EXERCISE-1

*** MARK IS MORE THAN ONE CORRECT QUESTIONS.**

SECTION A: COULOMB'S LAW

A.1 Five balls, numbered 1 to 5, are suspended using separate threads. Pairs (1, 2), (2, 4), (4, 1) show electrostatic attraction, while pairs (2, 3) and (4, 5) show repulsion, therefore ball 1 must be:
(A) Positively charged (B) Negatively charged (C) Neutral (D) Made of metal

A.2* Select the correct alternative :
(A) The charge gained by the uncharged body from a charged body due to conduction is equal to half of the total charge initially present.
(B) The magnitude of charge increases with the increase in velocity of charge
(C) Charge can not exist without matter although matter can exist without charge
(D) Repulsion is the true test of electrification (electrification means body has net charge)

A.3 Mark out the correct option.
(A) The total charge of the universe is constant.
(B) The total positive charge of the universe is constant.
(C) The total negative charge of the universe is constant
(D) The total number of charged particles in the universe is constant.

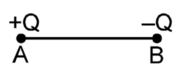
A.4 A point charge Q_1 exerts some force on a second point charge Q_2. If a 3rd point charge Q_3 is brought near, the force of Q_1 exerted on Q_2(Without changing their respective positions):
(A) Will increase (B) Will decrease
(C) Will remain unchanged
(D) Will increase if Q_3 is of the same sign as Q_1 and will decrease if Q_3 is of opposite sign.

A.5 Three charge +4q, Q and q are placed in a straight line of length ℓ at points distance 0, $\ell/2$ and ℓ respectively. What should be the value of Q in order to make the net force on q to be zero?
(A) –q (B) –2q (C) –q/2 (D) 4q

A.6 Two small balls having equal positive charge Q (coulomb) on each are suspended by two insulating strings of equal length L, from a hook fixed to a stand. If the whole set up is taken in a satellite then the angle θ between the two strings is : (in equillibrium)
(A) 0º (B) 90º (C) 180º (D) 0º < θ <180º

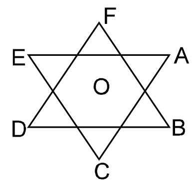
A.7 In above question the tension in each string is :
(A) 0 (B) $\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{L^2}$ (C) $\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{2L^2}$ (D) $\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{4L^2}$

A.8 Two point charges of the same magnitude and opposite sign are fixed at points A and B. A third point charge is to be balanced at point P by the electrostatic force due to these two charges. The point P:



(A) lies on the perpendicular bisector of line AB (B) is at the mid point of line AB
(C) lies to the left of A (D) none of these.

A.9 The electric force on 2μc charge placed at the centre O of two equilateral triangles each of side 10 cm, as shown in figure is P. If charge A, B, C, D, E & F are 2μc, 2μc, 2μc, -2μc, -2μc, -2μc respectively, then force acting on P is :



(A) 21.6 N (B) 64.8 N (C) 0 (D) 43.2 N

A.10 Two point charges q_1 = 20μC and q_2 = 25μC are placed at (–1, 1, 1) m and (3, 1, –2)m, with respect to some coordinate axes. Find magnitude and unit vector along force on q_2?

A.11 What is the percentage change in distance if the force of attraction between two point charges increases to 4 times keeping magnitude of charges constant?

A.12 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 1.0×1.0^{-8} C, the second 8×10^{-8} C, the third 27×10^{-8} C and so on. Find the magnitude of the electric force acting on a 1 C charge placed at the origin.

A.13 (i) Two charged particles having charge 2.0×10^{-8} C and mass 1.8×10^{-6} Kg each are joined by an insulating string of length 1 m and the system is kept on a smooth horizontal table. Find the tension in the string.

(ii) If suddenly string is cut then what is the acceleration of each block?
(iii) Are they having equal acceleration?

A.14 (i) A charge q_0 is placed at the centre of a regular pentagon having equal charges q at its corners. Find the force on q_0? (Assume a = distance from centre to corner for pentagon)

(ii) If charge of one of the corners is removed then find out magnitude of force acting on q_0 ?
(iii) If two adjacent charges are removed from corners then find out magnitude of force acting on q_0?

A.15 The distance between two fixed positive charges 4e and e is ℓ. How should a third charge 'q' be arranged for it to be in equilibrium? Under what condition will equilibrium of the charge 'q' be stable (for displacement on the line joining 4e and e) or will it be unstable?

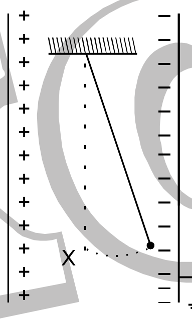
A.16 Two particles A and B, each having a charge Q are placed a distance d apart. Where should a particle of charge q be placed on the perpendicular bisector of AB so that it experiences maximum force? What is the magnitude of the maximum force?

SECTION B : ELECTRIC FIELD

B.1 There is a uniform electric field in X-direction. If the work done in moving a charge of 0.2 C through a distance of 2 metre along the line making an angle of 60º with X-direction is 4 joule, then the value of E is :

(A) $\sqrt{3}$ N/C (B) 4 N/C (C) 5 N/C (D) 20 N/C

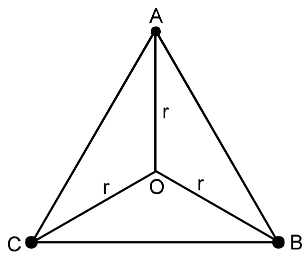
B.2 A simple pendulum has a length ℓ, mass of bob m. The bob is given a charge q coulomb. The pendulum is suspended between the vertical plates of charged parallel plate capacitor. Which produces a uniform electric field of strength E between the plates, then assuming that it does not collide with the plate calculate the time period T =



(A) $2\pi\sqrt{\frac{\ell}{g}}$ (B) $2\pi\sqrt{\left\{\frac{\ell}{g+\frac{qE}{m}}\right\}}$

(C) $2\pi\sqrt{\left\{\frac{\ell}{g-\frac{qE}{m}}\right\}}$ (D) $2\pi\sqrt{\frac{\ell}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

B.3 Three equal point charges +Q are present at the points A, B, C of a triangle having equal sides. The intensity of electric field at O will be:



(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

(C) Zero (D) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{r^2}$

B.4 The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will be :

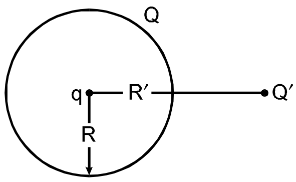
(A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{2\sqrt{3}R^2}$

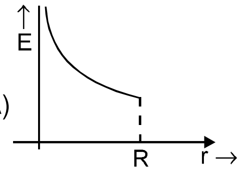
B.5 A charged particle of charge q and mass m is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after time 't' seconds is

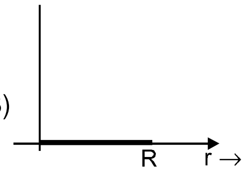
(A) $\frac{Eqm}{t}$ (B) $\frac{E^2q^2t^2}{2m}$ (C) $\frac{2E^2t^2}{mq}$ (D) $\frac{Eq^2m}{2t^2}$

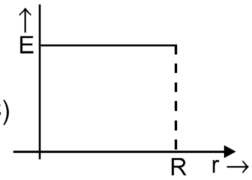
B.6 A charge 'q' is placed at the centre of a conducting spherical shell of radius R, which is given a charge Q. An external charge Q′ is also present at distance R′ (R′ > R) from 'q'. Then the resultant field will be best represented for region r < R by:

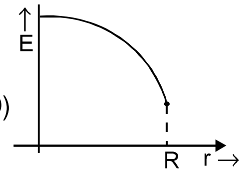
[where r is the distance of the point from q]



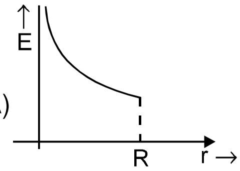
(A) 

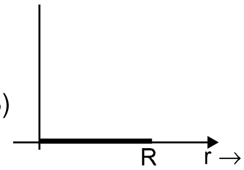
(B) 

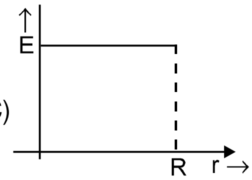
(C) 

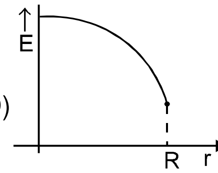
(D) 

B.7 In the above question if Q' is removed then which option is correct :

(A) 

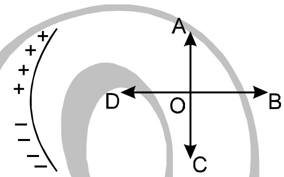
(B) 

(C) 

