

Legge di Gauss

inoltre: $\Phi_E(\Sigma) = \alpha \cdot E = \frac{q_{\text{int}}}{\epsilon_0}$

$\uparrow$
simmetria
semplici $\Downarrow$

$$\vec{E} = \frac{1}{\alpha} \frac{q_{\text{int}}}{\epsilon_0}$$

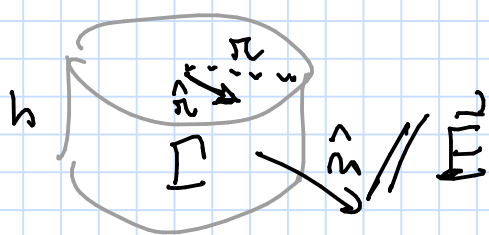
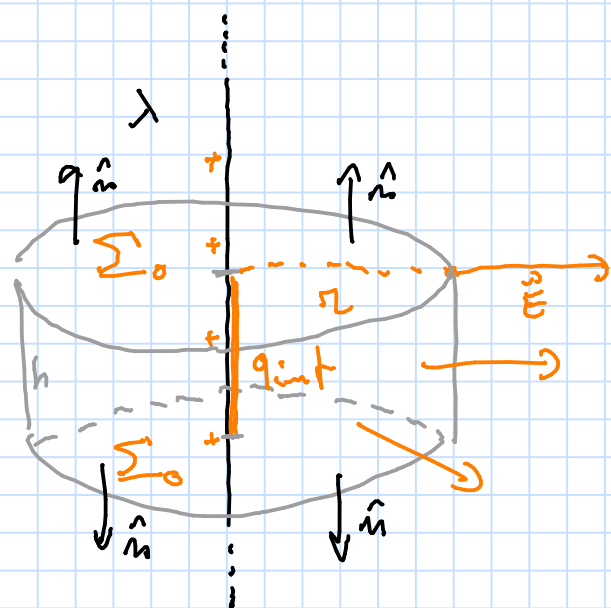
filo uniformemente carico infinito

$$[\lambda] = \frac{C}{m}$$

campo $\vec{E}(r)$ radiale

$$q_{\text{int}} = h \cdot \lambda$$

nelle Σ_0 $\vec{E} \perp \hat{n}$
 $\Rightarrow \Phi_E(\Sigma_0) = 0$



$$\Rightarrow \Phi_E(\Sigma) = \Sigma \cdot \vec{E} = 2\pi r h \cdot E(r)$$

$$\Phi_E(\Sigma) = h 2\pi r E(r) = \frac{h \cdot \lambda}{\epsilon_0}$$

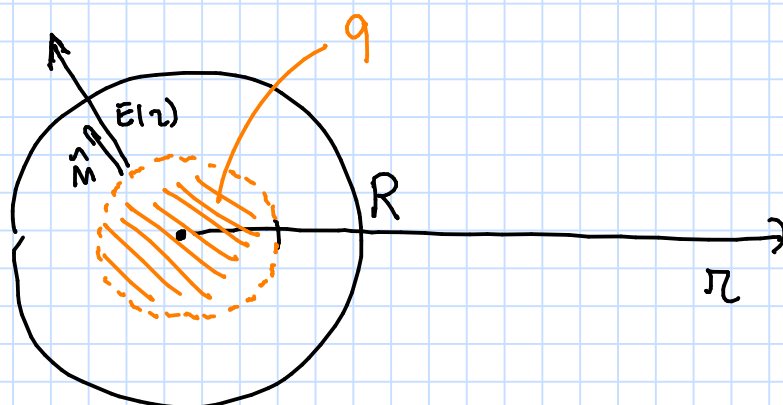
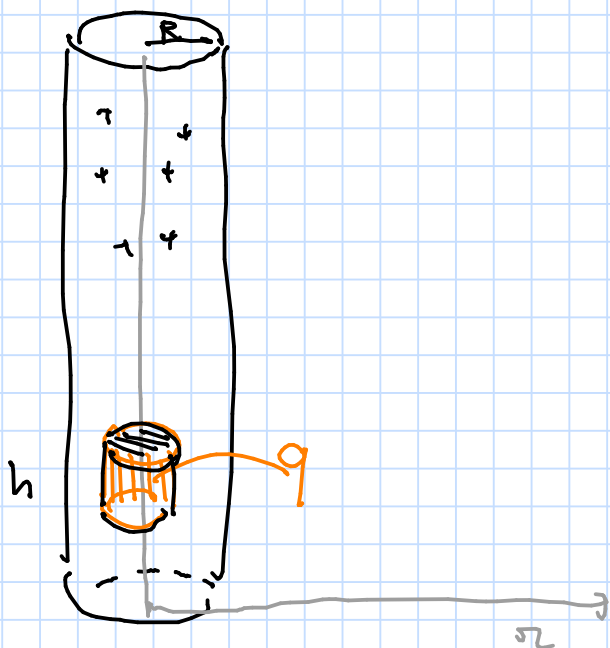
$$\vec{E}(r) = \frac{\lambda}{2\pi \epsilon_0 r} \hat{n} \quad \sim \frac{1}{r}$$

