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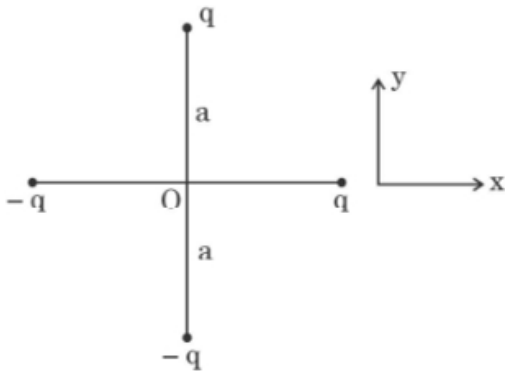
ELECTRIC FIELD AND CHARGES NUMERICALS

Class 12 - Physics

Time Allowed: 1 hour and 28 minutes **Maximum Marks: 45**

1. Two identical dipoles are arranged in x-y plane as shown in the figure. Find the magnitude and the direction of net electric field at the origin O. **[1]**



2. Two identical metallic spheres, having unequal, opposite charges are placed at a distance 0.90 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 of them. **[1]**

3. A uniform electric field is represented as $\vec{E} = \left(3 \times 10^3 \frac{N}{C}\right) \hat{i}$. Find the electric flux of this field through a square of side 10 cm when the: **[1]**

   a. plane of the square is parallel to y-z plane, and

   b. the normal to plane of the square makes an angle of 60^o with the x-axis.

4. 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 shell. What will be the surface charge density on the (i) inner surface, and (ii) outer surface of the shell? **[1]**

5. An electric dipole consists of two opposite charges of magnitude $\frac{1}{3} \times 10^{-7}$ C, separated by 2 cm. The dipole is placed in an external field of 3×10^7 NC^{-1}. What maximum torque does the electric field exert on the dipole? **[1]**

6. Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is 8.0×10^3 N m^2 C^{-1}. **[2]**

   i. What is the net charge inside the box?

   ii. If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box? Why or why not?

7. Two identical particles, each having a charge of 2.0×10^{-4} C and mass of 10g, are kept at a separation of 10 cm and then released. What would be the speeds of the particles when the separation becomes large? **[2]**

8. An infinite number of charges, each of q coulomb, are placed along x-axis at x = 1 m, 3 m, 9 m, and so on. Calculate the electric field at the point x = 0, due to these charges if all the charges are of the same nature. **[2]**

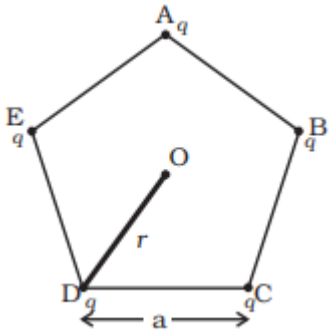
9. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 80.0 μCm^{-2}. **[2]**

   a. Find the charge on the sphere.

b. What is the total electric flux leaving the surface of the sphere?

10. A charged particle having a charge of -2.0×10^{-6} C is placed close to a non-conducting plate having a surface charge density of 4.0×10^{-6} Cm^{-2}. Find the force of attraction between the particle and the plate. **[2]**

11. Five charges, q each are placed at the corners of a regular pentagon of side **a** (Fig.). **[3]**



a. i. What will be the electric field at O, the centre of the pentagon?

ii. What will be the electric field at O if the charge from one of the corners (say A) is removed?

iii. What will be the electric field at O if the charge q at A is replaced by –q?

b. How would your answer to (a) be affected if pentagon is replaced by n- sided regular polygon with charge q at each of its corners?

12. You are given a charge +Q at the origin O (Refer to Fig.). Consider a sphere S with centre (2, 0, 0) of radius $\sqrt{2}$ m. Consider another sphere of radius $\sqrt{2}$ m centered at the origin. Consider the spherical caps **[3]**

i. PSQ

ii. PRQ

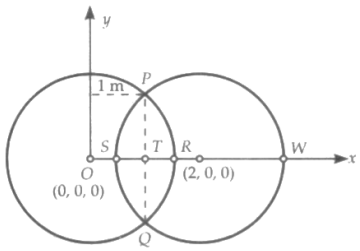
iii. PWQ, with normals outward to the respective spheres, and

iv. the flat circle PTQ with normal along the x-axis.

a. What is the sign of electric flux through each of the surfaces (i)-(iv)?

b. What is the relation between the magnitudes of fluxes through surfaces (i)-(iv)?

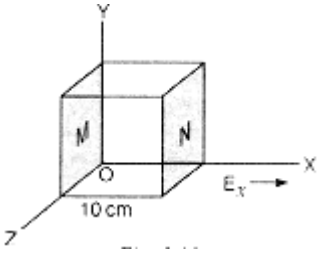
c. Calculate the flux through the surface (ii) directly. Assume that the area of the cap (ii) is A.



13. In Fig., the electric field is directed along positive X- direction and given by **[3]**

$E_x = 5\ A\ x + 2\ B$,

where E is in NC^{-1} and x is in metre. A and B are constants with dimensions.



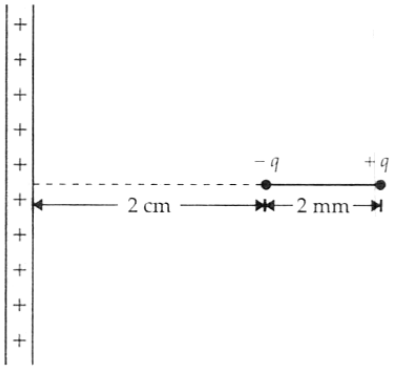
Taking A = 10 $NC^{-1}m^{-1}$ and B = 5 $NC^{-1}m^{-1}$, calculate

i. the electric flux through the cube.

ii. net charge enclosed within the cube

14. Calculate the field due to an electric dipole of length 10 cm and consisting of charges of $\pm 100\ \mu C$ at a point 20 cm from each charge. **[3]**

15. An electric dipole consists of charges $\pm 2 \times 10^{-8}$ C, separated by a distance of 2 mm. It is placed near a long line charge of density $4.0 \times 10^{-4}\ Cm^{-1}$, as shown in Fig., such that the negative charge is at a distance of 2 cm from the line charge. Calculate the force acting on the dipole. **[3]**



16. ABCD is a square of side 5 m. Charges of + 50 C, - 50 C and + 50 C are placed at A, C and D respectively. Find the resultant electric field at B. **[5]**

17. a. Find expressions for the force and torque on an electric dipole kept in a uniform electric field. **[5]**
    b. Derive an expression for the work done in rotating a dipole from the angle θ_0 to θ_1 in a uniform electric field E.

18. a. An electric dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$ at an angle θ with it. Derive the expression for torque ($\vec{\tau}$) acting on it. Find the orientation of the dipole relative to the electric field for which torque on it is (i) maximum, and (ii) half of maximum. **[5]**
    b. Two point charges q_1 = + 1 μC and q_2 = + 4 μC are placed 2 m apart in air. At what distance from q_1 along the line joining the two charges, will the net electric field be zero?