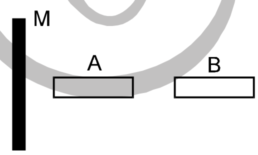
(D) 

B.8 A solid sphere of radius R has a volume charge $\rho = \rho_0 r^2$ (Where ρ_0 is a constant and r is the distance from centre). At a distance x from its centre for x < R, the electric field is directly proportional to :
(A) $1/x^2$ (B) $1/x$ (C) x^3 (D) x^2

B.9 The linear charge density on upper half of a segment of ring is λ and at lower half it is $-\lambda$. The direction of electric field at centre O of ring is :
(A) along OA (B) along OB
(C) along OC (D) along OD



B.10* A large nonconducting sheet M is given a uniform charge density. Two uncharged small metal rods A and B are placed near the sheet as shown in figure.
(A) M attracts A (B) M attracts B
(C) A attracts B (D) B attracts A



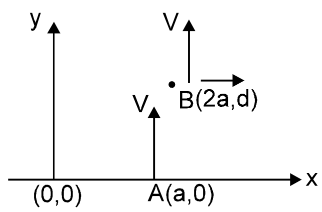
B.11* A uniform electric field of strength E exists in a region. An electron (charge –e, mass m) enters a points A perpendicularly with velocity V. It moves through the electric field & exits at point B.Then:

(A) $E = -\dfrac{2amv^2}{ed^2}\hat{i}$

(B) Rate of work done by the electric field at B is $\dfrac{4ma^2v^3}{d^3}$

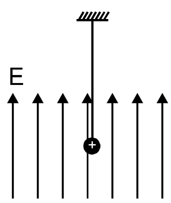
(C) Rate of work by the electric field at A is zero

(D) Velocity at B is $\dfrac{2av}{d}\hat{i} + v\hat{j}$



B.12* At distance of 5cm and 10cm outwards from the surface of a uniformly charged solid sphere, the potentials are 100V and 75V respectively. Then
(A) potential at its surface is 150V.
(B) the charge on the sphere is $(5/3) \times 10^{-9}$C.
(C) the electric field on the surface is 1500 V/m.
(D) the electric potential at its centre is 225V.

B.13 If a positively charged pendulum is oscillating in a uniform electric field as shown in Figure. Its time period of SHM as compared to that when it was uncharged.



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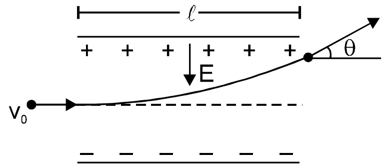
(A) Will increase (B) Will decrease
(C) Will not change (D) Will first increase then decrease

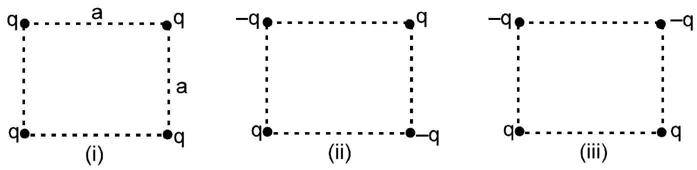
B.14 A water particle of mass 10.0 mg and having a charge of 1.50×10^{-6} C stays suspended in a room. What is the magnitude of electric field in the room ? What is its direction ?

B.15 A uniform electric field E is created between two parallel, charged plates as shown in figure. An electron enters the field symmetrically between the plates with a speed v_0. The length of each plate is l. Find the angle of deviation of the path of the electron as it comes out of the field.



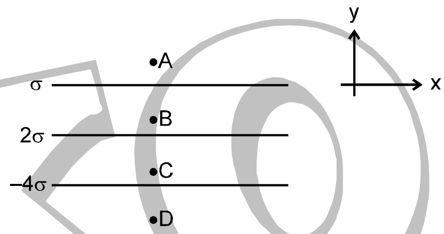
B.16 Ten charges are placed on a meter stick at regular interval starting from 10cm mark at an interval of 10cm. The magnitude of the charges are q, 4q, 9q,.........Find the field intensity at the zero mark of the stick.

B.17 In the following figures find the electric field at a point 'P' on the axis of the square. The distance of 'P' from the centre is 'x'.



B.18 In the above question find electric field for two cases
(a) x = 0
(b) x >> a. Also explain physical meaning of result of part (b)

B.19 If three infinite charged sheets of uniform surface charge densities σ, 2σ and –4σ are placed as shown in figure, then find out electric field intensities at points A, B, C and D.



B.20 (i) The electric field intensity at a distance 20 cm from the centre of a uniformly charged nonconducting solid sphere of radius 10 cm is E. Then what is the electric field intensity at a distance 5 cm from the centre? Find the electric field at r = 20 cm in terms of E, and at 20 cm (outside) from the surface and at 5 cm (inside) from the surface.
(ii) Question if the distances given are from surface of sphere.

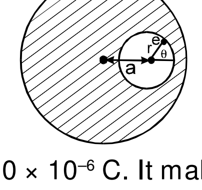
B.21 Repeat the question if sphere is a hollow nonconducting sphere of radius R and uniform surface charge density σ.

(i) 0 (ii) $\dfrac{\sigma R^2}{\varepsilon_0 (r+R)^2}\hat{r}$

B.22 A charge of 16×10^{-9} C is fixed at the origin of coordinates, a second charge of unknown magnitude is at x = 3m, y = 0 and a third charge of 12×10^{-9} C is at x = 6m, y = 0. What is the value of the unknown charge if the resultant field at x = 8m, y = 0 is 20.25 N/C directed towards positive x-axis?

B.23 A clock face has negative charges -q, -2q, -3q,........., -12q fixed at the position of the corresponding numerals on the dial. The clock hands do not disturb the net field due to point charges. At what time does the hour hand point in the same direction as electric field at the centre of the dial. All the parts of the clock are of nonconducting material.

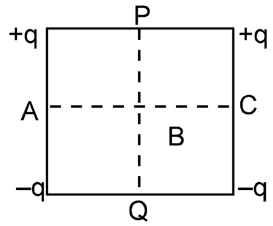
B.24 A cavity of radius r is present inside a solid dielectric sphere of radius R, having a volume charge density of ρ. The distance between the centres of the sphere and the cavity is a. An electron e is kept inside the cavity at an angle θ = 45^0 as shown. How long will the electron take to touch the sphere again?



B.25 The bob of a simple pendulum has a mass of 40 g and a positive charge of 4.0×10^{-6} C. It makes 20 oscillations in 45 s. A vertical electric field pointing upward and of magnitude 2.5×10^4 N/C is switched on. How much time will it now take to complete 20 oscillations ?

SECTION C : ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE

C.1 Figure represents a square carrying charges +q, +q, –q, –q at its four corners as shown. Then the potential will be zero at points



(A) A, B, C, P and Q (B) A, B and C (C) A, P, C and Q (D) P, B and Q

C.2 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 from A to B. The potential
(A) continuously increases (B) continuosly decreases
(C) increases then decreases (D) decreases than increases

C.3 If a uniformly charged spherical shell of radius 10 cm has a potential V at a point distant 5 cm from its centre, then the potential at a point distant 15 cm from the centre will be :

(A) $\frac{V}{3}$ (B) $\frac{2V}{3}$ (C) $\frac{3}{2}V$ (D) 3V

C.4 A hollow uniformly charged sphere has radius r. If the potential difference between its surface and a point at distance 3r from the centre is V, then the electric field intensity at a distance 3r from the centre is:
(A) V/6r (B) V/4r (C) V/3r (D) V/2r

C.5 A hollow sphere of radius 5 cm is uniformly charged such that the potential on its surface is 10 volt then potential at centre of sphere will be :
(A) Zero (B) 10 volt
(C) Same as at a point 5 cm away from the surface
(D) Same as at a point 25 cm away from the centre

C.6 A hollow sphere is uniformly charged. Inside the sphere
(A) The potential is zero but the electric field is finite
(B) The electric field is zero but the potential is finite
(C) Both the electric field and the potential are finite
(D) Both the electric field and the potential are zero

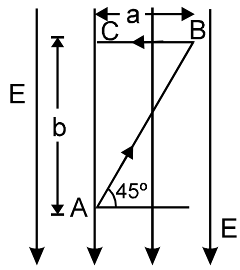
C.7 Two spherical conductors of radii 4 m and 5 m are charged to the same potential. If σ_1 and σ_2 are the respective values of the surface charge densities on the two conductors, then the ratio $\frac{\sigma_1}{\sigma_2}$ is :

(A) $\frac{5}{4}$ (B) $\frac{4}{5}$ (C) $\frac{25}{16}$ (D) $\frac{16}{25}$

C.8* Which of the following quantites 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 a two - charge system
(D) change in potential energy of a two-charge system

C.9 A 5 coulomb charge experiences a constant force of 2000 N when moved between two points separated by a distance of 2 cm in a uniform electric field. The potential difference between these two points is :
(A) 8 V (B) 200 V (C) 800 V (D) 20,000 V

C.10 The potential difference between points A and B in the given uniform electric field is :



(A) Ea (B) $E\sqrt{(a^2+b^2)}$ (C) Eb (D) $(Eb/\sqrt{2})$

C.11 A particle of charge Q and mass m travels through a potential difference V from rest. The final momentum of the particle is :

(A) $\frac{mV}{Q}$ (B) $2Q\sqrt{mV}$ (C) $\sqrt{2m\ QV}$ (D) $\sqrt{\frac{2QV}{m}}$

C.12 A point charge 20 μC is shifted from infinity to a point P in an electric field with zero acceleration. If the potential of that point is 1000 volt, then
(i) find out work done by external agent against electric field?
(ii) what is the work done by electric field?
(iii) If the kinetic energy of charge particle is found increase by 10 mJ when it is brought from infinity to point P then what is the total work done by extenal agent?
(iv) what is the work done by electric field in the part (iii)
(v) If a point charge 30 μC is released at rest at point P, then find out its kinetic energy at a large distance?

