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Electric dipole, electric field due to a dipole

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 01
CHAPTER NAME : ELECTRIC CHARGES AND FIELDS

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LEARNING OUTCOME

By the end of this section, student will be able to:

- **Describe a permanent dipole**
- **Describe an induced dipole**
- **Define and calculate an electric dipole moment**
- **Explain the physical meaning of the dipole moment.**
- **Ideal dipole**
- **Electric field due to dipole (a)axial line (b) equatorial line**

REVIEW

1. Define Electric field and electric field intensity ?
2. What is the unit and dimension of electric field intensity ?
3. Why two lines of force never intersect each other ?
4. Why electric field inside a conductor is zero ?
5. Why electric field lines do not form closed loops ?

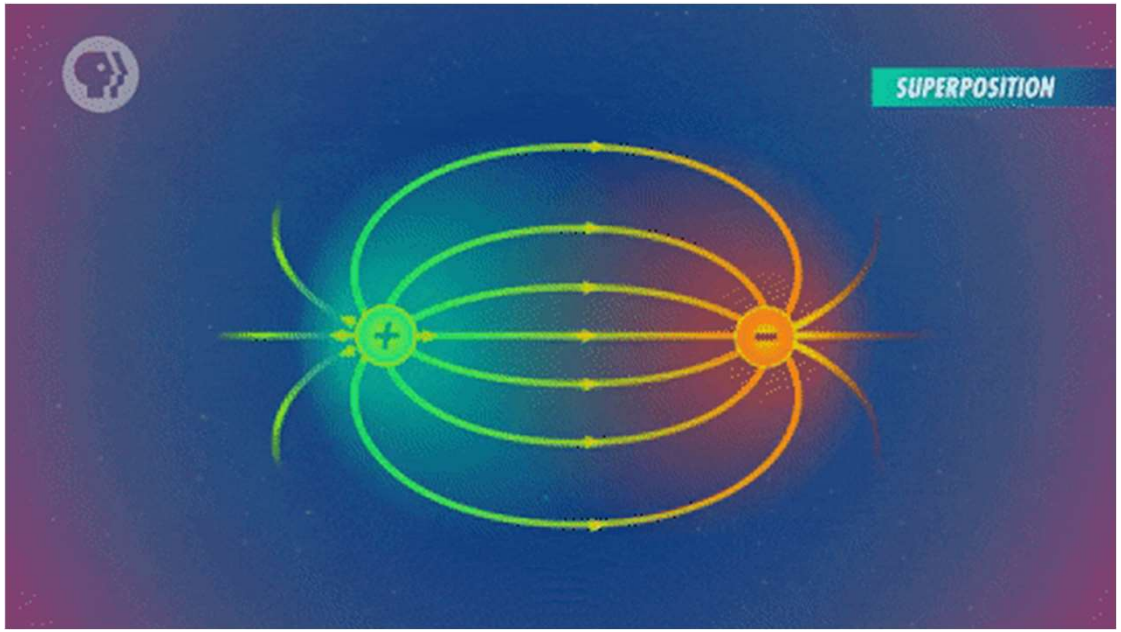
Electric Dipole

When two equal and opposite charges are separated by a short distance they constitute an electric dipole.(length of the dipole = 2a)

Examples:-

Water (H_2O), ammonia (NH_3), Chloroform ($CHCl_3$) are examples of a permanent electric dipole.

In these molecules center of +ve and the center of -ve charges do not coincide. So they have a permanent dipole moment.

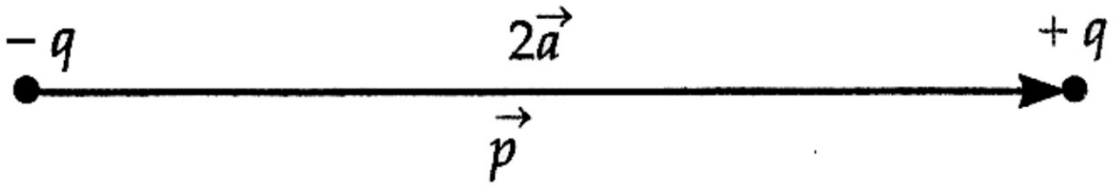


Electric dipole moment

The strength of electric dipole is measured by a vector quantity known as electric dipole moment.

