Sir. C.V. RAMAN Coaching centre

Idappadi - 2025.

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XII physics

unit - 1 - study material.

prepared by

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1/4/25

Physics

Electrostatics

Charge → q (symbol) → Coulomb (unit) → Two types → +q, -q

Classification of charge → +, −

Classification of charge → Benjamin franklain → America

Current → symbol → I

Current → Unit → Ampere

$n^c \rightarrow$ nano Coulomb (10^{-9}) c

$p^c \rightarrow$ Pico Coulomb (10^{-12}) c

$M^c \rightarrow$ Micro Coulomb (10^{-6}) c

Charge

→ Conductor

→ Semiconductor

→ Insulator

Conductor

↓

Allowed

↓

Example

↓

* Metal
* human body
* Earth

Semiconductor

↓

Semi level allowed

↓

Example

↓

* Ge
* Si

Insulator

↓

Not Allowed

↓

* Ebonite (hard rubber)
* Rubber
* Plastics
* Wooden board

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$+q \quad +q$
$-q \quad -q$

→ Same charge
→ Like charge
→ Repulsive

$+q \quad -q$
$-q \quad +q$

→ Opposite charge
→ UnLike charge
→ Attractive

Coulomb force

$$q_1 \xrightarrow[r^2]{I} q_2$$

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = K \frac{q_1 q_2}{r^2}$$

$q_1 q_2 \rightarrow$ Charge

$r \rightarrow$ Distance

$F \rightarrow$ force

$K \rightarrow$ Constant $\quad K = \frac{1}{4\pi\varepsilon_0}$

$\varepsilon_0 \rightarrow$ Permittivity of free space

$\varepsilon_0 \rightarrow 8.854 \times 10^{-12} Fm$

$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

Vector form

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \cdot \hat{r}_{12}$$

To find Values $= \frac{1}{4\pi\varepsilon_0}$

$$\frac{1}{4\pi\varepsilon_0} = \frac{1}{4 \times 3.14 \times 8.854 \times 10^{-12}}$$

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

One Coulomb Value $= 9 \times 10^9$

Derive One coulomb Values

Coulomb's force

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$$

$q_1 = 1C \quad q_2 = 1C \quad r = 1\,m$

$$F = \frac{1}{4\pi\varepsilon_0}\,\frac{1 \times 1}{(1)^2}$$

$$F = \frac{1}{4\pi\varepsilon_0}\,\frac{1}{1}$$

$$F = \frac{1}{4\pi\varepsilon_0}$$

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

$$F = 9 \times 10^9\,N$$

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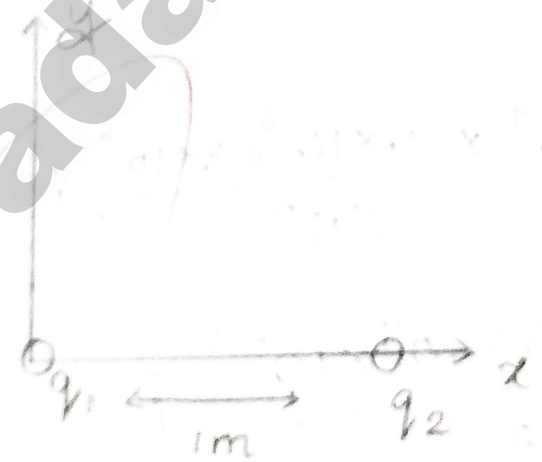
1) Example 1.2



$q_1 = +2\mu C$

$q_2 = +3\mu C$

Same Charge

Like charge

Repulsive nature

Coulomb's force

$$\vec{F_{21}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$$

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

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

$$r = 1 m$$

$$\vec{F_{21}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} . \hat{r}_{12}$$