C.13 What is the potential at origin if two equal point charges 'q' are placed at (a, 0) and (–a, 0)?

C.14 Six equal point charges 'q_0' are placed at six corners of a regular hexagon of side 'a'. Find out work required to take a point charge 'q'
(i) From infinity to the centre of hexagon.
(ii) From infinity to a point on the axis which is at a distance '$\sqrt{3}$ a' from the centre
(iii) Does your answer to part (i) and (ii) depends on the path followed by the charge.

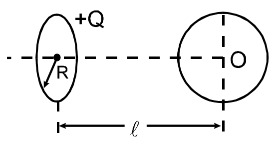
C.15 12 J of work has to be done against an existing electric field to take a charge of 0.01 C from A to B. How much is the potential difference $V_B - V_A$?

C.16 An electric field of 30 N/C exists along the negative x-axis in space. Calculate the potential difference $V_B - V_A$ where the points A and B are given by,
(a) A = (0, 0) ; B = (0, 2m) (b) A = (4m, 2m) ; B = (6m, 5m)

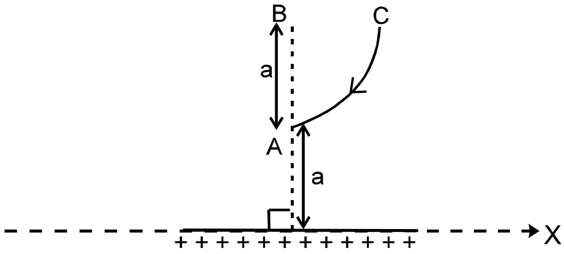
C.17 A particle of charge $+3 \times 10^{-9}$ C is in a uniform field directed to the left. It is released from rest and moves a distance of 5 cm after which its kinetic energy is found to 4.5×10^{-5} J.
(a) What work was done by the electrical force?
(b) What is the magnitude of the electrical field?
(c) What is the potential of the starting point with respect to the end point?

C.18 A positive charge Q = 50 μC is located in the xy plane at a point having position vector $r_0 = (2\hat{i}+3\hat{j})$m where $\hat{i}$ and $\hat{j}$ are unit vectors in the positive directions of X and Y axis respectively. Find:
(a) The electric intensity vector and its magnitude at a point of coordinates (8 m, - 5 m).
(b) Work done by external agent in transporting a charge q = 10 μC from (8 m, 6 m) to the point (4 m, 3 m).

C.19 A thin ring of radius R has been non-uniformly charged with an amount of electric charges Q and placed in relation to a conducting sphere in such a way that the centre of the sphere O, lies on the axis at a distance of ℓ from the plane of the ring. Determine the potential of the sphere.

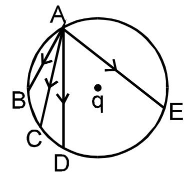


C.20 For an infinite line of charge having charge density λ lying along x-axis, the work required in moving charge from C to A along are CA is :



(A) $\frac{q\lambda}{\pi\varepsilon_0}\log_e\sqrt{2}$ (B) $\frac{q\lambda}{4\pi\varepsilon_0}\log_e\sqrt{2}$ (C) $\frac{q\lambda}{4\pi\varepsilon_0}\log_e 2$ (D) $\frac{q\lambda}{2\pi\varepsilon_0}\log_e\frac{1}{2}$

C.21 In the electric field of a point charge q a certain charge is carried from point A to B, C, D and E the work done: (q is at the centre of circle)



(A) Is least along the path AB
(B) Is least along the path AD
(C) Is zero along each path AB, AC, AD and AE
(D) Is least along AE

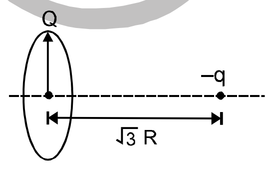
SECTION D : ELECTRIC POTENTIAL ENERGY OF A POINT CHARGE

D.1 If a positive charge is shifted from a low potential region to high potential region. the electrical potential energy :
(A) Increases (B) Decreases
(C) Remains constant (D) May increase or decrease.

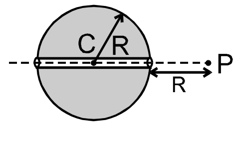
D.2 In bringing an electron towards another electron, electrostatic potential energy of the system :
(A) Deceases (B) Increases
(C) Becomes zero (D) Remains same

D.3 A particle of mass 2 g and charge 1μC is held at rest on a frictionless horizontal surface at a distance of 1 m from a fixed charge 1 mC. If the particle is released it will be repelled. The speed of the particle when it is at distance of 10 m from the fixed charge is:
(A) 100 m/s (B) 90 m/s (C) 60 m/s (D) 45 m/s

D.4 A point charge having charge '–q' and mass 'm' is released at rest on the axis of a uniformly charged fix ring of total charge 'Q' and radius 'R' from a distance $\sqrt{3}$ R . Find out its velocity when it reaches to centre of ring.



D.5 A solid uniformly charged non-conducting sphere of total charge Q and radius R contains a tunnel of negligible diameter. If a point charge –q of mass 'm' is released at rest from point P as shown in figure then find out its velocity at following points
(i) At the surface of sphere (ii) At the centre of the sphere



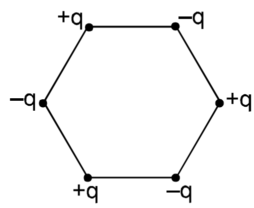
D.6 Two identical charges 5 μC each are fixed at a distance 8 cm between them and a charged particle of mass 9 × 10^{-6} kg and – 10 μC is placed at a distance 5 cm from each of them and is released. Find the speed of the particle when it is nearest to the two charges.

SECTION E : POTENTIAL ENERGY OF A SYSTEM OF POINT CHARGES

E.1 Six charges of magnitude + q and –q are fixed at the corners of a regular hexagon of edge length a as shown in the figure. The electrostatic interaction energy of the charged particles is :

(A) $\frac{q^2}{\pi\in_0 a}\left[\frac{\sqrt{3}}{8}-\frac{15}{4}\right]$ (B) $\frac{q^2}{\pi\in_0 a}\left[\frac{\sqrt{3}}{2}-\frac{9}{4}\right]$

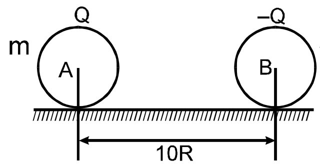
(C) $\frac{q^2}{\pi\in_0 a}\left[\frac{\sqrt{3}}{4}-\frac{15}{2}\right]$ (D) $\frac{q^2}{\pi\in_0 a}\left[\frac{\sqrt{3}}{2}-\frac{15}{8}\right]$



E.2 Two smooth spherical non conducting shells each of radius R having uniformly distributed charge Q &

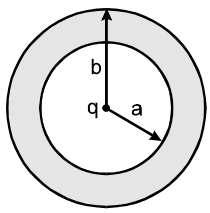
Teko Classes, Maths : Suhag R. Kariya (S. R. K. Sir), Bhopal Phone : 0 903 903 7779, 0 98930 58881.

– Q on their surfaces are released on a smooth non-conducting surface when the distance between their centres is 10 R. The mass of A is m and that of B is 2 m. The speed of A just before A and B collide is: [Neglect gravitational interaction]



(A) $\sqrt{\frac{2kQ^2}{15mR}}$ (B) $\sqrt{\frac{4kQ^2}{15mR}}$ (C) $\sqrt{\frac{8kQ^2}{15mR}}$ (D) $\sqrt{\frac{16kQ^2}{15mR}}$

E.3 A point charge q is brought from infinity and is placed at the centre of a conducting neutral spherical shell of inner radius a and outer radius b, then work done by external agent is:

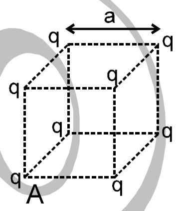


(A) 0 (B) $\frac{kq^2}{2b}$

(C) $\frac{kq^2}{2b} - \frac{kq^2}{2a}$ (D) $\frac{kq^2}{2a} - \frac{kq^2}{2b}$

E.4 Two positive point charges 15 μC and 10 μC are 30 cm apart. Calculate the work done in bringing them closer to each other by 15 cm.

