$$W = \frac{Q^2}{2C} = \frac{1}{2} C \mathcal{E}^2$$ per un condensatore generico

$S$: sup. armature

$d$: dist. tra "

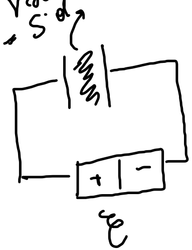
$\sigma$: dens. sup. carica sulle armature

Per condensatore piano: $C = \varepsilon_0 S/d$

$$W = \frac{1}{2}\varepsilon_0 \frac{S}{d} \mathcal{E}^2$$

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

volume $S \cdot d$





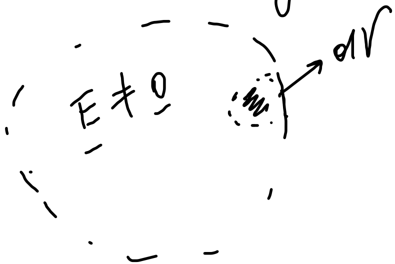
$E$ é uniforme: $\mathcal{E} = \underbrace{E \cdot d} = \frac{\sigma}{\varepsilon_0} d$

$$W = \frac{1}{2}\varepsilon_0 \frac{S}{\cancel{d}} \underbrace{E^2 d^{\cancel{2}}}_{\mathcal{E}^2} = \frac{1}{2}\varepsilon_0 \underbrace{(S \cdot d)}_{\text{volume}} \cdot E^2 = w_E \cdot \text{Volume}$$

$w_E = \frac{1}{2}\varepsilon_0 E^2$ : densitá di energia $\frac{\text{energia}}{\text{volume}}$

$[w_E] = J/m^3$

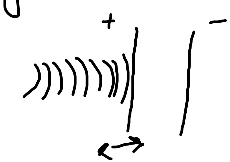
Se $\underline{E}$ è disuniforme




$$dW = \frac{1}{2}\varepsilon_0 E^2 dV$$

$$W = \sum_{\text{volume}} dW = \int_{\text{volume}} \frac{1}{2}\varepsilon_0 E^2 dV$$

Microfono




C

Pongo sul cond. una carica $Q$

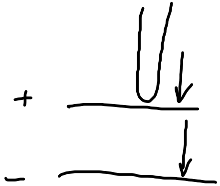
$$C = \varepsilon_0 \frac{S}{d}$$

$$C = \frac{Q}{\Delta V} \; ; \; \Delta V = \frac{Q}{C}$$

$d \updownarrow \Rightarrow C \updownarrow$

$Q$ cost

$\Delta V \updownarrow$



$Q$ $\quad d \downarrow \quad C = \varepsilon_0 \frac{S}{d} \quad C \uparrow$

$\Delta V = \frac{Q}{C} \quad \Delta V \downarrow$

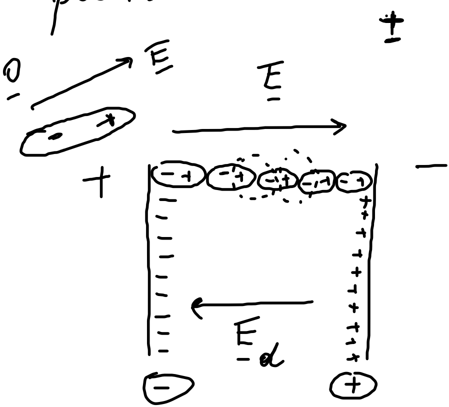
## Condensatori con dielettrici

Defibrillatore

$+Q$

1) Dielettrici non polari
2) " polari

$\underline{E} \neq 0$



Con dielettrico

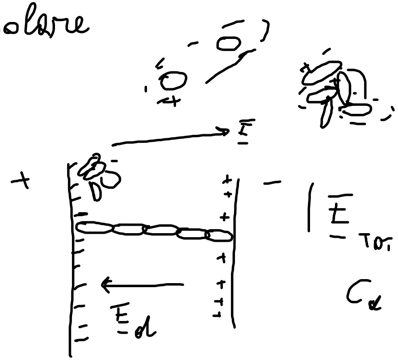
$$|\underline{E}_{TOT}| = |\underline{E} + \underline{E}_d| < |\underline{E}|$$

$$\Rightarrow \Delta V_d = |\underline{E}_{TOT}| \cdot d < \Delta V$$

$$C = \frac{Q}{\Delta V} \qquad C_{vuoto} = \frac{Q}{\Delta V_{vuoto}} \qquad C_d = \frac{Q}{\Delta V_d}$$

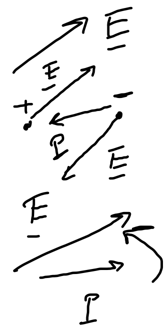
$$C_d > C_{vuoto} \qquad C_d = \underbrace{K}_{\text{costante dielettrica}} \cdot C_{vuoto}$$

