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ELECTROSTATIC POTENTIAL AND POTENTIAL ENERGY

Conservative force

- Gravitational force
- Spring force.
- Electrostatic force

Potential Energy [General]

→ [Defined only for Conservative force]

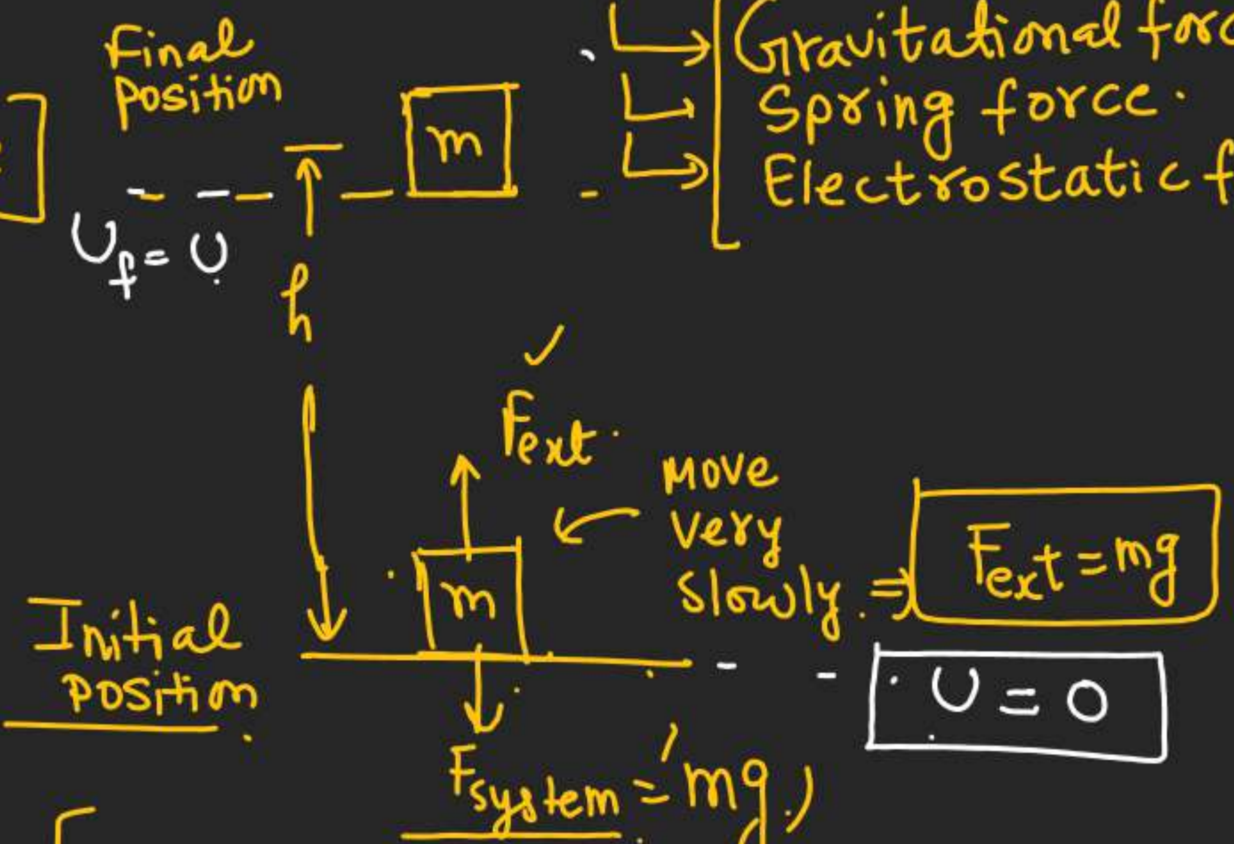
→ $$\boxed{-W_{\substack{\text{system} \\ \text{force}}} = +W_{\text{ext agent}} = \Delta U}$$

→ Def^n :- [Work done by ext agent against the system force (Conservative)

or −ve of the work done by system force.

is stored in the form of useful amount of energy within the body.

