LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

Electric Potential
&
Capacitance

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Today's GOALS!

- Relation between Electric field and potential

Potential

$$V = -\frac{W_{EF}}{q_0}$$

$$\boxed{\phi = \int \vec{E} \cdot d\vec{S}_{\uparrow \text{area}}}$$

$$V = +\frac{W_{ext\,agent}}{q_0} \quad [\text{slowly}]$$

$$V\Big|_{V}^{0} = -\int \frac{\vec{F}}{q_0} \cdot d\vec{r} = -\int_{0}^{\infty} \vec{E} \cdot d\vec{r}$$

$$\int_{V_{r_1}}^{V_{r_2}} dV = -\int_{r_1}^{r_2} \vec{E} \cdot d\vec{r}$$

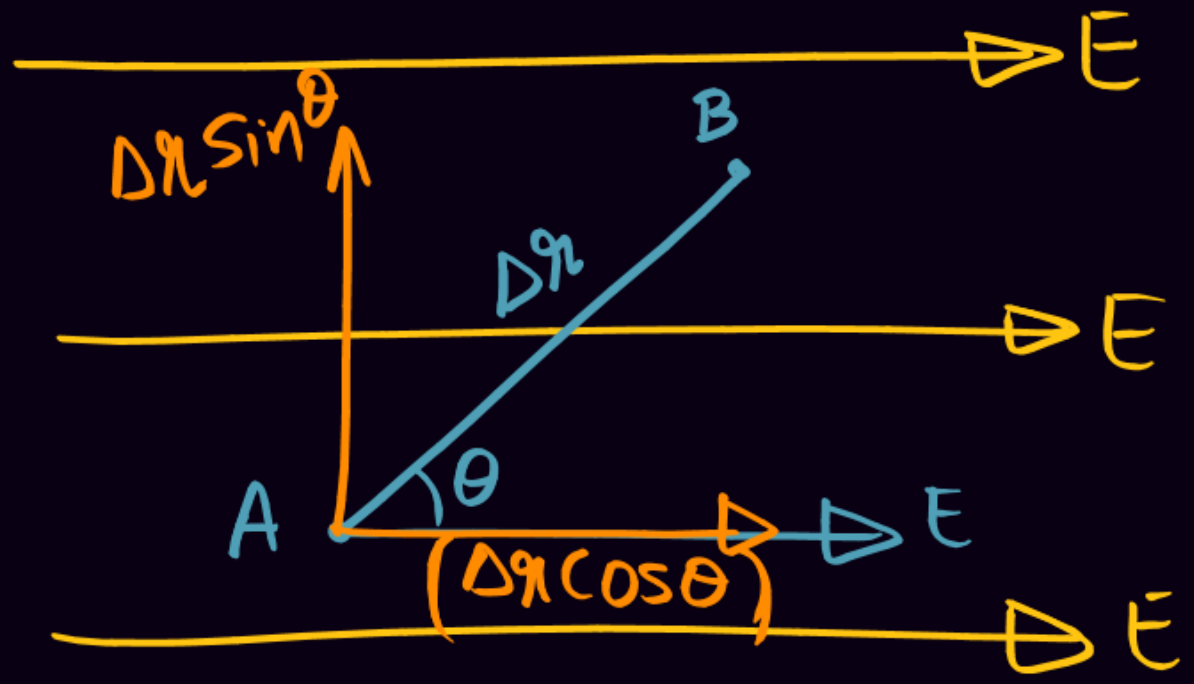
Relation b/w field and potential

$$\boxed{\int dV = -\int \vec{E}\cdot d\vec{r}}$$

[use it when $\vec{E}$ is given & V is to be calculated].

$$\vec{E} \underset{d}{\overset{\int}{\rightleftarrows}} V$$

① If field is uniform.



NOTE:- In the direction of field potential decreases.

