located just above the centre of the flat face of a hemisphere of radius R as shown in the adjacent figure. What is the electric flux:
   (a) through the curved surface, and
   (b) through the flat face ?
8. A cylinder (radius R) is placed in an electric field as shown in the adjacent figure. The total outgoing flux is

(A) πR^2E (B) $2\pi R^2E$ (C) $4\pi R^2E$ (D) $\pi R^2E/2$

Relation Between Field (E) and Potential (V)

1. Potential in the x-y plane is given as V = 5(x^2 + xy) volts. Find the electric field at the point having coordinates (1, -2, 0).

Equipotential Surfaces

1. Given figures shows the lines of constant potential in a region in which an electric field is present. The values of potentials are as written. At which of the points A, B and C is the magnitude of the electric field greatest?

2. someequi-potential surfaces are shown in figure (1) and (2). What can you say about the magnitude and direction of the electric field ?

3. electric field in a region is given by E = (2i+3j – 4k) V/m. Find the potential difference between points (0, 0, 0) and (1, 2, 3).

Electric Potential Energy of a Uniformly Charged Sphere

1. Determine the interaction energy of the point charges of the following setup.

Dipole in External Electric Field

1. Two tiny spheres, each of mass M and having charges +q and –q, are connected by a massless rod of length L. They are placed in a uniform electric field at an angle θ with **E** ($\theta \approx 0$). Calculate the minimum time in which the system aligns itself parallel to **E.**

Problems

1. two isolated metallic solid spheres of radii R and 2R are charged such that both of these have same charge density σ. The spheres are located far away from each other, and connected by a thin conducting wire. Find the new charge density on the bigger sphere.

2. Three charges q_1, q_2 andq_3 are located at the vertices of an equilateral triangle of side 'a'. Find the electric potential energy of the system.

3. A point charge +Q is placed at the centre of an isolated conducting shell of radius R. Find the electrostatic potential energy stored outside the spherical shell if the shell also contains charge +Q distributed uniformly over it.

Objective

1. consider the situation depicted in the adjacent 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, B, C lie on a circle centred at 'q'. Therefore,

(A) $W_A < W_B < W_C$ (B) $W_A > W_B > W_C$ (C) $W_A = W_B = W_C$
(D) $W_A > W_B > W_C$

2. A solid insulating sphere of radius R is given a charge Q. If at a point inside the sphere the potential is 1.5 times the potential at the surface, this point will be

(A) at a distance of 2R/3 from the centre
(B) at the centre
(C) at a distance of 2R/3 from the surface
(D) data insufficient

3. Two point charges each of charge +q are fixed at (+a, 0) and (-a,0). Another positive point charge q placed at the origin is free to move along x-axis. The charge q at the origin in equilibrium will have

(A) maximum force and minimum potential energy
(B) minimum force and maximum potential energy
(C) maximum force and maximum potential energy
(D) minimum force and minimum potential energy

4. it requires 1 mJ of work to move two identical positive charge +q from infinity so that they are separated by distance 'a'. How much work is required to move four identical positive charges +q from infinity so that they are arranged at the vertices of a tetrahedron with edge length a?

(A) 3 mJ (B) 4 mJ (C) 6mJ (D) 16 mJ

5. two concentric conducting sphere having radii a and b are charged to q_1 and q_2, respectively. The potential difference between 1 and 2 will be

(A) $\frac{q_1}{4\pi\varepsilon_0 a}$ - $\frac{q_2}{4\pi\varepsilon_0 b}$ (B) $\frac{q_2}{4\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$
(C) $\frac{q_1}{4\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$ (D) none of these

Exercise - 3

1. (i) if you know **E** at a given point, can you calculate V at the point? If not, what further information do you need.
(ii) if **E** equals zero at a given point, must V equal zero for that point?

2. n identical drops, each having a charge q and radius r, collapse to form a single large drop of radius R and charge Q. If E is the electric field at the surface of each small drop, then find the electric field at the surface of the larger drop.