& this energy is called P.E]



$W_{\text{ext agent}} = +mgh$

$W_{\text{system force}} = -mgh$

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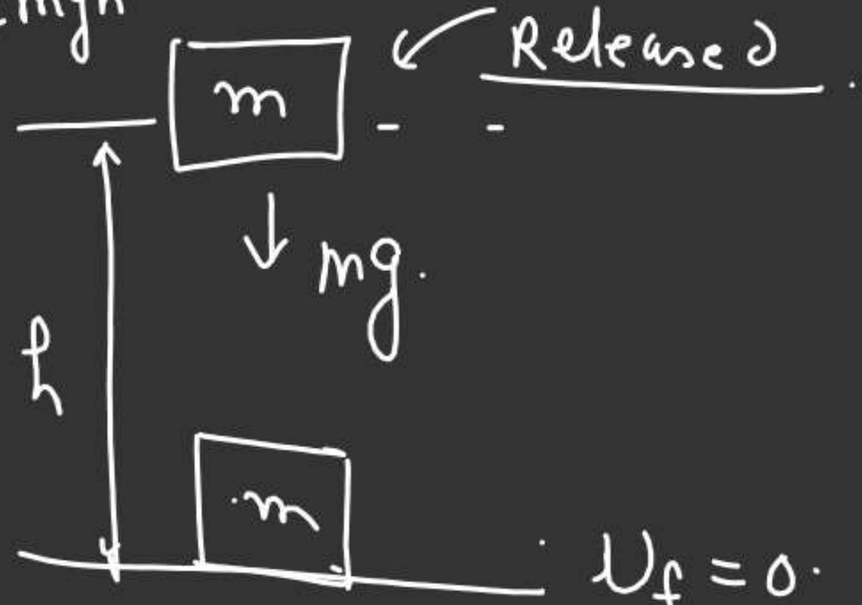
$-W_{system} = \Delta U$

$-W_{system} = (U_f - U_i)$

(*) $\boxed{W_{system} = -(U_f - U_i)}$

[If System force is doing work P.E of the body decreases]

$U_i = mgh$



$U_f = 0$

$\Rightarrow \boxed{W_{ext\,agent} = (U_f - U_i)}$

If ext agent is doing work then P.E of the System increases

$\Rightarrow$ If work done against gravity $\Rightarrow$ Gravitational P.E

$\Rightarrow$ If work done against Spring force $\Rightarrow$ Spring P.E

$\Rightarrow$ If work done against electric field then $\Rightarrow$ "Electrostatic P.E"

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Electrostatic potential Energy. & Electrostatic potential

↳ $$\boxed{\frac{\Delta U}{q} = \Delta V}$$ (XX)

(*) Change in P.E per Unit Charge is Change in Potential

(*) $$\boxed{\frac{U}{q} = V}$$

U → Potential Energy

V → (Potential)

"P.E per unit Charge is our potential"

V → S.I → (J/c)

↳ volt (V)

(*) Relation b/w field & potential

$$\boxed{-W_{system} = +W_{ext\,agent} = \Delta U}$$

(Force on q_0 due to Q)

$$dW_{system} = \vec{F}_{q_0/Q} \cdot d\vec{r}$$

$+Q$ Rest r $(+q_0)$ dr $\vec{E}_Q$

$$\vec{F}_{q_0/Q} = q_0 \vec{E}_Q$$

$$dW_{system} = q_0(\vec{E} \cdot d\vec{r})$$

$$\boxed{dW_{system} = -dU}$$

$$|\vec{F}_{q_0/Q}| = q_0 E_Q = \left(\frac{q_0 K Q}{r^2}\right)$$

$$-dU = q_0 \vec{E} \cdot d\vec{r}$$

(Work done per unit charge)

$$\frac{dU}{q_0} = -\vec{E} \cdot d\vec{r}$$

$$\boxed{\int_{V_i}^{V_f} dV = -\int_{r_i}^{r_f} \vec{E} \cdot d\vec{r}} \quad (*)$$

$$\boxed{dV = -\vec{E} \cdot d\vec{r}} \quad (**)$$

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(*) Relation b/w field & potential →

$$\boxed{-W_{system} = +W_{ext\,agent} = \Delta U}$$

Force on q_0 due to Q

$$dW_{system} = \vec{F}_{q_0/Q} \cdot d\vec{r}$$

$$\vec{F}_{q_0/Q} = q_0 \vec{E}_Q$$

$$dW_{system} = q_0(\vec{E} \cdot d\vec{r})$$

$$\boxed{dW_{system} = -dU}$$

$$|\vec{F}_{q_0/Q}| = q_0 E_Q = \left(\frac{q_0 K Q}{r^2}\right)$$

$$-dU = q_0 \vec{E} \cdot d\vec{r}$$

(work done per unit charge)

$$\frac{dU}{q_0} = -\vec{E} \cdot d\vec{r}$$

$$\boxed{dV = -\vec{E} \cdot d\vec{r}} \quad (**)$$

$$\boxed{\int_{V_i}^{V_f} dV = -\int_{r_i}^{r_f} \vec{E} \cdot d\vec{r}} \quad (*)$$

