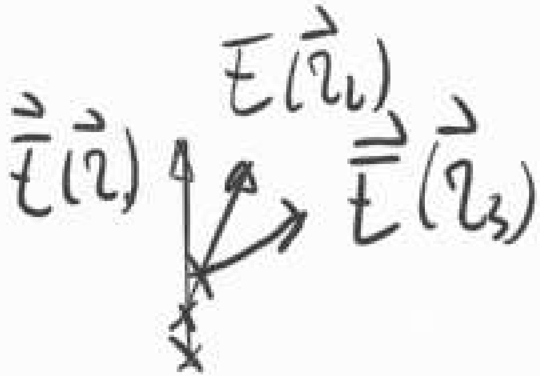
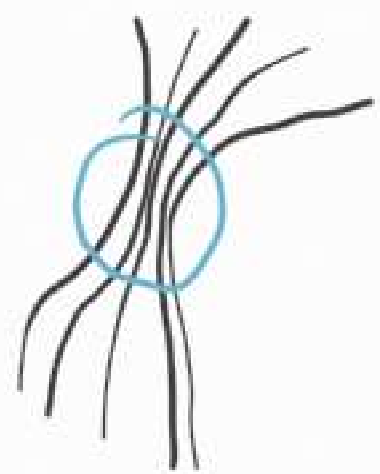
$$\vec{E} = \frac{q}{4\pi\varepsilon_0}\frac{\hat{r}}{r^2}$$



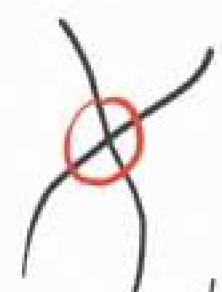
LINEE DI CAMPO (FORZA)

1) // AL CAMPO, STESSA DIREZIONE E VERSO DI $\vec{E}$

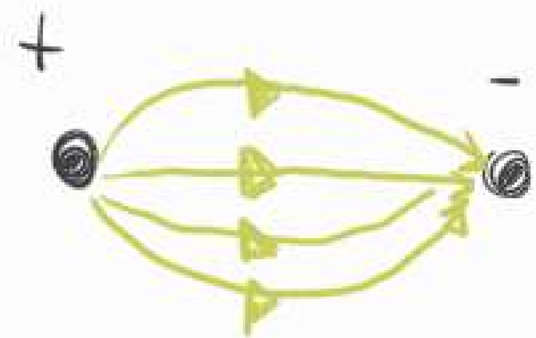
2) LINEE DENSE → CAMPO FORTE



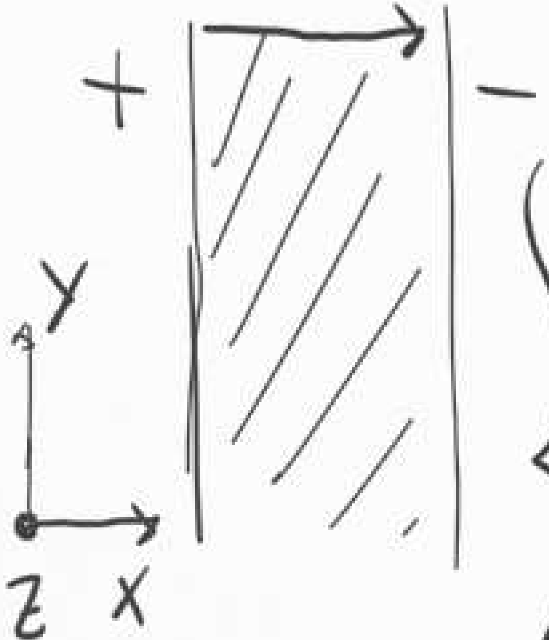
3) LINEE NON SI INCROCIANO



4)



$$\vec{F} = q_0 \vec{E} = m\vec{a} \Rightarrow \vec{a} = \frac{q_0 \vec{E}}{m}$$



$$(x_0, y_0, z_0) = \vec{r}_0 \,, \qquad \vec{v}_0 = (v_{0x}, v_{0y}, v_{0z})$$

$$\begin{cases} \vec{a} = (a_x, 0, 0) \,, \quad a_x = \dfrac{qE}{m} \\ v_x(t) = v_{0x} + a_x t \\ x(t) = x_0 + v_{0x} t + \dfrac{1}{2} a_x t^2 \end{cases}$$

$$\begin{cases} a_y = 0 \\ v_y(t) = v_{0y} \\ y(t) = y_0 + v_{0y} t \end{cases}$$

