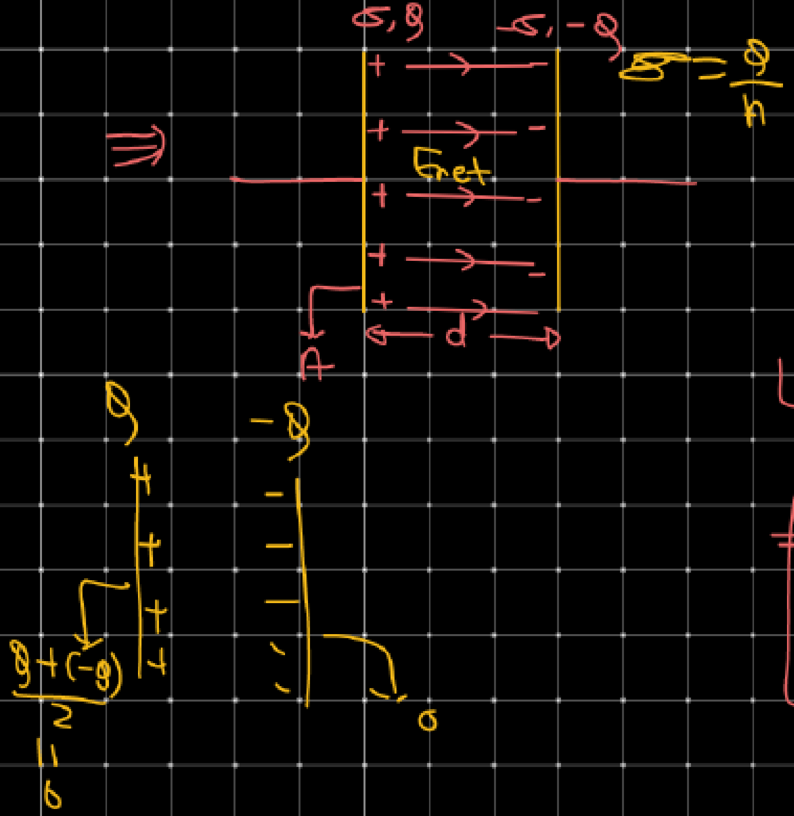
↳ Parallel Plate Capacitor (PPC)



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

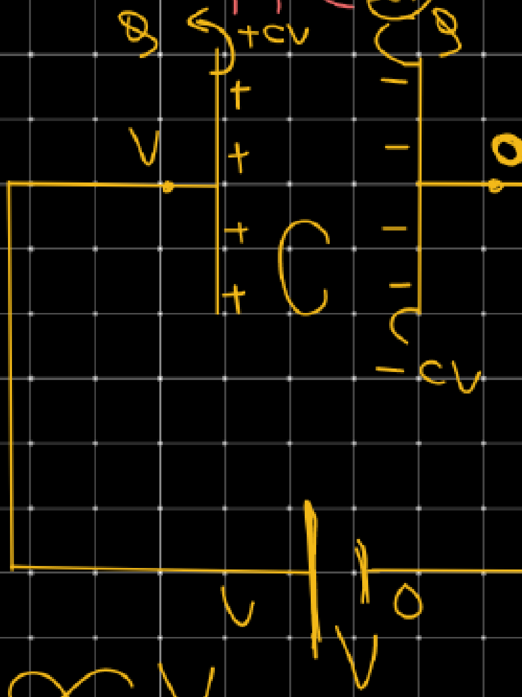
$$\boxed{E_{in} = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}}$$

$$(\Delta V)_{b/w\,Plate} = E\,d = \frac{\sigma d}{\varepsilon_0} = \frac{Q d}{A\varepsilon_0}$$

$$\hookrightarrow C = \frac{+Q}{\Delta V} = \frac{A\varepsilon_0}{d}$$

$$\Rightarrow \boxed{C_m = \frac{A\varepsilon_0\underline{\underline{\varepsilon_r}}}{d}}$$

⇒ when PPC -CV Connected with battery :



$\boxed{Q = CV}$

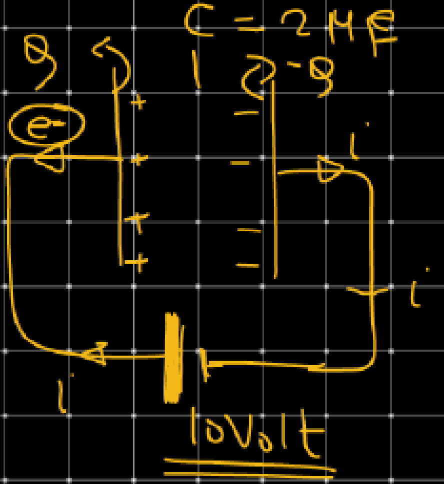
↳ Potential across the Capacitor is $\underline{\underline{V}}$.