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

$$\vec{F_{21}} = 9 \times 10^9 \times \frac{2 \times 10^{-6} \times 3 \times 10^{-6}}{(1)^2} . \hat{i}$$

$$\vec{F_{21}} = \frac{9 \times 6 \times 10^9 \times 10^{-12}}{1} . \hat{i}$$

$$\vec{F_{21}} = \frac{54 \times 10^{9-12}}{1} . \hat{i}$$

$$\vec{F_{21}} = 54 \times 10^{-3} \hat{i} . N$$

Coulomb's Law obey newton's III Law

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

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

b) $q_1 = +2\mu C$

$q_2 = -3\mu C$

$r = 1m$

opposite charge

unlike charge

Attractive charge (nature)

$$\vec{F_{21}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \cdot \hat{r_{12}}$$

$$\vec{F_{21}} = \frac{9\times10^9 \times 2\times10^{-6} \times (-3)\times10^{-6}}{(1)^2} \hat{r}_{12}$$

$$\vec{F_{21}} = 9 \times 10^9 \times (-6) \times 10^{-12} \cdot \hat{i}$$

$$\vec{F_{21}} = -54 \times 10^{-3} N \hat{i}$$

Applying Newton's III Law

$\hat{r_{12}} = \hat{i}$

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

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

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

c)

$q_1 = +2\,\mu C$

$q_2 = -3\,\mu C$

Water ($\varepsilon_r = 80$)

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \cdot \hat{r}_{12}$$

$$\vec{F}_{21} = \frac{(9\times10^{9}) \times (2\times10^{-6})(-3\times10^{-6})}{(1)^2} \cdot \hat{i}$$

$$\vec{F}_{21} = \frac{9\times10^{9} \times (-6\times10^{-12})}{1} \cdot \hat{i}$$

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

$\varepsilon_r \rightarrow$ Relative Permittivity

$$\frac{\vec{F}_{21}^{\,w}}{\varepsilon_r} = \frac{-54\times10^{-3}\, N.\hat{i}}{80}$$

$$= \frac{-54}{80} \times 10^{-3}\, N.\hat{i}$$

$$= -0.675\times10^{-3}\, N.\hat{i}$$

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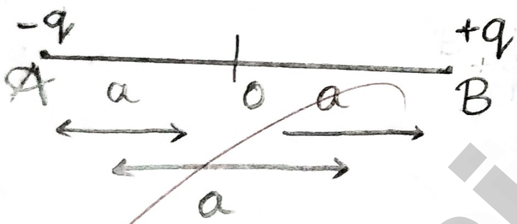
1) Electric field due to a Dipole

Axis line

Equational plane

Dipole



unit → Cm

= a+a

= 2a

P → Electric dipole momentum (Vector quantity)

2a → small distance

a → Distance

$P = q \times 2a$

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

Electric field

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

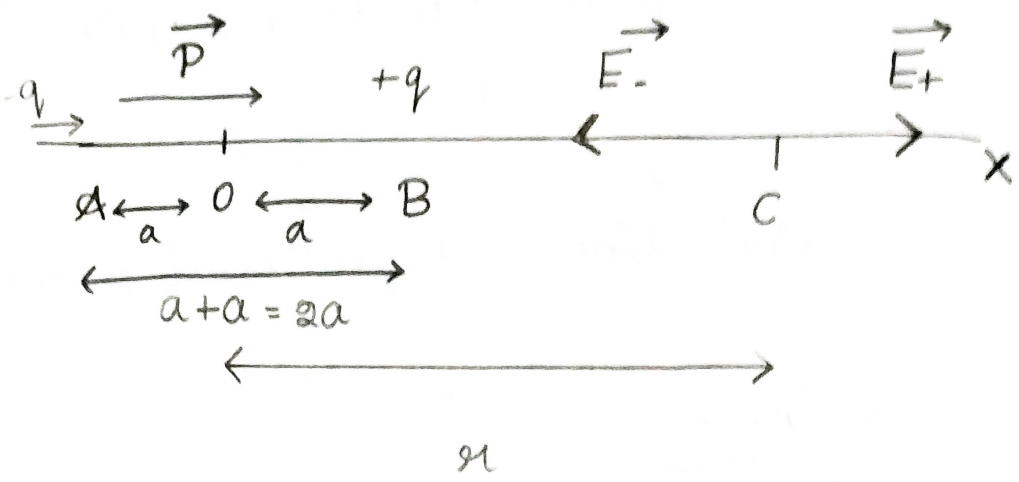
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \cdot \hat{r}$$

