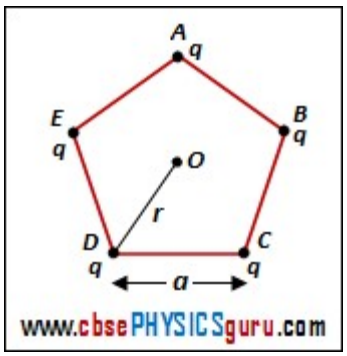
Assignment- Electric Charges and Field

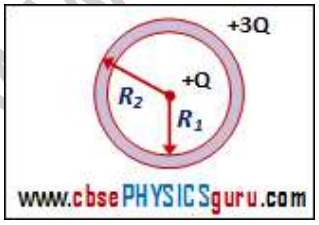
1. *Two equal positive charges, each of 2 μC are placed 6 m apart. They interact with a third positive charge of 3 μC situated at a distance of 4 m on the perpendicular bisector of the line joining the two charges from the mid-point of this line. Calculate the magnitude and direction of the force on the 3 μC charge.*
2. *Two identical conducting spheres X and Y are charged by induction such that sphere X has charge + q and sphere Y has charge —q. A third identical sphere, initially uncharged, is first touched to sphere X, separated and then touched to sphere Y and then separated. What is the final charge on each of the three spheres?*
3. *Plot a graph showing the variation of Coulomb's force (F) versus $1/r^2$, where r is the distance between the two charges of each pair of charges (1 μC, 2 μC) and (1 μC, -3 μC). Interpret the graphs obtained.*
4. *Two point charges, having equal charges separated by 1 m distance in air, experience a force of 8 N. What will be the force experienced by them, if they are held in water, at the same distance? (Given, K water = 80)*
5. *Two protons are separated by a distance of 1.0m. Calculate the electrostatic force between them. Calculate the force (a) when the protons are replaced by α-particles and the distance of separation is doubled. (b) when the protons are placed in water (Dielectric constant K = 80).*
6. *Two identical metal spheres, having unequal, opposite charges are placed 0.09 m apart in air. After bringing them in contact with each other, they are again placed at the same distance apart. Now the force of repulsion between them is 0.025 N. Calculate the final charge on each sphere.*
7. *Two charges + Q and – Q are kept at points ($-x_2$, 0) and (x_1, 0) respectively, in the XY-plane. Find the magnitude and direction of the net electric field at the origin (0, 0).*
8. *Two similarly equally charged identical metal spheres A and B repel each other with a force F. A third identical uncharged sphere C is touched to sphere A and then placed at the midpoint between A and B. Calculate the net electrostatic force on C.*
9. *A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge Q is placed at the centre of the spherical cavity. What will be surface charge density on (i) the inner surface, and (ii) the outer surface?*
10. *Five charges, q each are placed at the corners of regular pentagon of side a as shown in the figure.*



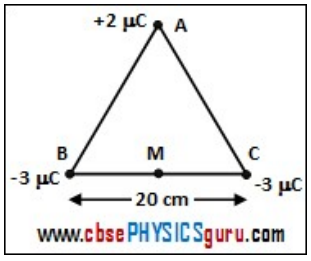
(i) *(a) What will be the electric field at O, the centre of the pentagon? (b) What will the electric field at O, if charge from one of the corners (say A) is removed? (c) What will be the electric field at O, if charge q at A is replaced by – q?*

(ii) *How would you answer be affected, if pentagon is replaced by n-sided regular polygon with charge q at each of its corners.*

11. *A point charge +Q is placed inside a charged conducting spherical shell of inner radius $R_1$and outer radius R_2, as shown in the figure. The charge on the outer surface of the shell is +3Q. What is the net charge on the conducting shell?*



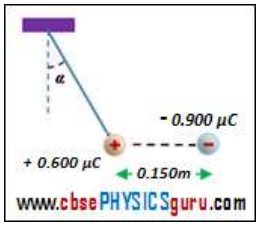
12. *Three point charges of +2 μC, -3 μC and -3 μC are kept at the vertices A, B and C respectively of an equilateral triangle of side 20 cm as shown in the figure. What should be the sign and magnitude of the charge to be placed at the mid-point (M) of side BC so that the charge at A remains in equilibrium?*



13. *Two identical point charges Q each are separated by a distance r. A third point charge q is placed on the line joining the two charges such that all the*

three charges are in equilibrium. What is the magnitude, sign and position of the third charge q?