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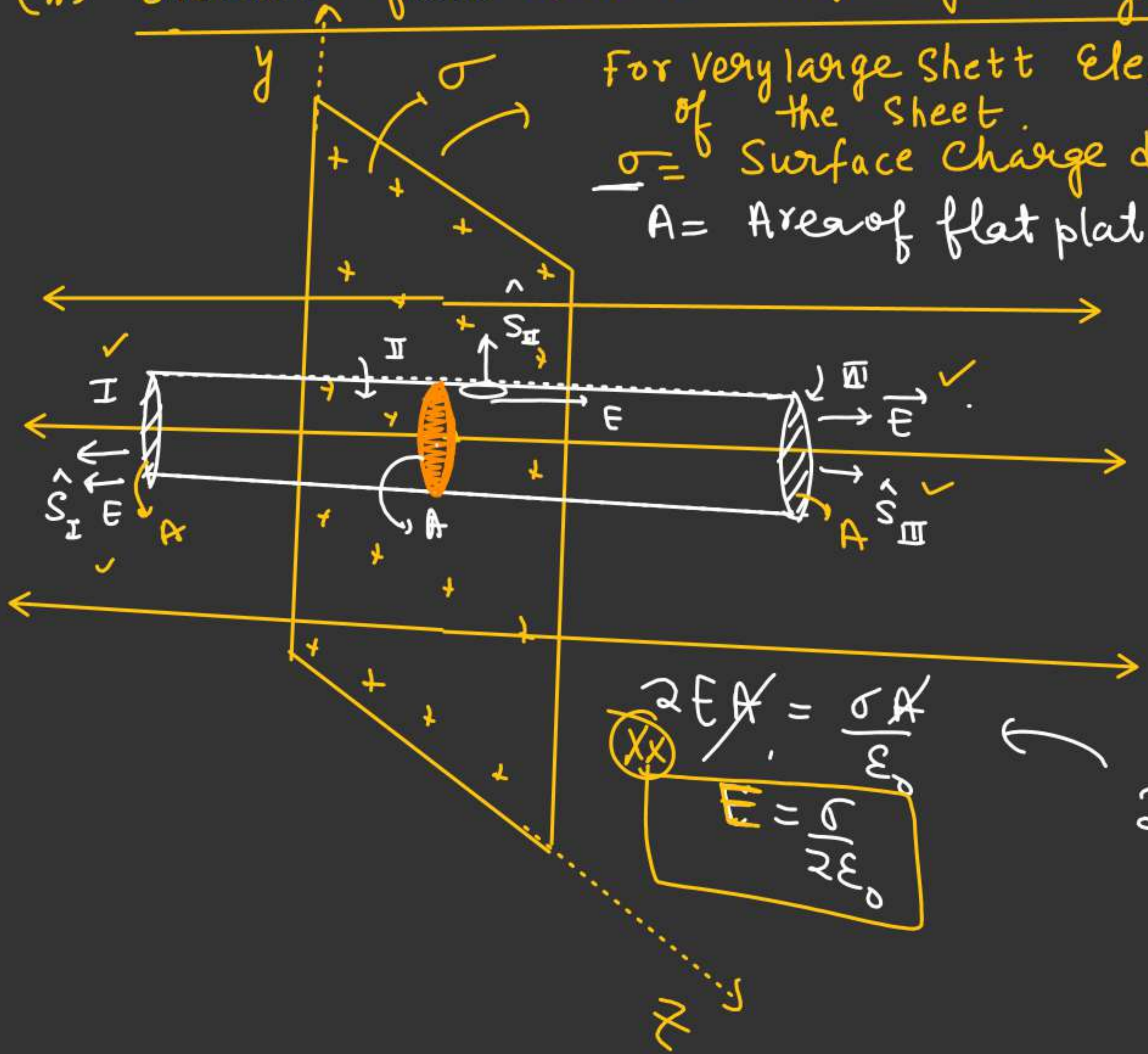
(*) Application of Gauss's Law