↳ C is the Capacitance of Capacitor.

$$Q = CV$$
$$\underline{\underline{Q = CV}}$$

$$Q \propto V$$
$$\underline{\underline{Q = CV}}$$

Q1)



$Q = ?$

$Q = CV$

$Q = (2\mu F) \times 10$

$$\boxed{Q = 20\mu C}$$

$$\underline{\underline{Q = 20\mu C}}$$

$Q = 20 \times 10^{-6}\ C$

$$\boxed{Q = 2 \times 10^{-5}\ C}$$

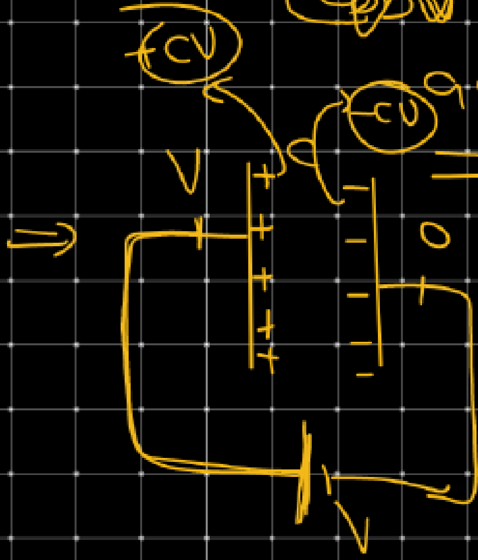
⇒ $\boxed{\text{PPC}}$

$$Q \propto \Delta V$$

$$\boxed{Q = C\Delta V}$$

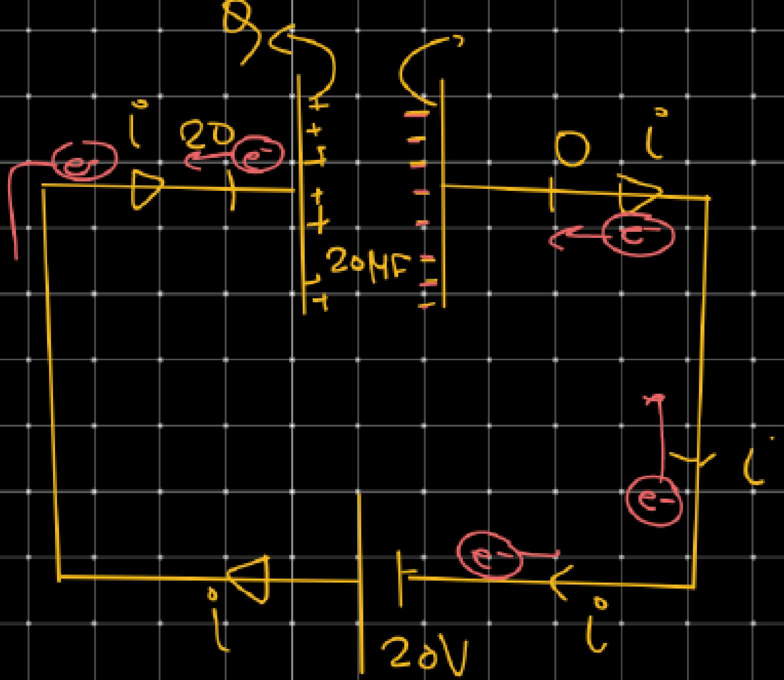
↳ ΔV → Potential diff across Plate

↳ Capacitance of Capacitor.



⇒ Potential across the plate = V.