(radiale)

↳ tubo uniformemente carico
(cilindro indefinito)

$$E(r) \begin{cases} r < R \\ r > R \end{cases}$$

carica per unità di volume
 ρ



$$r < R$$

$$q = \rho \cdot \text{vol.} \\ = \rho \pi r^2 h$$

$$\oint_{\Sigma} E(r) = \Sigma \cdot E = 2\pi r h E$$

$$\oint_{\Sigma} E = \cancel{2\pi r h} E = \frac{\rho \pi \cancel{r^2 h}}{\epsilon_0} \Rightarrow E(r) = \frac{\rho r}{2\epsilon_0} \quad (r < R)$$

(G)

per $r > R$



$$q = \pi R^2 \cdot h \cdot \rho = h \lambda$$

$$\lambda = \pi R^2 \rho$$

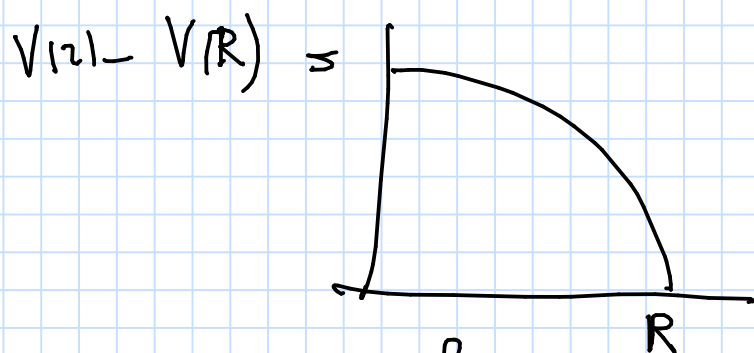
e si riutilizza ragionamento
del filo

$$r > R$$

$$E(r) = \frac{\sigma R^2}{2\epsilon_0 r} = \frac{\lambda}{2\pi\epsilon_0 r}$$

potenziale : $r < R$

$$V(r) - V(R) = \int_r^R E(r) dr = \dots = \frac{\lambda}{4\pi\epsilon_0 R^2} (R^2 - r^2)$$



$$\begin{aligned} V(r_1) - V(r_2) &= \int_{r_1}^{r_2} \vec{E} \cdot d\vec{r} = \frac{\lambda}{2\pi\epsilon_0} [-\ln r_1 - (-\ln r_2)] \\ &= \frac{\lambda}{2\pi\epsilon_0} \ln \frac{r_2}{r_1} \end{aligned}$$

