Ladungen $\longleftrightarrow$ Feldern

$$\boxed{\begin{array}{l}\vec{E}(\vec{r},t)\\ \vec{B}(\vec{r},t)\end{array}}$$

$$\vec{r} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

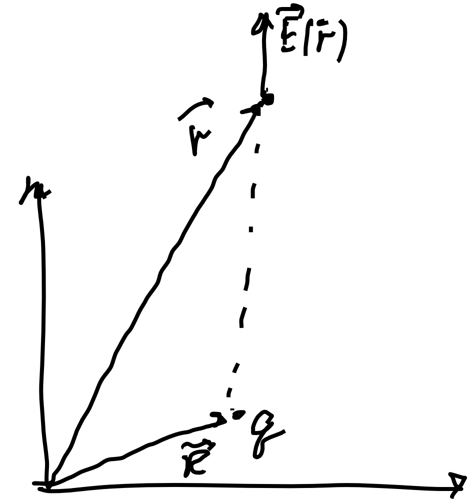
Masse m

$$m\ddot{\vec{r}} = \vec{F}(\vec{r},t) \longrightarrow \vec{r}(t)$$

$$\vec{F} = q\cdot\vec{E}(\vec{r},t) + q\cdot\vec{v}\times\vec{B}(\vec{r},t)$$

q - el. Ladung

$$\vec{E} = \begin{pmatrix} E_x(\vec{R}, t) \\ E_y(\vec{R}, t) \\ E_z(\vec{R}, t) \end{pmatrix}$$



$$E_x = E_x(\vec{R}, t) = E_x(x, y, z, t)$$

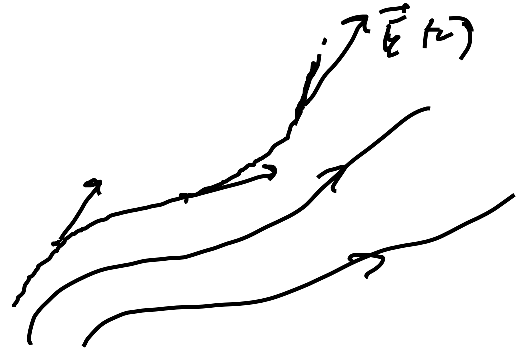
$$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon} \cdot \frac{q(\vec{r} - \vec{R})}{|\vec{r} - \vec{R}|^3}$$

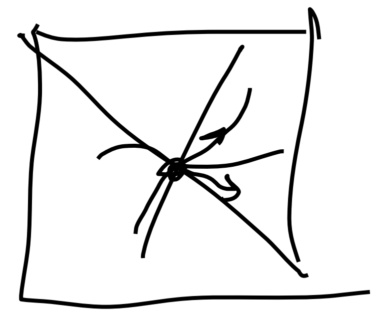
$$\begin{cases} \nabla \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t} \\ \nabla \times \vec{B} = \mu_0 \varepsilon_0 \dfrac{\partial \vec{E}}{\partial t} \end{cases}$$

Vektorfelder

$$\vec{E}(\vec{r}) = \{ E_i(\vec{r}) \}, \quad i = x, y, z$$

$$E_i(x, y, z)$$





Partielle Ableitung

$$f(x, y, z)$$

$$\frac{\partial f}{\partial x} = \lim_{\Delta x \to 0} \frac{f(x+\Delta x, y, z) - f(x, y, z)}{\Delta x}$$

$$\frac{\partial}{\partial x}(x y z) = y z, \qquad \frac{\partial}{\partial y}(x y z) = x z$$

$f(x,y,z)$: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$.

$$\begin{cases} \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \\ \nabla \times \vec{B} = \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \end{cases}$$

$$\nabla = \begin{pmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \\ \frac{\partial}{\partial z} \end{pmatrix}$$

$$\nabla f(x,y,z) = \begin{pmatrix} \partial_x \\ \partial_y \\ \partial_z \end{pmatrix} f(x,y,z) = \begin{pmatrix} \partial_x f \\ \partial_y f \\ \partial_z f \end{pmatrix}$$

$$f = xyz : \quad \nabla f = \begin{pmatrix} yz \\ xz \\ xy \end{pmatrix}$$

KM: $\vec{F}(\vec{r}) = -\nabla V(\vec{r}) = -\operatorname{grad} V(\vec{r})$

Skalarprodukt

$$\vec{a} = \begin{pmatrix} a_x \\ a_y \\ a_z \end{pmatrix}, \qquad \vec{b} = \begin{pmatrix} b_x \\ b_y \\ b_z \end{pmatrix}$$

$$(\vec{a} \cdot \vec{b}) = a_x b_x + a_y b_y + a_z b_z = \sum_{i=1}^{3} a_i b_i = (\vec{b} \cdot \vec{a})$$

$$\vec{a} = \nabla, \qquad \vec{b} = \vec{E}(\vec{r})$$

$$\nabla \cdot \vec{E} = \nabla_x E_x + \nabla_y E_y + \nabla_z E_z = \partial_x E_x + \partial_y E_y + \partial_z E_z = \rho(x,y,z) \text{ — Skalar}$$

$$\vec{E} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}. \qquad \nabla \cdot \vec{E} = \partial_x x + \partial_y y + \partial_z z = 3.$$

$$\boxed{\nabla \cdot \vec{E} = \operatorname{div} \vec{E}(\vec{r})}$$

$$\nabla \cdot \vec{E} \neq \vec{E} \cdot \nabla$$

$$\vec{E} \cdot \nabla = E_x \partial_x + E_y \partial_y + E_z \partial_z$$

Vektorprodukt

$$\vec{a} \times \vec{b} = \begin{vmatrix} \hat{e}_x & \hat{e}_y & \hat{e}_z \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = \hat{e}_x (a_y b_z - a_z b_y) +$$

$$+ \hat{e}_y (a_z b_x - a_x b_z) +$$

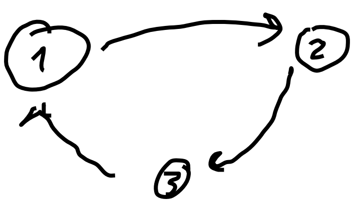
$$+ \hat{e}_z (a_x b_y - a_y b_x)$$

$$\hat{e}_x = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad \hat{e}_y = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \quad \hat{e}_z = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

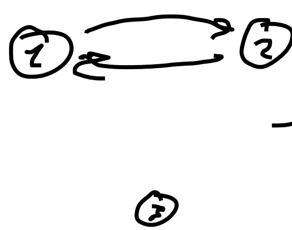
Levi-Civita-Tensor ε_{ijk}, $i = \overline{1,3}$, $j = \overline{1,3}$, $k = \overline{1,3}$

$$\varepsilon_{123} = 1$$

$$\varepsilon_{ijk} = \varepsilon_{kij} = \varepsilon_{jki} \Rightarrow \varepsilon_{123} = \varepsilon_{312} = \varepsilon_{231} = 1$$



zyklisch



$\to (-1)$

$$\varepsilon_{ijk} = -\varepsilon_{jik}$$

$$\varepsilon_{123} = -\varepsilon_{213}$$

$$\varepsilon_{213} = -1 =$$

$$= \varepsilon_{321} = \varepsilon_{132}$$

$$\varepsilon_{iik} = 0 : \quad \varepsilon_{112} = \varepsilon_{122} = \dots = 0$$