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

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

$$\boxed{\Delta V = -\vec{E} \cdot \Delta\vec{r}} \rightarrow \text{displacement}$$

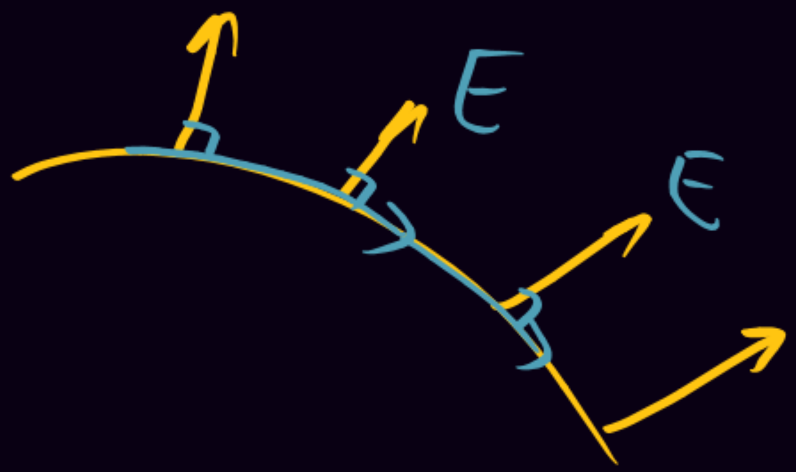