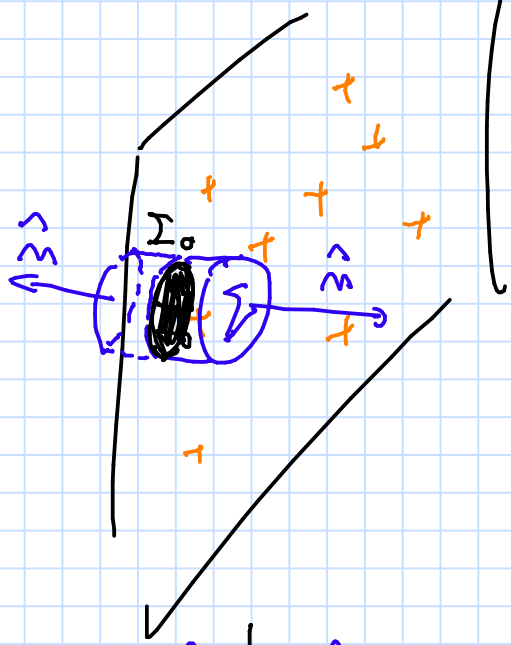
nota: è necessario considerare differenze di potenziale, ... $\ln r$

$$"V(r)" = \frac{\lambda}{2\pi\epsilon_0} [-\ln r]$$

piano uniformemente carico indefinito

carica per unità di superficie σ

$$[\sigma] = \frac{C}{m^2}$$

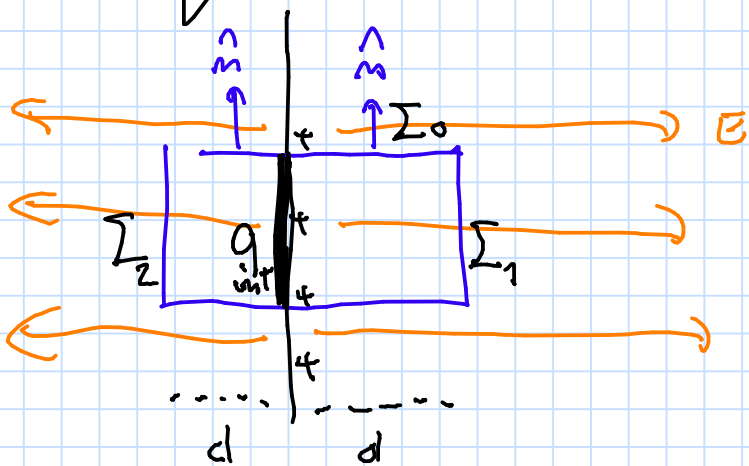


per simmetria

$\vec{E} \perp$ piano

$\vec{E}$ parallelo a dx e dx del piano

sui lati (Σ_0) $\hat{n} \perp \vec{E}$
 $\phi(\Sigma_0) = 0$



$$\phi_E = \Sigma_1 E + \Sigma_2 E$$

$$= \Sigma E \cdot 2$$

