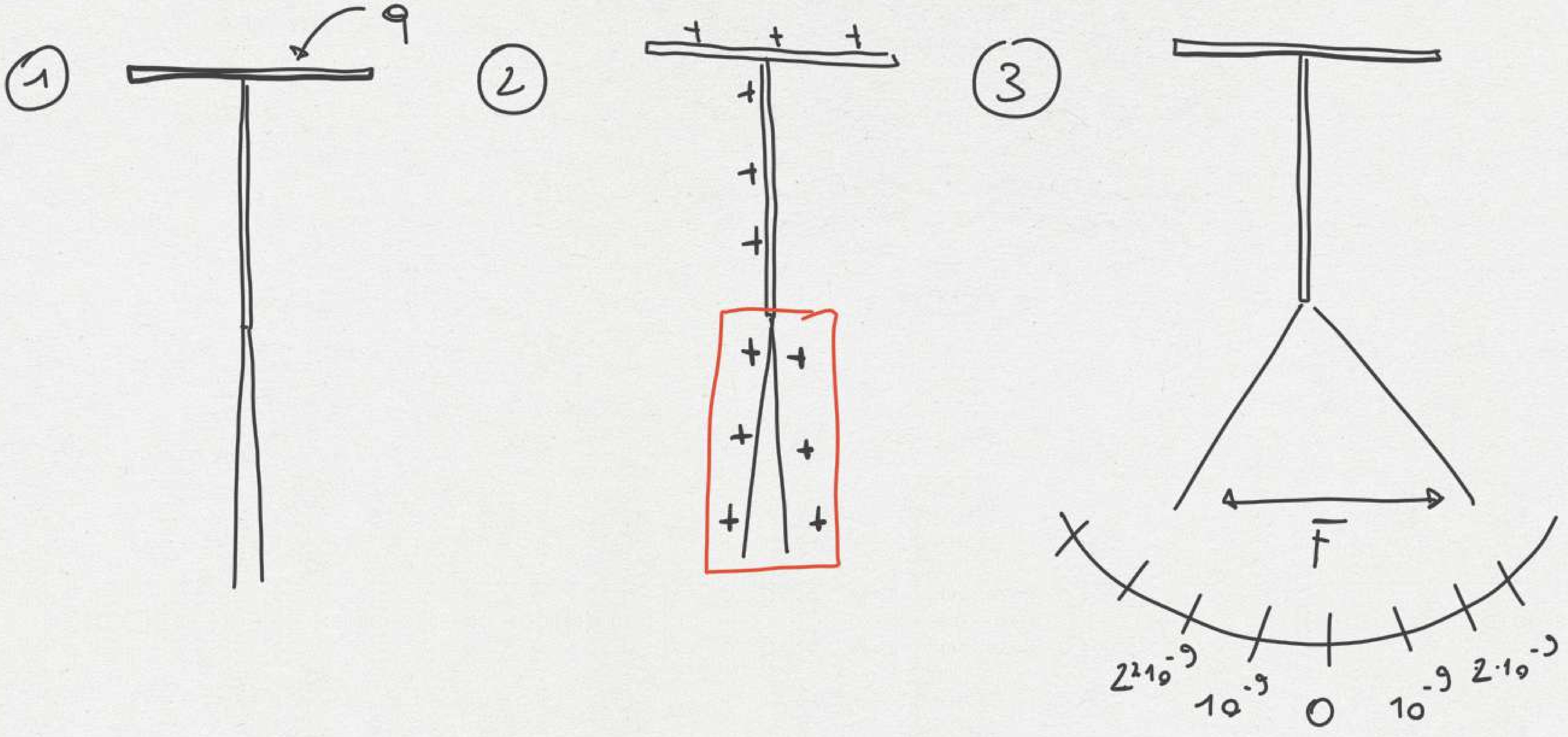