↳ $Q = CV$



$$\hookrightarrow Q = C\Delta V$$

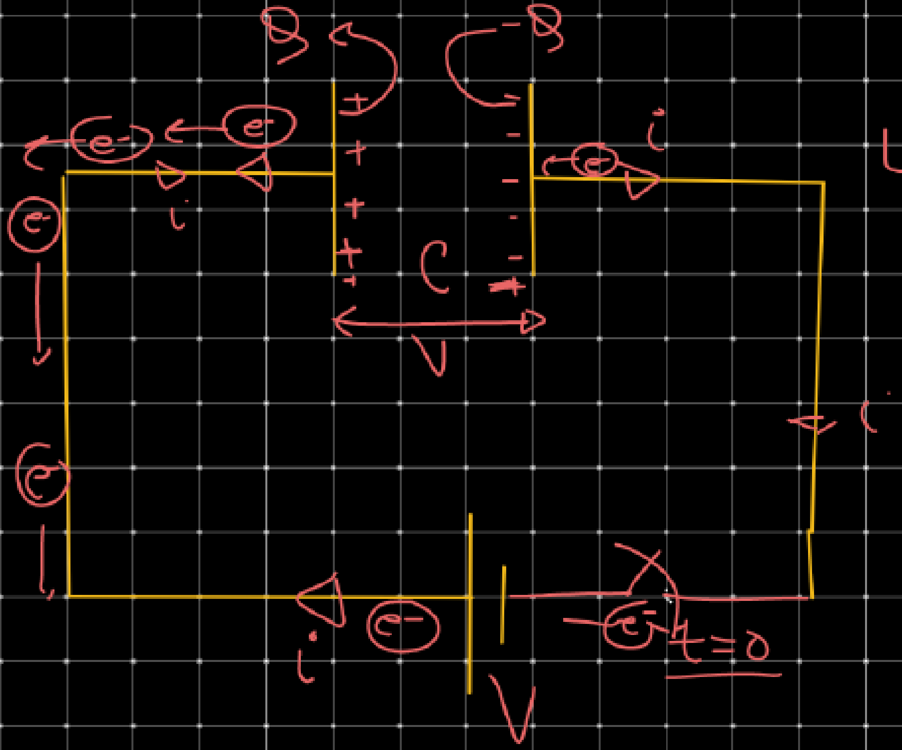
$$= \underline{\underline{CV}}$$

$$Q = CV$$

$$= (20\mu F)(20V)$$

$$= 400\mu C$$

$$= \underline{\underline{4 \times 10^{-4} C}}$$

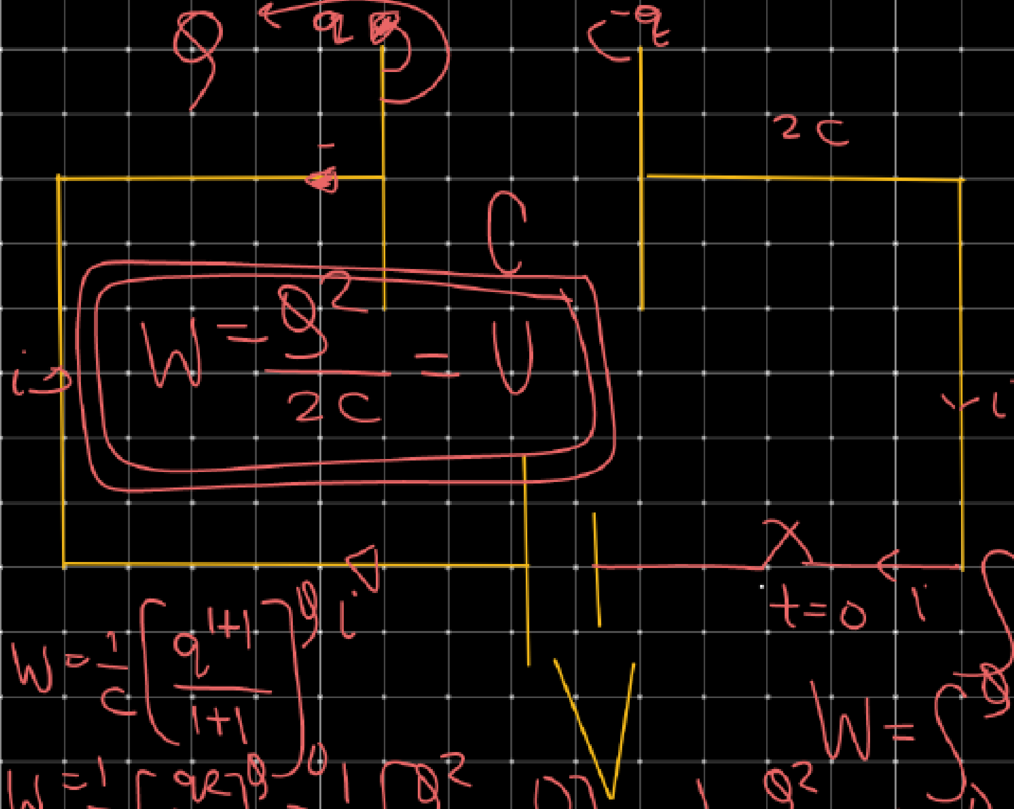


t=0 , Swith is closed.