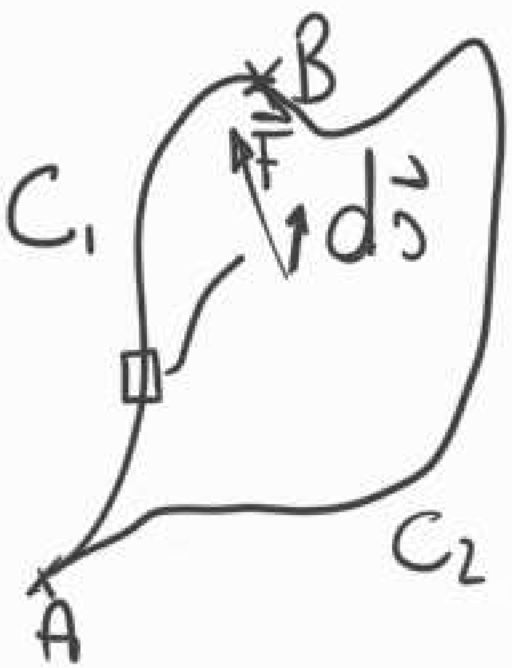
$$U_K = \frac{1}{2} m v^2 \,, \quad \Delta U_K(t) = U_K(t) - U_K(0) =$$

$$= \frac{1}{2} m \left(v_x^2(t) - \underline{\underline{v_x^2(0)}} \right) = \frac{1}{2} m \left(\cancel{v_{0x}^2} + a_x^2 t^2 + 2 v_{0x} a_x t - \cancel{v_{0x}^2} \right) =$$

$$= \frac{1}{2} m a_x \left(a_x t^2 + 2 v_{0x} t \right) = m a_x \left(\frac{1}{2} a_x t^2 + v_{0x} t \right) =$$

$$= m a_x \underline{\left(x(t) - x_0 \right)} = \underline{F \Delta s(t)} = \boxed{W}$$

LAVORO



$$dW = \vec{F} \cdot d\vec{s} \Rightarrow W = \int_{C_1} \vec{F} \cdot d\vec{s} \neq \int_{C_2} \vec{F} \cdot d\vec{s}$$

CONSERVATIVA:

$$\int_{C_1} \vec{F} \cdot d\vec{s} = \int_{C_2} \vec{F} \cdot d\vec{s} = \int_A^B \vec{F} \cdot d\vec{s}$$

$$\int_{C_1+C_2} \vec{F} \cdot d\vec{s} = \int_{C_1} \vec{F} \cdot d\vec{s} + \int_{C_2} \vec{F}\, d\vec{s} = \int_A^B \vec{F} \cdot d\vec{s} + \int_B^A \vec{F}\, d\vec{s} = \int_A^B \vec{F}\, d\vec{s} -$$

$$- \int_A^B \vec{F} \cdot d\vec{s} = 0 = \oint \vec{F} \cdot d\vec{s}$$

$$W = \int_A^B \vec{F}\cdot d\vec{s} = \underline{q_0} \boxed{\int_A^B \vec{E}\cdot d\vec{s}} \longrightarrow \vec{E} \text{ È CONSERVATIVO}$$

$$\oint_C \vec{E}\cdot d\vec{s} = 0$$

$$\int_A^B \vec{E}\cdot d\vec{s} = V(A) - V(B) = -\left(V(B) - V(A)\right) \equiv -\Delta V$$

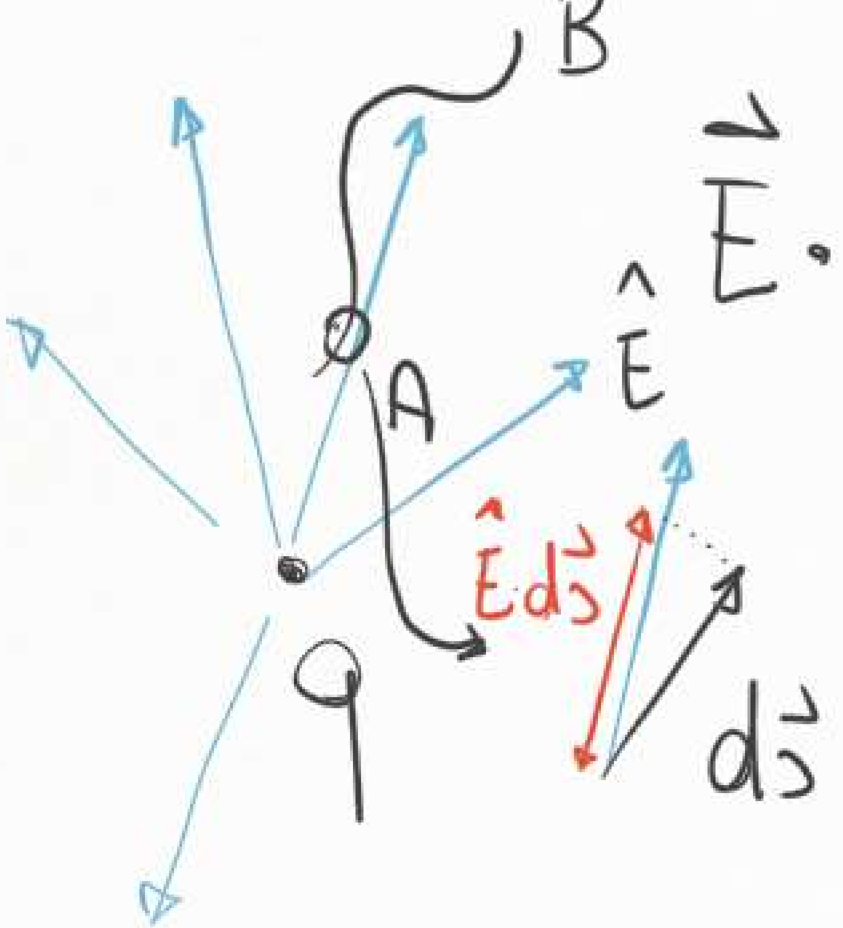
DIFFERENZA DI POTENZIALE

$$\boxed{W = -q_0 \Delta V = -\Delta U_e} = \Delta U_K \Rightarrow$$

$$\underbrace{\Delta U_e + \Delta U_K}_{} = 0 \qquad \hookrightarrow \; q_0 \Delta V = \Delta U_e$$