$$q_{int} = \Sigma \cdot \sigma$$

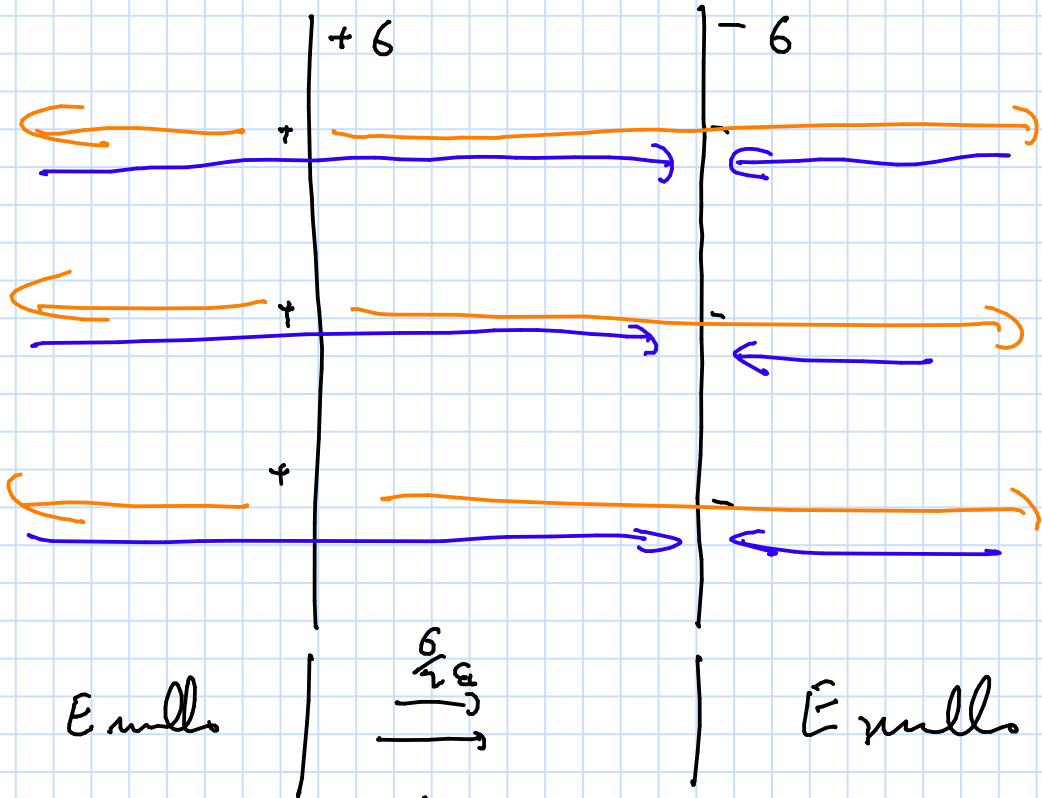
$$\phi_E = 2 E \Sigma \Rightarrow \Sigma \frac{\sigma}{\epsilon_0}$$

$$\Rightarrow E = \frac{\sigma}{2 \epsilon_0} \quad x > 0$$

$$\vec{E} = -\frac{\sigma}{2 \epsilon_0} \hat{x}$$

$$\vec{E} = \frac{\sigma}{2 \epsilon_0} \hat{x}$$





$$\left| \vec{E} \right|_{\frac{6}{2\epsilon_0}} = \left| \vec{E} \right|_6$$

$$\frac{6}{2\epsilon_0}$$

$$\vec{E} = \frac{6}{\epsilon_0}$$

all' interno

esercizio

?

6

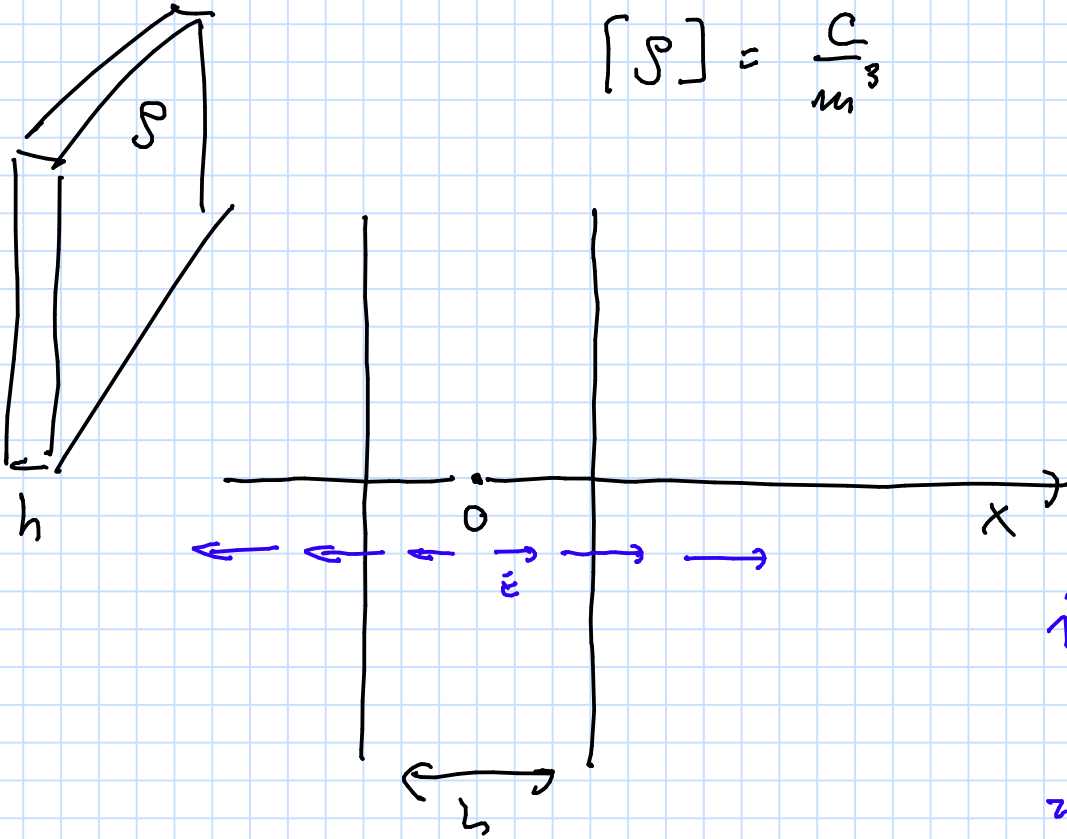
?