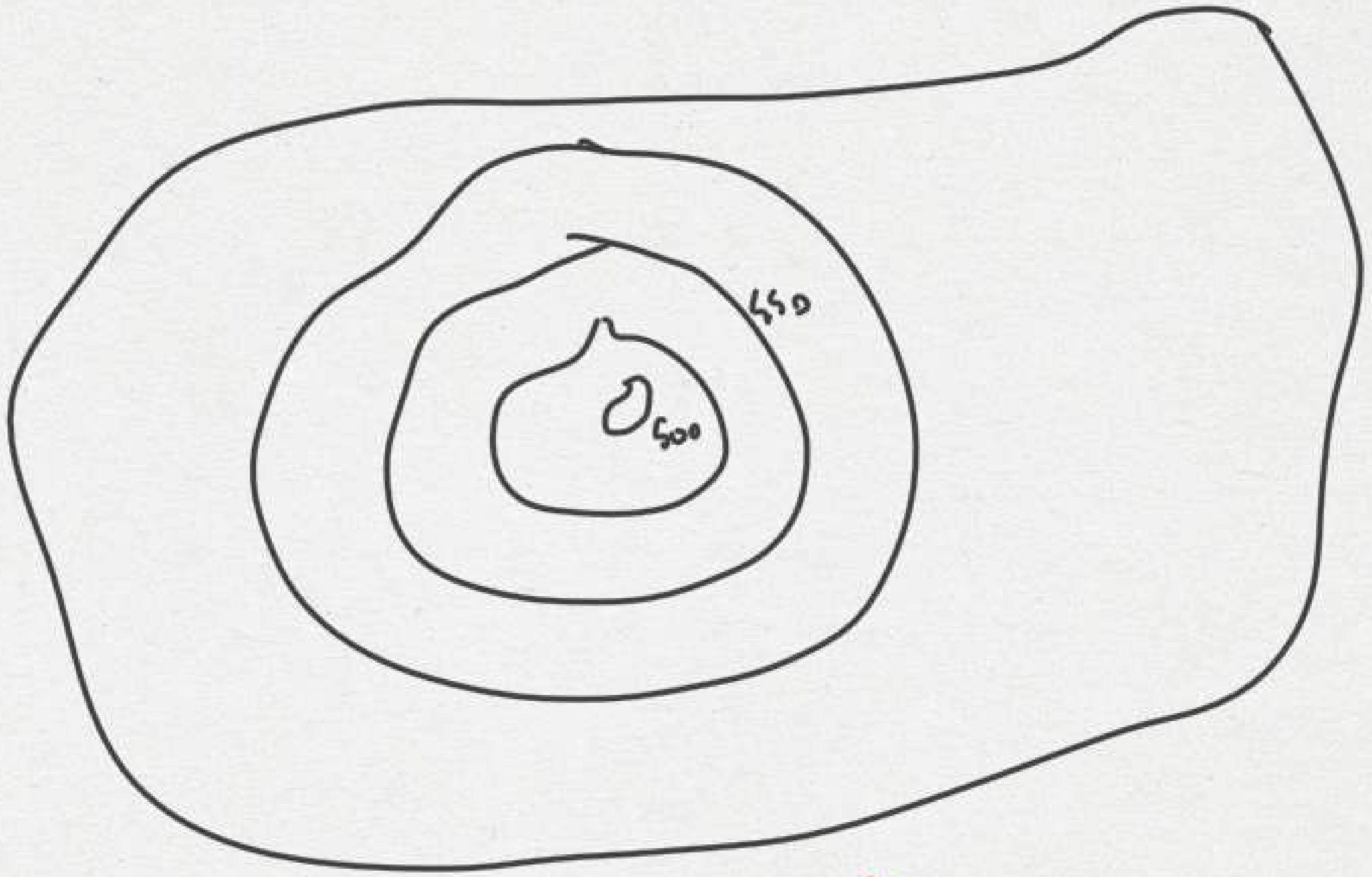
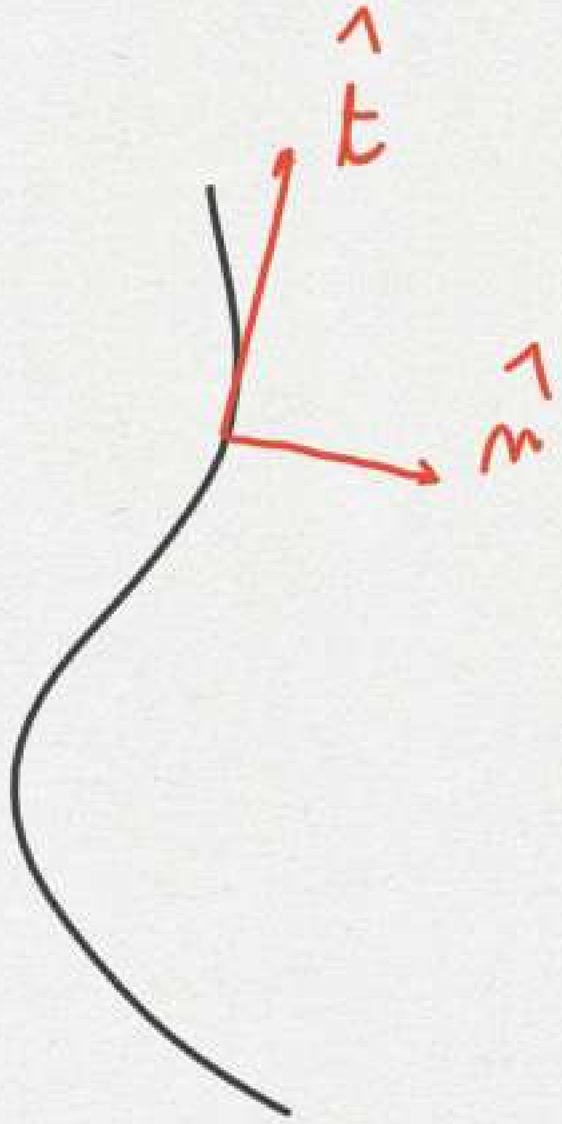