14. *A small sphere of mass 8.00 × 10^{-2} kg and charge + 0.600 μC is hung by a mass-less string. A charge of - 0.900 μC is held 0.150 m away from the sphere and directly to the right of it, so the string makes an angle α with the vertical as shown in the figure. Find (a) the angle α, and (b) tension in the string.*



15. *A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge Q/2 is placed at its centre C and another charge + 2Q is placed outside the shell at a distance x from the centre as shown in the figure. Find (a) the force on the charge at the centre of shell and at point A, (b) the electric flux through the shell.*

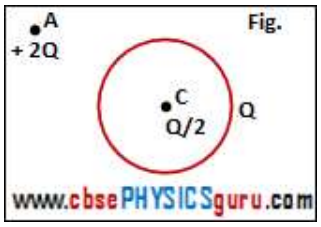
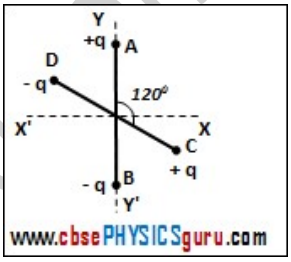
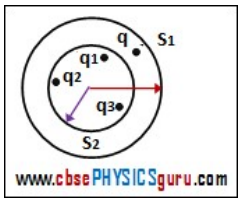


Fig.

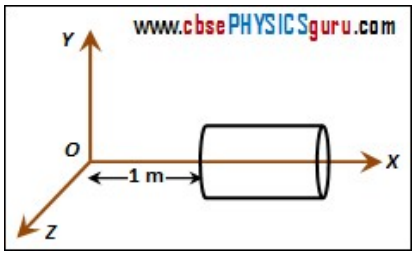
16. *Two small identical electrical dipoles AB and CD, each of dipole moment p are kept at an angle of 120^0 as shown in the figure. What is the resultant dipole moment of this combination? If this system is subjected to electric field (E) directed along +X direction, what will be the magnitude and direction of the torque acting on this?*



17. *What is the work done in rotating an electric dipole of dipole moment p from its position of stable equilibrium to its position of unstable equilibrium in a uniform electric field E?*
18. *Calculate the electric flux through a surface of area 0.2 m^2 lying in Y- Z plane if the electric field is given by $\vec{E} = 2\hat{\imath} + 4\hat{\jmath} + 4\hat{k}$.*
19. *The electric flux through the surface S_1 shown in the figure is four times the flux through the surface S_2. Find the magnitude of the charge q if $q_1 = 2\mu C$, $q_2 = -4\ \mu C$ and $q_3 = 3\ \mu C$.*



20. *Two infinitely long parallel wires having linear charge densities λ_1 and λ_2 respectively are placed at a distance of R. What is the force per unit length on either wire?*
21. *Force acting on a charged particle kept between the pair of plates, having equal and opposite charge, is F. If one of the plates is removed, find the force acting on the same particle.*
22. *Two small spheres carrying equal charges q coulombs are suspended from a common point by two insulating strings each of length L metre. The whole set-up is taken in a satellite into gravity-free space. What is the angle between the strings and the tensions in the strings?*
23. *A particle of mass m and charge q is projected at a speed u in a direction opposite to a uniform electric field E. How much distance will it cover before coming to momentary rest? How long will it take to do so?*
24. *A hollow cylindrical box of length 1 m and area of cross-section 25 cm^2 is placed in a three dimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E} = 50x\hat{\imath}$, where E is in N/C and x is in metre. Find (i) net flux through the cylinder and (ii) charge enclosed by the cylinder.*
25. *An electron is revolving around a long line charge having charge density of 2 x 10^{-8} C/m. Show that: (i) The speed of the electron is independent of the radius of electron's orbit. Also calculate the kinetic energy of the electron. (ii) Kinetic energy of electron is independent of the mass of the electron and radius of the orbit of electron.*



26. *Two identical balls each having mass 'm' and charge 'q' are hung from silk threads each of length 'L'. Assume that the threads make small angles with the vertical then show that charge on each ball is given by $q = \left(\frac{2\pi\varepsilon_0\, mgx^3}{L}\right)^{1/2}$ where x is the distance between the two balls.*