$$\int_A^B \vec{E}\cdot d\vec{l} = -\Delta V_{AB}, \quad [W] = [q][\Delta V] \Rightarrow$$

$$[\Delta V] = \frac{[W]}{[q]} = \boxed{\frac{J}{C}} = \boxed{V}$$



$$\vec{E}\cdot d\vec{l} = E\hat{E}\cdot d\vec{l} = E\,dr = \frac{q}{4\pi\varepsilon_0}\frac{dr}{r^2}$$

$$\Downarrow$$

$$\int_A^B \vec{E}\cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0}\int_A^B \frac{dr}{r^2} = \frac{q}{4\pi\varepsilon_0}\int_{r_A}^{r_B} \frac{dr}{r^2} =$$

$$= \frac{q}{4\pi\varepsilon_0}\left(-\frac{1}{r}\right)_{r_A}^{r_B} = -\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_B}-\frac{1}{r_A}\right) = -\left(V(B)-V(A)\right)$$

$$\boxed{V(r) = \frac{q}{4\pi\varepsilon_0}\frac{1}{r} + C} \Rightarrow \int f(x)\,dx = F(x) + C$$

$$C = 0 \Rightarrow V(r) \xrightarrow[r\to\infty]{} 0$$

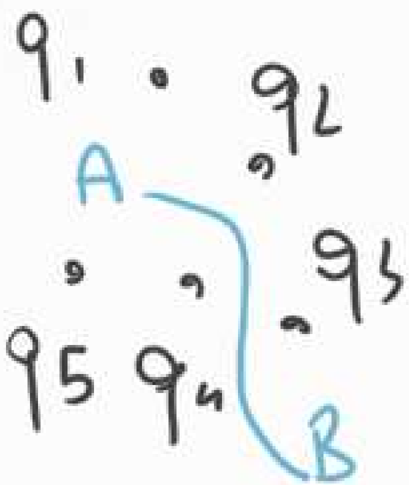
$$\boxed{V \neq \Delta V}$$

CAMPO SCALARE

$[\underline{\text{NUMERO}}] = V$

$$\boxed{V(r) = \frac{q}{4\pi\varepsilon_0}\frac{1}{r}}$$

CARICA PUNTIFORME



$$\vec{E} = \sum_i \vec{E}_i \Rightarrow -\int_A^B \vec{E}\cdot d\vec{s} = -\int_A^B \sum_i \vec{E}_i \cdot d\vec{s} =$$

$$= -\sum_i \int_A^B \vec{E}_i \cdot d\vec{s} = \sum_i \underbrace{\left(-\int_A^B \vec{E}_i \cdot d\vec{s}\right)}_{} =$$

$$= \sum_i \Delta V_i = \Delta V \Rightarrow$$

$$\sum_i \left(V_i(B) - V_i(A)\right) = V(B) - V(A) \Rightarrow$$

$$\boxed{V(B) = \sum_i V_i(B)}$$

$$V(r) = \sum_i V_i(r) \xrightarrow[\text{CONTINUE}]{\text{DISTRIBUZIONI}} V(r) = \int_\tau dV = \frac{1}{4\pi\varepsilon_0}\int_\tau \frac{dq}{r}$$

$$dq = \rho\, d\tau \Rightarrow \underbrace{V(r) = \iiint \frac{\rho\, d\tau}{r}\frac{1}{4\pi\varepsilon_0}}$$

$$\vec{A} = (x,y,z),\quad \vec{B} = \vec{A} + d\vec{r} = \vec{A} + (dx, dy, dz)$$

$$\boxed{dV} = -\vec{E}\cdot d\vec{r} = -E_x\,dx - E_y\,dy - E_z\,dz \leftarrow$$

$$dV = \frac{\partial V}{\partial x}dx + \frac{\partial V}{\partial y}dy + \frac{\partial V}{\partial z}dz \leftarrow$$

$$E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$$

$$\vec{E} = -\left(\frac{\partial V}{\partial x}, \frac{\partial V}{\partial y}, \frac{\partial V}{\partial z}\right) = -\vec{\nabla} V \qquad \boxed{\vec{\nabla} \times \vec{E} = \partial_t \vec{E}}$$

$$\vec{\nabla} = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$$

STOKES

$$\oint_{C} \vec{E} \cdot d\vec{s} = \int_{\Sigma} \boxed{\vec{\nabla}} \times \vec{E} \; \hat{n} \, d\Sigma = 0 \iff \boxed{\vec{\nabla} \times \vec{E} = 0}$$