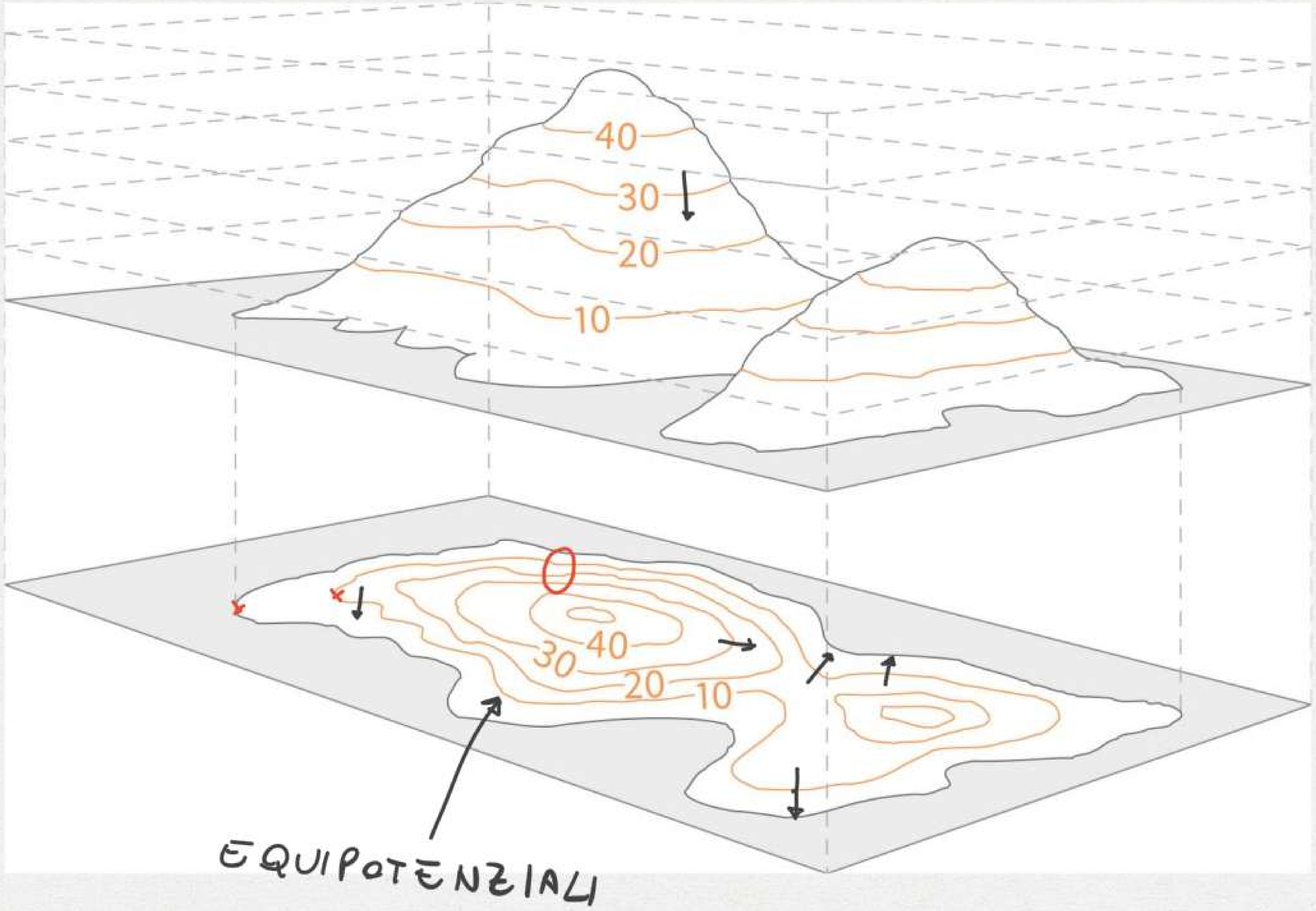