3. The electric field a region of space has the components $E_y = E_z = 0$ and E_x = (4.00 N/C)x. Point A is on the y-axis at y = 3.0 m and point B is on the x-axis at x = 4.0 m. What is the potential difference $V_B - V_a$?
4. Find the net potential energy of the system of charges shown in the adjacent figure.
5. An electric field E = (20i+30j) N/C exists in the space. If the potential at the origin is taken to be zero. Find the potential at (2m, 2m)
6. if the intensity of electric field at a distance x form the centre in the axial position of a small electric dipole is equal to intensity at distance y in equatorial position, then

(A) x = y (B) x = y/2 (C) $y = x/2^{2/3}$ (D) $y = x/2^{1/3}$

7. in the electric field due to a point charge q, a test charge is carried from A to the point B, C, D and E lying on the same circle around q. The work done is

(A) the least along AB
(B) the least along AD
(C) zero along any one of the paths AB, AD, AC and AE
(D) the least along AE

8. the adjacent figure shows charged spherical shells A, B and C having charge densities σ, -σ, σ and radii a, b, c, respectively. If $V_A = V_C$, then b equals to

(A) a + c (B) $\sqrt{a^2 + c^2}$ (C) $\sqrt{ac}$
(D) none of these

9. the variation of potential with distance r from a fixed point is shown in the figure. The electric field at r = 3 cm and r = 5 cm are, respectively,

(A) 0, 2 V/cm (B) 2 V/cm, -2 V/cm (C) 0, -2 V/cm
(D) 2 V/cm, 0

Earthing a Conductor

1. Figure shows three concentric thin spherical shells A, B and C of radii a, b and c, respectively. The shells A and C are given charge q and –q, respectively, and shell B is earthed. Find the charges appearing on the surfaces of A, B and C.

Parallel Plate Capacitor

1. A parallel plate capacitor is made of two square plates of 50 cm x 50 cm size and separation between the plates of 0.5 mm. Calculate its capacitance.

Plates of Parallel Plate Capacitor Given Different Charges

1. Find capacitance of a conducting sphere of radius R.

Parallel Combination

1. Find Equivalent capacitance between points A and B.

Force of Dielectrics

1. Two blocks of dielectric constants k_1 and k_2 are filled in a capacitor in the arrangements shown in figure. Find out the capacitance in each case.
2. in the circuit shown in the figure, if the point B is earthed, find the potential of point A.

3. Two spherical cavities of radii a and b are hollowed out from the interior of a neutral conducting sphere of radius R. At the centre of each cavity, a point charge is placed. Call these charges q_a and q_b.
   (A) Find the surface charges σ_a, σ_b, and σ_R.
   (B) what is the field outside the conductor?
   (C) what is the field within each cavity?
   (D) what is the force on q_a and q_b ?
   (E) which of these answers would change if a third charge q_c were brought near the conductor?
4. in the adjacent circuit, find the potential difference across AB.
5. what charges will flow after the shorting of the switch S in the circuit given in the figure, through section A and B ?

Objective

1. A thin metallic shell contains charge Q on it. A point charge q is placed at the centre of the shell and another charge q_1 is placed outside it as shown in the adjacent figure. All charges are positive. The force on the charge at the centre is
(A) Towards left (B) Towards right (C) upward (D) Zero

2. A charge +q is brought near an isolated metal cube having no charge initially
   (A) the cube becomes positively charged.
   (B) the cube becomes negatively charged.
   (C) the external surface becomes negatively charged and the interior becomes positivel Charged?
   (D) the interior remains charge free and the surface gets non- uniform charge distribution.