↳ t=∞ Steady state.

$$Q = C V$$

⟹ Energy Store in Capacitor :-



$$\boxed{W = \frac{Q^2}{2C} = U}$$

↳ at $t = 0^+$ Swith is on

at any instant, charge on Capacitor is q

↳ Potential drop across the Capacitor $[q = CV']$

$$V' = \frac{q}{C}$$

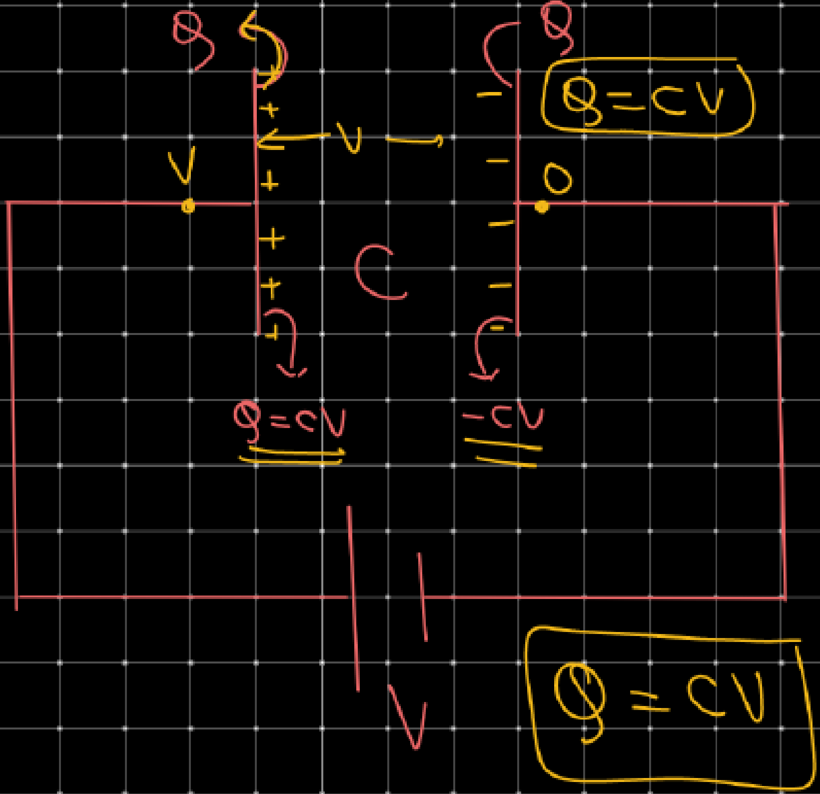
work done to increase dq charge on Capacitor

$$\int dw = (dq)\,V' = dq \times \frac{q}{C}$$

$$W = \int_0^{Q} \frac{q}{C}\,dq = \frac{1}{C}\int_0^{Q} q\,dq$$

$$W = \frac{1}{C}\left[\frac{q^{1+1}}{1+1}\right]_0^{Q}$$

$$W = \frac{1}{C}\left[\frac{q^2}{2}\right]_0^{Q} = \frac{1}{C}\left(\frac{Q^2}{2} - \frac{0}{2}\right) = \frac{1}{C}\frac{Q^2}{2} = \boxed{W = \frac{Q^2}{2C}}$$



$$\boxed{Q=CV}$$

$$\boxed{Q=CV}$$

At Steady State- $\boxed{t=\infty}$

Energy store = $\frac{Q^2}{2C}$

$Q = CV$

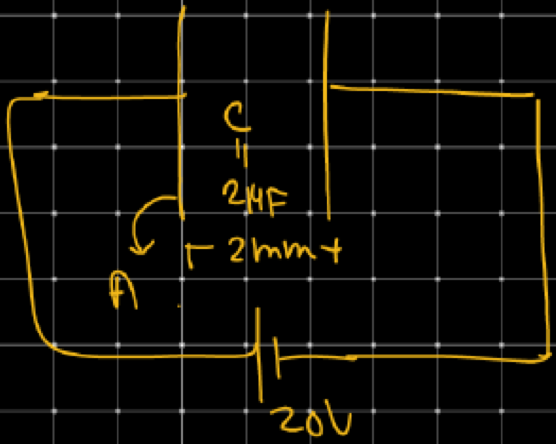
$$U = \frac{Q^2}{2C} = \frac{(CV)^2}{2C} = \boxed{\frac{1}{2}CV^2}$$