1
q
2
3
F
2·10^-9
10^-9
0
10^-9
2·10^-9

$z = f(x, y)$

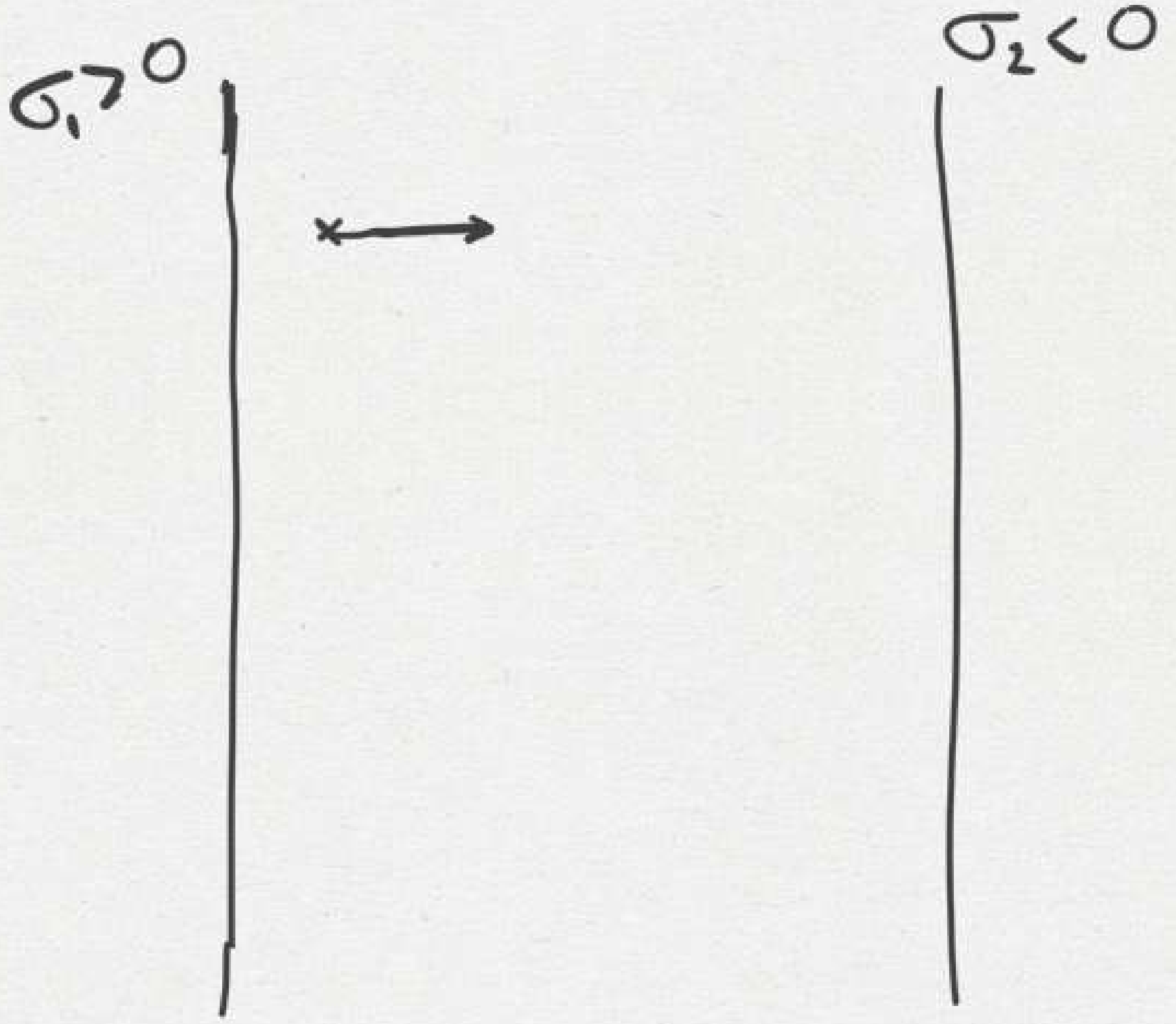






$$U = U_k + U_e = \text{cost}$$

$$\begin{cases} U_k = \frac{1}{2} m v^2(t) \\ U_e = q_0 V\left(x(t), y(t), z(t)\right) \end{cases}$$



