XII - PHYSICS (NEW SYLLABUS)

Electrostatics → problem study material

unit ①

Important problem questions with Answer.

① A sample of HCl gas is placed in a uniform electric field of magnitude 3×10^4 NC^{-1}. The dipole moment of each HCl molecule is 3.4×10^{-30} Cm. calculate the maximum torque experienced by each HCl molecule

solution:-

HCl gas

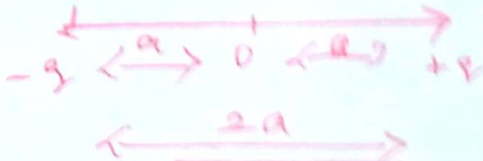
Torque (திருப்பு விசை)

$\tau = pE \sin\theta$

$\theta = 90^\circ$

$\sin 90^\circ = 1$

electric dipole moment



$p = q \times 2a$

$\tau = pE \sin 90^\circ$

$\tau = pE (1)$

$\tau = pE$

τ → Torque

p → Electric dipole moment

E → Electric field

p → 3.4×10^{-30} Cm

Cm → coulomb metre

E → 3×10^4 NC^{-1}

$\tau = pE \sin\theta$

$\tau = 3.4 \times 10^{-30} \times 3 \times 10^{4} \times (1)$

$\tau = 3.4 \times 3 \times 10^{-30} \times 10^{4}$

$\tau = 3.4 \times 3 \times 10^{-30+4}$

$\tau = 3.4 \times 3 \times 10^{-26}$

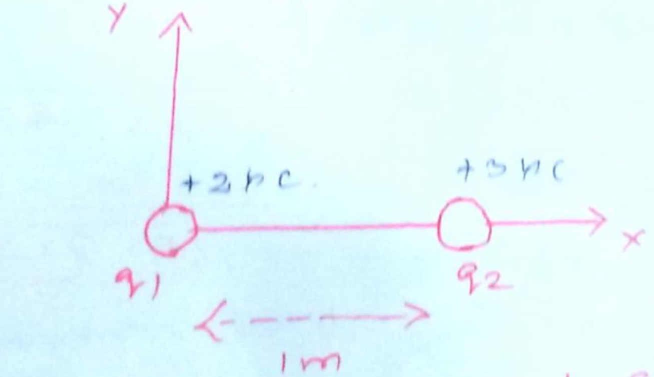
$\tau = 10.2 \times 10^{-26}$ Nm

maximum torque (பெரும திருப்புவிசை)

$\tau_{max} = 10.2 \times 10^{-26}$ Nm

---

(2) Consider two point charges q_1 and q_2 at rest as shown in the figure.



$q_1 = +2\,\mu C$ and $q_2 = +3\,\mu C$

Solution:- q_1 and q_2 → positive charge

$q_1 = +2\,\mu C = +2 \times 10^{-6}$ C

$q_2 = +3\,\mu C = +3 \times 10^{-6}$ C

Force $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} . \hat{r}$

The charge q_2 due to q_1 is given by

$q_2 \rightarrow q_1$

$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} . \hat{r}_{12}$

$\hat{r}_{12} = \hat{i}$

$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} . \hat{i}$

To find $\frac{1}{4\pi\epsilon_0}$ values are

$\frac{1}{4\pi\epsilon_0} = \frac{1}{4 \times 3.14 \times 8.854 \times 10^{-12}}$

$= \frac{10^{12}}{4 \times 3.14 \times 8.854}$

$= \frac{10^{12}}{12.56 \times 8.854} = \frac{10^{12}}{111.20624}$

$= 9 \times 10^{9}$ N

$\frac{1}{4\pi\epsilon_0} = 9 \times 10^{9}$ N

Force

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$$

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{i}$$

Given

$q_1 = +2\mu C = +2\times10^{-6} C$
$q_2 = +3\mu C = +3\times10^{-6} C$
$r = 1m$

$$\vec{F}_{21} = (9\times10^9)\times\frac{2\times10^{-6}\times3\times10^{-6}}{(1)^2}.\hat{i}$$

$$\vec{F}_{21} = \frac{9\times10^9\times2\times10^{-6}\times3\times10^{-6}}{1}.\hat{i}$$

$$\vec{F}_{21} = \frac{9\times2\times3\times10^9\times10^{-6}\times10^{-6}}{1}.\hat{i}$$