E.5 Eight equal point charges each of charge 'q' and mass 'm' are placed at eight corners of a cube of side 'a'.



(i) Find out potential energy of charge system
(ii) Find out work required by external agent against electrostatic forces and by electrostatic forces to increase all sides of cube from a to 2a.
(iii) If all the charges are released at rest then find out their speed when they are at the corners of cube of side 2a.
(iv) If keeping all other charges fix , charge of corner 'A' is released then find out its speed when it is at infinite distance?
(v) If all charges are released at rest then find out their speed when they are at a very large distance from each other.

E.6 You are given an arrangment of three point charges q, 2q and xq separated by equal finite distances so that electric potential energy of the system is zero. Calculate the value of x.

SECTION F : SELF ENERGY AND ENERGY DENSITY

F.1 The energy stored per unit volume in an electric field of strength E volt/metre in a medium of dielectrc constant K (in Joule/metre^3) is :

(A) $\frac{1}{2}\varepsilon_0 E^2$ (B) $\frac{1}{2}K\varepsilon_0 E^2$ (C) $\frac{1}{2}.\frac{\varepsilon_0 E^2}{K}$ (D) $\frac{1}{2}k^2\varepsilon_0^2 E$

F.2 If ' n ' identical water drops each charged to a potential energy U coalesce to a single drop, the potential energy of the single drop is(Assume that drops are uniformly charged):
(A) $n^{1/3}$ U (B) $n^{2/3}$ U (C) $n^{4/3}$ U (D) $n^{5/3}$ U

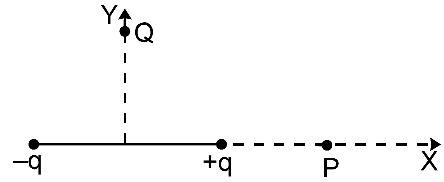
F.3 A spherical shell of radius R with a uniform charge q has point charge q_0 at its centre. Find the work performed by the electric forces during the shell expansion from radius R to 2R. Also find out work done by external agent against electric forces.

F.4 Two identical nonconducting spherical shells having equal charge Q are placed at a distance d apart. When they are released find out kinetice energy of each sphere when they are at a large distance.

F.5 A spherical shell of radius R with uniform charge q is expanded to a radius 2R. Find the work performed by the electric forces in this process.

SECTION G : DIPOLE

G-1 Due to an electric dipole shown in fig., the electric field intensity is parallel to dipole axis :



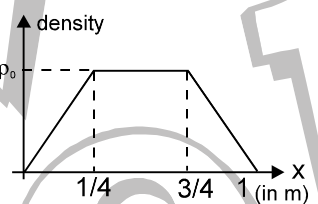
(A) at P only (B) at Q only (C) both at P and at Q (D) neither at P nor at Q

G-2 An electric dipole consists of two opposite charges each of magnitude 1.0 μC separated by a distance of 2.0 cm. The dipole is placed in an external field of 1.0×10^5 N/C. The maximum torque on the dipole is :
(A) 0.2×10^{-3} N-m (B) 1.0×10^{-3} N-m (C) 2.0×10^{-3} N-m (D) 4.0×10^{-3} N-m

G-3 A dipole of electric dipole moment P is placed in a uniform electric field of strength E. If θ is the angle between positive directions of P and E, then the potential energy of the electric dipole is largest when θ is :
(A) zero (B) $\pi/2$ (C) π (D) $\pi/4$

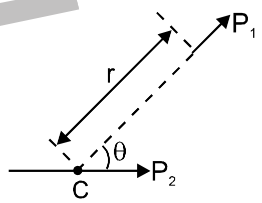
G-4 Two opposite and equal charges 4×10^{-8} coulomb when placed 2×10^{-2} cm apart form a dipole. If this dipole is placed in an external electric field 4×10^8 N/C, the value of maximum torque and the work done in rotating it through 180º from its initial orientation which is along electric field will be :
(A) 64×10^{-4} N-m and 44×10^{-4} J (B) 32×10^{-4} N-m and 32×10^{-4} J
(C) 64×10^{-4} N-m and 32×10^{-4} J (D) 32×10^{-4} N-m and 64×10^{-4} J

G-5 The volume charge density as a function of distance X from one face inside a unit cube is varying as shown in the figure. Then the total flux (in S.I. units) through the cube if $\rho_0 = 8.85 \times 10^{-12}$ C/m³ is:



(A) 1/4 (B) 1/2 (C) 3/4 (D) 1

G-6 Two short electric dipoles are placed as shown (r is the distance between their centres). The energy of electric interaction between these dipoles will be:
(C is centre of dipole of moment P_2)

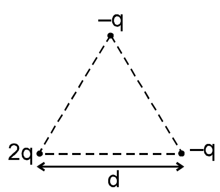


(A) $\dfrac{2k\ P_1P_2\cos\theta}{r^3}$ (B) $\dfrac{-2k\ P_1P_2\cos\theta}{r^3}$

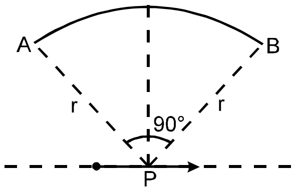
(C) $\dfrac{-\ 2kP_1P_2\sin\theta}{r^3}$ (D) $\dfrac{-\ 4kP_1P_2\cos\theta}{r^3}$

G-7* An electric dipole is kept in the electric field produced by a point charge.
(A) dipole will experience a force.
(B) dipole can experience a torque.
(C) dipole can be in stable equilibrium.
(D) it is possible to find a path in the field on which work required to move the dipole is zero.

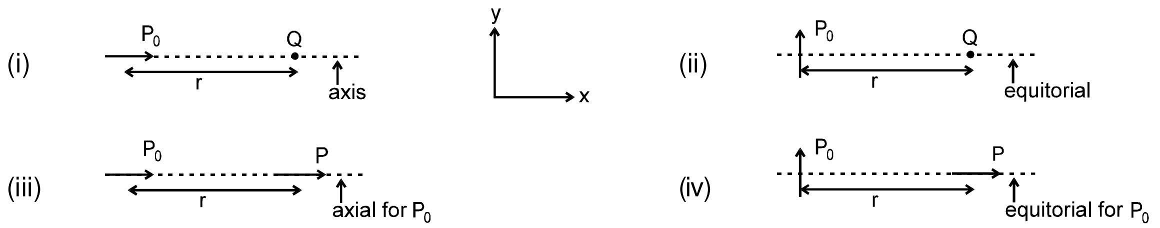
G-8 Three charges are arranged on the vertices of an equilateral triangle as shown in figure. Find the dipole moment of the combination.



G-9 A charge ' q ' is carried from a point A (r, 135º) to point B (r, 45º) following a path which is a quadrant of circle of radius ' r '. If the dipole moment is $\vec{P}$, then find out the work done by external agent ?

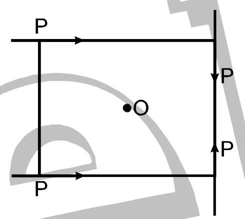


G-10 Find out force experienced by short dipole $\vec{P}_0$ in following different arragnement as shown in figures.
[Assume point charge is Q, $\vec{P}_0 = q_0(2a)$ and $\vec{P} = q(2a)$]



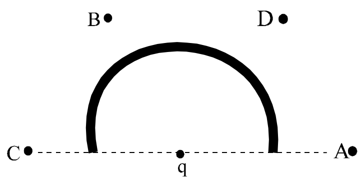
G-11 Find out the magnitude of electric field intensity at point (2, 0, 0) due to a dipole of dipole moment, $\vec{P} = \hat{i} + \sqrt{3}\,\hat{j}$ kept at origin? Also find out the potential at that point.

G-12 Four short dipoles each of dipole moment $\vec{P}$ are placed at the vertices of a square of side a. The direction of the dipole moments are shown in the figure. Find the electric field and potential at the centre 'O' of the square.



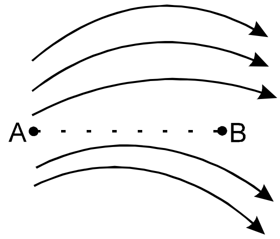
SECTION H : FLUX CALCULATION AND GAUSS'S LAW

H-1* Figure shows a charge q placed at the centre of a hemisphere. A second charge Q is placed at one of the positions A, B, C and D. In which position(s) of this second charge, the flux of the electric field through the hemisphere remains unchanged ?