$t = 0$

$U_k = 0$

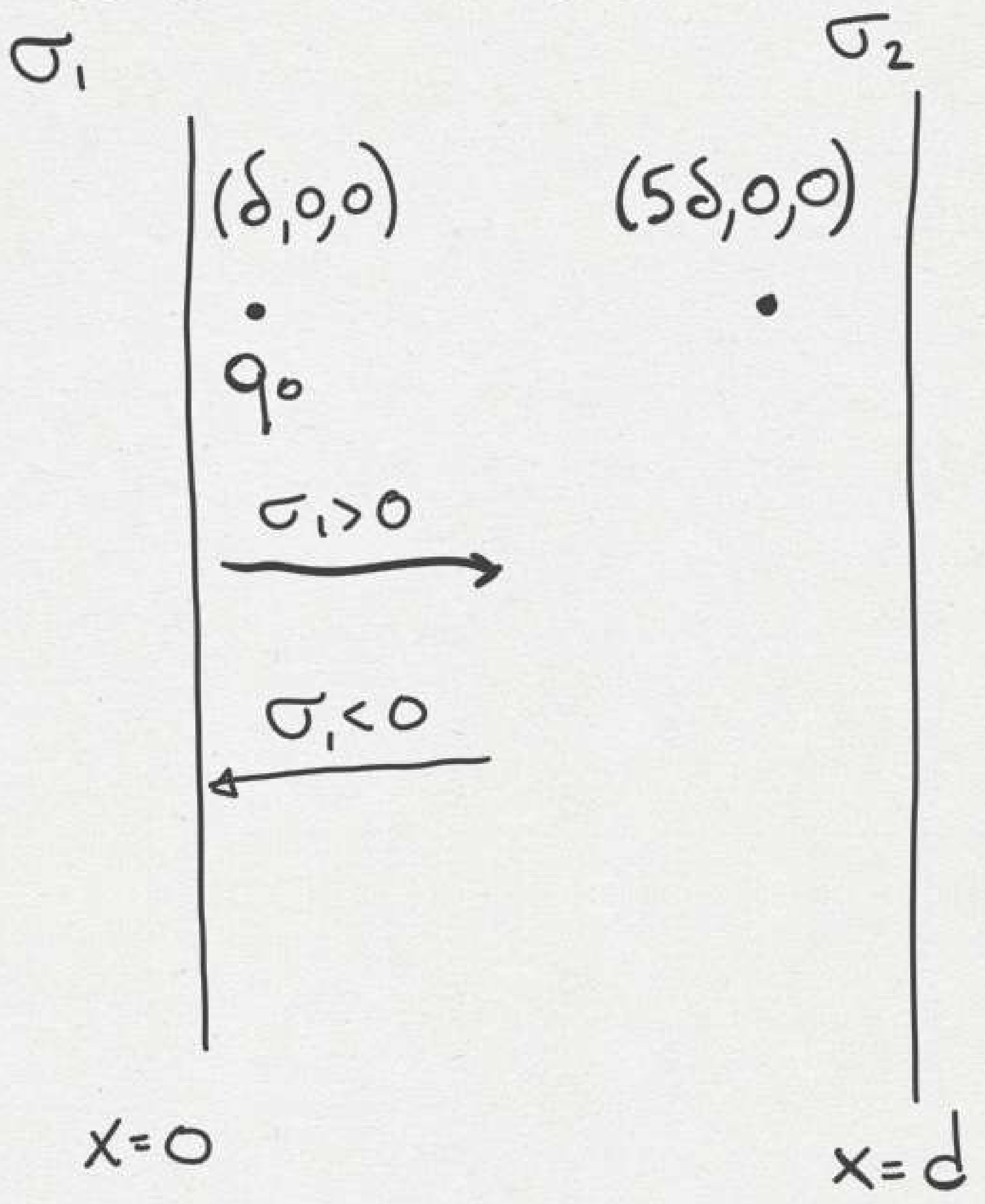
$U_e = A$

$t > 0$

$U_k > 0$

$U_e = A - U_k$

ESERCIZIO 8



$$W = \int_{\delta}^{5\delta} \vec{F}\cdot d\vec{s} = q_0 \int_{\delta}^{5\delta} \vec{E}\cdot d\vec{s}$$

$$\vec{E}_1 = \frac{\sigma_1}{2\varepsilon_0}\hat{x} \quad , \quad \vec{E}_2 = -\frac{\sigma_2}{2\varepsilon_0}\hat{x} \Rightarrow$$

$$\vec{E} = \frac{\sigma_1 - \sigma_2}{2\varepsilon_0}\hat{x} \Rightarrow$$

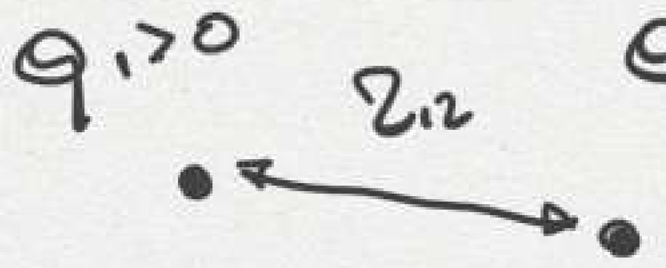
$$W = \frac{q_0(\sigma_1-\sigma_2)}{2\varepsilon_0}\int_{\delta}^{5\delta} dx = \frac{q_0(\sigma_1-\sigma_2)}{2\varepsilon_0} 4\delta > 0$$