6

?

matte uniformemente cariche infinite

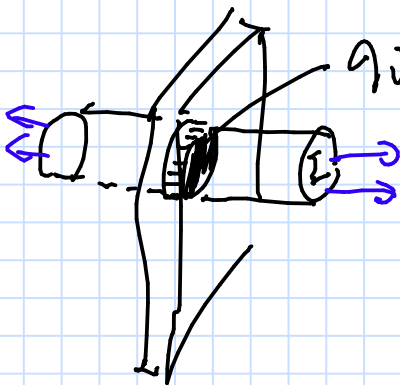
$$[\rho] = \frac{C}{m^3}$$



simmetria

- 1) $+x / -x$
 $E(x) = -E(-x)$
- 2) $\vec{E} // \hat{x}$

$x > \frac{h}{2}$ (esterno)



$$q_{int} = \rho \cdot h \cdot \Sigma$$

$$\Phi_E = 2 \Sigma E = \frac{\rho h \Sigma}{\epsilon_0}$$

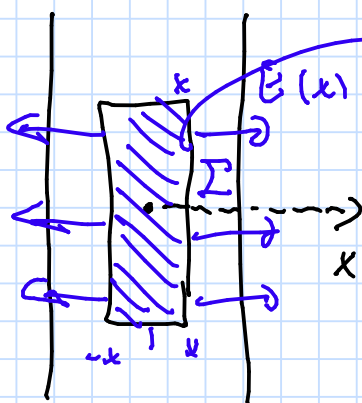
(9)

esterno

$$E = \frac{\rho h}{2 \epsilon_0}$$

$$\sigma = \rho h$$

$x < \frac{h}{2}$ (interno)



