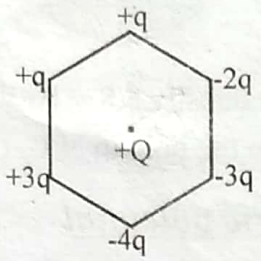
Properties of charge and Coulomb's law

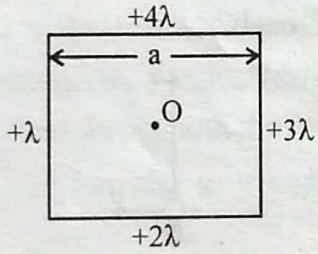
1. Six charges are kept at the vertices of a regular hexagon as shown in the figure. If magnitude of force applied by +Q on +q charge is F, then net electric force on the +Q is nF. Find the value of n.



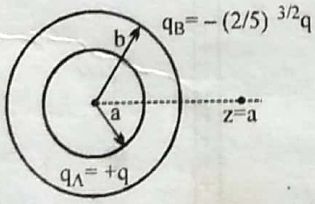
Electric field

2. A clock face has negative charges $-q, -2q, -3q, \ldots\ldots, -12q$ fixed at the positions of the corresponding numerals on the dial. Assume that 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 is electric field at the centre of the dial.

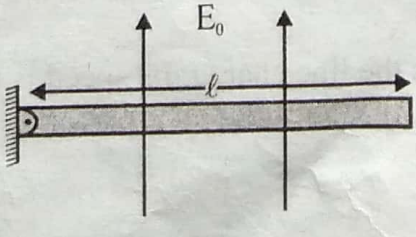
3. Four uniformly charged wires of length a are arranged to form a square. Linear charge density of each wire is as shown. Electric field intensity at centre of square is $\frac{nk\lambda}{a}$ then value of n



4. Two concentric rings, one of radius 'a' and the other of radius 'b' have the charges +q and $-(2/5)^{-3/2}q$ respectively as shown in the figure. Find the ratio b/a if a charge particle placed on the axis at z = a is in equilibrium.

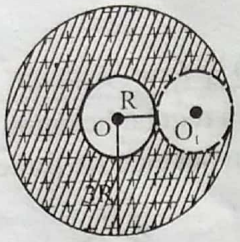


5. A thin insulating uniformly charged (linearly charged density λ) rod is hinged about one of its ends. It can rotate in vertical plane. If rod is in equilibrium by applying vertical electric field E as shown in figure. Find the value of E(in N/C). (Given that mass of rod 2 kg, $\lambda = 10\ C/m$, ℓ=1m, g=10 m/s^2)



Gauss' law

6. A thick shell with inner radius R and outer radius 3R has uniform density ρ c/m^3. It has a spherical cavity of radius R as shown in the figure. The electric field at the centre O_1 of the cavity is :-

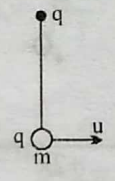


7. A spherical shell has uniform charge density 8.8×10^{-11} C/m^2. If a pin hole is made in the surface of the shell then find the electric field in the hole in N/C. (Take $\epsilon_0 = 8.8 \times 10^{-12}$ S.I. units)

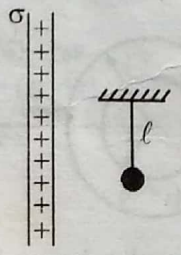
Electric potential energy and electric potential

8. A particle of positive charge Q is assumed to have fixed position at P. A second particle of mass m and negative charge –q moves at a constant speed in a circle of radius r_1, centred at P. Derive an expression for the work W that must be done by an external agent on the second particle in order to increase the radius of the circle of motion, centred at P to r_2. Express W in terms of quantities chosen from among m, r_1, r_2, q, Q and ε_0 only.

9. The bob of a pendulum has mass m = 1 kg and charge q = 40 μC. Length of pendulum is l = 0.9 m. The point of suspension also has the same charge 40 μC.
(a) What the minimum speed u should be imparted to the bob so that it can complete vertical circle?
(b) What should be u if q was 20μC each?

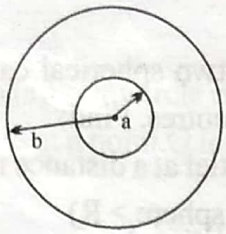


10. A simple pendulum of length ℓ and bob mass m is hanging in front of a large nonconducting sheet of surface charge density σ. If suddenly a charge $+q$ is given to the bob in the position shown in figure. Find the maximum angle through which the string is deflected from vertical.