Vector quantity

unit → NC^{-1}

B B
4)th 5m

Axis line



OA = a

OB = a

AB = 2a

OC = r

AB → Two points

+q → Positive charge

-q → Negative charge

r, a → Distance

2a → Small distance

P → Electric dipole moment

+q charge

E_+

(B Point) $E_+ = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$

$$\vec{E_+} = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-a)^2} \cdot \hat{P} \longrightarrow (1)$$

$-q$ charge

(E_-)

(A Point)

$$E_- = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$$

$$E_- = \frac{1}{4\pi\varepsilon_0} \left(\frac{-q}{(r+a)^2} \right)$$

$$\vec{E_-} = -\frac{1}{4\pi\varepsilon_0} \frac{q}{(r+a)^2} \cdot \hat{p} \rightarrow (2)$$

Total electric field

$$\vec{E_{total}} = \vec{E_+} + \vec{E_-}$$

$$\vec{E_{total}} = \left[\frac{1}{4\pi\varepsilon_0} \frac{q}{(r-a)^2} \cdot \hat{p} + \left(-\frac{1}{4\pi\varepsilon_0} \frac{q}{(r+a)^2} \cdot \hat{p} \right) \right]$$

$$= \left[\frac{q}{4\pi\varepsilon_0} \frac{1}{(r-a)^2} \cdot \hat{p} - \frac{q}{4\pi\varepsilon_0} \frac{1}{(r+a)^2} \cdot \hat{p} \right]$$

$$= \frac{q}{4\pi\varepsilon_0} \left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2} \right] \cdot \hat{p}$$

$$= \frac{q}{4\pi\varepsilon_0} \left[\frac{(r+a)^2 - (r-a)^2}{(r-a)^2 (r+a)^2} \right] \cdot \hat{p}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{(r^2+a^2+2ra)-(r^2+a^2-2ra)}{(r^2-a^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{\cancel{r^2}+\cancel{a^2}+2ra-\cancel{r^2}-\cancel{a^2}+2ra}{(r^2-a^2)^2}\right]\cdot\hat{p}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4ra}{(r^2-a^2)}\right]\cdot\hat{p}$$

$r >> a$ (a neglected)

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4\cancel{r}a}{\cancel{r^4}}\right]\cdot\hat{p}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4a}{r^3}\right]\cdot\hat{p}$$