Dielettrico polare




$|E_{tot}| < |E|$

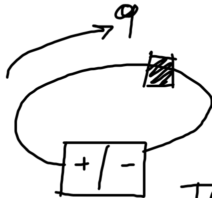
$C_d > C_{vuoto}$




$F = +qE$
$F = -qE$
} uguali e contrarie

Rotazione di $P$
parallelarsi a $E$

# Correnti elettriche




$$I_{media} = \frac{\Delta Q}{\Delta t} \qquad [I] = \frac{C}{s} = \text{Ampere} \quad A$$

$$I(t) = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t}$$

# Modello microscopico delle correnti

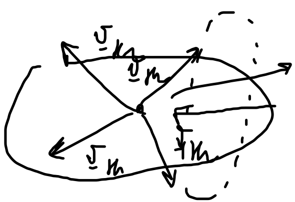
Conduttore

particelle libere

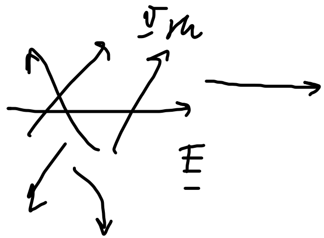
$$\langle E \rangle = \frac{3}{2} k_B T = \frac{1}{2} m v_{th}^2 \qquad \text{Se } T \neq 0$$

$$\Rightarrow v_{th} = \left(\frac{3 k_B T}{m}\right)^{\frac{1}{2}}$$

T in Kelvin $T \sim 300\,K$




$$I = 0$$

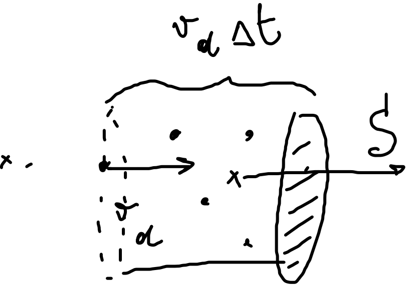



con $\underline{E} \neq 0$
c'è un moto ordinato
lungo il $\underline{E}$
$\underline{E}$ uniforme

$\underline{F} = q\underline{E} \Rightarrow a = q\underline{E}/m$

+ collisioni con il reticolo

: $\underline{v}_d$ velocità di deriva




$\Delta t$ : Quanta carica attraversa
la sezione $S$ in $\Delta t$?
Carica in un cilindro di dimensioni
$S \times (v_d \Delta t)$

n: densità dei portatori

$$\frac{\text{\# portatori liberi}}{m^3}$$

$$\#\text{ portatori in } (S \cdot v_d \Delta t) = n \cdot S \cdot v_d \cdot \Delta t$$

$$\Delta Q = \text{Carica} = q \cdot (\#\text{ portatori}) = q\, n\, S\, v_d\, \Delta t$$

q: carica del portatore (es. elettrone)

$$I = \frac{\Delta Q}{\Delta t} = \overbrace{q n v_d}^{j} \cdot \underbrace{S}$$

$j$ densità sup. di corrente

$j = q n v_d$

$$[j] = \frac{A}{m^2}$$

es 27.1 Filo di rame $S = 3.31 \cdot 10^{-6}\, m^2$

$I = 10\ A$

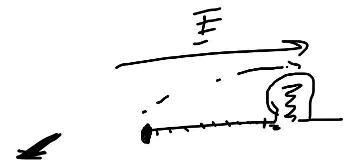
$I = j \cdot S$

$\rho_{rame} = 8.92\ g/cm^3$

1 elettrone / atomo

$n$ ? $v_d$ ?

$$\rho = \frac{massa}{volume} = \frac{(massa\ molare)\cdot(\#\ moli)}{volume}$$




$$\frac{\#\,moli}{volume} = \frac{\rho}{massa\ molare}$$

$$\frac{\#\ particelle}{volume} = N_A \cdot \frac{\#\,moli}{volume} = \frac{N_A\cdot\rho}{massa\ molare} = \frac{6\cdot 10^{23}\ part/\cancel{mol}\cdot 8.92\ \cancel{g}/cm^3}{63.5\ \cancel{g}/\cancel{mol}} \simeq 8.5\cdot 10^{22}\ \frac{part}{cm^3}$$

$$\frac{\#\ portatori}{volume} = \underbrace{\left(\frac{\#\ port.}{particella}\right)}\cdot\left(\frac{\#\ particelle}{volume}\right) \simeq 8.5\cdot 10^{22}\ part/cm^3$$

$q \simeq 1.6\cdot 10^{-19}\ C$

$$I = S\cdot q v_d\cdot n \Rightarrow v_d = \frac{I}{S\cdot q\cdot n} \quad 1 \simeq 0.22\ mm/s$$

$v_{th} \simeq 10^5\ m/s$