Definition:- The product of magnitude of either charge and distance between two charges.

$$\vec{P} = q \times \overrightarrow{2a}$$

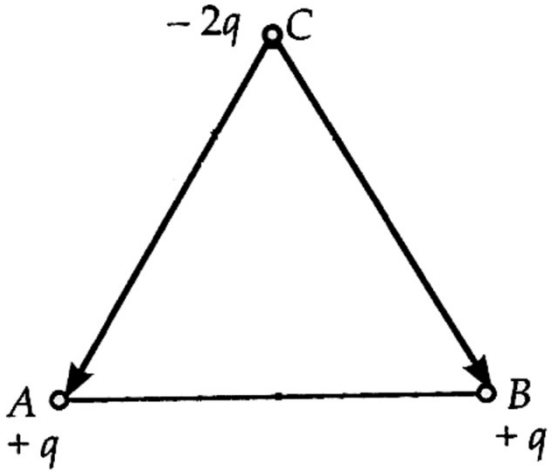


POINTS TO REMEMBER

1. The direction of dipole moment is from –ve to +ve charge.
2. S.I unit C m, dimension = $[L^1T^1A^1]$
3. Net charge in dipole is zero but net field at any point is nonzero.

Numerical

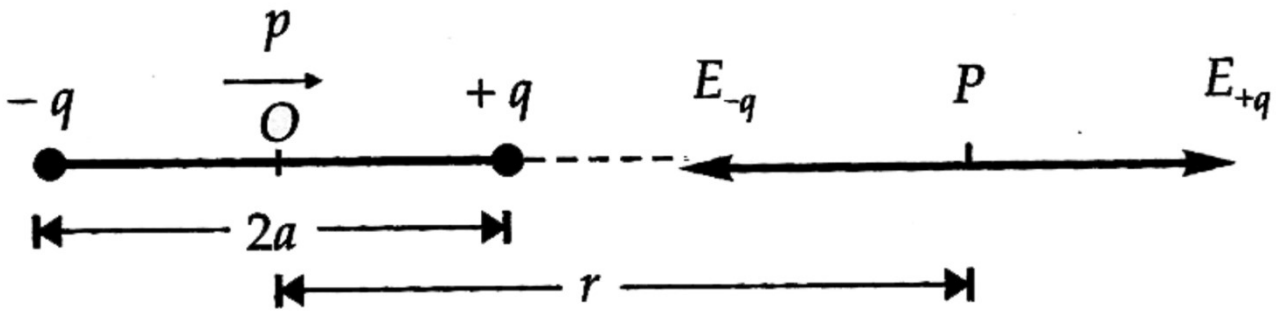
Question: Find out the net dipole moment of the system as given below.



Electric Field due to Electric Dipole

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$

In vector form $$\vec{E}_{axial} = +\frac{1}{4\pi\varepsilon_0}\frac{2\vec{P}}{r^3}$$



Electric field at an axial point of dipole.

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POINTS TO REMEMBER

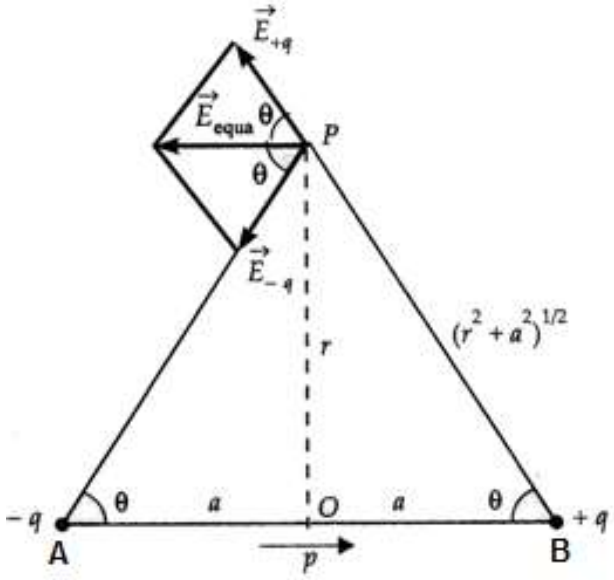
1. +ve sign indicates $\vec{E}_{axial}$ and $\vec{P}$ is in the same direction. So the angle between $\vec{E}_{axial}$ and $\vec{P}$ is 0^0.