$$\Delta V = -E \boxed{\Delta r \cos\theta}$$

$\Delta V = - E$ (distance in the dir. of field).

① $\vec{E}$ is uniform

$$\Delta V = -\vec{E}\cdot\Delta\vec{r}$$

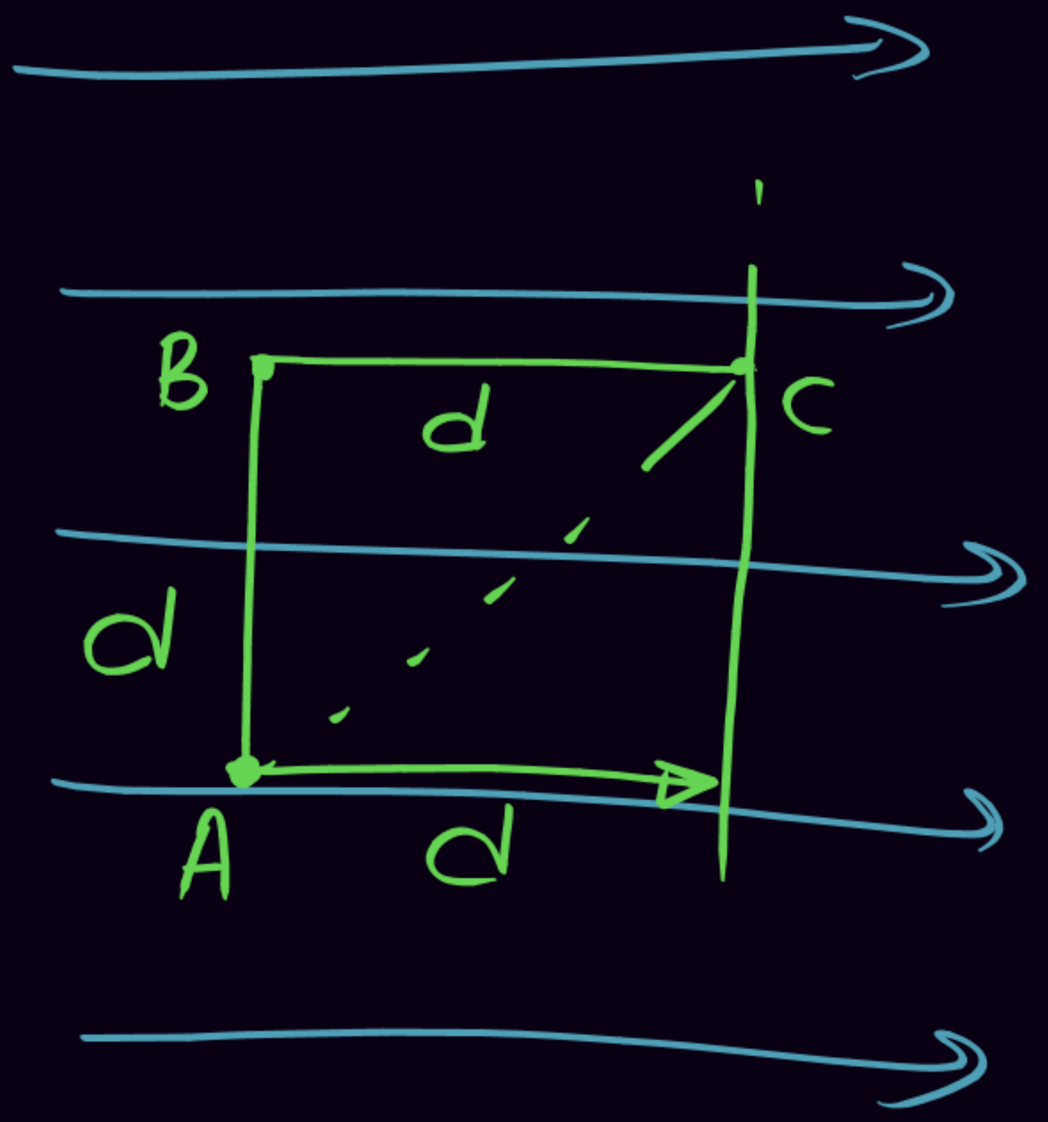
$$\Delta V = -E\,\Delta r_{\parallel \text{ to field}}$$