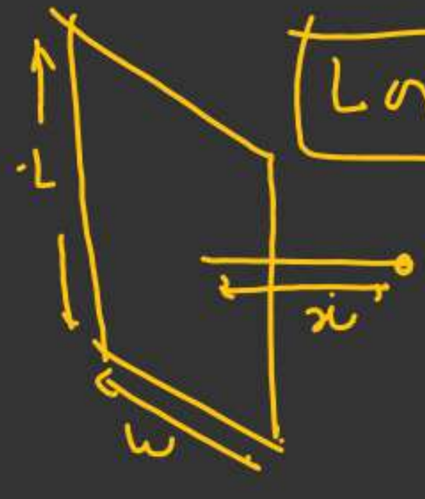
(*) Electric field due to uniformly charge very large thin Sheet:-



For very large Shett Electric field lines are pendicular to the plane of the Sheet.

σ = Surface Charge density.

A = Area of flat plat.



L or w << x

$$\oint \vec{E}\cdot d\vec{s} = \frac{q_{enc}}{\varepsilon_0}$$

$$\Downarrow$$

$$\int_{I} \vec{E}\cdot d\vec{s} + \int_{II} \vec{E}\cdot d\vec{S} + \int_{III} \vec{E}\cdot d\vec{s} = \frac{q_{enc}}{\varepsilon_0}$$

$$\int_{II}\vec{E}\cdot d\vec{S} \Rightarrow 0 \qquad \vec{E} \perp d\vec{s}$$

$$\int_{I} \vec{E}\cdot d\vec{s} = \int_{III} \vec{E}\cdot d\vec{s} = E\int ds \qquad \vec{E} \parallel d\hat{s}$$

$$2E \underbrace{\int_{I} ds}_{A} = \frac{\sigma A}{\varepsilon_0}$$

$$2E\cancel{A} = \frac{\sigma \cancel{A}}{\varepsilon_0}$$

XX

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

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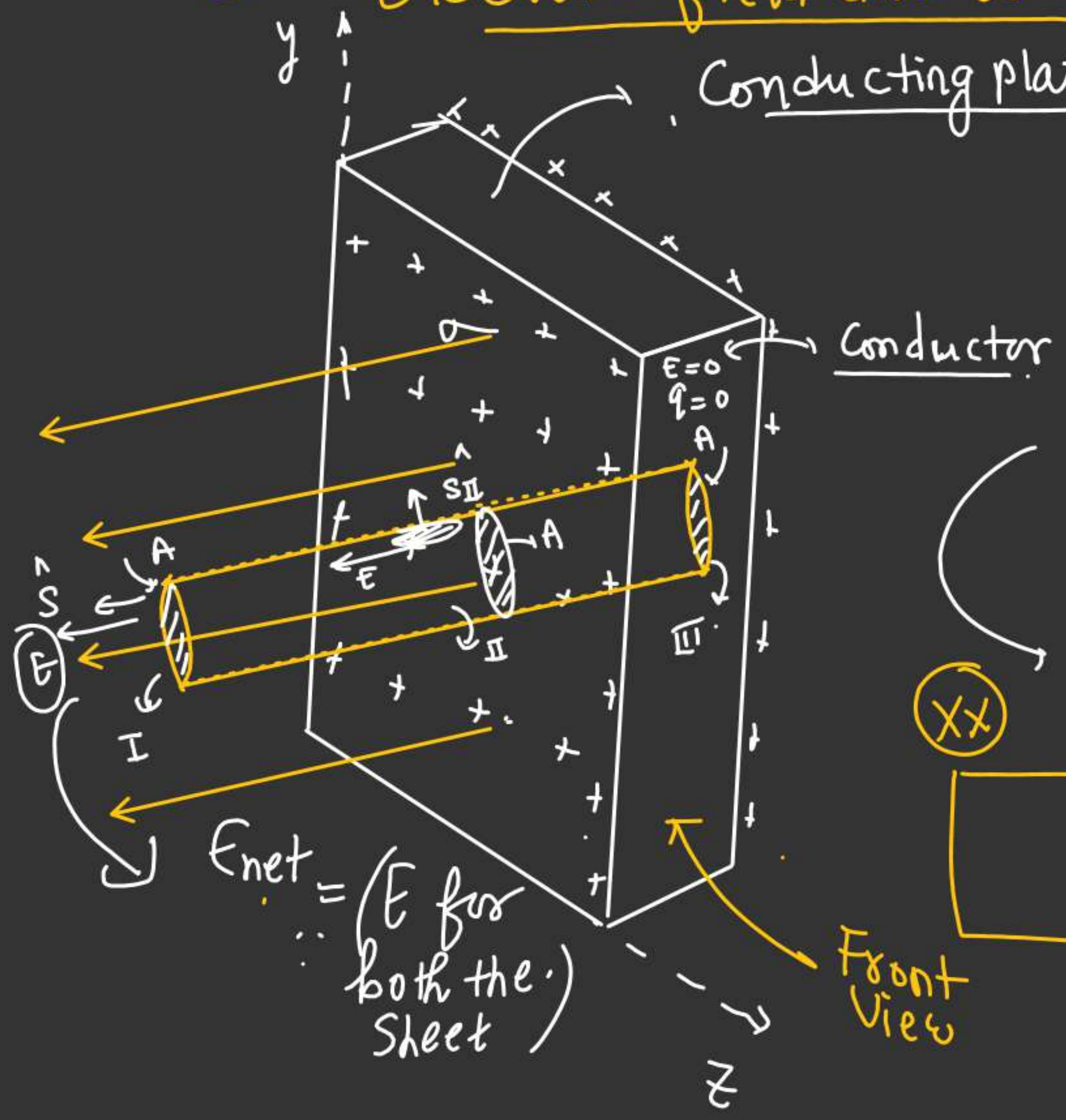
⊗ Electric field due to Very large Conducting plate :