(A) A (B) B (C) C (D) D

H-2 The figure shows the electric lines of force emerging from a charged body. If the electric fields at A and B are E_A and E_B respectively and if the distance between A and B is r, then

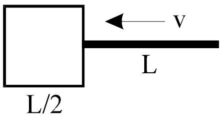


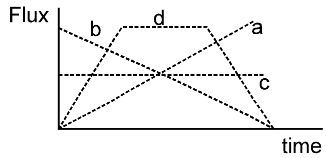
(A) $E_A < E_B$ (B) $E_A > E_B$
(C) $E_A = \frac{E_B}{r}$ (D) $E_A = \frac{E_B}{r^2}$

H-3 Select the correct statement :
(A) The electric lines of force are always closed curves

(B) Electric line of force is parallel to equipotential surface
(C) Electric line of force is perpendicular to equipotential surface
(D) Electric line of force is always the path of a positively charged particle.

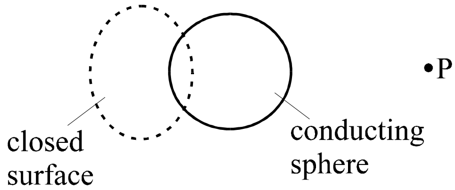
H-4 Figure (a) shows an imaginary cube of edge L/2. A unifromly charged rod of length L moves towards left at a small but constant speed v. At t = 0, the left end just touches the centre of the face of the cube opposite it. Which of the graphs shown in fig.(b) represents the flux of the electric filed through the cube as the rod goes through it ?

(a) 

(b) 

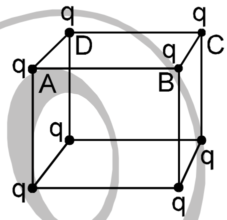
(A) a (B) b (C) c (D) d

H-5* Figure shows a closed surface which intersects a conducting sphere. If a positive charge is placed at the point P, the flux of the electic field through the closed surface



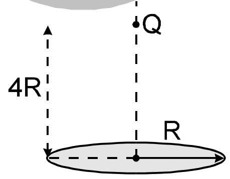
(A) will remain zero (B) will become positive
(C) will become neagative (D) will become undefined

H-6 Eight point charges (can be assumed as small spheres uniformly charged and their centres at the corner of the cube) having values q each are fixed at vertices of a cube. The electric flux through square surface ABCD of the cube is



(A) $\frac{q}{24\epsilon_0}$ (B) $\frac{q}{12\epsilon_0}$ (C) $\frac{q}{6\epsilon_0}$ (D) $\frac{q}{8\epsilon_0}$

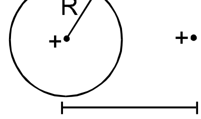
H-7 A charge Q is placed at a distance of 4R above the centre of a disc of radius R. The magnitude of flux through the disc is ϕ. Now a hemispherical shell of radius R is placed over the disc such that it forms a closed surface. The flux through the curved surface taking direction of area vector along outward normal as positive, is



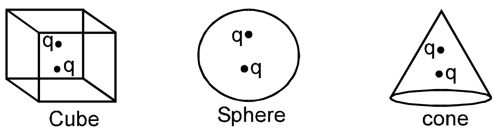
(A) zero (B) ϕ (C) $-\phi$ (D) 2ϕ

H-8 Find out the electric flux through an area 10 m^2 lying in XY plane due to an electric field $\vec{E} = 2\hat{i} - 10\hat{j} + 5\hat{k}$.

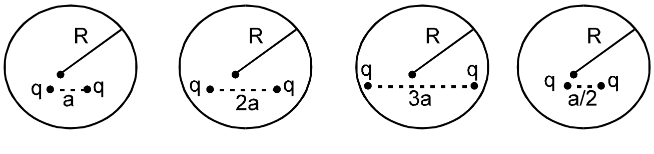
H-9 Find the flux of the electric field through a spherical surface of radius R due to a charge of 8.85 x 10^{-8}C at the centre and another equal charge at a point 2R away from the centre



H-10 Two point charges are placed at a certain ditance (as shown in figures) inside a cube , sphere and a cone. Arrange the order of flux through the closed surfaces.



H-11 In which of the following case the flux is maximum through close spherical gaussian surface of radius R ?

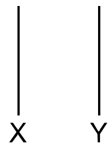


H-12 What do you predict by the statement about the nature of charge in a close surface. "In a close surface lines which are leaving the surface are double then the lines which are entering in it".

H-13 The electric field in a region is given by $\vec{E} = \frac{E_0 x}{\ell}\hat{i}$. Find the charge contained inside a cubical volume bounded by the surface x = 0, x = a, y = 0, y = a, z = 0 and z = a. Take $E_0 = 5 \times 10^3$ N/C, ℓ = 2 cm and a = 1 cm.

SECTION I : CONDUCTOR AND IT'S PROPERTIES

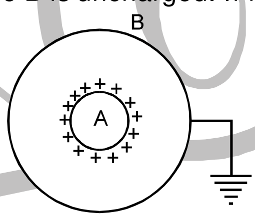
I.1 Two conducting plates X and Y, each having large surface area 'A' as shown in figure (on one side) are placed parallel to each other. The plate X is given a charge Q whereas the other is neutral. The electric field at a point in between the plates is given by:



(A) $\frac{Q}{2A}$
(B) $\frac{Q}{2A\varepsilon_0}$ towards left
(C) $\frac{Q}{2A\varepsilon_0}$ towards right
(D) $\frac{Q}{2\varepsilon_0}$ towards right

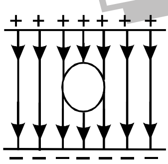
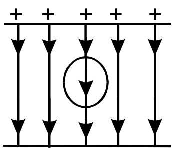
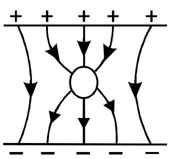
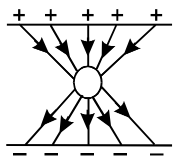
I.2 A charge Q is unifromly distributed over a large plastic plate. The electric field at a point P close to the centre of the plate is 10 V/m. If the plastic plate is replaced by a copper plate of the same geometrical dimensions and carriying the same charge Q, the electric field at the point P will become
(A) zero (B) 5 V/m (C) 10 V/m (D) 20 V/m

I.3* A and B are two concentric spherical shells. A is given a charge Q while B is uncharged. If now B is earthed as shown in Figure.Then:

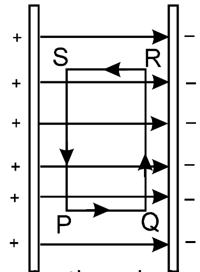


(A) The charge appearing on inner surface of B is -Q
(B) The field inside and outside A is zero
(C) The field between A and B is not zero
(D) The charge appearing on outer surface of B is zero

I.4 An uncharged sphere of metal is placed in a uniform electric field produced by two large conducting parallel plates having equal and opposite charges, then lines of force look like

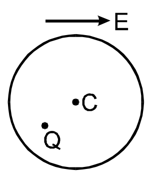
(A) 
(B) 
(C) 
(D) 

I.5 The amount of work done in Joules in carrying a charge +q along the closed path PQRSP between the oppositely charged metal plates is (where E is electric field between the plates)



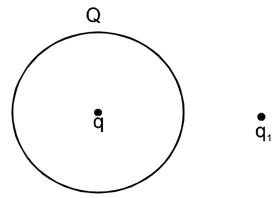
(A) zero
(B) q
(C) qE (PQ + QR + SR + SP)
(D) q/ε_0

I.6 A positive point charge Q is kept (as shown in the figure) inside a neutral conducting shell whose centre is at C. An external uniform electric field E is applied. Then



(A) force on Q due to E is zero
(B) net force on Q is zero
(C) net force acting on Q and conducting shell considered as a system is zero
(D) net force acting on the shell due to E is zero.

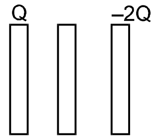
I.7 A thin, metallic spherical shell contains a chrage Q on it. A point charge q is placed at the centre of the shell and another charge q_1 is placed outside it as shown in fig. All the three charges are positive. The force on the charge at the centre is



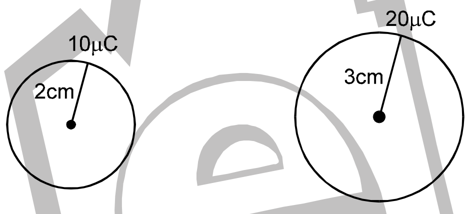
(A) towards left (B) towards right
(C) upward (D) zero

I.8 The net charge given to an isolated conducting solid sphere:
(A) must be distributed uniformly on the surface
(B) may be distributed uniformly on the surface
(C) must be distributed uniformly in the volume
(D) may be distributed uniformly in the volume.