11. A particle of mass m carrying charge 'q' is projected with velocity (v) from point P towards an infinite line charge from a distance 'a'. Its speed reduces to zero momentarily at point Q which is at a distance a/2 from the line charge. If another particle with mass m and charge –q is projected with the same velocity v from point P towards the line charge. Its speed is found to be $\frac{Nv}{\sqrt{2}}$ at point 'Q'. Find the value of N.

12. Outer cylinder of the coaxial nonconductor of radius 'b' is given a positive potential V relative to the inner cylinder of radius 'a' as shown in the figure (charge distribution is uniform). A charge q (mass = m) is set free with negligible velocity at the surface of the inner cylinder. Find the velocity (in m/s), when it hits the outer cylinder. [consider V = 10, q = –20, m = 1 all in S.I. Units]



13. Consider the configuration of a system of four charges each of value +q. Find the work done by external agent in changing the configuration of the system from figure (i) to fig (ii).

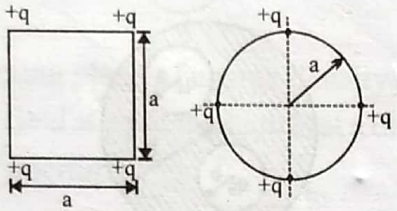


fig (i) fig (ii)

14. A positive charge Q is uniformly distributed throughout the volume of a nonconducting sphere of radius R. A point mass having charge $+q$ and mass m is fired towards the centre of the sphere with velocity v from a point at distance $r(r > R)$ from the centre of the sphere. Find the minimum velocity v so that it can penetrate $R/2$ distance of the sphere. Neglect any resistance other than electric interaction. Charge on the small mass remains constant throughout the motion.

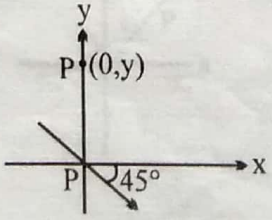
15. The electric field strength depends only on the x, y and z coordinates according to the law

$E = \dfrac{a(x\hat{i} + y\hat{j} + z\hat{k})}{\left(x^2 + y^2 + z^2\right)^{3/2}}$, where a = 122.5 SI unit and is a constant. Find the potential difference (in volt) between (3, 2, 6) and (0, 3, 4).

Electric dipole

16. A dipole of dipole moment $\vec{p} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ is placed at point A(2,–3,1). The electric potential due to this dipole at the point B(4,–1,0) is (ab) × 10^9 volt here 'a' represents sign (for negative answer select 0 for positive answer select 1. Write the value of $(a+b)^2$. The parameters specified here are in S.I. units.

17. A dipole is placed at origin of coordinate system as shown in figure, find the electric field at point P (0, y).



18. A charge $+Q$ is fixed at the origin of the coordinate system while a small electric dipole of dipole-moment $\vec{p}$ pointing away from the charge along the x-axis is set free from a point far away from the origin.

(a) calculate the K.E. of the dipole when it reaches to a point $(d, 0)$ **[IIT-JEE 2003]**

(b) calculate the force on the charge $+Q$ due to the dipole at this moment.

Conductors

19. A conducting sphere of radius R has two spherical cavities of radius a and b. The cavities have charges q_a and q_b respectively at their centres. Find:

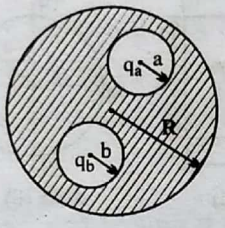
(a) The electric field and electric potential at a distance r

(i) r (distance from O, the centre of sphere > R)

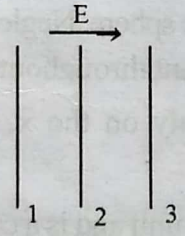
(ii) r (distance from B, the centre of cavity b) < b

(b) Surface charge densities on the surface of radius R, radius a and radius b.

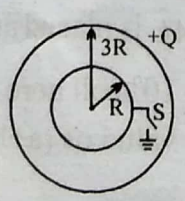
(c) What is the force on q_a and q_b?



20. Three uncharge conducing large plates are placed parallel to each other in a uniform electric field. Find the induced charge density on each surface of each plate.



21. Two thin conducting shells of radii R and $3R$ are shown in figure. The outer shell carries a charge $+Q$ and the inner shell is neutral. The inner shell is earthed with the help of switch S. Find the charge attained by the inner shell.



22. A conducting liquid bubble of radius a and thickness t ($t << a$) is charged to potential V. If the bubble collapses to a droplet, find the potential on the droplet. **[IIT-JEE 2005]**