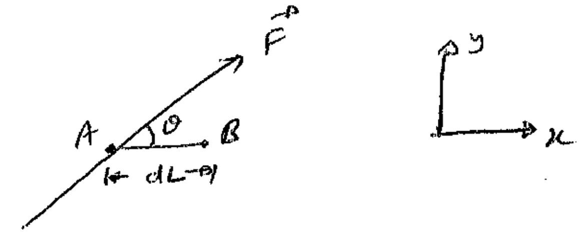
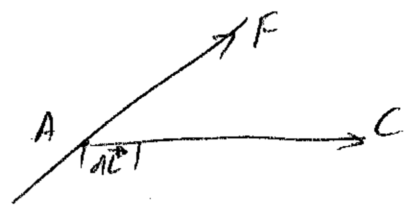
ENERGY AND POTENTIAL: ①



WHEN A FORCE $\vec{F}$ IS APPLIED TO AN OBJECT AT A (WHICH IS ALLOWED TO MOVE ONLY IN X-DIRECTION), THE WORK DONE IN MOVING THE OBJECT OVER A DISTANCE dL IS

$$dW = \vec{F} \cdot d\vec{L} \longrightarrow (1)$$

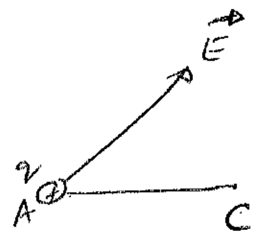
$d\vec{L}$ IS A VECTOR JOINING A & B. IF THE OBJECT IS MOVED FROM ITS INITIAL POSITION (i.e. A) TO A FINAL POSITION (C) & IF THE FORCE IS NOT CONSTANT DURING THIS MOVEMENT, WE NEED TO INTEGRATE EQ. (1) TO ~~GET~~ OBTAIN THE TOTAL WORK.



$$W = \int dW = \int_{INIT}^{FINAL} \vec{F} \cdot d\vec{L} \longrightarrow (2)$$

INIT → A
FINAL → C

NEXT, LET US CONSIDER THE WORK DONE WHILE MOVING A CHARGE FROM A TO C DUE TO COULOMB FORCE OF ATTRACTION OR REPULSION.



THE FORCE ON A CHARGE q PLACED IN AN ELECTRIC FIELD INTENSITY $\vec{E}$ IS

$$\vec{F}_E = q\vec{E} \quad \rightarrow (3)$$

HERE, THE SUBSCRIPT E ~~DENOTES THE~~ REMINDS US THAT THE FORCE IS DUE TO FIELD. LET AN EXTERNAL SOURCE PROVIDE A FORCE F THAT IS EQUAL & OPPOSITE TO THE FORCE DUE TO FIELD, I.E.

$$\vec{F} = -\vec{F}_E = -q\vec{E} \quad \rightarrow (4)$$

USING EQ. (2), THE WORK DONE IS

$$\boxed{W = -q\int_{INIT}^{FINAL} \vec{E}\cdot d\vec{L}} \quad \rightarrow (5)$$

FORCE PER UNIT +VE CHARGE $= \frac{\vec{F}}{q} = \vec{E}$ = ELECTRIC FIELD

WORK PER UNIT +VE CHARGE $= \frac{W}{q} = V$ = POTENTIAL DIFFERENCE

$$\therefore \boxed{V = -\int_{INIT}^{FINAL} \vec{E} \cdot d\vec{L}}$$

INIT → A

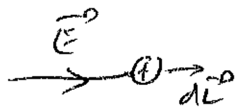
FINAL → C

POTENTIAL DIFFERENCE V IS THE WORK ~~AN~~ DONE BY AN EXTERNAL SOURCE IN MOVING A UNIT +VE CHARGE FROM ONE POINT TO ANOTHER.

V_{CA} SIGNIFIES THE POTENTIAL DIFFERENCE BETWEEN POINTS C & A AND IS THE WORK DONE IN MOVING THE UNIT +VE CHARGE FROM A TO C.

$$\boxed{V_{CA} = -\int_{A}^{C} \vec{E} \cdot d\vec{L}}$$

EXAMPLE: SUPPOSE E IS CONST, & $\vec{E}$ IS IN THE DIRECTION OF $d\vec{L}$.

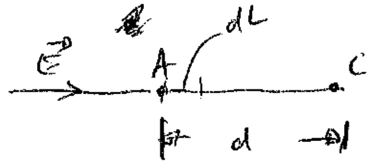


$$\vec{E} \cdot d\vec{L} = |\vec{E}||d\vec{L}| \cos 0^\circ$$

$$= E\,dL$$

$$\therefore \quad V_{CA} = -\int_{\text{INIT}}^{\text{FINAL}} E\,dL = -E \int_{\text{INIT}}^{\text{FINAL}} dL$$

INIT → A
FINAL → C



$$V_{CA} = -Ed$$

or

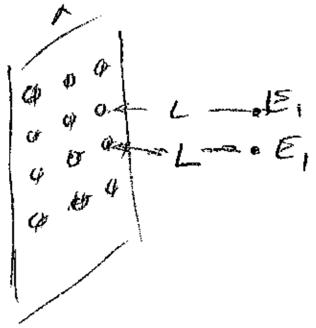
$$\boxed{E = \frac{-V_{CA}}{d}}$$

V

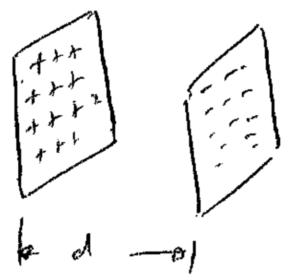
m

UNITS: V_{CA} → VOLTAGE or V
d → METERS
E → VOLT/m

CONSIDER AN INFINITE PLANE CONSISTING OF CHARGES WITH UNIFORM SURFACE DENSITY, ρ_S.



SUPPOSE THE ELECTRIC FIELD AT A DISTANCE L FROM ~~THE~~ A PARTICULAR POINT ON THE PLANE IS E_1. DUE TO SYMMETRY OF THE ~~PLANE~~ SOURCE, (THIS POINT IS NOT DISTINGUISHABLE), THE FIELD AT ANY ~~ALL POINT~~ DISTANCE L FROM THE SOURCE SHOULD ALSO BE E_1. THUS, WE SEE THAT THE FIELD AT A PLANE AT A DISTANCE L FROM THE CHARGE PLANE SHOULD BE CONSTANT ($= E_1$). USING GAUSS'S LAW, IT CAN BE SHOWN THAT E IS CONSTANT EVERYWHERE.



CAPACITOR

EACH OF THE CAPACITOR PLATE IS AN APPROXIMATION TO THE INFINITE PLANE OF CHARGES. HENCE, THE ELECTRIC FIELD INTENSITY BETWEEN THE PLATES IS APPROXIMATELY CONSTANT.