$$= \frac{1}{4\pi\varepsilon_0}\,\frac{q\times 4a\cdot\hat{p}}{r^3}$$

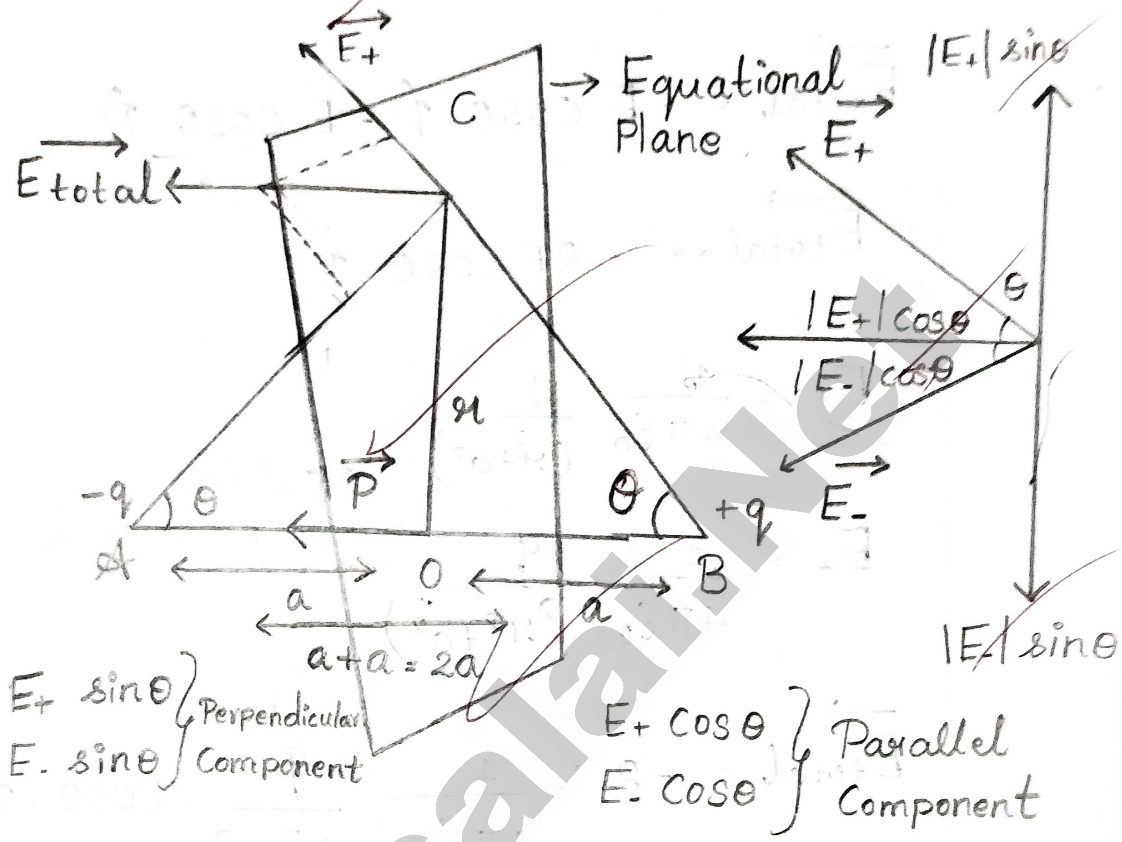
$$= \frac{1}{4\pi\varepsilon_0}\,\frac{2(q\times 2a\times\hat{p})}{r^3}$$ $q\times 2a\times\hat{p} = \vec{p}$

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

$$\vec{E}_{total} \Rightarrow \frac{1}{4\pi\varepsilon_0}\,\frac{2\vec{p}}{r^3}$$

9/4/25

Electric field due to an electric dipole at a Point on Equational Plane



AB = Two Points

$\vec{P}$ = Electric dipole moment

$P = q \times 2a$

$\vec{P} = q \times 2a \cdot \hat{P}$

a = distance

2a = Small distance

$-q$ = Negative charge

$+q$ = Positive charge

O = Centre of the Point

r = distance

θ = Angle

Scanned with ACE Scanner

$\vec{E}_{total}$ = Total Electric field

$$\vec{E}_{total} = -|E_+| \cos\theta . \hat{p} - |\vec{E_-}| \cos\theta . \hat{p}$$

$$\vec{E}_{total} = -E\cos\theta . \hat{p} - E\cos\theta . \hat{p}$$

$$\vec{E}_{total} = -2E\cos\theta . \hat{p}$$

$$E_+ = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2+a^2)}$$

$$E_- = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2+a^2)}$$

Same magnitude

$$\vec{E}_{total} = -2 \times \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} . \cos\theta . \hat{p}$$

$$\cos\theta = \frac{a}{\sqrt{r^2+a^2}}$$

$$\vec{E}_{total} = -2 \times \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} \frac{a}{(\sqrt{r^2+a^2})} . \hat{p}$$

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{2qa}{r^2+a^2(\sqrt{r^2+a^2})} . \hat{p}$$

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{2qa \cdot \hat{p}}{(r^2+a^2)(r^2+a^2)^{1/2}}$$

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{\vec{p}}{(r^2+a^2)^{1+2}}$$

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{\vec{p}}{(r^2+a^2)^{3/2}}$$

$r >> a$ (a neglected)

