# [C] विद्युत द्विध्रुव के कारण विद्युत विभव
## Electric potential due to dipole

AB = 2l

'O' एक मध्य बिन्दु है

OA = OB = l

OP = r

AP = r + l cosθ

BP = r − l cosθ

रचना: → PM ≅ PA

MP ≅ AP

AP = MO + OP

= r + l cosθ

$\cos\theta = \frac{b}{h} = \frac{OM}{OA}$

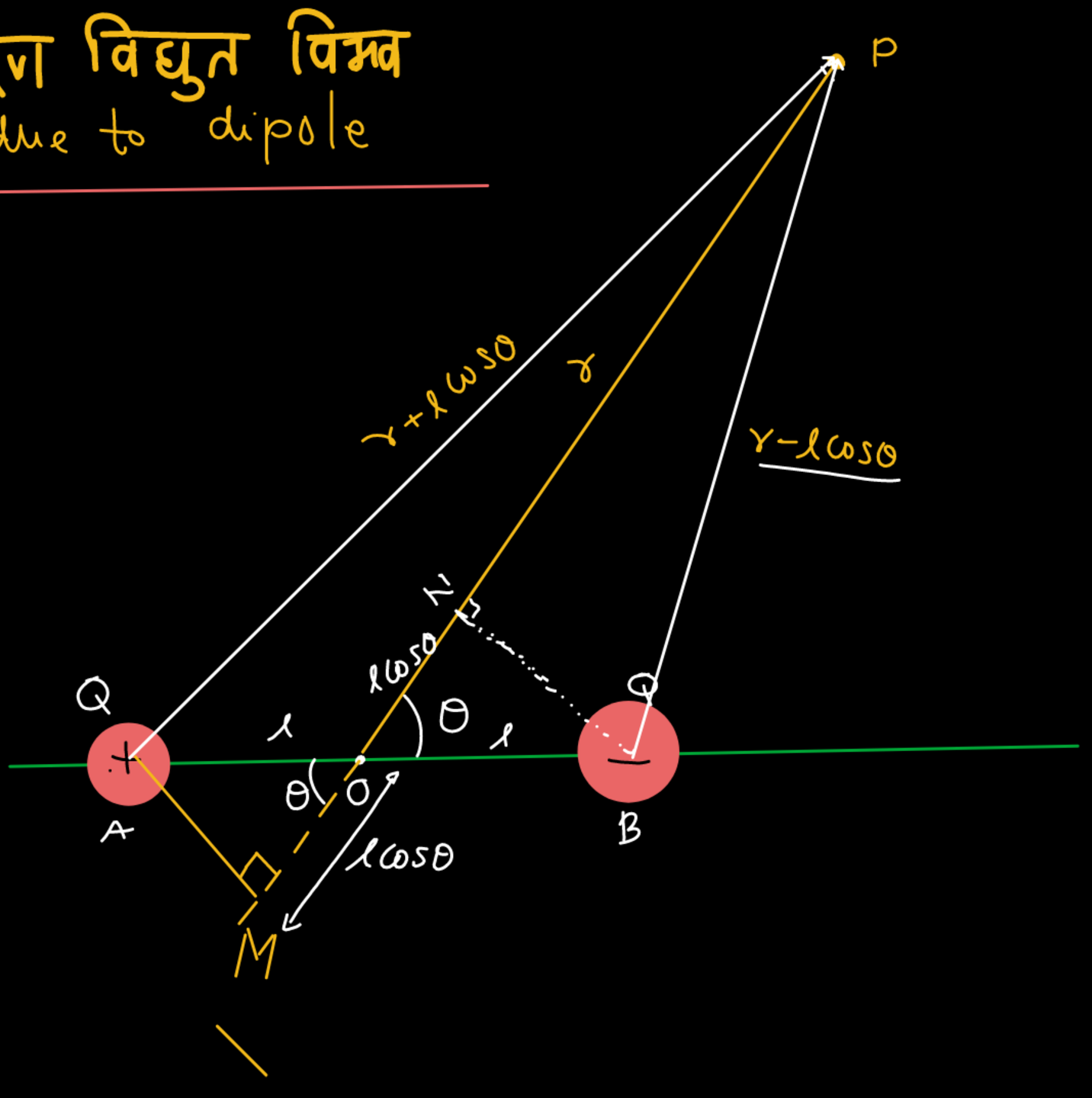
OM = OA cosθ

= l cosθ

PB ≅ PN

= OP − ON

= r − l cosθ



## > विद्युत द्विध्रुव के कारण बिन्दु 'P' का विभव

$$V_P = \frac{kQ}{r+l\cos\theta} + \left(\frac{-kQ}{r-l\cos\theta}\right)$$

$$= \frac{kQ}{r+l\cos\theta} - \frac{kQ}{r-l\cos\theta}$$

$$= kQ\left\{\frac{1}{r+l\cos\theta} - \frac{1}{r-l\cos\theta}\right\}$$