$$\vec{F}_{21} = 54\times10^9\times10^{-6-6}.\hat{i}$$

$$\vec{F}_{21} = 54\times10^9\times10^{-12}.\hat{i}$$

$$\vec{F}_{21} = 54\times10^{9-12}.\hat{i}$$

$$\vec{F}_{21} = 54\times10^{-3}\ N\hat{i}$$

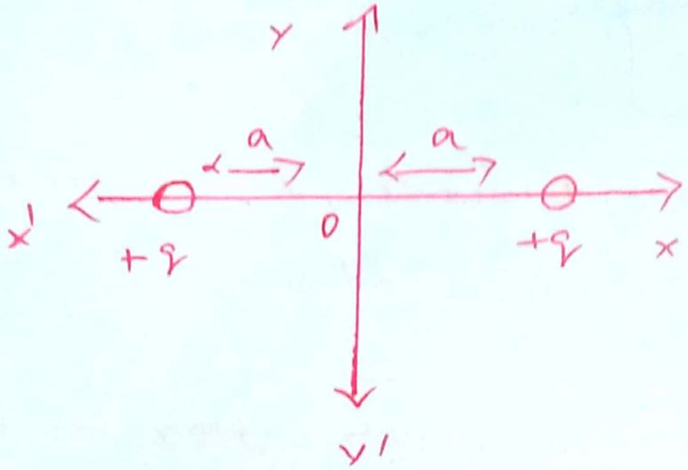
Newton's Third law

$$\vec{F_{12}} = -\vec{F_{21}}$$

$$\vec{F_{12}} = -54 \times 10^{-3} N \hat{i}$$

---

③ Calculate the electric dipole moment for the following charge configuration



Solution:- Electric dipole moment

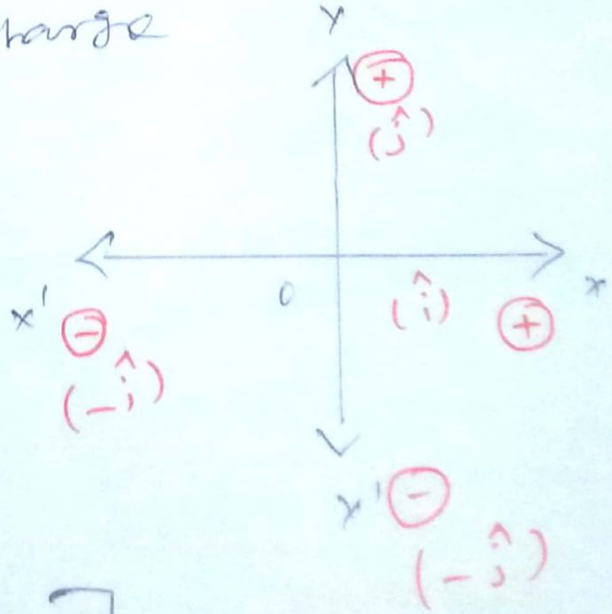
(i) Equal charge

x ($\hat{i}$) → positive direction

x' ($-\hat{i}$) → Negative direction

y ($\hat{j}$) → positive direction

y' ($-\hat{j}$) → Negative direction



$\vec{P} = [(+q)(a\hat{i})] + [(+q)(-a\hat{i})]$

$\vec{P} = (+q)(a\hat{i}) - q(a)\hat{i}$

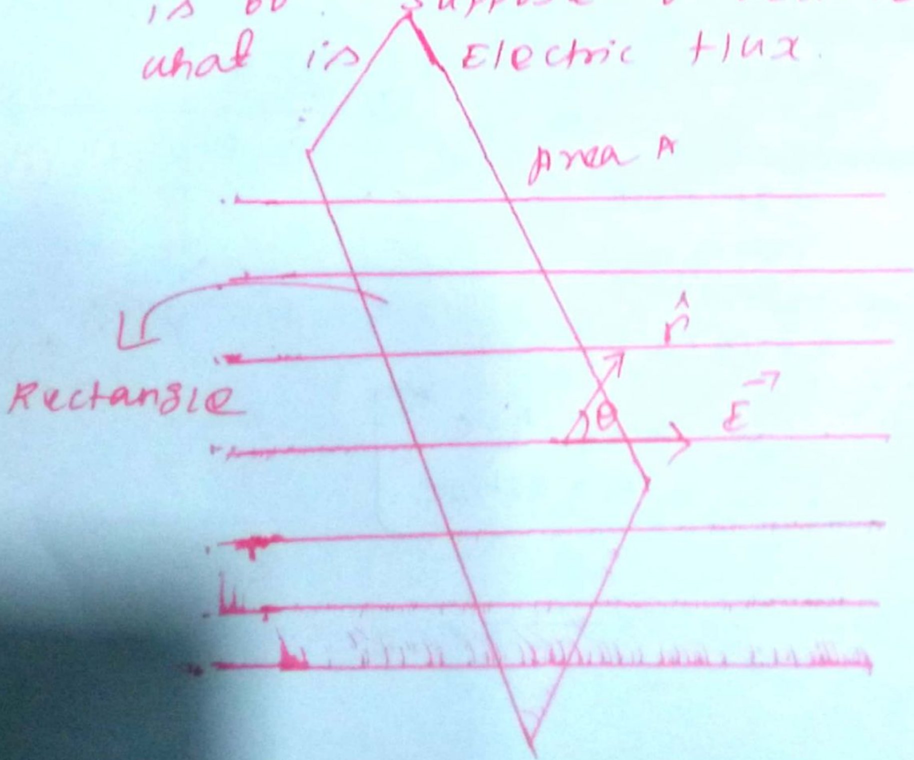
$\vec{P} = (+qa\hat{i}) - (qa\hat{i})$

$\boxed{\vec{P} = 0}$

That is Electric dipole moment charge configuration zero.