2. $E_{axial} \alpha \frac{1}{r^3}$

Electric Field due to Electric Dipole

$$\Rightarrow E_{net} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$$

In vector form $$\vec{E}_{net} = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{P}}{r^3}$$



Electric field at an equatorial point of a dipole.

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POINTS TO REMEMBER

1. For small dipole, the ratio between electric field intensities at the axial and equatorial points at the same distances from the center is 2: 1.

2. The electric field intensity at the center is; $\vec{E} = -\frac{k\vec{p}}{a^3}$. (Since at the center, r = 0)

3. The angle between the electric field intensity and the dipole moment at the equatorial point is 180^0.

Numerical

Question: Graphically represent the variation of the electric field with distance for

a) Isolated charge

b) Electric dipole

Numerical

Question: What is the angle between electric field intensities at

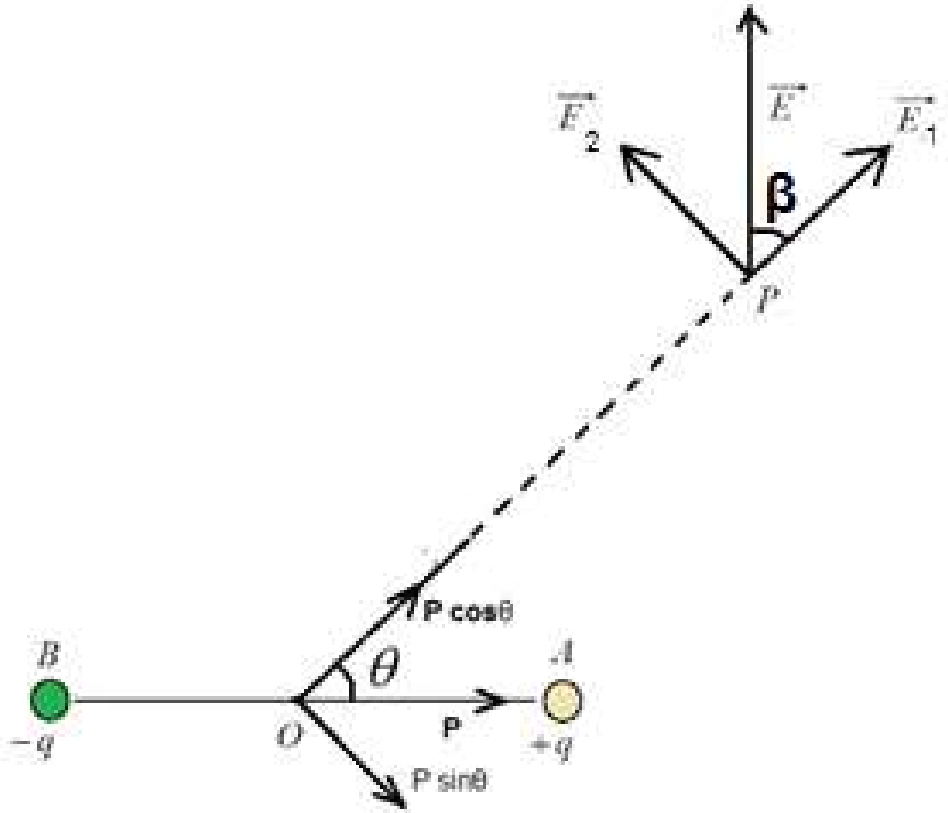
(a) Axial end on position and electric dipole moment

(b) Equatorial position and electric dipole moment

(c) Axial end on position and equatorial bisector position

Numerical

Question: Find out the electric field at a general point due to a short electric dipole



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Electric Multipole

According to the number of charges in the system, it is called

- Monopole (one pole)
- Dipole (Two poles),
- Quadrupole (Four poles)
- Octo pole (eight-poles)

HOME ASSIGNMENT

1. What is the difference between electric dipole and electric dipole moment?
2. How is electric dipole calculated?
3. What is the significance of electric dipole?
4. Is electric dipole moment scalar or vector?
5. Why electric dipole moment is from negative to positive?

THANKING YOU

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