[In the dir $\perp$ to field potential remains constant.

[Equipotential surface:- The surface on which potential remains constant is called equipotential surface.

On equipotential surface $E \perp$ perpendicular to the surface at all points.

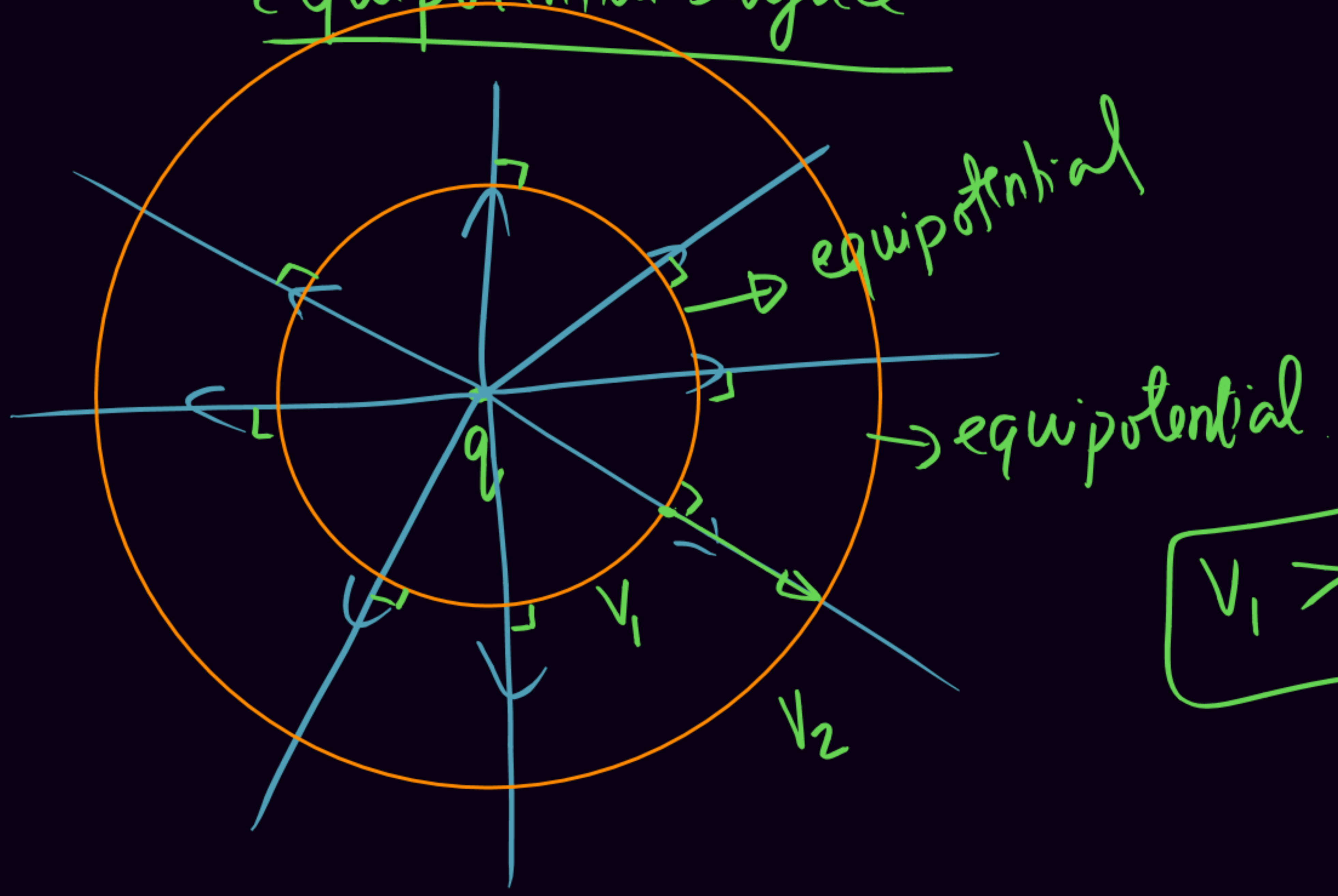


$$\boxed{V_A = V_B > V_C} \; *$$

$$\boxed{(V_B - V_C) = Ed}$$

$$\boxed{(V_A - V_C) = Ed.}$$

Equipotential surface



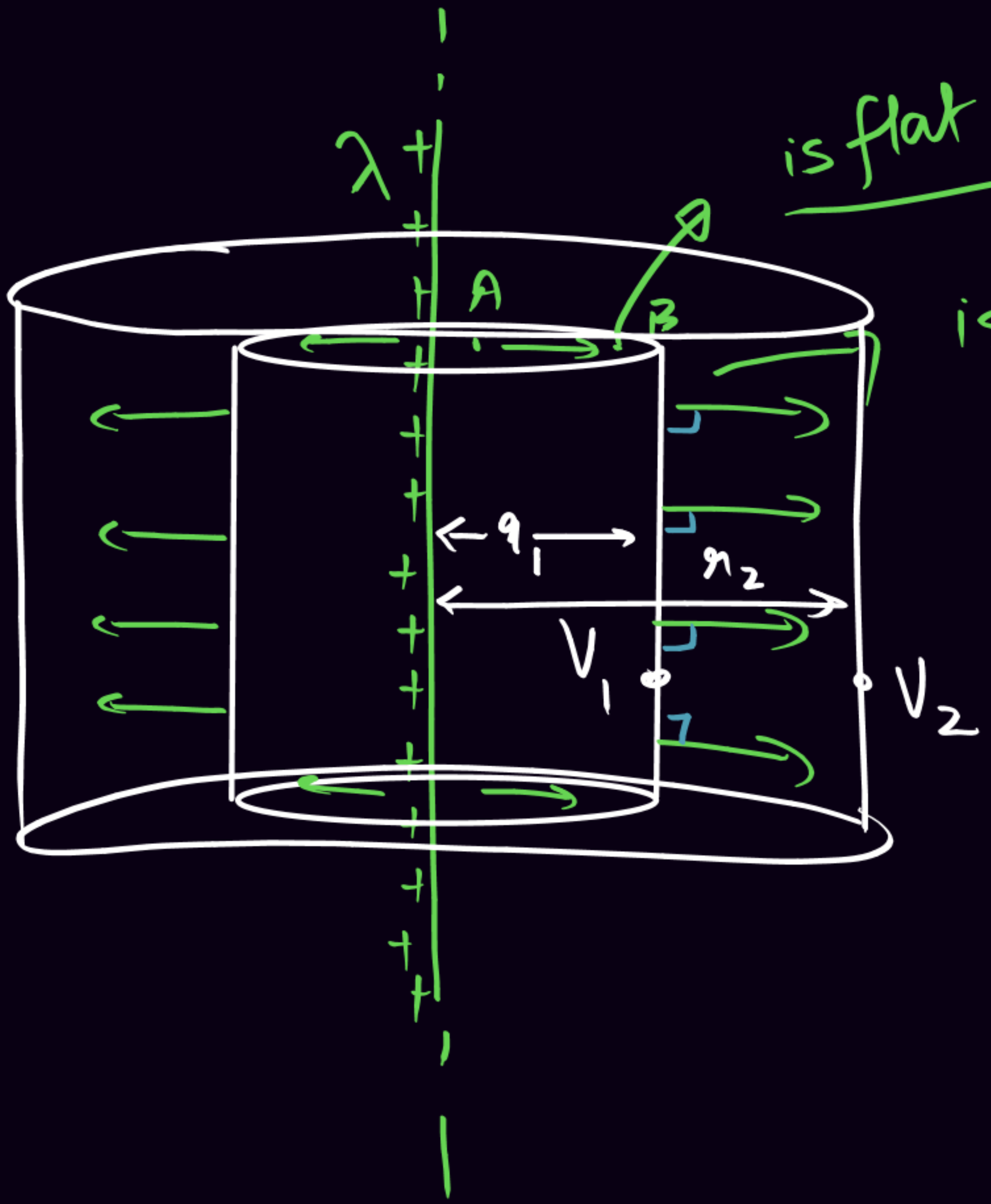
