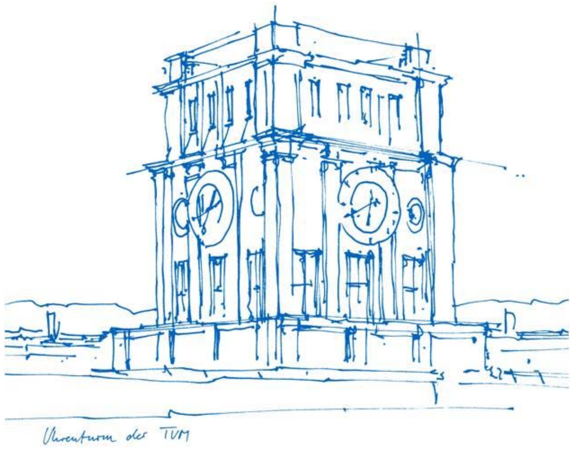
Lecture

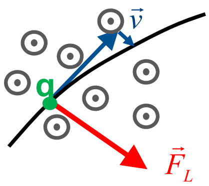
Electricity and Magnetism

Electrostatic Field vs. Magnetostatic Field



Electrostatic Field vs. Magnetostatic Field

Phänomenlogische Gegenüberstellung



$\vec{E}$ -Field	$\vec{B}$ -Field
<u>forces:</u> act on resting and moving charges; Coulomb‘s force	act on moving charges: Lorentz force
<u>Field generated by:</u> (resting) electric charges	Moving charges = electric current (there are no magnetic charges).
Gauss‘s law: $\int_{\partial V} \vec{D}(\vec{r})d\vec{a} = Q(V(\vec{r})) = \int_V \rho(\vec{r})d^3r$	solenoidality of B-field: $\int_{\partial V} \vec{B}(\vec{r})d\vec{a} = 0$
or differential: $div\vec{D}(\vec{r}) = \rho(\vec{r})$	$div\vec{B}(\vec{r}) = 0$
„The sources of the electrostatic field are the electric charges.“	There are no magnetic charges, not magnetic monopoles; B-Feld is solenoidal.

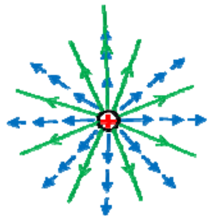
Electrostatic Field vs. Magnetostatic Field

$\vec{E}$ -Field

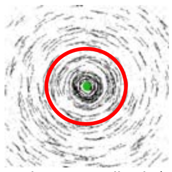
$\vec{B}$ -Field

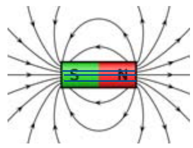
Field lines:

Field lines start and end at eletric charges



Field lines are always closed.





http://www.chemgapedia.de/vsengine/vlu/vsc/de/ph/14/ep/einfuehrung/magnetfeld/stroeme.vlu.html

Is a potential field (conservative); gradient field

$$rot\vec{E}(\vec{r}) = 0$$

Is not conservative, no potential field, not a gradient field

$$rot\vec{B}(\vec{r}) \neq 0$$

Field generation – mathematical description

By electric charges
Gauss's law, Poisson's equation

$$\int_{\partial V} \vec{D}(\vec{r})d\vec{a} = Q(V(\vec{r})) = \int_{V} \rho(\vec{r})d^3r$$

By electric currents
Ampère's circuital law

$$\int_{\partial A} \vec{H}(\vec{r})d\vec{r} = I(A) = \int_{A} \vec{j}(\vec{r})d\vec{a}$$

Electrostatic Field vs. Magnetostatic Field

$\vec{E}$ -Field

$\vec{B}$ -Field

Corresponding fields:

$\vec{E}$ -Field: takes into account materials, is the „measurable field"

$\vec{D}$ -Feld: takes into account only field-generating quantities (charges)

$$\vec{D}(\vec{r}) = \varepsilon\vec{E}(\vec{r})$$

$\vec{B}$ -Field: takes into account materials, is the „measurable field"

$\vec{H}$ -Feld: takes into account only field-generating quantities (electric currents)

$$\vec{B}(\vec{r}) = \mu\vec{H}(\vec{r})$$

Electromagnetism: coupling between $\vec{E}$ -field und $\vec{B}$ -field

Ampére-Maxwell's circuital law:

$\vec{H}$ -Feld generated by electric currents, but also by time-varying $\vec{D}$ -fields:

$$\int_{\partial A} \vec{H}(\vec{r})d\vec{r} = I(A) = \int_{A} (\vec{j}(\vec{r}) + \frac{\partial\vec{D}}{dt})d\vec{a}$$

Chapter 4: Induction: $\vec{E}$ -fields also generated by time-varying $\vec{B}$ -fields