3. Two conducting plates P and S with large surface area A are placed as shown in the figure. A charge q is given to plate P. The electric field between the plates at any point is
   (A) $\frac{q}{3A\varepsilon_0}$ (B) $\frac{q}{2A\varepsilon_0}$
   (C) $\frac{q}{A\varepsilon_0}$ (D) $\frac{2q}{A\varepsilon_0}$
4. the equivalent capacitance between P and Q in the figure is
   (A) $\frac{A\varepsilon_0}{2d}$ (B) $\frac{3A\varepsilon_0}{2d}$

(C) $\frac{2A\varepsilon_0}{d}$ (D)$\frac{5}{3}\frac{A\varepsilon_0}{d}$

5. in the figure, the p.d. between P and Q is

(A) 12 V (B) 8 V (C) 4 V (D) Zero

6. The charge following across the circuit on closing the key K is

(A) CV (B) CV/2 (C) 2CV (D) Zero

7. the conducting spherical shells shown in the figure are connected by a conductor. The capacitance of the system is

(A) $4\pi \in_0 \frac{ab}{b-a}$ (B) $4\pi \epsilon_0 a$ (C)$4\pi \epsilon_0 b$ (D) $4\pi \frac{\epsilon_0 a^2}{b} - a$

Exercise - 4

1. why capacitance of a capacitor for practical purpose is generally measured in μF and pF?
2. the space between the plates of a parallel plate capacitor is filled with a dielectric as shown in figures (1) and (2). The area of each plate is A and permittivity of the dielectric id $\in_r$. find the capacitance is each case.

3. a closed metallic box id charged upto potential V_0. What will be the potential at the centre of the box?
4. consider a thin, isolated, conducting, spherical shell that is uniformly charged to a constant charge density σ . How much work does it take to move a small positive test charged q_0

(A) From surface of the shell to the interior, through a small hole,

(B) From one point on the surface to another regardless to path,

(C) from one point of another point inside the shell,

(D) from any point P outside the shell over any path, whether or not it pierces the shell , back to P?

(E) for the given condition does it matter whether or not the shell is conducting?

5. A thin, metallic spherical shell contains a charge Q on it. A point charge q is placed at the centre of the shell and another charge q_0 is placed outside it at distance r_0 ,as shown in figure. All three charges are positive. Find

(A) magnitude of force on q due to charge q_0

(B) magnitude of net force on charge q due to all charges in space.

6. a parallel plate capacitor is to be designed with a voltage rating 1kV, using a material of dielectric constant 3 and dielectric strength about 10^7 V/m. For safety, we should like the field never to exceed say 10% of the dielectric strength. What minimum area of the plates is required to have a capacitance of 50 pF?

7. A and B are two concentric spheres. If A is given a charge Q while B is earthed as shown in figure, then

(A) the charge densities of A and B are same

(B) the field inside and outside A is zero

(C) the field between A and B is not Zero

(D) the field inside and outside B is Zero

8. there are two concentric metal shells of radii r_1, and r_2 ($>r_1$). If the outer shell has a charge q and the inner shell is grounded, the change on the inner shell is

(A) Zero (B) $-(r_1/r_2)q$ (C) r_1r_2q (D) ∞

9. A parallel plate capacitor is connected to an ideal battery which provides a fixed potential difference. Originally, the energy stored in the capacitor is U_0. If the distance between the plates is doubled, then new energy stored in the capacitor will be

(A) $4U_0$ (B) $2U_0$ (C) U_0 (D) $U_0/2$

10. the capacitance of two condensers in parallel is four times their capacitance when they are connected in series. The ratio of their individual capacitances will be

(A) 1:2 (B) 1:1 (C) 2:1 (D) 4:1

11. the equivalent capacitance between point A and B of a combination shown in the figure is

(A) C (B) 2C (C) C/2 (D) none of these

Assignment

Section – 1

Part – A

1. A small sphere of mass m carries a charge q. It hangs from a light inextensible thread of length ℓ making an angle θ with an infinite line of charge as shown in the figure. Find the linear charge density.

2. A uniform conducting sphere having charge +q and radius a is placed at the centre of a spherical conducting shell of inner radius b and outer radius c. The outer shell carries a charge of –q. Find field E(r) at locations (a) within the sphere (r<a), (b) between the sphere and shell (a<r<b), (c) outside the shell (r>c).