$$V_1 = \frac{kq}{r_1}$$

$$V_2 = \frac{kq}{r_2}$$

$$\boxed{V_1 > V_2} \qquad \boxed{r_2 > r_1}$$

is flat surface equipotential? $\Rightarrow$ No

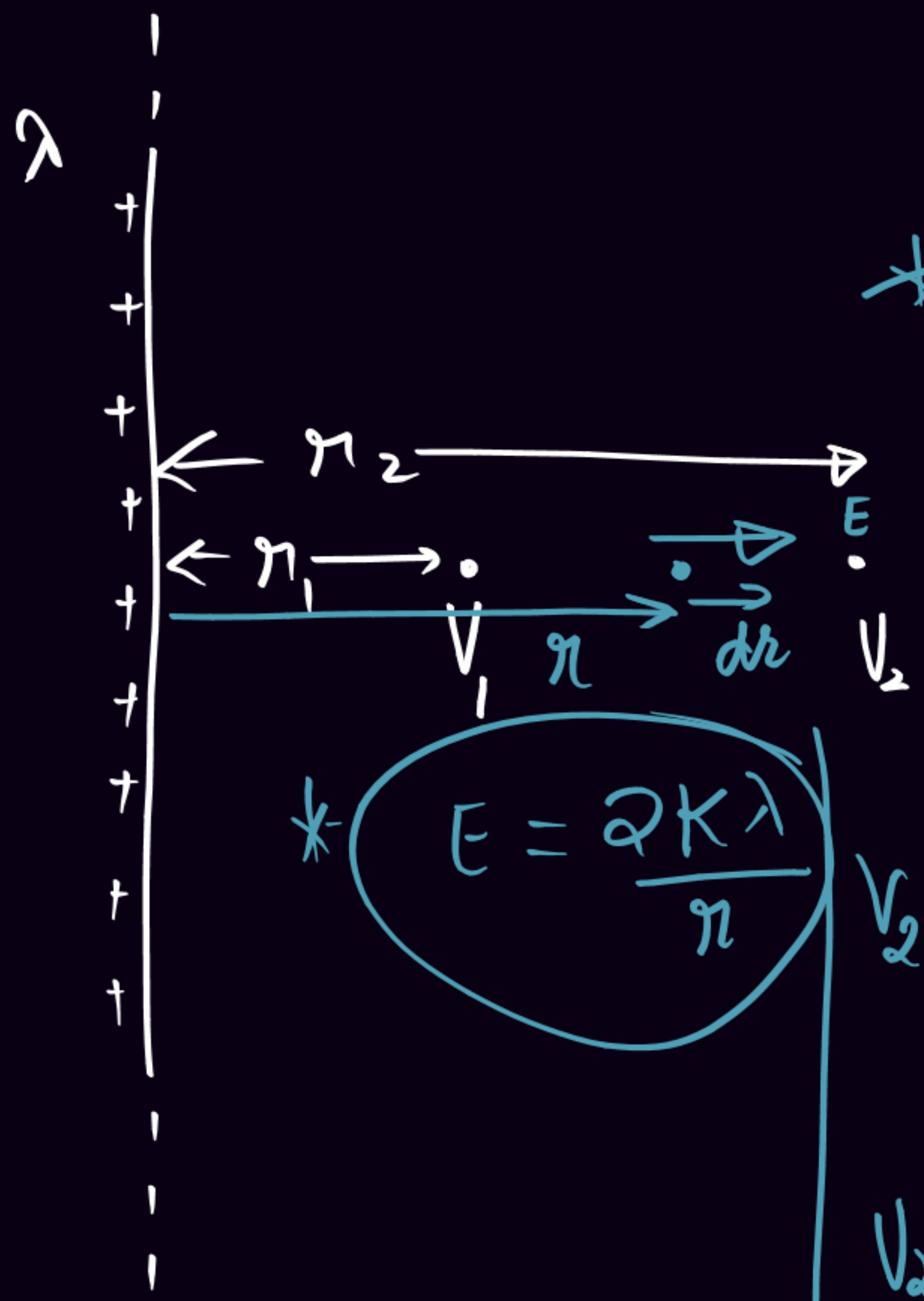
is curved surface equipotential?



