MUKUL

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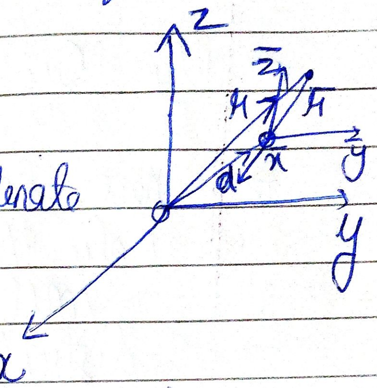
Physics Presentation.

→ **Effect of change of coordinate Origin on Electric Dipole and Quadrupole moments.**

Defination of dipole moment = $P_i = \int_V r_i \, dq$

$\bar{P_i} = \int_V \bar{r_i} \, d\bar{q}$



$dq = d\bar{q}$ as charge is independent of coordinate system.

So by triangular law of vector addition

$\vec{d} + \vec{\bar{r}} = \vec{r}$

$\Rightarrow \bar{r} = r - d$

& $\bar{r_i} = r_i - d_i \rightarrow (i)$

$\bar{r_j} = r_j - d_j \rightarrow (ii)$

Using Eq(i)

$\bar{P_i} = \int_V (r_i - d_i) \, dq$

$= \int_V r_i dq - \int d_i dq$

$\boxed{\bar{P_i} = P_i - d_i q} \rightarrow$ (A)

||ly for Quadrupole moment $\bar{Q_{ij}} = \int_V \bar{r_i} \bar{r_j} \, d\bar{q}$

$\bar{Q_{ij}} = ?$ & $Q_{ij} = \int_V r_i r_j \, dq$

Using (i) & (ii)

$\bar{Q_{ij}} = \int (r_i - d_i)(r_j - d_j) \, dq$

$= \int r_i r_j dq - \int r_i d_j dq - \int r_j d_i dq + \int d_i d_j dq$

$\boxed{\bar{Q_{ij}} = Q_{ij} - P_i d_j - P_j d_i + d_i d_j q} \rightarrow$ (B)

Eq^n A & B are desired result for Origin dependency for dipole & Quadrupole moment.

Discussion about Result

→ Both are valid for discrete distribution of charges.

→ In Eq^n A is P is independent of origin only when charge distribution is neutral ($q=0$)

→ Illy Q_{ij} is origin independent only when $q=0$ & $P=0$

→ These Results can be generalized as:
only the leading non vanishing electric multipole moment of an arbitrary charge distribution is origin independent.

→ If $q \neq 0$, A shows that $\alpha = P/q$ gives $\bar{P} = 0$. It is always possible to find an origin $\bar{O}$ ~~at~~ such that electric dipole moment is zero.