$$\oint \vec{E}\cdot d\vec{s} = \frac{q_{enc}}{\varepsilon_0}$$

$$\int_{I} \vec{E}\cdot d\vec{s} + \int_{II} \vec{E}\cdot d\vec{s} + \int_{III} \vec{E}\cdot d\vec{s} = \frac{\sigma A}{\varepsilon_0}$$

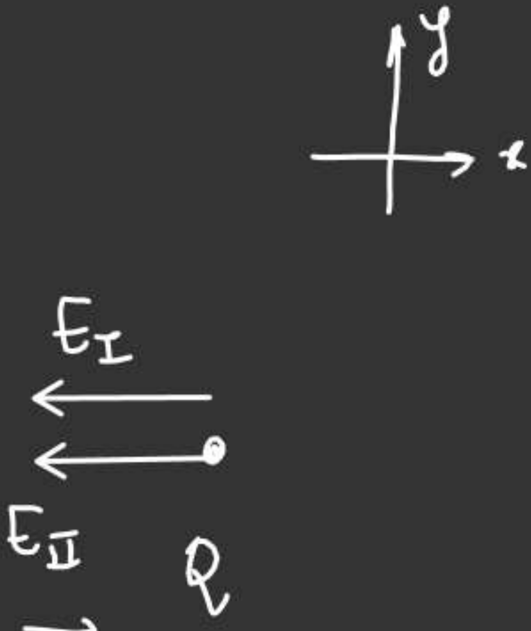
I: $\vec{E} \parallel d\hat{s}$ II: $\vec{E} \perp d\hat{s}$ III: 0, $\boxed{E=0}$

XX

$$E A = \frac{\sigma A}{\varepsilon_0}$$

$$\boxed{E = \frac{\sigma}{\varepsilon_0}}$$

$$\boxed{\sigma = \frac{Q}{A}}$$



$$\vec{E}_Q = \left(\frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}\right)(-\hat{i})$$

$$\vec{E}_Q = \left(\frac{\sigma}{\varepsilon_0}\right)(-\hat{i})$$

$$\vec{E}_P = \vec{E}_I + \vec{E}_{II}$$

$$= \left(\frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}\right)(+\hat{i})$$