$\boxed{V_1 > V_2}$

$\boxed{V_1 - V_2 = ?}$

find $V_1 - V_2$



$* \; E = \frac{2k\lambda}{r}$

$$* \int_{V_1}^{V_2} dV = -\int_{r_1}^{r_2} \vec{E}\cdot d\vec{r}$$

$$V_2 - V_1 = -\int_{r_1}^{r_2} E\,dr\cos 0$$

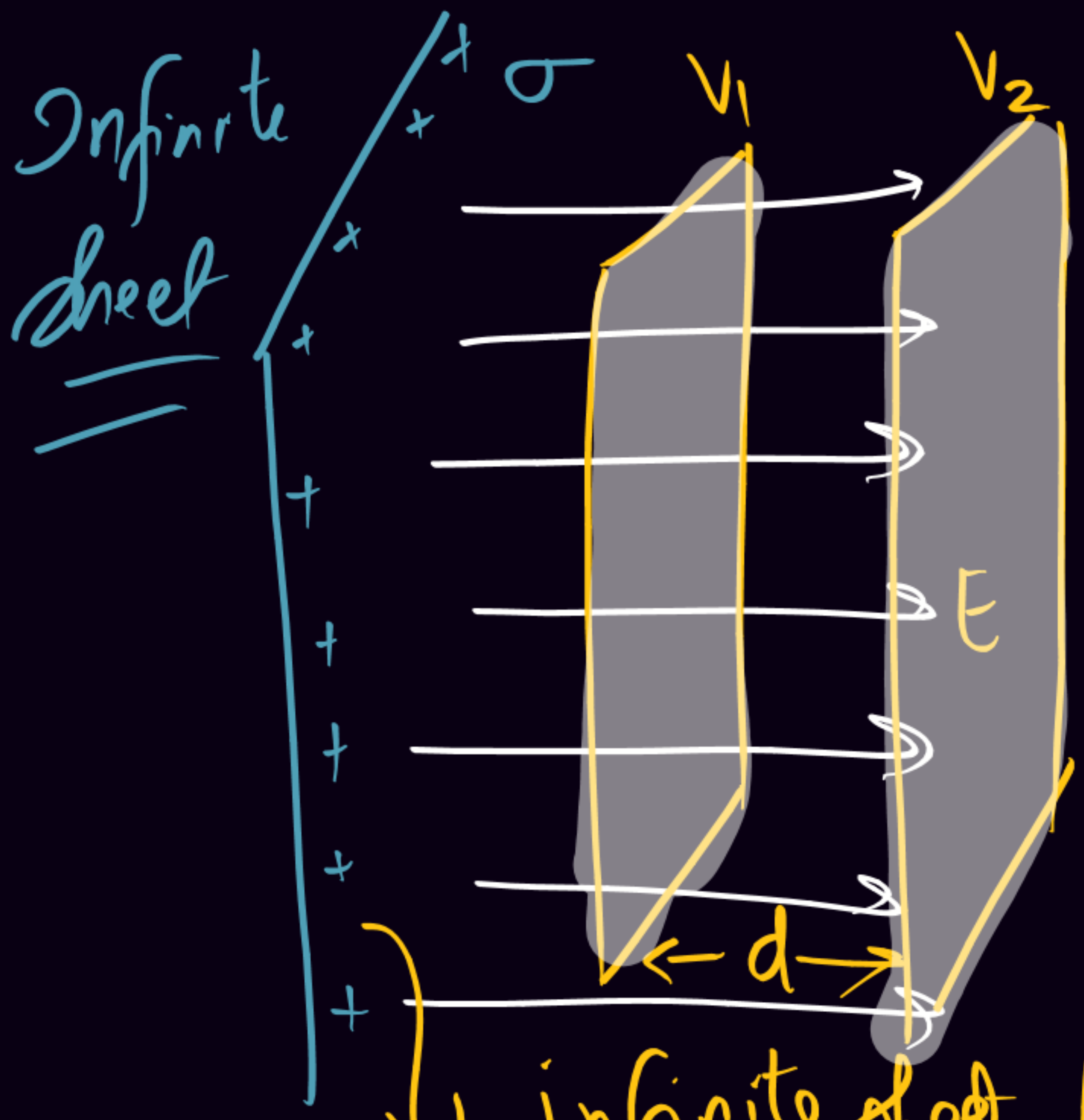
$$V_2 - V_1 = -\int_{r_1}^{r_2} \frac{2k\lambda}{r}\,dr$$

$$= -2k\lambda \ln r \Big|_{r_1}^{r_2}$$

$$V_2 - V_1 = -2k\lambda \ln\left(r_2/r_1\right)$$

$$\boxed{V_1 - V_2 = 2k\lambda \ln\left(\frac{r_2}{r_1}\right)}$$

X



$V_1 > V_2$

$V_1 - V_2 = E\,d$

$$\boxed{V_1 - V_2 = \frac{\sigma}{2\varepsilon_0}\,d}$$

infinite sheet ki field uniform hoti h

$$\int dV = \int \vec{E} \cdot d\vec{r}$$

If field is uniform

$$\boxed{\Delta V = -\vec{E} \cdot \Delta\vec{r}}$$

Q

A(1, 2, 3) $\vec{E} = (\hat{i} - \hat{j} + 2\hat{k})$ [uniform]

B(−1, 3, 0)

Find $V_A - V_B$.