3. A non-conducting ring of radius 0.5 m carries a total charge of $1.11x10^{-1}$ C, distributed non-uniformly on its circumference, producing an electric field in space. Find the calue of the line integral $-\int_{\infty}^{\ell} \dots \dots \dots . .$ (ℓ=0 being the centre of the ring), in colt.

4. A charge is distributed over two concentric hollow spheres of radii r and R (>r) such that their surface densities are equal. Find the potential at their common centre.

5. A certain charge 'Q' is to be divided into two parts, q and Q –q. What is the relationship of 'Q' to 'q' if the two parts, placed at a given distance 'r' apart, are to have maximum Coulombic repulsion? What is the work done in reducing the distance between them to half its value?

6. A thin glass rod is bent into a semicircle of radius r. A charge +q is uniformly distributed along the upper half, and a charge –q is uniformly distributed along the lower half as shown in figure. Find the electric field ... at P, the centre of the semicircle.

7. An infinite number of charges, each of equal magnitude q, are placed along the x-axis at x=1, x=2, x=4, x=8, ... and so on. Find the potential and electric field at the point x=0 due to this set of charges. What will be the potential and electric field if, in the above setup, the consecutive charges have3 opposite sign (if positive charge is kept at point x=1)?

8. A solid non-conducting sphere of radius R carries a non-uniform charge distribution with charge density ..=.. (r/R), where ..is a constant, Show that (a) the total charge on the sphere is Q= π.. R^3, and (b) the electric field inside the sphere is given by $E=\frac{1}{4\pi\epsilon_0}\frac{Q}{R^4}r^2$

9. A cone made of an insulating material has a total charge Q spread uniformly over its sloping surface. Calculate the energy required to bring a small test charge q from infinity to the apex A of the cone. The cone has a slope length L.

10. A 1 ..F and a 2 ..F capacitor are connected in series across a 1200 V supply.
   (a) Find the charge on each capacitor and coltage across each capacitor.
   (b) The charged capacitors are disconnected from the line and from each other, and are now reconnected with terminals of like sign together. Find the final charge on each capacitor and voltage across each capacitor.

11. In the figure shown, find the charge on each capacitor (a) when the switch S os open, and (b) when the switch S is closed.

Objective

(Multi choice single correct)

1. Two equal negative charges –q are fixed at the pints (0,a) and (0,-a) on the y-axis. A positive charge Q is released from rest at the point (2a,0) on the x-axis. The charge Q will

(A) execute simple harmonic motion about the origin.

(B) move to the origin and remain at rest.

(C) move to infinity

(D) execute oscillatory but not simple harmonic motion

2. Electric charges q, q and -2q are placed at the corners of an equilateral triangle ABC of side L. The magnitude of electric dipole moment of the system is

(A) qL (B) 2qL (C) $(\sqrt{3})\ qL$ (D) 4Ql

3. A positively charged pendulum is oscillating in a uniform electric field as shown in the figure. Its time period, as compared to that when it was unchanged

(A) will increase (B) will decrease

(C) will not change (D) will first increase and then decrease

4. two connected charges of +q and –q respectively are at fixed distance AB apart in a non- uniform electric field whose lines of forces are shown in the figure. The resultant effect on the two charges is

(A) a torque vector in the plane of the two charge is

(B) a resultant force in the plane of the paper and no resultant force.

(C) a torque vector normal to the plane of the paper and no resultant force.

(D) a torque vector normal to the plane of the paper and a resultant force in the plane of the paper.

5. two identical thin rings, each of radius R meters, are coaxially placed a distance R meters apart. If Q_1 C and Q_2 c are the charges uniformly spread on the two rings, the work done in moving a charge q from the centre of one ring to that of the other is

(A) Zero

(B) $q(Q_1 - Q_2)(\sqrt{2} - 1) / (\sqrt{2}4\pi\epsilon_0 R)$

(C) $q\sqrt{2}(Q_1 - Q_2) / (44\pi\epsilon_0 R)$

(D) $q(Q_1 + Q_2)(\sqrt{2} + 1) / (\sqrt{2}4\pi\epsilon_0 R)$

6. which of the following changes to an ideal parallel plate capacitor, connected to an ideal battery, will result in an increase in the charge of the capacitor?