$$q_{int} = 2x \cdot \Sigma \cdot \rho$$

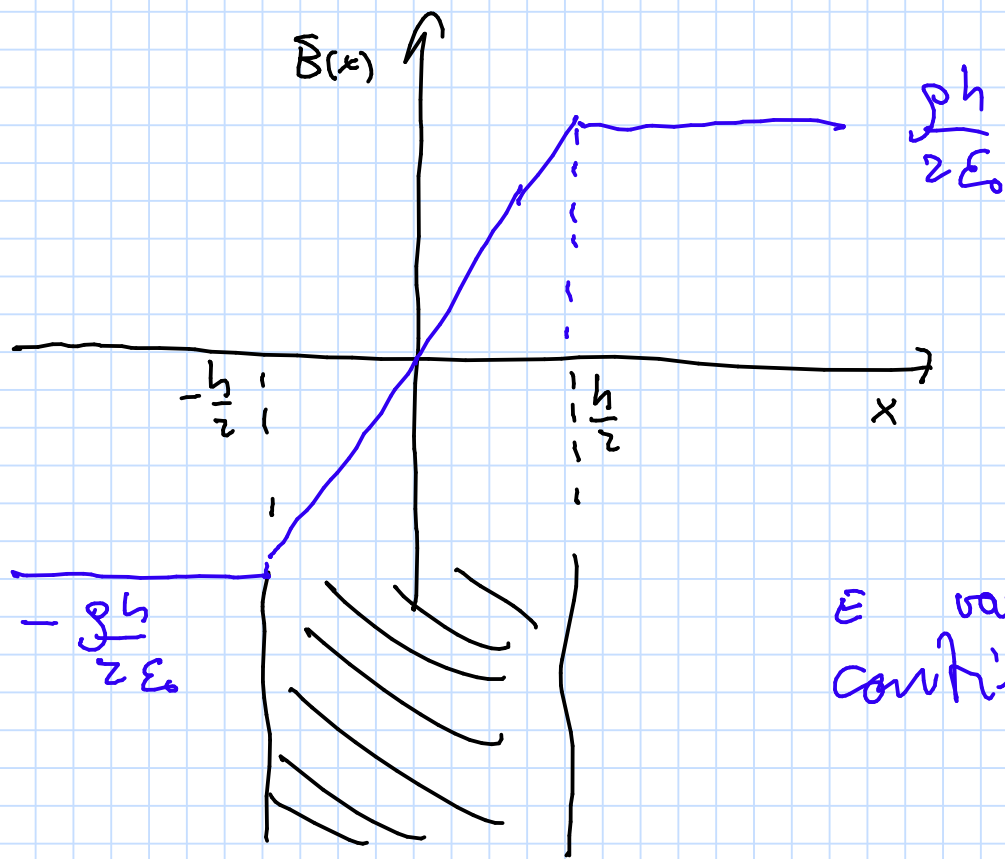
$$\Phi_E = 2 \Sigma E = 2x \Sigma \rho$$

(9)