$$V_A - V_B = -\vec{E} \cdot (\vec{r}_A - \vec{r}_B)$$

$$= -(\hat{i} - \hat{j} + 2\hat{k}) \cdot \left((\hat{i} + 2\hat{j} + 3\hat{k}) - (-\hat{i} + 3\hat{j} + 0\hat{k})\right)$$

$$= -(\hat{i} - \hat{j} + 2\hat{k}) \cdot (2\hat{i} - \hat{j} + 3\hat{k})$$

$$= -(2 + 1 + 6)$$

$$\boxed{V_A - V_B = -9\,V}$$ *

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

$$\boxed{\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}}$$

$$d\vec{r} = dx\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}$$

$$\vec{E}\cdot d\vec{r} = E_x\,dx + E_y\,dy + E_z\,dz$$

$$\boxed{\int dV = -\int E_x\,dx - \int E_y\,dy - \int E_z\,dz}$$

$$\int_{V_1}^{V_2} dV = -\int_{x_1}^{x_2} E_x\,dx - \int_{y_1}^{y_2} E_y\,dy - \int_{z_1}^{z_2} E_z\,dz.$$

Q If $\vec{E} = x\hat{i} + 2y\hat{j} - 3z\hat{k}$ then find potential diff b/w $A(2,1,3)$ & $B(3,1,2)$.

$$\int_{V_A}^{V_B} dV = -\int_2^3 x\,dx - \cancel{\int_1^1 2y\,dy} + \int_3^2 3z\,dz$$

$$V_B - V_A = -\frac{x^2}{2}\Big|_2^3 + 3\frac{z^2}{2}\Big|_3^2$$

$$-\frac{1}{2}\left(3^2-2^2\right) + \frac{3}{2}\left(2^2-3^2\right)$$

$$-\frac{5}{2} + \frac{3}{2}(-5)$$

$$-\frac{5}{2}(1+3)$$

$$\Rightarrow -10\text{ V}.$$

Q $\vec{E} = y\hat{i} + x\hat{j}$

H.W find the ΔV between the points $(2,1)$ & $(3,-2)$

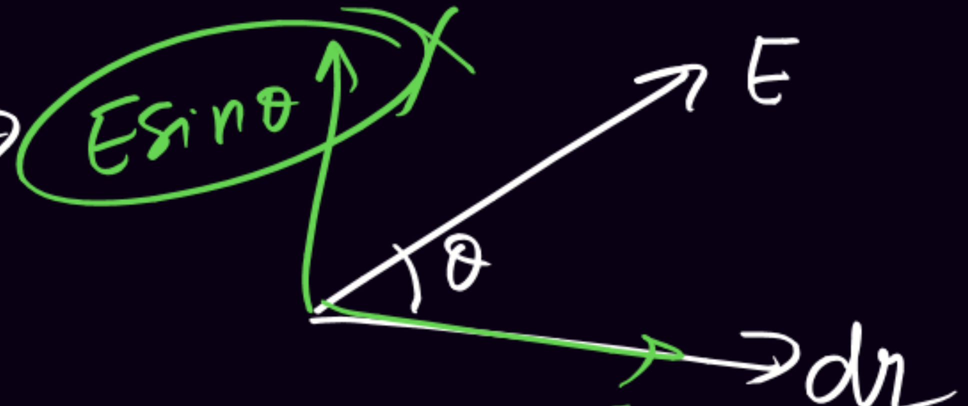
Calculation of field from potential $\vec{E}$

$$\vec{E} \underset{d}{\overset{\int}{\rightleftarrows}} V$$

$$dV = -\vec{E}\cdot\vec{dr}$$

$$dV = -E\,dr\cos\theta$$

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



$$\underline{\underline{E\cos\theta}} = E_{dr}$$

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

$$E_x = -\frac{\partial V}{\partial x}$$ (Partial differentiation)

$$E_y = -\frac{\partial V}{\partial y}$$

$$E_z = \frac{\partial V}{\partial z}$$

$$\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$$

$$\boxed{\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}}$$

Thank You Lakshyians