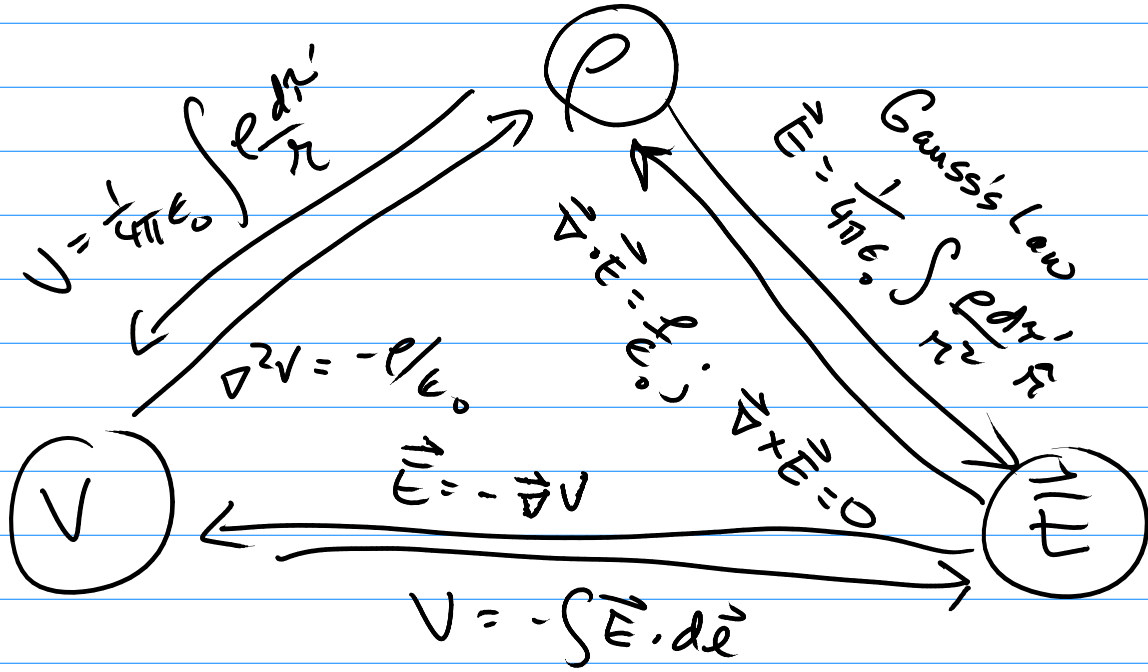
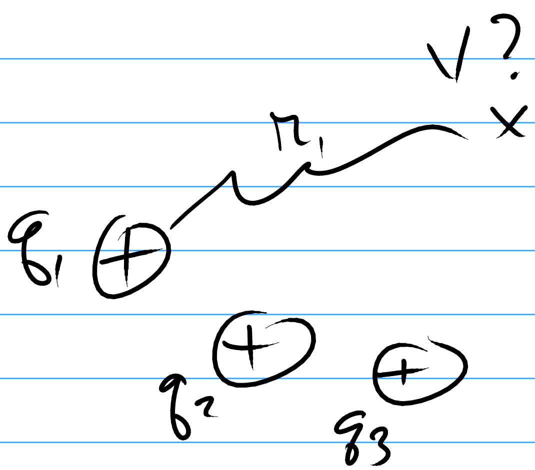


$\vec F = q\vec E$ $\Delta PE = q\,\Delta V$ $W_{n\text{-}c} = \Delta(KE + PE)$

$$\int \vec\nabla\cdot\vec E\,d\tau = \oint \vec E\cdot d\vec a = \frac{q_{enc}}{\epsilon_0} = \int \frac{\rho}{\epsilon_0}\,d\tau$$

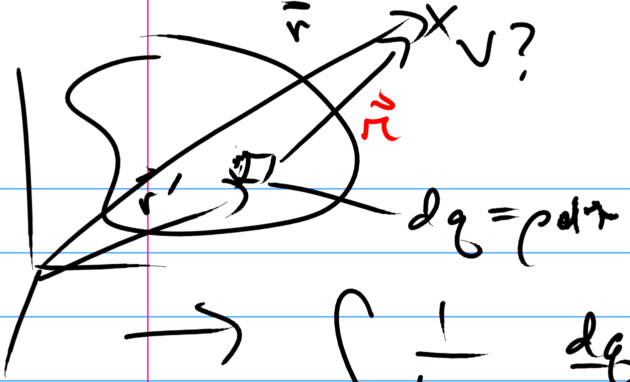
$$E = -\frac{dV}{dx} \qquad V = -\int -\frac{dV}{dx}\,dx = V$$



$$V = -\int \vec E\cdot d\vec l$$

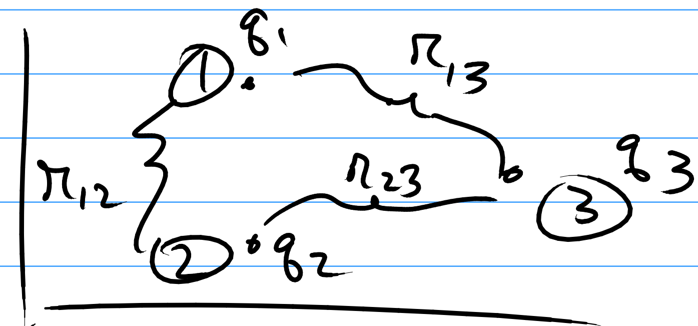
$$\vec E_1 + \vec E_2 + \vec E_3$$

$$= -\int E_1\cdot d\vec l + \int E_2\cdot d\vec l - \int E_3\cdot d\vec l$$



$$= \frac{1}{4\pi\epsilon}\frac{q_1}{r_1} + \frac{1}{4\pi\epsilon_0}\frac{q_2}{r_2} + \frac{1}{4\pi\epsilon_0}\frac{q_3}{r_3}$$