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{\vec{p}}{(r^{\cancel{2}})^{3/\cancel{2}}}$$

$$\vec{E}_{total} = -\frac{1}{4\pi\varepsilon_0} \frac{\vec{p}}{r^3}$$

09/01/25

Torque [Electric Field]

$\tau = PE \sin\theta$

$\tau \rightarrow$ Torque

$P \rightarrow$ Electric dipole moment

$E \rightarrow$ Electric field

$P = Cm$
$E = NC^{-1}$

Unit $\rightarrow$ Nm

Vector Quantity

Maximum Range

$\tau_{max} = PE \sin\theta$

$\tau_{max} = PE \sin 90^\circ$

$\tau_{max} = PE (1)$

$\tau_{max} = PE$

Minimum Range

$\theta = 180^\circ$ (or) 0°

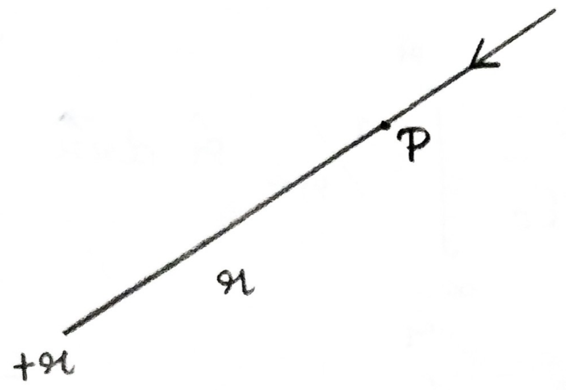
$\tau_{min} = PE \sin\theta$

$\tau_{min} = PE \sin(180^\circ)$

$\tau_{min} = 0$

.4.25
.B
th 5m

Electric Potential due to a Point Charge



Consider

Positive charge q

Origin fixed

$r \rightarrow$ Distance

$$V = \int_{\infty}^{r} (-\vec{E})\,\vec{dr}$$

$E \rightarrow$ Electric field

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\,\frac{q}{r^2}\,.\,\hat{r}$$

$$V = \int_{\infty}^{r} -\frac{1}{4\pi\varepsilon_0}\,\frac{q}{r^2}\,.\,\hat{r}\,\vec{dr}$$

$$V = -\int_{\infty}^{r} \frac{1}{4\pi\varepsilon_0}\,\frac{q}{r^2}\,.\,\hat{r}\,\vec{dr}$$

$$V = -\int_{\infty}^{r} \frac{q}{4\pi\varepsilon_0} \frac{1}{r^2} \hat{r} \cdot \vec{dr}$$

$\vec{dr} = dr\hat{r}$

$$V = \frac{-q}{4\pi\varepsilon_0} \int_{\infty}^{r} 1/r^2 \; \hat{r} \; dr\hat{r}$$

$$V = \frac{-q}{4\pi\varepsilon_0} \int_{\infty}^{r} 1/r^2 \; \hat{r}\hat{r} dr$$