---

④ calculate the electric flux through the Rectangle of sides 5 cm and 10 cm kept in the region of a uniform electric field 100 NC^{-1}. The angle θ is 60^0. suppose θ becomes zero, what is Electric flux.



solution:-

Given

The Electric flux through the rectangle

5 cm = 5×10^{-2} m

and 10 cm = 10×10^{-2} m

uniform Electric field

$E = 100\ NC^{-1}$

Angle $\theta = 60^0$

Electric flux

$\phi_E = \vec{E} \cdot \vec{A}$

$\phi_E = EA\cos\theta$

$\phi_E \rightarrow$ Electric flux (மின்புல பாயம்)

$E \rightarrow$ Electric field (மின்புலம்)

$A \rightarrow$ cross sectional Area (குறுக்கு வெட்டு பரப்பு)

$\theta \rightarrow$ angle (கோணம்)

$\phi_E = 100 \times 5 \times 10^{-2} \times 10 \times 10^{-2} \times \cos 60^0$

$\phi_E = 100 \times 5 \times 10 \times 10^{-2} \times 10^{-2} \times \cos 60^0$

$\phi_E = 100 \times 5 \times 10 \times 10^{-2-2} \times \cos 60^0$

$\phi_E = 5000 \times 10^{-4} \times \cos 60^\circ$

$\cos 60^\circ = 1/2$

$\phi_E = 5000 \times 10^{-4} \times \frac{1}{2}$

$\phi_E = \frac{5000}{2} \times 10^{-4}$

$\phi_E = \frac{2500 \times 2 \times 10^{-4}}{2}$

$\phi_E = 2500 \times 10^{-4}$

$\phi_E = 0.25 \, Nm^2 C^{-1}$

For $\theta = 0^\circ$

$\phi_E = \vec{E} \cdot \vec{A}$

$\phi_E = EA \cos\theta$

$\phi_E = 100 \times 5 \times 10 \times 10^{-4} \times \cos(0^\circ)$

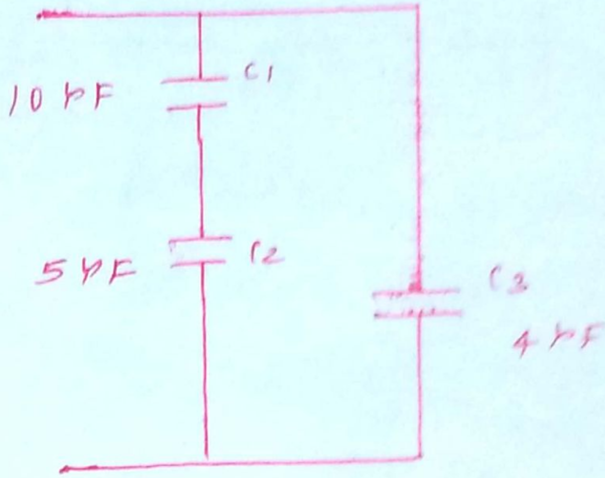
$\cos(0^\circ) = 1$

$\phi_E = 5000 \times 10^{-4} \times (1)$

$\phi_E = 5000 \times 10^{-4}$

$\phi_E = 0.5 \, Nm^2 C^{-1}$

(5). Calculate the effective capacitance of the combination shown in figure.



Solution:-

Given

$C_1 = 10\ \mu F = 10 \times 10^{-6} F$

$C_2 = 5\ \mu F = 5 \times 10^{-6} F$

$C_3 = 4\ \mu F = 4 \times 10^{-6} F$

C_1 and C_2 → Two capacitor connected series connection

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$$

C_s → Effective capacitance of the capacitor of the series combination.

$$\frac{1}{C_s} = \frac{1}{10} + \frac{1}{5}$$

$$\frac{1}{C_s} = \frac{10 \times 5}{10+5} = \frac{50}{15}$$

$$\frac{1}{C_s} = \frac{10 \times \cancel{5}}{3 \times \cancel{5}} = \frac{10}{3} \mu F$$

$$\boxed{\frac{1}{C_s} = \frac{10}{3} \times 10^{-6} F}$$

parallel combination

$$C_p = C_s + C_3$$

$$C_p = \frac{10}{3} + 4$$

$$C_p = \frac{10 + 12}{3}$$

$$C_p = \frac{22}{3} \mu F$$

$$C_p = \frac{22}{3} \times 10^{-6} F$$

$$C_p = 7.33 \mu F \quad \text{(or)}$$

$$\boxed{C_p = 7.33 \times 10^{-6} F}$$

G. THIRUMOORTHI
MSc, BEd, (ph.d)
(PHYSICS)
IDAPPADI (TK)
SALEM (DT) 637101.