se $q_0 > 0$

$\sigma_1 > \sigma_2$

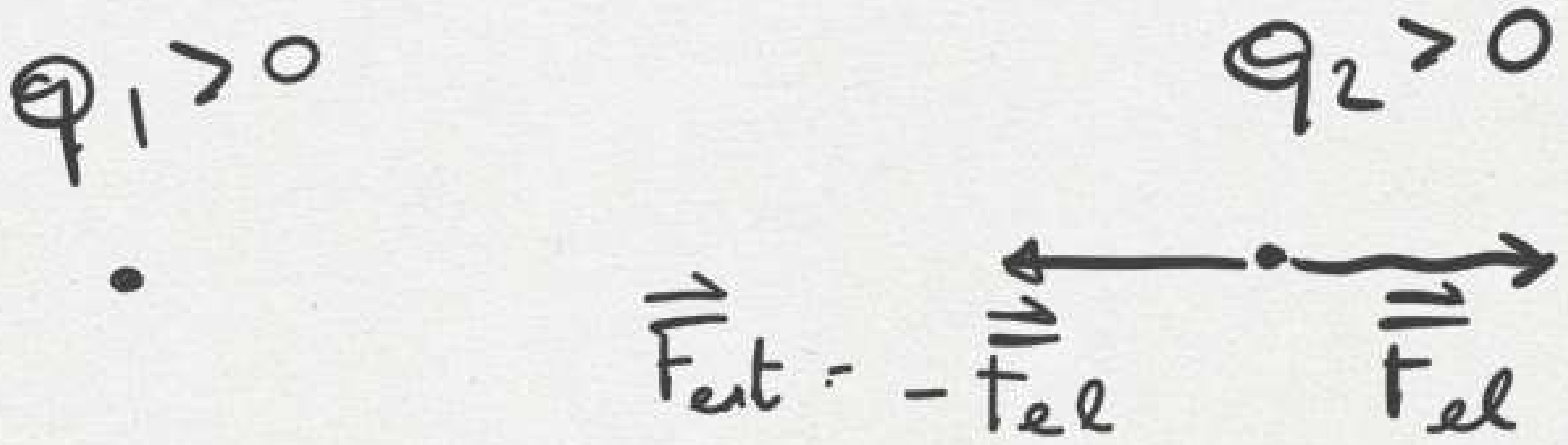
$$\boxed{W = -q_0 \Delta V}$$

①



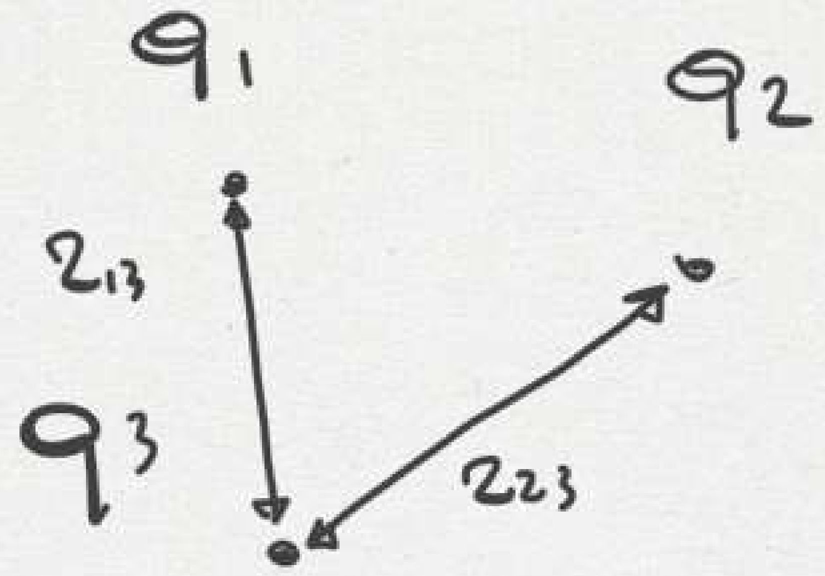
$$\underline{W_{ext}} = \int_{\infty}^{r_{12}} \vec{F}_{ext}\cdot d\vec{s} = -\int_{\infty}^{r_{12}} q_2\vec{E}_1\cdot d\vec{s} = -q_2\int_{\infty}^{r_{12}} \vec{E}_1\cdot d\vec{s} =$$

$$= q_2\left(V(r_{12}) - V(\infty)\right) = q_2\,\Delta V_{12} = \underline{\Delta U_e}$$