I.9 Three identical metal plates with large equal surface areas are kept parallel to each other as shown in figure. The leftmost plate is given a charge Q, the rightmost a charge – 2Q and the middle one remains neutral. Find the charge appearing on the outer surface of the rightmost plate.

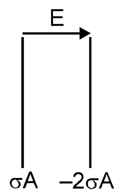


I.10 Figure shows two isolated conducting spheres of radius 2cm and 3cm containing charges 10μC and 20μC respectively. When the spheres are connected by a conducting wire then find out following :
(i) Ratio of the final charge. (ii) Final charge on each sphere.
(iii) Ratio of final charge densities. (iv) Heat loss during the process.

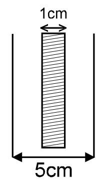


I.11 Two concentric hollow conducting spheres of radius a and b (b>a) contains charges Q_a and Q_b respectively. If they are connected by a conducting wire then find out following
(i) Final charges on inner and outer spheres.
(ii) Heat produced during the process.

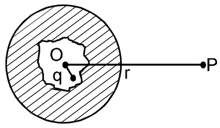
I.12 Two thin conducting plates (very large) parallel to each other carrying total charges σA and -2σ A respectively (where A is the area of each plate), are placed in a uniform external electric field E as shown. Find the surface charge on each surface.



I.13 The distance between two large plates is d = 5 cm and the intensity of the field in it is E = 300 V/cm. An uncharged metal bar which is 1 cm thick, is inserted between the plates as shown. Determine the potential difference between the plates of the capacitor before and after the bar is introduced.



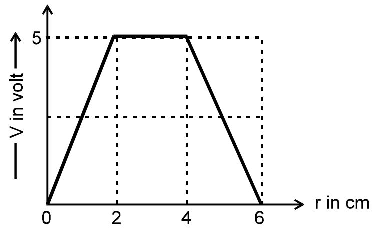
I.14 The point charge 'q' is within an electrically neutral conducting shell whose outer surface has spherical shape. Find potential V at point P lying outside shell at a distance 'r' from centre O of outer sphere.



SECTION J : QUESTIONS BASED ON RELATION BETWEEN $\vec{E}$ AND V :

J.1* The electric field intensity at a point in space is equal in magnitude to :
(A) The potential gradient there (B) The electric charge there
(C) The force, a unit charge would experience there (D) The force, an electron would experience there

J.2 The variation of potential with distance r from a fixed point is shown in Figure. The electric field at r = 5 cm, is :
(A) (2.5) V/cm (B) (–2.5) V/cm
(C) (–2/5) cm (D) (2/5) V/cm



J.3 The electric potential V as a function of distance x (in metre) is given by
$V = (5x^2 + 10x - 9)$ volt
The value of electric field at x = 1 m would be :
(A) – 20 volt/m (B) 6 volt/m (C) 11 volt/m (D) –23 volt/m

J.4 A uniform electric field having a magnitude E_0 and direction along positive X-axis exists. If the electric potential V is zero at x = 0, then its value at x = +x will be :
(A) $V_x = xE_0$ (B) $V_x = -xE_0$ (C) $V_x = x^2E_0$ (D) $V_x = -x^2 E_0$

J.5 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 20V/cm (B) may be equal to 20V/cm
(C) may be greater than 20V/cm (D) may be less than 20V/cm

J.6 The electric field in a region is directed outward and is proportional to the distance r form the origin. Taking the electric potential at the origin to be zero, the electric potential at a distance r :
(A) is uniform in the region (B) is proportional to r
(C) is proportional to r^2 (D) increases as one goes away from the origin.

J.7 If $V = x^2y + y^2z$ then find $\vec{E}$ (x, y, z)

J.8 If $V = 2r^2$ then find out (i) $\vec{E}$ (1, 0, –2) (ii) $\vec{E}(r = 2)$

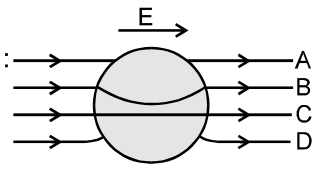
J.9 An electric field $\vec{E} = (20\hat{i} + 30\hat{j})$ N/C exists in the space. If the potential at the origin is taken to be zero, find the potential at (2m, 2m).

J.10 If $E = 2r^2$ then find V(r)

J.11 If $\vec{E} = 2y\,\hat{i} + 2x\,\hat{j}$ then find V (x, y, z)

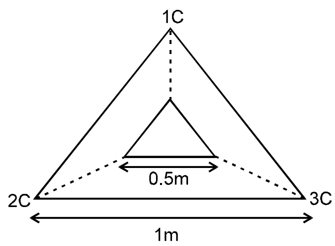
EXERCISE-2

1. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path(s) shown in figure as
(a) A (b) B
(c) C (d) D **[JEE '96, 2/100]**



2. A non-conducting ring of radius 0.5 m carries a total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field $\vec{E}$ every where in space . The value of the line integral $\int_{\ell=\infty}^{\ell=0} -\vec{E}.d\vec{\ell}$ (ℓ = 0 being centre of the ring) in volts is :
(a) + 2 (b) – 1 (c) – 2 (d) zero **[JEE '97, 1]**

3. Three point charges of 1 C, 2 C and 3 C are placed at the corners of an equilateral triangle of side 1 m. Calculate the work required to move these charges to the corners of a smaller equilateral triangle of sides 0.5 m as shown in the figure . **[REE '97, 5]**



4. Select the correct alternative :
(a) A positively charged thin metal ring of radius R is fixed in the xy–plane with its centre at the origin O . A negatively charged particle P is released from rest at the point (0, 0, z_0) where $z_0 > 0$. Then the motion of P is :

Teko Classes, Maths : Suhag R. Kariya (S. R. K. Sir), Bhopal Phone : 0 903 903 7779, 0 98930 58881.

(A) periodic, for all values of z_0 satisfying $0 < z_0 \leq \infty$
(B) simple harmonic, for all values of z_0 satisfying $0 < z_0 \leq R$
(C) approximately simple harmonic, provided $z_0 << R$
(D) such that P crosses O & continues to move along the negative z-axis towards $x = -\infty$

(b) A charge +q is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$, ... ad. inf. on the x-axis and a charge -q is fixed at each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$, ...ad. inf. Here x_0 is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be $\frac{Q}{4\pi \in_0 r}$. Then the potential at the origin due to the above system of charges is:

(A) 0 (B) $\frac{q}{8\pi \in_0 x_0 \ell n 2}$ (C) ∞ (D) $\frac{q\, \ell n 2}{4\pi \in_0 x_0}$

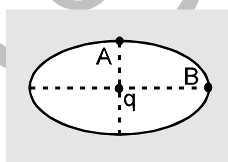
(c) A nonconducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre :
(A) increases as r increases, for $r < R$ (B) decreases as r increases, for $0 < r < \infty$
(C) decreases as r increases, for $R < r < \infty$ (D) is discontinuous at $r = R$.

[JEE '98Mains, 2+2+2/200]

5. A conducting sphere S_1 of radius r is attached to an insulating handle. Another conducting sphere S_2 of radius R is mounted on an insulating stand. S_2 is initially uncharged. S_1 is given a charge Q, brought into contact with S_2 and removed, S_1 is recharged such that the charge on it is again Q & it is again brought into contact with S_2 & removed. This procedure is repeated n times
(a) Find the electrostatic energy of S_2 after n such contacts with S_1 .
(b) What is the limiting value of this energy as $n \to \infty$? **[JEE '98 Mains, 8/200]**

6. An infinite number of charges each equal to q are placed along the x-axis at x = 1, x = 2, x = 4, x = 8..... and so on. Find the potential and the electric field at the point x = 0 due to this set of charges. What will be the potential and field in the above set, if he consecutive charges have opposite sings? **[JEE '98 Mains, 4 /200]**

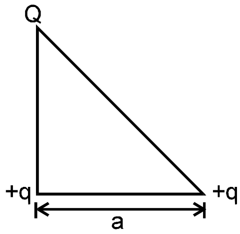
7. (a) An ellipsoidal cavity is carved within a perfect conductor . A positive charge q is placed at the center of the cavity . The points A and B are on the cavity surface as shown in the figure . Then :



(A) electric field near A in the cavity = electric field near B in the cavity
(B) charge density at A = charge density at B
(C) potential at A = potential at B
(D) total electric field flux through the surface of the cavity is q/ε_0 . **[JEE '99 Scr., 3/100]**