$$= kQ\left\{\frac{r-l\cos\theta-(r+l\cos\theta)}{(r+l\cos\theta)(r-l\cos\theta)}\right\}$$

$$= kQ\left\{\frac{\cancel{r}-l\cos\theta-\cancel{r}-l\cos\theta}{r^2-l^2\cos^2\theta}\right\}$$

— $[r \gg l]$

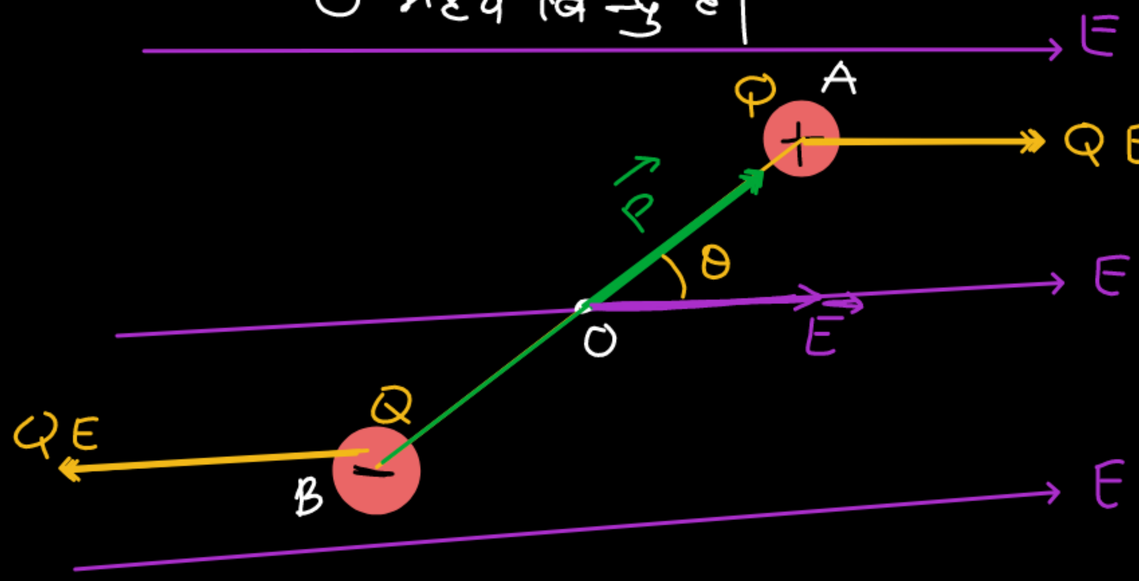
$$= kQ\left\{\frac{-2l\cos\theta}{r^2}\right\}$$

$$= \frac{-kQ(2l)\cos\theta}{r^2}$$

$$\boxed{V_P = -\frac{kp\cos\theta}{r^2}}$$

# > बाह्य क्षेत्र में द्विध्रुव की स्थितिज ऊर्जा

## Potential energy of dipole in external field



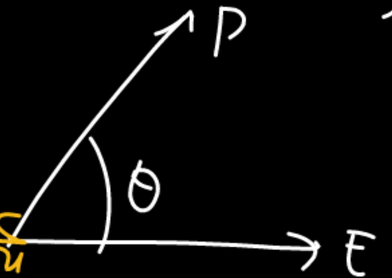

कुल बल = 0

$\tau \neq 0$

$\vec{\tau} = \vec{P} \times \vec{E}$ - - - $\left[\vec{A} \times \vec{B} = AB\sin\theta\,\hat{n}\right]$