(A) Decreasing the potential difference across the plates?

(B) Decreasing the area of the plates.

(C) Decreasing the separation of the places.

(D) None of the above.

7. three capacitors are connected with the source of electromotive force E as shown I n the figure. Then, the energy drawn from the source is

(A) $\frac{1}{2}CE^2$ (B) $\frac{3}{2}CE^2$ (C) $3CE^2$(D) $2CE^2$

8. a hollow conducting sphere of inner. Radius R and outer Radius 2R is given a charge Q as shown in the figure, then the

(A) potential at A and B is different

(B) potential at O and B is different

(C) potential at O and C is different
(D) potential at A, B, C and O is same
9. two positive and two negative charges are kept in x-y plane in free space as shown in the figure. The magnitude of electric field due to the system of charges at a point P (0,y) will be (y >> d)

(A) $\frac{\sqrt{5}qd}{4\pi\varepsilon_0 y^3}$ (B) $\frac{2dq}{4\pi\varepsilon_0 y^3}$ (C) $\frac{dq}{4\pi\varepsilon_0 y^3}$ (D) $\frac{3dq}{4\pi\varepsilon_0 y^3}$

10. find the capacitance of a system of three parallel plates each of area A separated by distances d_1 and d_2 . the space between them is filled with dielectrics of relative permittivitysε_1 and ε_2. The dielectric constant of free space is ε_0

(A) $\frac{\varepsilon_1\varepsilon_2\varepsilon_0 A}{\varepsilon_1\varepsilon_2+\varepsilon_2 d_1}$ (B) $\frac{\varepsilon_1\varepsilon_2\varepsilon_0 A}{\varepsilon_1 d_{12}+\varepsilon_2 d_2}$ (C) $\frac{\varepsilon_1\varepsilon_2 A}{\varepsilon_0(\varepsilon_1+\varepsilon_2)(d_1+d_2)}$ (D) $\frac{A}{\varepsilon_2\varepsilon_1\varepsilon_0(\varepsilon_1 d_1+\varepsilon_2 d_2)}$

11. A parallel plate capacitor is connected across a source of constant potential difference. When a dielectric plate is introduced between the two plates, then
(A) some charge from the capacitor will flow back into the source
(B) some extra charge from the source will flow into the capacitor
(C) the electric field intensity between the two plates increases
(D) energy of the capacitor does not change

12. the figure shows a circuit of four capacitors. The effective capacitance between X and Y is
(A) 2 μF (B) 1 μF (C) 3μF (D) 1.5 μF

13. A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then the battery is disconnected. A slab of dielectric constant k is then inserted between the plates. If Q, E and n denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and the work done on the system in question, in the process of inserting the slab, then
(A) Q = $\varepsilon_0 \frac{AV}{d}$ (B) Q = $\varepsilon_0 kA \frac{V}{d}$ (C) E = V/kd
(D) w = $\frac{\varepsilon_0 AV^2}{2d}\left(\frac{1}{k} - 1\right)$

14. the lines of force of the electric field of a positive charge (+q) and a negative charge (-q) are shown in figure, then
(A) the work done is moving a small positive charge (+q_0) from Q to P will be positive by the electrostatic field.
(B) The work done is moving a small negative charge (-q_0) from B to A will be positive by the external force.
(C) in going from B to A in absence of any external force, the kinetic energy of a small negative charge (-q_0) decreases.
(D) in going from Q to P in absence of any external force, the kinetic energy of a small negative charge (-q_0) increases.