$\hat{r}\hat{r} = 1$

$$V = \frac{-q}{4\pi\varepsilon_0} \int_{\infty}^{r} 1/r^2 \; dr$$

$$V = \frac{-q}{4\pi\varepsilon_0} \int_{\infty}^{r} r^{-2} dr$$

$$\int x dx = \frac{x^{n+1}}{n+1} + c$$

$$= \frac{r^{-2+1}}{-2+1}$$

$$= \frac{r^{-1}}{-1}$$

$$= -r^{-1}$$

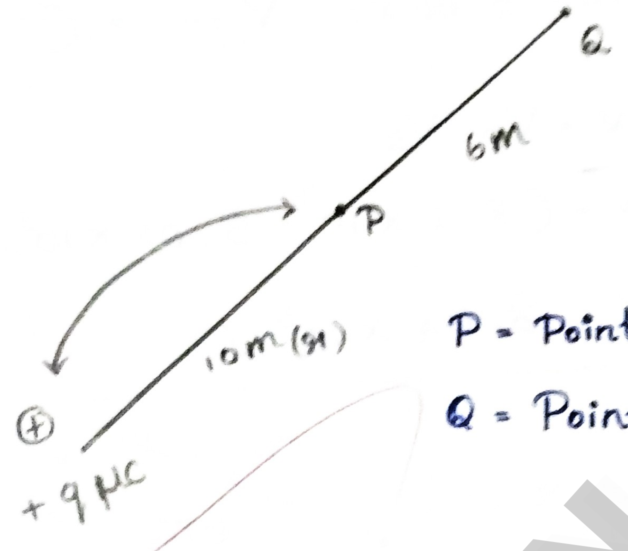
$$= -1/r$$

$$V = \frac{-q}{4\pi\varepsilon_0} \left[-1/r \right]_{\infty}^{r}$$

$$V = \left(\frac{q}{4\pi\varepsilon_0}\right) \left[\frac{1}{r} - \frac{1}{\infty} \right]$$

$$V = \frac{q}{4\pi\varepsilon_0} \; 1/r$$

2) Example 1.12



P = Point Potential

Q = Point Potential

$$V_P = \frac{1}{4\pi\varepsilon_0} \frac{q}{r_P}$$

P Point

$$V_P = \frac{9\times10^9 \times 9\times10^{-6}}{10}$$

$$V_P = \frac{81}{10} \times 10^3$$

$$V_P = 8.1\times10^3 V \longrightarrow ①$$

Q Point

$$V_Q = \frac{1}{4\pi\varepsilon_0} \frac{q}{r_Q} \quad (10+6)$$

$$V_Q = \frac{9\times10^9 \times 9\times10^{-6}}{16}$$

$$V_Q = \frac{81}{16} \times 10^3$$

$$V_Q = 5.06 \times 10^3 \text{ V} \longrightarrow (2)$$

$$\Delta V = V_P - V_Q$$

$$\Delta V = (8.1 \times 10^3 - 5.06 \times 10^3) \text{ V}$$

$$\Delta V = 3.04 \times 10^3 \text{ V}$$

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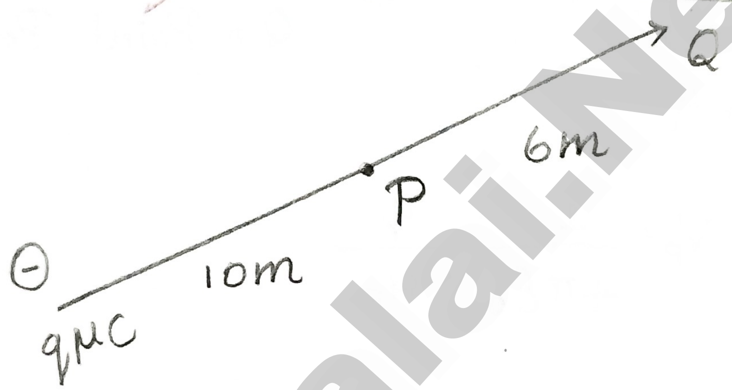
3)



$$V_P = \frac{1}{4\pi\varepsilon_0} \frac{q}{r_P}$$

P Point

$$V_P = \frac{9 \times 10^9 \times (-9) \times 10^{-6}}{10}$$

$$V_P = \frac{-81}{10} \cdot 10^3$$

$$V_P = -8.1 \times 10^3 \text{ V}$$

Q Point

$$V_Q = \frac{1}{4\pi\varepsilon_0} \frac{q}{r_q}$$

$$V_Q = \frac{9 \times 10^9 \times (-9) \times 10^{-6}}{16}$$

$$V_Q = \frac{-81}{16} \times 10^3$$

$$V_Q = -\frac{8.1}{16} \times 10^3$$

$$V_Q = -5.06 \times 10^3 V$$

$$\Delta V = V_P - V_Q$$

$$\Delta V = (-8.1 \times 10^3 V - (-5.06 \times 10^3 V))$$

$$\Delta V = (-8.1 \times 10^3 V + 5.06 \times 10^3)V$$

$$\Delta V = -3.04 \times 10^3 V$$

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