(b) A non-conducting disc of radius a and uniform positive surface charge density σ is placed on the ground, with its axis vertical. A particle of mass m and positive charge q is dropped, along the axis of the disc, from a height H with zero initial velocity. The particle has $\frac{q}{m} = \frac{4\varepsilon_0 g}{\sigma}$.
(a) Find the value of H if the particle just reaches the disc.
(b) Sketch the potential energy of the particle as a function of its height and find its equilibrium position. **[JEE '99 Mains, 5+5 /100]**

8. (a) The dimensions of $\left(\frac{1}{2}\right) \varepsilon_0 E^2$ (ε_0: permittivity of free space; E: electric field) are:



(A) MLT^{-1} (B) ML^2T^{-2} (C) MLT^{-2} (D) ML^2T^{-1} (E) $ML^{-1}T^{-2}$

[JEE 2000 Scr.,3/105]

(b) Three charges Q, +q and +q are placed at the vertices of a right−angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero if Q is equal to :

(A) $\frac{-q}{1+\sqrt{2}}$ (B) $\frac{-2q}{2+\sqrt{2}}$ (C) -2q (D) +q

[JEE 2000 Scr.,3/105]

(c) Four point charges + 8 μC, − 1 μC, − 1 μC and + 8 μC, are fixed at the points, $-\sqrt{\frac{27}{2}}$ m, $-\sqrt{\frac{3}{2}}$ m, $+\sqrt{\frac{3}{2}}$ m and $+\sqrt{\frac{27}{2}}$ m respectively on the y−axis. A particle of mass 6×10^{-4} kg and of charge + 0.1 μC moves along the -x direction. Its speed at x = + ∞ is v_0. Find the least value of v_0 for which the particle will cross the origin. Find also the kinetic energy of the particle at the origin. Assume that space is gravity free. Given $1/(4\pi\varepsilon_0) = 9 \times 10^9$ Nm²/C².

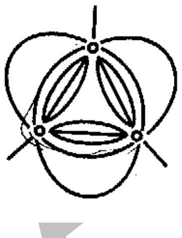
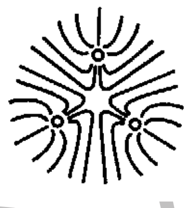
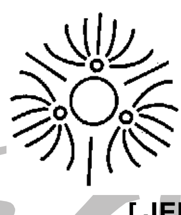
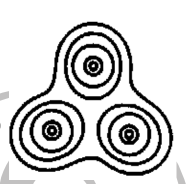
[JEE 2000 Mains,10/ 100]

9. (a) A uniform electric field pointing in positive x-direction exists in a region. Let A be the origin, B be the point on the x-axis at x = + 1 cm and C be the point on the y-axis at y = + 1 cm. Then the potentials at the points A, B & C satisfy :

(A) $V_A < V_B$ (B) $V_A > V_B$ (C) $V_A < V_C$ (D) $V_A > V_C$

[JEE 2001Scr.,3/105]

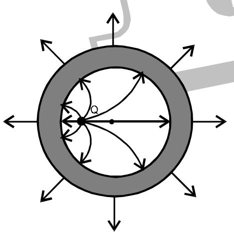
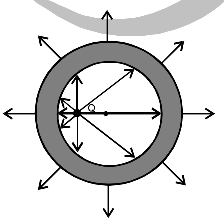
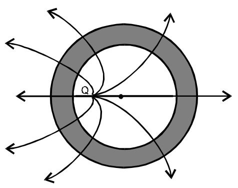
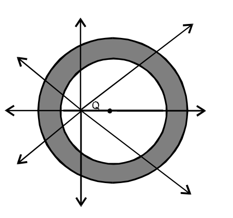
(b) Three positive charges of equal value q are placed at the vertices of an equilateral triangle. The resulting lines of force should be sketched as in :

(A)  (B)  (C)  (D) 

[JEE 2001Scr.,3/105]

(c) A small ball of mass 2×10^{-3} kg having a charge of 1 μC is suspended by a string of length 0.8 m. Another identical ball having the same charge is kept at the point of suspension. Determine the minimum horizontal velocity which should be imparted to the lower ball so that it can make complete revolution. **[JEE 2001 Mains, 5/100]**

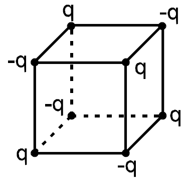
10. A point charge 'q' is placed at a point inside a hollow conducting sphere. Which of the following electric force pattern is correct?

(A)  (B)  (C)  (D) 

[JEE 2003 Scr., 3/90]

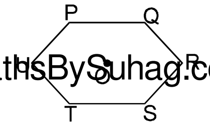
11. Eight charges each of magnitude 'q', are placed at the vertices of a cube of side a. The nearest neighbours of any charge have opposite sign. Find the work required to dismental the system.

[JEE 2003Mains, 2/60]



12. A point positive charge Q is fixed at origin and a dipole P is placed at very large distance on x-axis with $\vec{P}$ point away from the origin. Find the kinetic energy of the dipole when it is at a distance 'd' from origin and at that moment, find the force on charge by dipole. **[JEE 2003 Mains, 4/60]**

13. Six charges q,q,q, − q, −q and −q are to be arranged on the vertices of a regular hexagon PQRSTU such that the electric field at centre is double the field produced when only charge 'q' is placed at vertex R.

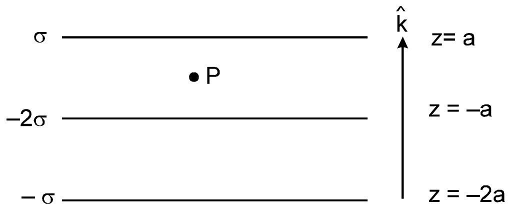


The sequence of the charges from P to U is

(A) q, –q, q, q, –q, –q (B) q, q, q, –q, –q, –q

(C) –q, q, q, –q, –q, q (D) –q, q, q, q, –q, –q **[JEE 2004 Scr, 3/84]**

14. Three large parallel plates have uniform surface charge densities as shown in the figure. Find out electric field intensity at point P.

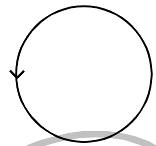


(A) $-\dfrac{4\sigma}{\epsilon_0}\hat{k}$ (B) $\dfrac{4\sigma}{\epsilon_0}\hat{k}$ (C) $-\dfrac{2\sigma}{\epsilon_0}\hat{k}$ (D) $\dfrac{2\sigma}{\epsilon_0}\hat{k}$

[JEE 2005 Scr., 3/60]

15. A bubble of conducting liquid is charged to potential v, it has radius a and thickness t << a. It collapses to form a droplet. Find potential of the droplet. **[JEE 2005 Mains, 2/60]**

16. A field line is shown in the figure. This field can not represent **[JEE 2006 Mains, 5/184]**

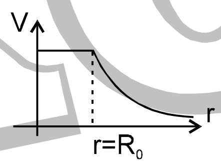


(A) Magnetic field (B) Electrostatic field

(C) Induced electric field (D) Gravitational field

17. For spherical symmetrical charge distribution, variation of electric potential with distance from centre is given in diagram. Given that : **[JEE 2006 Mains, 5/184]**

$V = \dfrac{q}{4\pi\varepsilon_0 R_0}$ for $r \le R_0$ and $V = \dfrac{q}{4\pi\varepsilon_0 r}$ for $r \ge R_0$.



Then which option(s) are correct :

(A) Total charge within $2R_0$ is q.

(B) Total electrostatic energy for $r \le R_0$ is zero.

(C) At $r = R_0$ electric field is dicontinuous.

(D) There will be no charge anywhere except at $r = R_0$

ANSWER

EXERCISE # 1

SECTION A :

A.1 C **A.2** C,D **A.3** A **A.4** C
A.5 A **A.6** C **A.7** D **A.8** D
A.9 D

A.10 |F| = 0.18 N, $\hat{F} = \frac{(4\hat{i} - 3\hat{j})}{5}$.

A.11 Decreased to 50% of initial value.

A.12 4.95×10^5 N

A.13 (i) 3.6×10^{-6} N (ii) 2 m/s^2 (iii) No
(Magnitude is same but direction is different)

A.14 (i) 0,
(ii) $\frac{Kq_0q}{a^2}$, a = distance of corner from centre.
(iii) $\frac{2Kq_0q}{a^2}$ sin 36º,

A.15 $\frac{2\ell}{3}$ from charge 4 e (If q is positive stable, If q is negative unstable)

A.16 $\frac{d}{2\sqrt{2}}$, $\frac{4}{3\sqrt{3}}$ $\frac{Qq}{4\pi\varepsilon_0 d^2}$

SECTION B :

B.1 D **B.2** D **B.3** D **B.4** C
B.5 B **B.6** A **B.7** A **B.8** C
B.9 C **B.10** C,D **B.11** A,B,C,D
B.12 B,C,D **B.13** A

B.14 200/3 = 66.67 N/C, upward

B.15 The electron deviates by an angle $\theta = \tan^{-1}\frac{eEl}{mv_0^2}$

B.16 $\frac{10q}{4\pi\varepsilon_0.r^2}$ where r = 10cm.