$$W_{ext} = -W$$

②



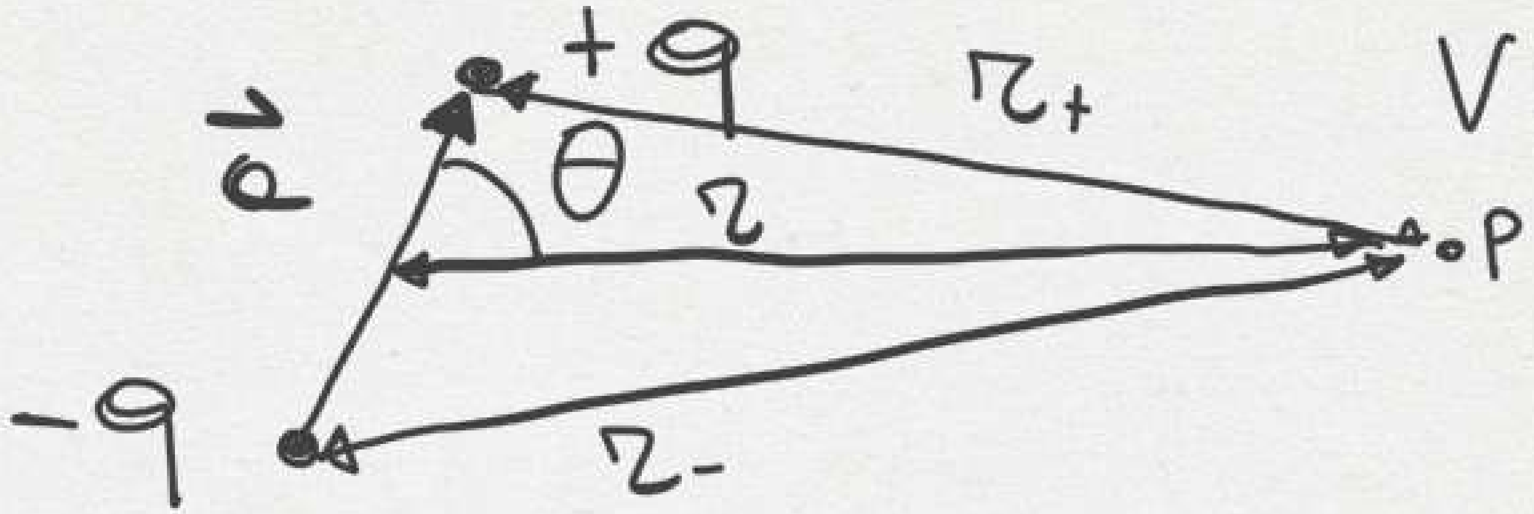
$$W_{ext} = -\int_{\infty}^{r_{13}} q_3\vec{E}_1\cdot d\vec{s} - \int_{\infty}^{r_{23}} q_3\vec{E}_2\cdot d\vec{s} = q_3\,\Delta V_{13} + q_3\,\Delta V_{23} \implies$$

$$\Delta U_{TOT} = q_2\overline{\Delta V_{12}} + q_3\,\Delta V_{13} + q_3\,\Delta V_{23}\,,$$

$$\Delta V_{ij} = \frac{q_i}{4\pi\varepsilon_0}\frac{1}{r_{ij}} \implies \Delta U_{TOT} = \underbrace{\sum_{i=1}^{N}\sum_{j>i}^{N}} \frac{q_i q_j}{4\pi\varepsilon_0 r_{ij}}$$

i	j	coppie
1	1	1-1, 1-2, 1-3
2	2	2-1, 2-2, 2-3
3	3	3-1, 3-2, 3-3

DIPOLO ELETTRICO



$$V(P) = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_+} - \frac{1}{r_-}\right)$$

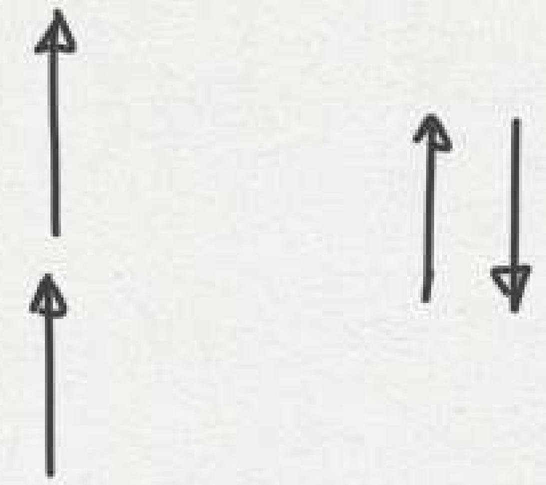
CI METTIAMO NEL LIMITE

$a \ll r$, $\quad \frac{a}{r} \ll 1$

$$V(P) \xrightarrow[a \ll r]{} \frac{q\vec{a}\cdot\hat{r}}{4\pi\varepsilon_0 r^2} = \frac{qa\cos\theta}{4\pi\varepsilon_0 r^2} \equiv \frac{p\cos\theta}{4\pi\varepsilon_0 r^2} = \frac{\vec{p}\cdot\hat{r}}{4\pi\varepsilon_0 r^2}$$ dove $\boxed{\vec{p}} = q\vec{a}$