$$\boxed{U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{QV}{2}}$$

$$U = \frac{1}{2}(CV)V = \frac{1}{2}QV = \frac{QV}{2}$$

Q1) At Steady State ① find ① Q , ⑪ E = ? ⑪ V

④ U



① $Q = CV = (2\mu F)\,20\text{Volt}$

$= 40\,\mu F\text{-}V$

$= 40\,\mu C$

$= 40\times10^{-6}\,C = 4\times10^{-5}\,C$

⑪ $\boxed{E = \frac{Q}{A\varepsilon_0} = \frac{\sigma}{\varepsilon_0}}$

(iii) $V = Ed = \frac{Qd}{A\varepsilon_0}$

$U = \frac{1}{2}CV^2$

$= \frac{Q^2}{2C} \Rightarrow \frac{1}{2}QV$

$\frac{1}{\cancel{2}}\times\overset{2}{\cancel{4}}\times10^{-5}\,C\times20$

$= 40\times10^{-5} = 4\times10^{-4}\,J$

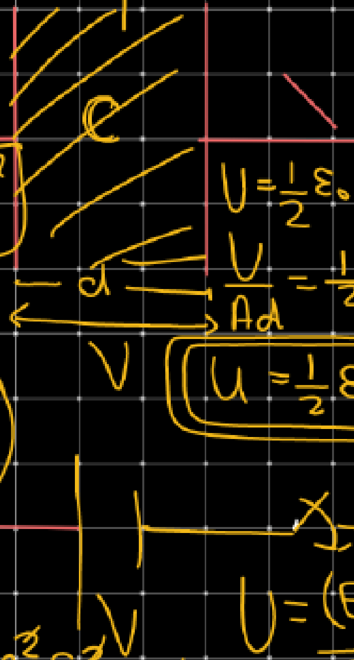
↳ Energy store inside the Capacitor & Energy density :-

$u =$

$$\boxed{\frac{U}{Ad} = \frac{1}{2}\varepsilon_0 E^2}$$

$V = Ad$

$$\frac{U}{V} = \boxed{u = \frac{1}{2}\varepsilon_0 E^2}$$



$$u = \frac{Q^2}{2CAd}$$

$$U = \frac{1}{2}\varepsilon_0 E^2 Ad$$

$$\frac{U}{Ad} = \frac{1}{2}\varepsilon_0 E^2$$

$$\boxed{u = \frac{1}{2}\varepsilon_0 E^2}$$

$$U = \frac{(EA\varepsilon_0)^2}{2 \times \frac{A\varepsilon_0}{d}}$$

$$U = \frac{E^2 A^{\cancel{2}} \varepsilon_0^{\cancel{2}} \times d}{2\cancel{A}\cancel{\varepsilon_0}}$$

$$U = \frac{1}{2}\varepsilon_0 E^2 Ad$$

① at steady state $(i = 0)$

⑪ Charge store on Capacitor

$$Q = CV$$

⑪⑪ Energy store by Capacitor

$$\boxed{U = \frac{Q^2}{2C}} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