B.17 (i) $\frac{4Kqx}{\left(\frac{a^2}{2}+x^2\right)^{3/2}}$, along the axis , $\frac{4Kq}{x^2}$, The whole system behaves as a point charge
(ii) 0 (iii) $\frac{2Kqa}{\left(\frac{a^2}{2}+x^2\right)^{3/2}}$

B.18 (a) (i) 0 (ii) 0 (iii) $\frac{4\sqrt{2}Kq}{a^2}$
(b) (i) $\frac{4Kq}{x^2}$ (ii) 0 (iii) $\frac{2Kqa}{x^2}$

B.19 $E_A = \frac{-\sigma}{2\varepsilon_0}\hat{j}$, $E_B = \frac{-3\sigma}{2\varepsilon_0}\hat{j}$,
$E_C = \frac{-7\sigma}{2\varepsilon_0}\hat{j}$, $E_D = \frac{\sigma}{2\varepsilon_0}\hat{j}$,

B.20 (i) 2E
(ii) For point in side the sphere 2E ; and for outside the sphere $\frac{4E}{9}$

B.21

B.22 -25×10^{-9}C

B.23 9:30

B.24 $\left(\frac{6\sqrt{2}mr\varepsilon_0}{ea\rho}\right)^{1/2}$

B.25 52 s

SECTION C :

C.1 B **C.2** D **C.3** B
C.4 A **C.5** B **C.6** B
C.7 A **C.8** BD **C.9** A
C.10 C **C.11** C

C.12 (i) 20 mJ. (ii) – 20 mJ (iii) 30 mJ
(iv) –20mJ (v) 30 mJ

C.13 $\frac{2Kq}{a}$.

C.14 (i) $\frac{6Kqq_0}{a}$ (ii) $\frac{3Kqq_0}{a}$ (iii) No

C.15 1200 volts **C.16** (a) 0 (b) 60

C.17 (a) + 4.5×10^{-5} J (b) 3×10^5 N/C
(c) 1.5×10^4 V

C.18 (a) 450 $(6\hat{i} - 8\hat{j})$ V/m, 4.5 k V/m (b) 1.579 J

C.19 $V = \frac{KQ}{\sqrt{R^2+\ell^2}}$ **C.20** A **C.21** C

SECTION D :

D.1 A **D.2** B **D.3** B

D.4 $v = \sqrt{\frac{Qq}{4\pi\epsilon_0 mR}}$

D.5 $v_{surface} = \sqrt{\frac{qQ}{4\pi\epsilon_0 mR}}$ (ii) $v_{cube} = \sqrt{\frac{qQ}{2\pi\epsilon_0 mR}}$

D.6 10^3 m/s

SECTION E :

E.1 D **E.2** C **E.3** C **E.4** 4.5 J

E.5 (i) $\frac{4Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]$

(ii) $W_{ext} = -\frac{2Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right], W_{el} = \frac{2Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]$

(iii) $\sqrt{\frac{Kq^2}{2ma}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]}$

(iv) $\sqrt{\frac{2Kq^2}{ma}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]}$ (v) $\sqrt{\frac{Kq^2}{ma}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]}$

E.6 $-\frac{2}{3}$

SECTION F :

F.1 B **F.2** D

F.3 $W_{el} = \frac{q(q_0+q/2)}{8\pi\varepsilon_0 R}$, $W_{ext} = -\frac{q(q_0+q/2)}{8\pi\varepsilon_0 R}$

F.4 K.E. = $\frac{1}{2}\frac{Q^2}{4\pi\varepsilon_0 d}$ **F.5** $\frac{q^2}{16\pi\varepsilon_0 R}$

SECTION G :

G-1 C **G-2** C **G-3** C

G-4 D **G-5** C **G-6** B **G-7** ABD

G-8 $qd\sqrt{3}$, along the bisector of the angle at 2q, away from the triangle

G-9 $\frac{\sqrt{2}\,q\,P}{4\pi\varepsilon_0 r^2}$

G-10 (i) $\frac{2KP_0Q}{r^3}(-\hat{i})$ (ii) $\frac{KP_0Q}{r^3}\hat{j}$

(iii) $\frac{6KP_0P}{r^4}\hat{i}$ (iv) $\frac{3KP_0P}{r^4}(-\hat{j})$

G-11 $|E| = \frac{\sqrt{7}K}{8}$, $V = \frac{K}{4}$ [where $K = 1/4\pi\epsilon_0$] .

G-12 $E = \frac{\sqrt{2}\,p}{\pi\epsilon_0 a^3}$, $V = \frac{\sqrt{2}\,p}{\pi\epsilon_0 a^2}$

SECTION H :

H-1 AC **H-2** B **H-3** C **H-4** D

H-5 D **H-6** C **H-7** C **H-8** 50 Nm^2/C.

H-9 $10^4\frac{N-m^2}{C}$ **H-10** $\phi_{cube} = \phi_{sphere} = \phi_{cone} = \frac{2q}{\varepsilon_0}$.

H-11 Same in all cases .

H-12 There is a positive charge in the close surface.

H-13 2.2×10^{-12} C

SECTION I :

I.1 C **I.2** C *I.3* *ACD* *I.4* *C*

I.5 A **I.6** D **I.7** D **I.8** A

I.9 $-\frac{Q}{2}$ **I.10** (i) $\frac{Q'_1}{Q'_2} = \frac{2}{3}$ (ii) 12 μC, 18 μC

(iii) $\frac{\sigma'_1}{\sigma'_2} = \frac{3}{2}$ (iv) 1.49 Joules.

I.11 **(i)** on inner shell = 0 , on outer shell = $Q_a + Q_b$

(ii) $\frac{KQ_a^2}{2}\left[\frac{1}{a}-\frac{1}{b}\right]$

I.12 $(\sigma - x)A$, xA, $-xA$, $(x - 2\sigma)A$ where $x = (2\varepsilon_0 E + 3\sigma)/2$

I.13 1500 V, 1200 V **I.14** $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

SECTION J :

J.1 AC **J.2** A **J.3** A **J.4** B

J.5 BC **J.6** C

J.7 $-2xy\,\hat{i} - (x^2 + 2yz)\,\hat{j} - y^2\hat{k}$

J.8 (i) $-4(\hat{i} - 2\hat{k})$ (ii) $\vec{E} = -8\hat{r}$

J.9 –100 V **J.10** $\frac{-2r^3}{3} + C$ **J.11** $-2xy + C$

EXERCISE # 2

1. D **2.** A **3.** 9.9×10^{10} J

4. (i) A, C (ii) D (iii) A, C

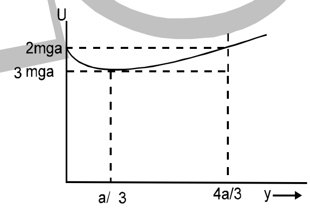
5. **(a)** $U_2 = \frac{a^2Q^2}{8\pi\epsilon_0 R}\left(\frac{1-a^n}{1-a}\right)^2$ where $a = \frac{R}{r+R}$

(b) $U_2\,(n \to \infty) = \frac{RQ^2}{8\pi\epsilon_0 r^2}$

6. $V = \frac{2q}{4\pi\varepsilon_0}$, $E = \frac{q}{3\pi\varepsilon_0}$; $V = \frac{q}{6\pi\varepsilon_0}$, $E = \frac{q}{5\pi\varepsilon_0}$.

7. **(a)** C

(b) (a) H = 4a/3 (b) $U(y) = 2mg\left[\sqrt{y^2+a^2} - y\right] +$ mgy; at equilibrium $\frac{dU}{dy} = 0 \Rightarrow y = \frac{a}{\sqrt{3}}$



8. **(a)** E **(b)** B **(c)** $v_0 = 3$ m/s; K.E. at origin = $(27 - 10\sqrt{6}) \times 10^{-4}$ J ≈ 2.5×10^{-4} J

9. **(a)** B **(b)** B **(c)** $\sqrt{\frac{275}{8}}$ = 5.86 m/s

10. A **11.** $\frac{4kq^2}{a}\left[3+\frac{1}{\sqrt{3}}-\frac{3}{\sqrt{2}}\right]$

12. **(i)** $U = p\frac{kQ}{d^2}$ **(ii)** $F = \frac{2kp}{d^3} \times Q\,(\hat{i})$

13. A **14.** C **15.** $v' = v\left(\frac{a}{3t}\right)^{1/3}$

16. BD **17.** ABCD