$$= \left(\frac{\sigma}{\varepsilon_0}\right)(+\hat{i})$$

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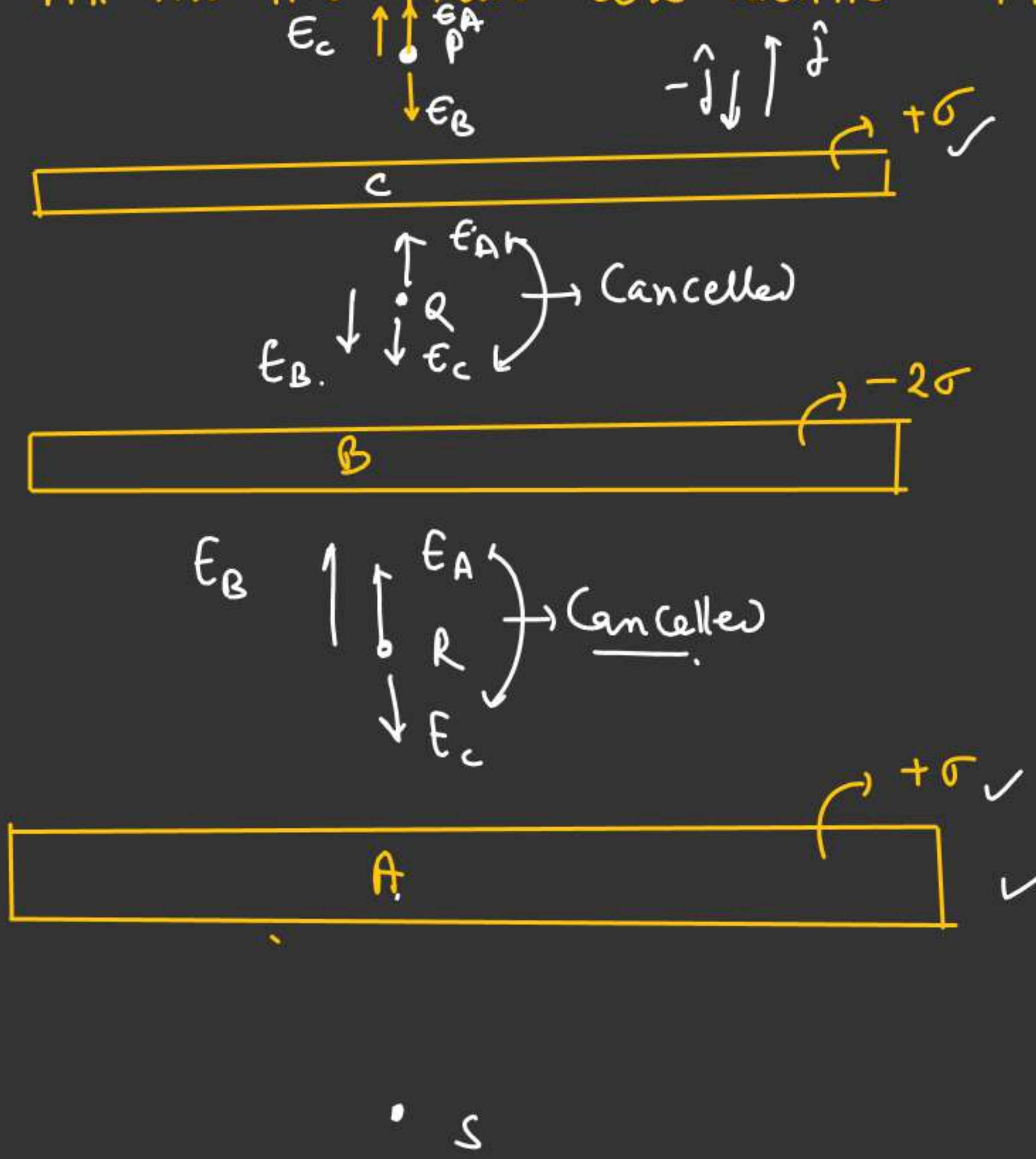
All the three plates are identical. Find net field at P, Q, R & S.



$$\vec{E}_P = \vec{E}_A + \vec{E}_c + \vec{E}_B$$

$$= \left(\frac{\sigma}{\varepsilon_0} + \frac{\sigma}{\varepsilon_0}\right)+\hat{j} - \left(\frac{2\sigma}{\varepsilon_0}\right)\hat{j}$$

$$= 0$$

$$\vec{E}_S = 0$$

$$\vec{E}_Q = \left(\frac{2\sigma}{\varepsilon_0}\right)(-\hat{j})$$

$$\vec{E}_R = \left(\frac{2\sigma}{\varepsilon_0}\right)(+\hat{j})$$