interno

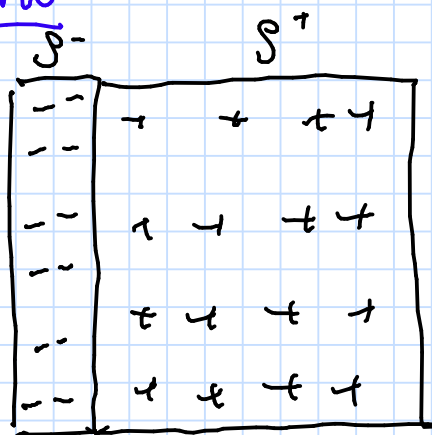
$$E(x) = \frac{x \rho}{\epsilon_0}$$

$$\text{se } x = \frac{h}{2} \Rightarrow E = \frac{\rho h}{2 \epsilon_0}$$



E varia con
continuità

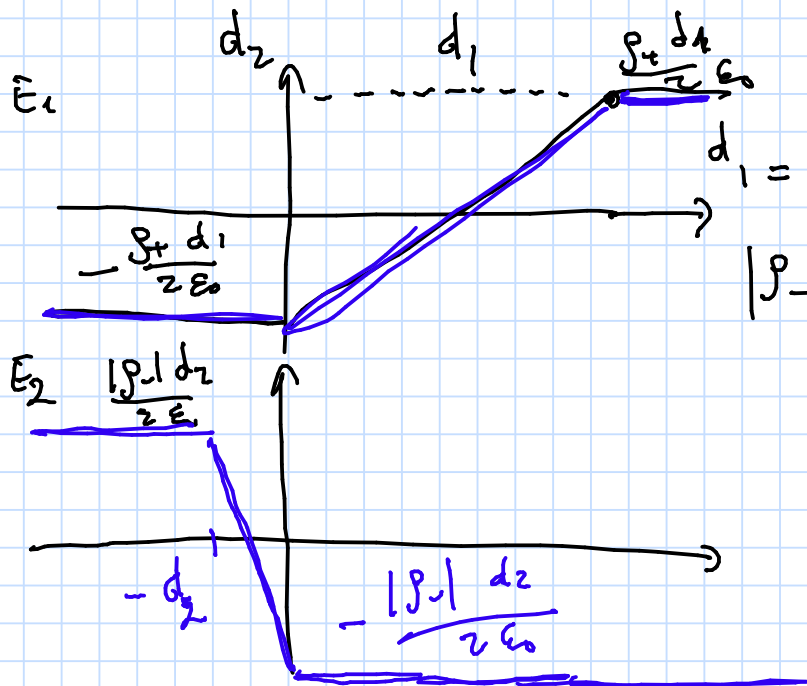
Esercizio



Neutro : $|\rho^+ d_1| = |\rho^- d_2|$
(stessa σ in modulo)

$$\rho^+ = 6 \cdot 10^{11} \frac{C}{m^3} \quad \rho^- = 6 \cdot 10^{17} \frac{C}{m^3}$$

$$= 0.1 \frac{C}{m^3}$$

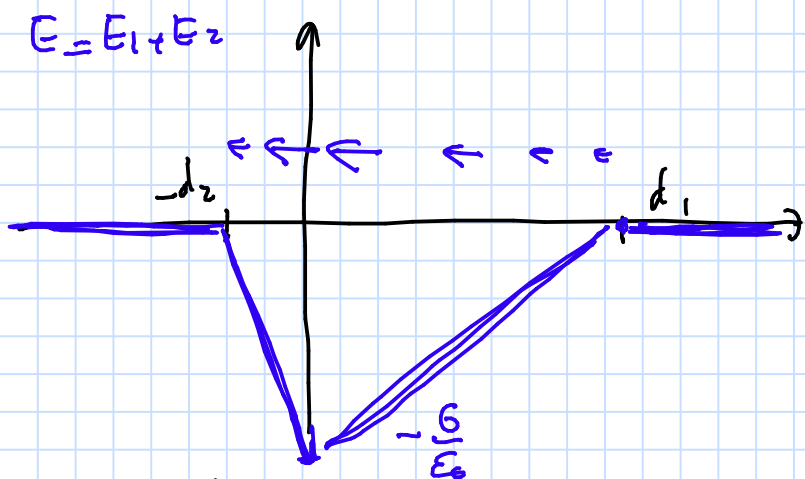


$$d_1 = 50 \mu m \quad d_2 = 10 \mu m$$

$$|\rho^-| = \frac{\rho^+ d_1}{d_2} = 5 \rho^+ = 3 \cdot 10^{18} \frac{C}{m^3}$$

$$\sigma = |\rho^+ d_1| = |\rho^- d_2|$$

$$\sigma = 5 \cdot 10^{-6} \frac{C}{m^2}$$



$$E(x) = \begin{cases} -\frac{\sigma}{\epsilon_0} \left(\frac{x}{d_2} + 1 \right) \\ -\frac{\sigma}{\epsilon_0} \left(1 - \frac{x}{d_1} \right) \end{cases}$$

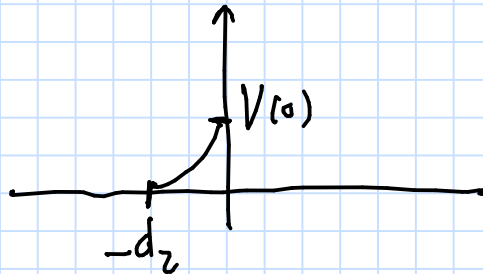


$$-d_2 < x < 0$$

$$\begin{aligned}
 V(x) &= - \int_{-\frac{d_2}{2}}^x E(x') dx' = - \int_{-d_2}^x \left(-\frac{\sigma}{\epsilon_0} \left(1 + \frac{x'}{d_2} \right) \right) dx' \\
 &= \frac{\sigma}{\epsilon_0} \left(x' + \frac{x'^2}{2d_2} \right) \Big|_{-d_2}^x \\
 &= \frac{\sigma}{\epsilon_0} \left(\frac{x^2}{2d_2} + x - \frac{d_2}{2} + d_2 \right)
 \end{aligned}$$