15. which is the following statements is/are correct
(A) the work done by the electric field of a nucleus in moving an electron around it in a complete orbit is zero irrespective of whether the orbit is circular or elliptical.
(B) the equipotential surfaces corresponding to the electric field of an isolated point charge concentric spheres with the point change as the common centre.
(C) ifcoulimb's law involved $1/r^3$ dependence instead of $1/r^2$, Gauss law would still hold good.
(D) A singleconductor cannot have any capacitance.

16. A deuteron and an α – particle are placed in an electric field. If F_1 and F_2 be the forces acting on them and a_1 and a_2 be their accelerations respectively, then

(A) $a_1 = a_2$ (B) $a_1 \neq a_2$ (C) $F_1 = F_2$ (D) $F_1 \neq F_2$

Numerical Based Type

1. A capacitor of capacitance $C_1 = 1\ \mu F$ withstands the maximum voltage $V_1 = 6.0$ kV while the capacitor of capacitance $C_2 = 2\ \mu F$, the maximum voltage $V_2 = 4.0$ kV. What voltage in kilo volt will the system of these two capacitors withstand if they are connected in series?

2. A sphere of radius R has uniformly distributed charge density . There is a spherical cavity as shown in the figure has centre at C .it is given that AB = d, OC = ℓ and the angle between OC and AB is 60^o . Find the potential difference in volt between A and B. If numerically $p\ell d = 54\varepsilon_0$

3. four rigid rods AB, BC, CD and DA each of linear mass density λ and length a are connected rigidly to form a square frame. This system is placed in an XYZ space as shown in the figure, such that it can freely rotate about an axis kk' (parallel to z-axis). The plane ABCD is on the y-z plane. The rods AB and CD are carrying charges of linear charge density ρ and ($-\rho$) respectively. An electric field is existing in the space, which is .... If the wire frame is rotated by a small angle $\Delta\theta$ about the kk' axis and released. Find the time in second required by the frame ABCD to regain its original position for the first time.

(λ = 1 kg/m, a = 2m, ρ = 1/3 C/m, $E_0 = \pi^2\ N/C$).

4. A 100 pF capacitor is charged to a potential difference of 24 V. It is connected to an uncharged capacitor of 20 pF. The new potential difference across the 100 pF capacitor is 10 K volt. Find the value of K.

Linked Comprehension Type

1. The electric potential at x = 2m is

(A) 10 V (B) 20 V (C) 30 V (D) 40 V

2. The greatest positive value of electric potential for points of the x-axis for which $0 \leq x \leq 6$ m is (A) 10 V (B) 20 V (C) 30 V (D) 40 V

3. The value of x for which potential is zero is

(A) 2 m (B) 3 m (C) 4 m (D) 5.5 m

Matrix Match Type

1. A spherical cavity of radius r is made in a conducting sphere of radius 2r. A charge q is kept at the centre of cavity is shown in the figure. Match the following

Coloum – 1	Coloum – 2
(A) Total field at (4r, 0, 0)	(p) $Kq/16r^2$
(B) Field at (4r, 0, 0)	(q) $4Kq/r^2$
(C) Total field at (-r/2, 0, 0)	(r) $Kq/25r^2$
(D) Field at (+r/2, 0, 0) due to q	(s) $4Kq/9r^2$
	(t) None of these

Section – II

1. At a certain distance from a point charge the field intensity is 500V/m and the potential is -300 V. The distance to the charge and the magnitude of the charge respectively are

(A) 0.6 m and 60 nC (B) 0.4 m and 20 nC

(C) 0.6 m and 40 nC (D) 0.6 m and 20 nC

2. Dipole is placed parallel to the electric field. If W is the work done in rotating the dipole 60^0, then work done in rotating it by 180^0 is

(A) 2 W (B) 3 W (C) 4 W (D) W/2

3. A large sheet carries uniform surface charge density σ. A rod of length 2ℓ has a linear charge density λ on one half and $-\lambda$ on the other half. The rod is hinged at mid point O and makes θ with the normal to the sheet. The torque experienced by the rod is