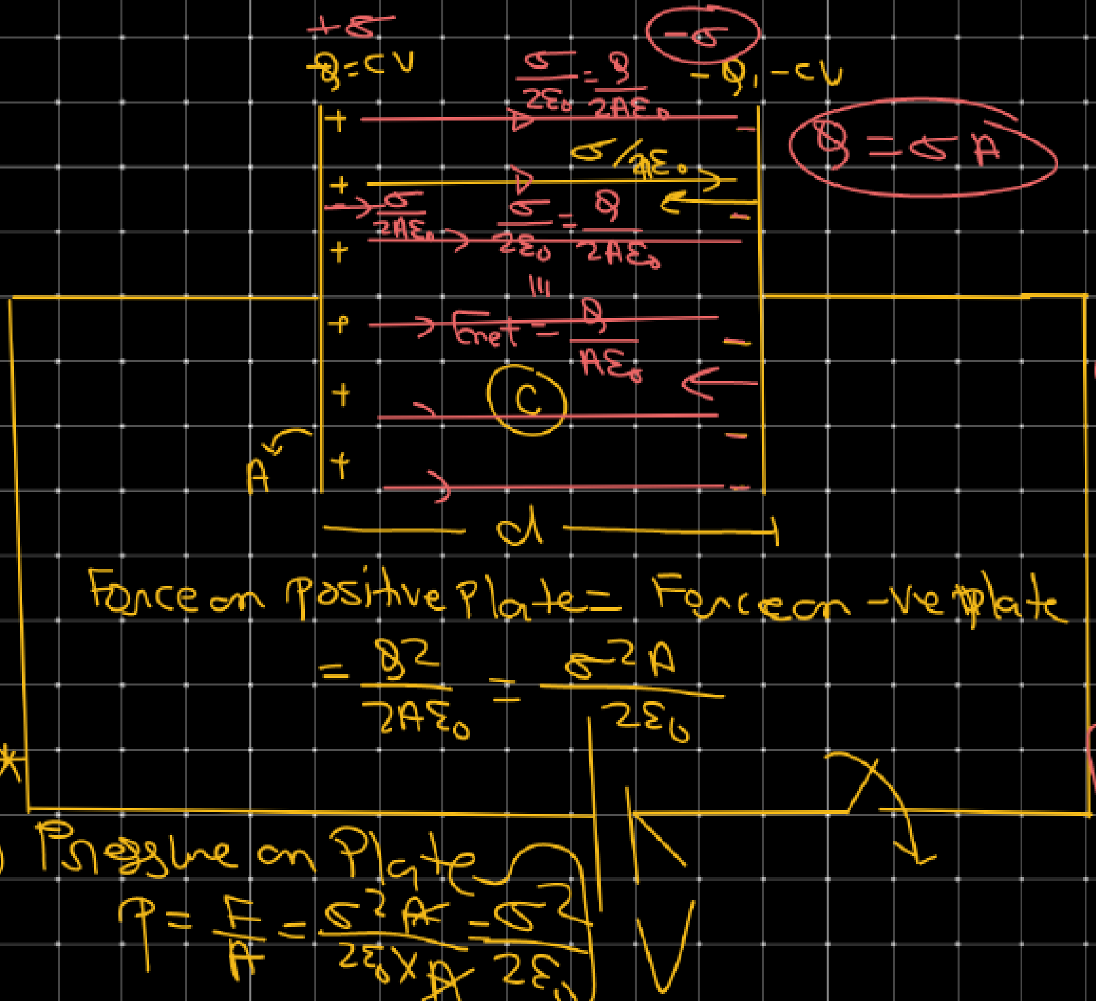
(iv) $\boxed{E = \frac{Q}{A\varepsilon_0}}$, $\boxed{C = \frac{A\varepsilon_0}{d}}$ $\quad U = \frac{E^2\varepsilon_0 Ad}{2}$

$$\boxed{Q = EA\varepsilon_0}$$

$$\boxed{Q = EA\varepsilon_0}$$

$$U = \frac{(EA\varepsilon_0)^2}{\frac{2A\varepsilon_0}{d}} = \frac{E^2 A^{\cancel{2}} \varepsilon_0^{\cancel{2}} d}{2\cancel{A}\cancel{\varepsilon_0}}$$

#



$\boxed{Q = \sigma A}$

At Steady state (t = ∞)

$$\boxed{C = \frac{A\varepsilon_0}{d}}$$

$$Q = CV$$

Force on (+ive) Plate

$$F = Q\left[E\right]$$

$$= Q\left[\frac{Q}{2A\varepsilon_0}\right]$$

$$\text{Force} = \frac{Q^2}{2A\varepsilon_0} = \frac{\sigma^2 A^2}{2A\varepsilon_0}$$

$$\boxed{\text{Force} = \frac{\sigma^2 A}{2\varepsilon_0}}$$

Force on positive plate = Force on -ve plate

$$= \frac{Q^2}{2A\varepsilon_0} = \frac{\sigma^2 A}{2\varepsilon_0}$$

**

① Pressure on Plate

$$P = \frac{F}{A} = \frac{\sigma^2 \cancel{A}}{2\varepsilon_0 \times \cancel{A}} = \boxed{\frac{\sigma^2}{2\varepsilon_0}}$$

⟹ The two PPC connected by 300V battery, charge collected at each Plate of PPC is 1μC. Find Energy Store in PPC.