$$V(-d_2) = 0$$

$$V(0) = \frac{\sigma d_2}{2 \epsilon_0}$$



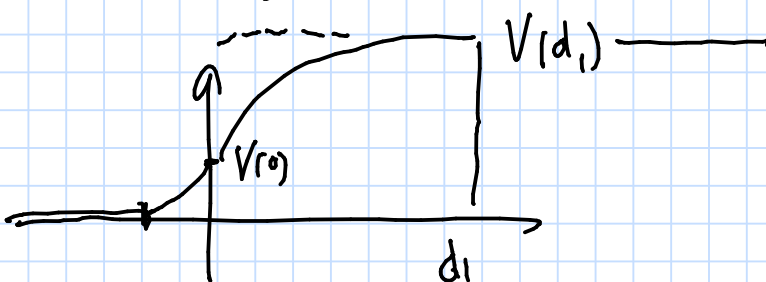
$$0 < x < d_1$$

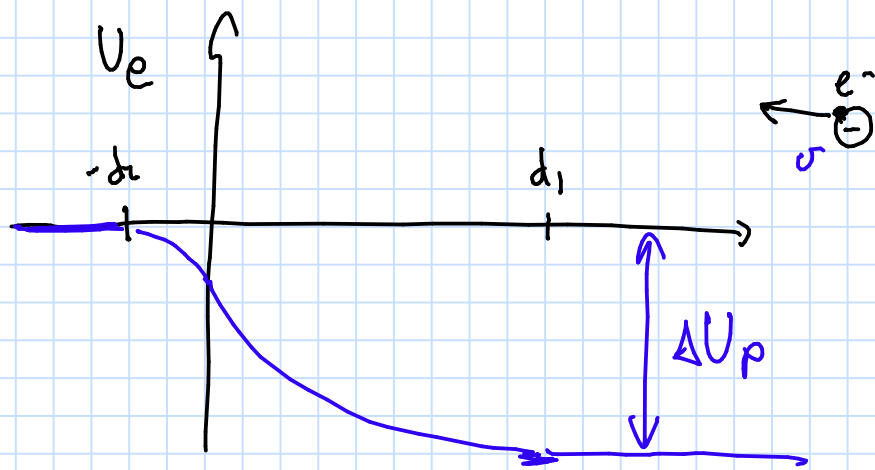
$$\begin{aligned}
 V(x) - V(0) &= - \int_0^x \left(-\frac{\sigma}{\epsilon_0} \left(1 - \frac{x'}{d_1} \right) \right) dx' \\
 &= \frac{\sigma}{\epsilon_0} \left(x' - \frac{x'^2}{2d_1} \right) \Big|_0^x
 \end{aligned}$$

$$V(x) = V(0) + \dots = \frac{\sigma}{\epsilon_0} \left(-\frac{x^2}{2d_1} + x + \frac{d_2}{2} \right)$$

$$V(d_1) = \frac{\sigma}{\epsilon_0} \left(\frac{d_1 + d_2}{2} \right)$$

$$= \frac{5 \cdot 10^{-6}}{8.85 \cdot 10^{-12}} \cdot 30 \cdot 10^{-6} = 16.9 \text{ V}$$





$$U_e = (-e) V$$

$E_{cin} \geq \Delta U_p \Rightarrow e^-$ scavalca barriera

$$\Delta U_p = |-e (V(d_1))| = 16.9 \text{ eV}$$

velocità minima per passare barriera

$$\frac{1}{2} m v^2 = \Delta U_p$$

$$v = \left(\frac{e \sigma}{m_e \epsilon_0} \left(\frac{d_1 + d_2}{2} \right) \right)^{\frac{1}{2}} \dots = \dots \quad \frac{m}{s}$$