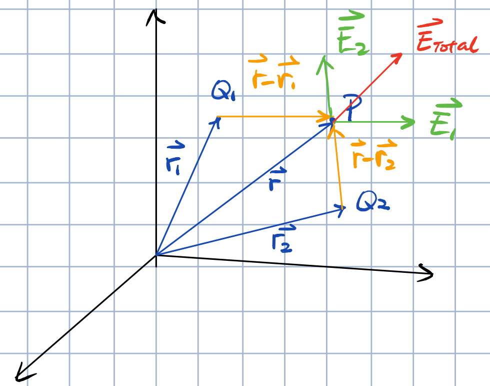
Principles of Superposition



- Consider two charges placed in space.
- What's the E-field produced at P by Q_1 & Q_2?

e.g. $Q_1, Q_2 > 0$

$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{|\vec{r}-\vec{r}_1|^3}(\vec{r}-\vec{r}_1)$$

$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0}\frac{Q_2}{|\vec{r}-\vec{r}_2|^3}(\vec{r}-\vec{r}_2)$$

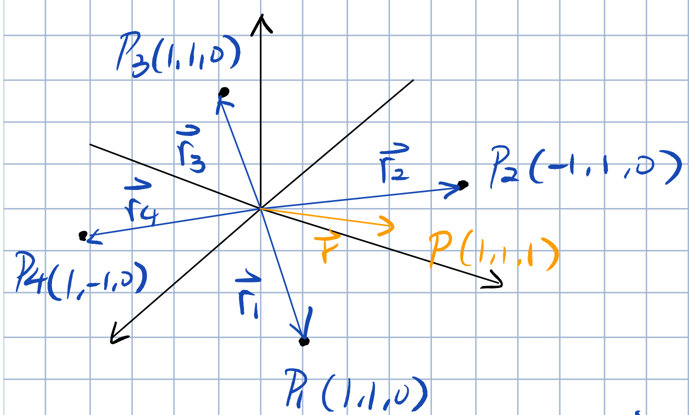
By Principle of Superposition: $\vec{E}_{Total} = \vec{E}_1 + \vec{E}_2$

Extension to N charges ....

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{N}\frac{Q_i}{|\vec{r}-\vec{r}_i|^3}(\vec{r}-\vec{r}_i)$$

Example.

Find $\vec{E}$ at $P(1,1,1)$ caused by four identical 3nC charges $P_1 - P_4$



$\vec{r} = \hat{x} + \hat{y} + \hat{z}$

$\vec{r}_1 = \hat{x} + \hat{y}$	$\vec{R}_1 = \hat{z}$	
$\vec{r}_2 = -\hat{x} + \hat{y}$	$\vec{R}_2 = 2\hat{x} + \hat{z}$	$R_2 = \sqrt{5}$
$\vec{r}_3 = -\hat{x} - \hat{y}$	$\vec{R}_3 = 2\hat{x} + 2\hat{y} + \hat{z}$	$R_3 = \sqrt{9}$
$\vec{r}_4 = \hat{x} - \hat{y}$	$\vec{R}_4 = 2\hat{y} + \hat{z}$	$R_4 = \sqrt{5}$

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{4}\frac{Q_i(\vec{r}-\vec{r}_i)}{|\vec{r}-\vec{r}_i|^3}$$

$$= \frac{3nC}{4\pi\varepsilon_0}\sum_{i=1}^{4}\frac{\vec{R}_i}{R_i^3}$$

$$= 29.96 \cdot \left[\frac{\hat{z}}{1} + \frac{2\hat{x}+\hat{z}}{(\sqrt{5})^3} + \frac{2\hat{x}+2\hat{y}+\hat{z}}{(\sqrt{9})^3} + \frac{2\hat{y}+\hat{z}}{(\sqrt{5})^3}\right]$$

$$= 6.82\,\hat{x} + 6.82\,\hat{y} + 32.8\,\hat{z}\ [V/m]$$

[illegible]