Sol) Solve)

$$U = \frac{q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV.$$

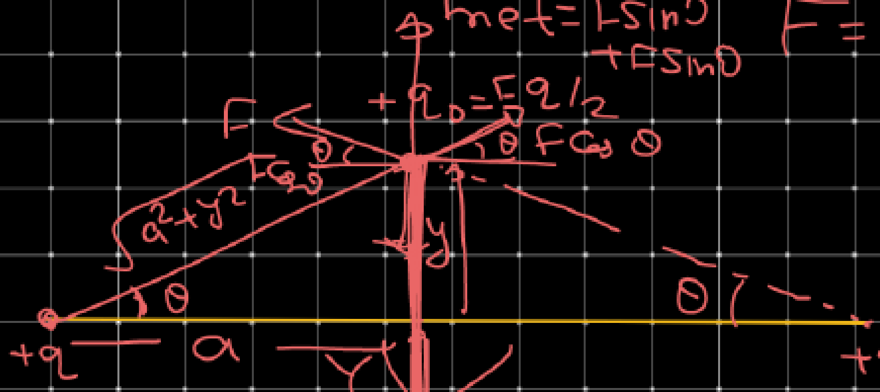
$$= \frac{1}{\cancel{2}} \times 1 \times 10^{-6} C \times \overset{150}{\cancel{300}} V$$

$$= 1.5 \times 10^{-6+2} J$$

$$= 1.5 \times 10^{-4} J = 150 \mu J$$

$$= .15 mJ$$

$F_{net} = F\sin\theta + F\sin\theta$



$$F = \frac{kqq_0}{(\sqrt{a^2+y^2})^2} = \frac{kqq_0}{(a^2+y^2)}$$

$$F_{net} = 2F\sin\theta.$$

$$= \frac{\cancel{2}\,kqq\cancel{/2}}{(a^2+y^2)}$$

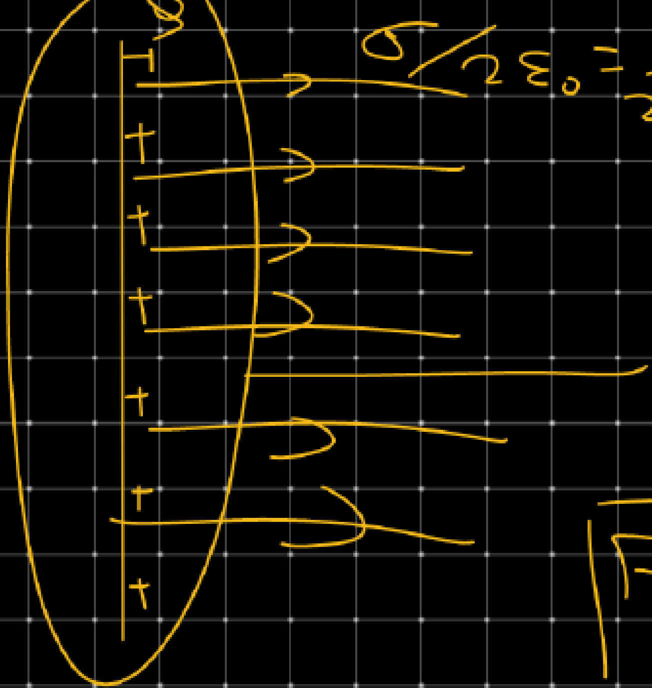
$$\sin\theta = \frac{Y}{\sqrt{a^2+y^2}}$$

$$F = \frac{2kq^2Y}{(a^2+y^2)^{3/2}} = \frac{2kq^2Y}{a^3} \qquad F = \frac{2kq^2}{(a^2+y^2)^1}\,\frac{Y}{(a^2+y^2)^{1/2}}$$

$y << a$ given

$$(a^2)^{3/2} = a^3.$$

$$\boxed{F \propto Y} \qquad \vec{F} \propto -\vec{Y}$$



$$\sigma/2\varepsilon_0 = \frac{Q}{2A\varepsilon_0}$$

$$F = qE$$
$$= Q \times \frac{Q}{2A\varepsilon_0}$$

$$\boxed{F = \frac{Q^2}{2A\varepsilon_0}}$$