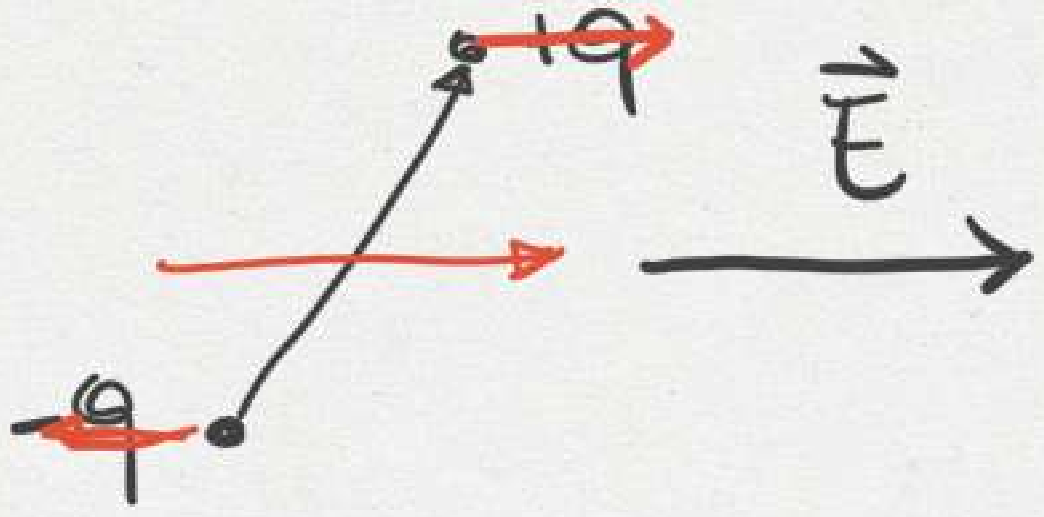
se $\theta = 0$, $\theta = \pi$

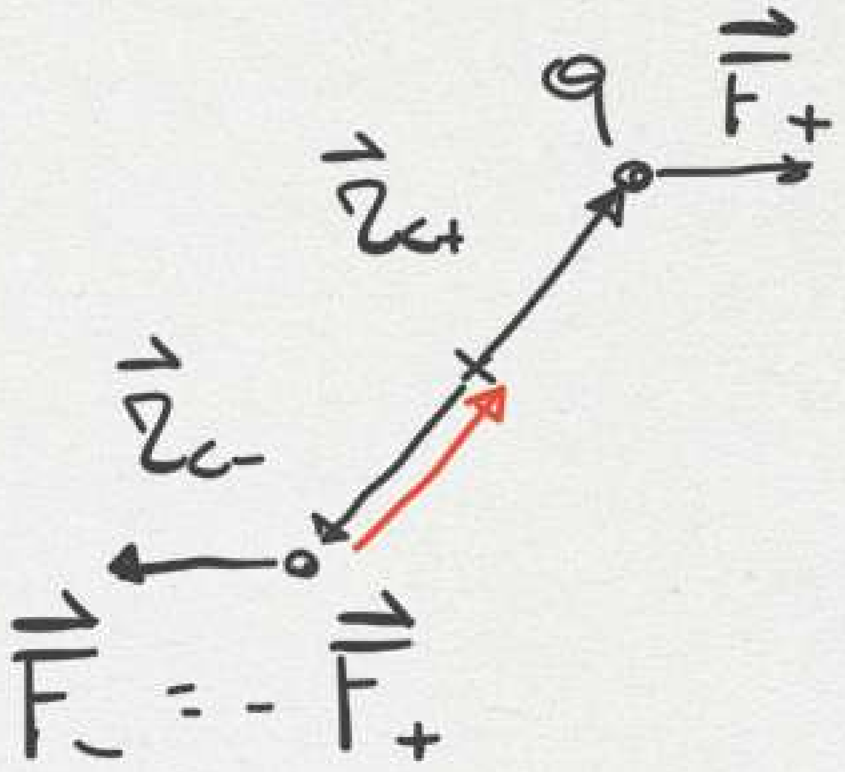
$$\vec{E}(\vec{r}) = \frac{2\vec{p}}{4\pi\varepsilon_0 r^3}$$



se $\theta = \frac{\pi}{2}$, $\theta = \frac{3}{2}\pi$

$$\vec{E}(\vec{r}) = -\frac{\vec{p}}{4\pi\varepsilon_0 r^3}$$





$$\vec{M} = \vec{r}_{c+} \times \vec{F}_+ - \vec{r}_{c-} \times \vec{F}_+ =$$

$$= \left(\vec{r}_{c+} - \vec{r}_{c-}\right) \times \vec{F}_+ = \vec{a} \times \vec{F}_+ = q\vec{a} \times \vec{E} =$$

$$= \underline{\vec{p} \times \vec{E}} \quad , \quad |\vec{M}| = pE\sin\theta$$

$$W = \int_{\theta_0}^{\theta_1} M(\theta)\, d\theta = pE(\cos\theta_1 - \cos\theta_0) = -\Delta U_e = -\left(U(\theta_1) - U(\theta_0)\right) \Rightarrow$$

$$\Rightarrow \quad U_e = -\vec{p} \cdot \vec{E}$$

$$U_T \sim k_B T \ll |pE|$$