(A) $\frac{\sigma\lambda\ell^2}{2\varepsilon_0}\cos\theta$ (B) $\frac{\sigma\lambda\ell}{2\varepsilon_0}cos^2\theta$

(C) $\frac{\sigma\lambda\ell^2}{2\varepsilon_0}\sin\theta$ (D) $\frac{\sigma\lambda\ell}{2\varepsilon_0}sin^2\theta$

4. Three point charges q, 2q and 8q are to be placed on a straight line 9 cm long. In order that the potential energy of the system be minimum. Their positions should be

(A) 2q and q at the ends (9 cm apart) and 8q at a distance of 3 cm from the 2q charge.
(B) 2q and 8q at the ends and q at a distance of 3 cm from the 8q charge.
(C) 2q and 8q at the ends and q at a distance of 6 cm from the 8q charge.
(D) q and 8q at the ends and 2q at a distance of 6 cm from the q charge.

5. the given diagram shows two infinite lines of charges having equal (in magnitude) linear charge density but with opposite sign. The electric field at any point on x- axis (for x >0) is along the unit vector

(A) cosθ… + sin θ … (B) ….. (C) ……. (D) –sin θ… + sin θ ….

6. A fully charged capacitor has a capacitance C. it is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity s and mass m. If the temperature of the block is raised by ΔT , the potential difference V across the capacitance is

(A) $\frac{\mathrm{ms}\,\Delta T}{C}$ (B) $\sqrt{\frac{2ms\,\Delta T}{C}}$ (C) $\sqrt{\frac{2mc\,\Delta T}{s}}$ (D) $\frac{\mathrm{ms}\,\Delta T}{s}$

7. A charged particle q is shot towards another charged particle Q which is fixed, with a speed v from a very large distance. It approaches W upto a closest distance r and then returns. If q were given a speed 2v, the closest distance of approach would be

(A) r (B) 2r (C) r/2 (D) r/4

8.electric potential in a particular region of space is $v = 5x - 3x^2y + 2yz^2$. The magnitude of electric field at point P (1 m, 0, -2 m) is

(A) 5 N/C (B) 6 N/C (C) 7.08 N/C (D) 9.0 N/C

9. Anσ particle passes rapidly through the exact centre of a hydrogen molecule, moving on a line perpendicular to the internuclear axis. The distance between the nuclei is b. Where on its path does the σ particle experience the greatest force? Assume that he the nuclei do not move much during the passage of the σ particle. Also neglect the electric field of the electrons in the molecule.

(A) $\frac{b}{2}$ (B) $\frac{b}{2\sqrt{2}}$ (C) $\frac{b}{\sqrt{2}}$ (D) none of these

10. A spherical conductor A contains two spherical cavities. The total charge on the conductor itself is zero. However, there is a point charge q_b at the centre away from the centre of the spherical conductor, there is another charge q_d.force acting on q_b , q_c , and q_d, are.

F_1, F_2, and F_3 respectively.[Assume all charge are positive]

(A) $F_1 < F_2 < F_3$ (B) $F_1 = F_2 < F_3$ (C) $F_1 = F_2 > F_3$ (D) $F_1 > F_2 > F_3$

11. Three infinite plane have a uniform surface charge distribution σ on its surface. All charges are fixed. On each of the three infinite planes, parallel to the y-z plane placed at x = - a, x = 0 and x = a, there is a uniform surface charge of the same density, σ . The potential difference between A and C is

(A) $\frac{\sigma}{2\,\varepsilon_0}a$ (B) $\frac{\sigma}{\varepsilon_0}$ (C) $\frac{\sigma a}{2\epsilon_0}$ (D) zero

12. find equivalent capacitance between A and B [Assume each conducting plate is having same dimensions and neglect the thickness of the plate, $\frac{\varepsilon_0 A}{d}$ = 7 μF where A is area of plates, A >> d]

(A) 7 μF (B) 11 μF (C) 12 μF (D) 12 μF