बल आघूर्ण का परिमाण : $\left[|\vec{A} \times \vec{B}| = AB\sin\theta\right]$

$$|\vec{\tau}| = \tau = PE\sin\theta$$




स्थितिज ऊर्जा में परिवर्तन = किया गया कार्य

$-\Delta U = W$

$$= \int \vec{\tau} \cdot d\vec{\theta} = \int PE\sin\theta\, d\theta \cdot \underline{\cos 180}$$

$$= -\int PE\sin\theta d\theta = -PE\int \sin\theta d\theta$$

$$-\Delta U = -PE(-\cos\theta) = PE\cos\theta$$

— $\Delta U = PE\cos\theta$

$\Delta U = -PE\cos\theta$

$U_f - U_i = -PE\cos\theta$ (0)

$U = -PE\cos\theta$ ★

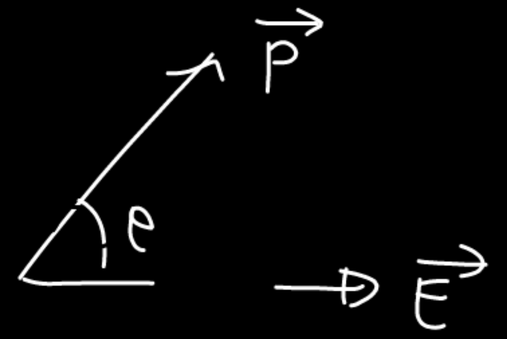
स्थितिज ऊर्जा

$U = -\vec{P}\cdot\vec{E}$

We know that

$\vec{A}\cdot\vec{B} = AB\cos\theta$

$\vec{P}\cdot\vec{E} = PE\cos\theta$




स्थितिज ऊर्जा $= -\vec{P}\cdot\vec{E} = PE\cos\theta$

(i) $\theta = 0°$; $\vec{P}$ $\vec{E}$; $U = -PE\cos 0° = -PE$

(ii) $\theta = 90°$; $\vec{P}$ $\vec{E}$; $U = -PE\cos 90° = 0$

(iii) $\theta = 180°$; $\vec{P}$ $180°$ $\vec{E}$; $U = -PE\cos 180°$

$= -PE(-1) = +PE$

$\gg V = \frac{W}{Q}$

$\gg V = \frac{pk\cos\theta}{r^2}$ ✓

$\gg V = \frac{kQ}{r}$ → [बिन्दु आवेश के कारण]

$\gg U = -\vec{P}\cdot\vec{E} = -PE\cos\theta$

$\gg U = \frac{kQ_1Q_2}{r}$ ($Q_1$ ——— $Q_2$, दूरी $r$)

$\gg V = -\int \vec{E}\cdot d\vec{r}$

$\gg V_{\text{द्विध्रुवीय अक्ष}} = \frac{pk}{r^2}$ (द्विध्रुव के कारण विद्युत विभव)

$\gg V_{\text{विषुवतीय}} = 0$ ( " " )

$$E = -\frac{dV}{dr}$$

> 1 volt = $\frac{1J}{1C}$

> 1A = $\frac{1C}{1s}$

> = (V·m) → विद्युत फ्लक्स का SI मात्रक

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

$$\phi_T = \frac{Q}{\epsilon_0}$$

(गॉस प्रमेय)

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

$$\phi = \vec{E}\cdot d\vec{A}$$

Faraday → आवेश का मात्रक

1 Faraday = 96500 C

आवेश का मात्रक → C

└ c.g.s मात्रक → esu

$1C = 3 \times 10^9$ esu