$$\rightarrow \int \frac{1}{4\pi\epsilon_0}\frac{dq}{r} = \frac{1}{4\pi\epsilon_0}\int \frac{\rho(x',y',z')\,dx'\,dy'\,dz'}{|\vec{r}-\vec{r}'|}$$



$$V_1 = \frac{1}{4\pi\epsilon_0}\frac{q_1}{r_{12}}$$

$$PE = q_2 \frac{q_1}{4\pi\epsilon_0 r_{12}}$$

$q_2 \to \infty$ with no q_1 present

$W_{net} = \Delta PE$

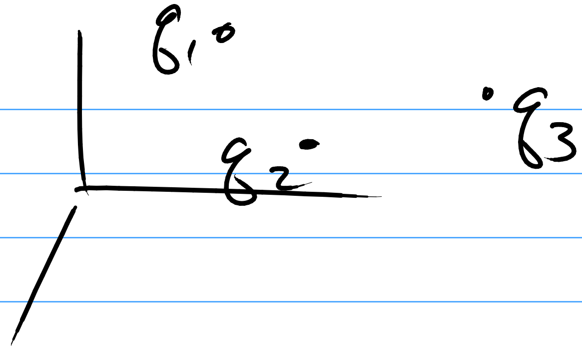
const speed motion $\Rightarrow \Delta KE = 0$

$$\frac{1}{4\pi\epsilon_0} = k$$

$$W = k\left(\frac{q_2 q_1}{r_{12}} + q_3\left(\frac{q_1}{r_{13}} + \frac{q_2}{r_{23}}\right)\right)$$

$$= k\left(\underline{\frac{q_2 q_1}{r_{12}}} + \boxed{\frac{q_3 q_1}{r_{13}}} + \frac{q_3 q_2}{r_{23}}\right)$$

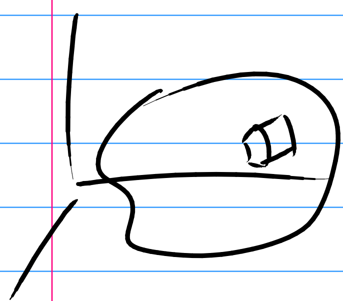
$$= \frac{1}{2}\left\{\frac{q_1}{4\pi\epsilon_0}\left(\underline{\frac{q_2}{r_{12}}} + \boxed{\frac{q_3}{r_{13}}}\right) + \frac{q_2}{4\pi\epsilon_0}\left(\underline{\frac{q_1}{r_{12}}} + \frac{q_3}{r_{23}}\right) + \frac{q_3}{4\pi\epsilon_0}\left(\boxed{\frac{q_1}{r_{13}}} + \frac{q_2}{r_{23}}\right)\right\}$$



$W = qV$

Voltage due to other charges that are in configuration

NOT bring each charge in bringing & summing work done in each charge in



$$W = \frac{1}{2} \sum_i q_i V(P_i) \longrightarrow \frac{1}{2} \int V \, dq$$

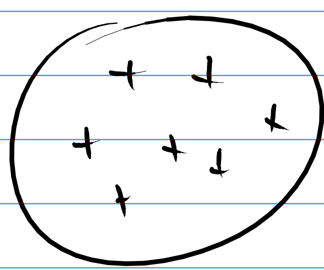
$dq \rightarrow \rho \, d\tau$

Cal W by assembling charges

voltage due to only charge present when I bring in q_i

$$W = \sum_i q_i V \longrightarrow \int V \, dq$$

Ex: sphere uniformly charged



Method $\quad W = \frac{1}{2}\int V\,dq = \frac{1}{2}\int V \rho\, d\tau$

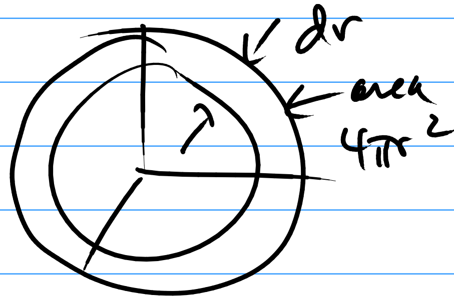
find $\quad V = -\int \vec{E} \cdot d\vec{l}$

need E

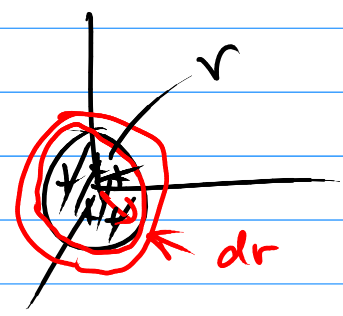
$\vec{E}_{\text{outside}} = k\dfrac{Q}{r^2} \qquad Q = \rho \frac{4}{3}\pi R^3$

$$V = -\int_{\infty}^{R} \vec{E}_{\text{outside}} \cdot dr\,\hat{r} - \int_{R}^{r} \underbrace{\vec{E}_{\text{in}}}_{= \frac{\rho r}{3\epsilon_0}} \cdot dr\,\hat{r} = \underbrace{\frac{3}{6}\frac{\rho R^2}{\epsilon_0} - \frac{\rho r^2}{6\epsilon_0}}_{V}$$

$$W = \frac{1}{2}\int_0^R V \overbrace{4\pi r^2 dr\,\rho}^{dq}$$



$$W = \int_0^R V\,dq \quad dq = \rho\, 4\pi r^2 dr$$



$V = k\,\rho\, \dfrac{\frac{4}{3}\pi r^3}{r}$

$\rho \frac{4}{3}\pi r^3$