| Electric field | Magnetic field |
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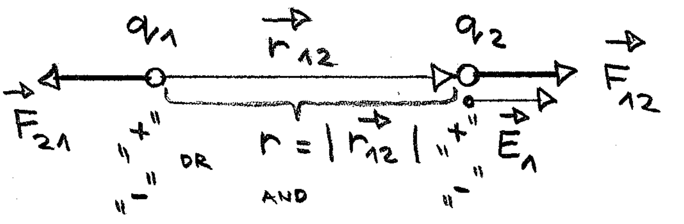
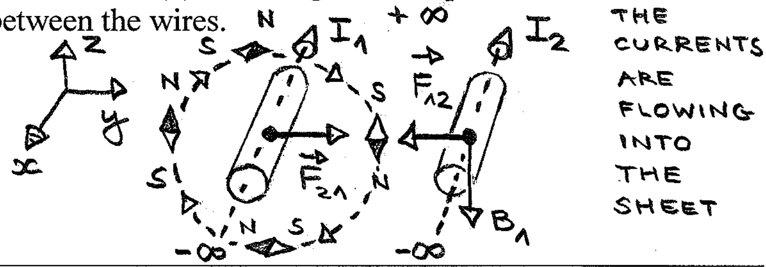
| The physical quantity describing the properties of the body is **electric charge** $q$ or $Q$ and its unit in the system SI is: **coulomb** (1 C) | The physical quantity describing the properties of the body is **current-length element** $I\ l$<br>*Current-length element = current × length of the wire*<br>unit in the system SI is: **ampere times meter** (1 A·m) |
| The basic law of interaction is the **Coulomb**'s **law** about the point charges: $F_{12} = k\dfrac{q_1\ q_2}{r^2}$, where $F_{12}$ is the force exerted by one point charge (1) onto another (2), $q_1$ and $q_2$ – values of charges, $r$ – distance between the point charges.<br><br> | The basic law of interaction is the **Ampere**'s law about the current-carrying wires: $F_{12} = K\dfrac{I_1 I_2 l_2}{r}$, where $I_1$ and $I_2$ are currents in the two parallel infinitely long wires, $F_{12}$ – force exerted by one wire (1) onto the piece of another wire (2), $l_2$ – length of this piece, $r$ – distance between the wires.<br><br> |
| The physical quantity describing the field is the **electric field strength** $E = \dfrac{F}{q}$, SI unit newton per coulomb 1 N/C = 1 V/m - **volt per meter** | The physical quantity describing the field is the **magnetic induction** or **magnetic flux density** $B = \dfrac{F}{I\ l}$, SI unit **tesla** 1 T = 1 N/(A m) - newton per ampere and meter |
| **Point charge** $q_1$ is generating the electric field $E_1$ in the location of another point charge $q_2$:<br>$E_1 = \dfrac{F_{12}}{q_2} = k\dfrac{q_1\ q_2}{r^2\ q_2} = k\dfrac{q_1}{r^2}$. | **Straight wire** carrying current $I_1$ is generating the magnetic inducton $B_1$ in the location of the current element $I_2\, l_2$: $B_1 = \dfrac{F_{12}}{I_2\ l} = K\dfrac{I_1 \cdot I_2}{r\ I_2\, l_2} l_2 = K\dfrac{I_1}{r}$ |
| The coefficient $k$ in the system SI: $k = 9\cdot 10^9\ \dfrac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}$,<br>$k = \dfrac{1}{4\pi\,\varepsilon_0}$ is used in the case of electric field with **spherical** symmetry properties. | The coefficient $K$ in the system SI: $K = 2\cdot 10^{-7}\,\mathrm{N/A^2}$,<br>$K = \dfrac{\mu_0}{2\pi}$ is used in the case of magnetic field with **cylindrical** symmetry properties. |
| The **permittivity constant** (permittivity of free space):<br>$\varepsilon_0 = \dfrac{1}{4\pi\cdot 9\cdot 10^9}\,\dfrac{\mathrm{C^2}}{\mathrm{N\cdot m^2}} \approx 8{,}85\cdot 10^{-12}\,\dfrac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}$ or $\dfrac{\mathrm{F}}{\mathrm{m}}$<br>is used in the case of the **uniform** electric field (the field lines are parallel and positioned with constant density) | The **permeability constant** (permeability of free space):<br>$\mu_0 = 4\pi\cdot 10^{-7}\,\dfrac{\mathrm{H}}{\mathrm{m}} = 4\pi\cdot 10^{-7}\,\dfrac{\mathrm{N}}{\mathrm{A^2}} \approx 1{,}26\,\dfrac{\mu\mathrm{N}}{\mathrm{A^2}}$<br>is used in the case of the **uniform** magnetic field (the field lines are parallel and positioned with constant density) |
| The physical quantity describing the impact of the substance on the field is **relative permittivity**:<br>$\varepsilon_r = \dfrac{E_0}{E} = \dfrac{E_{\mathrm{vacuum}}}{E_{\mathrm{substance}}}$. The product $\varepsilon = \varepsilon_0\,\varepsilon_r$ is then called the **absolute permittivity** of the substance.<br>The quantity $\varepsilon_r$ shows how many times **weaker** is the electric field in the substance than in the vacuum. | The physical quantity describing the impact of the substance on the field is **relative permeability**:<br>$\mu_r = \dfrac{B}{B_0} = \dfrac{B_{\mathrm{substance}}}{B_{\mathrm{vacuum}}}$. The product $\mu = \mu_0\,\mu_r$ is then called the **absolute permeability** of the substance.<br>The quantity $\mu_r$ shows how many times **stronger** is the magnetic field in the substance than in the vacuum. |
| If the body generates in the substance the electric field $E$, then the same body would generate in vacuum at the same distance the electric field $E_0 = \varepsilon_r\, E$. The electric field in vacuum $E_0$ is described by the **electric induction**<br>$D = \varepsilon_0\varepsilon_r\, E = \varepsilon\, E$ | If the wire generates in the substance the magnetic induction $B$, then the same wire would generate in vacuum at the same distance the magnetic induction $B_0 = B/\mu_r$. The magnetic field in vacuum $B_0$ is described by the **magnetic field strength**<br>$H = \dfrac{B}{\mu_0\mu_r} = \dfrac{B}{\mu}$ |

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| **Point charge** $q$ is generating at the distance $r$ from this charge the electric induction:<br>$D = \varepsilon_0 \varepsilon_r E = \varepsilon_0 \varepsilon_r \dfrac{E_0}{\varepsilon_r} = \varepsilon_0 \varepsilon_r \dfrac{1}{4\pi \varepsilon_0 \varepsilon_r} \dfrac{q}{r^2} = \dfrac{q}{4\pi r^2}$ | **Long straight wire** carrying current $I$ is generating at the distance $r$ from this wire the magnetic field strength:<br>$H = \dfrac{1}{\mu_0 \mu_r} \mu_r B_0 = \dfrac{1}{\mu_0 \mu_r} \mu_r \dfrac{\mu_0 I}{2\pi r} = \dfrac{I}{2\pi r}$ |
| To find the electric induction generated by some charge, we should divide the charge by the area of the surface on which the electric field arises:<br>$\text{Electric induction} = \dfrac{\text{charge}}{\text{area}} \rightarrow$ SI unit of $D$: $1 \dfrac{\text{C}}{\text{m}^2}$ | To find the magnetic field strength generated by some current-carrying wire we should divide the current by the length of the line on which the magnetic field arises:<br>$\text{Magnetic field strength} = \dfrac{\text{current}}{\text{length of the line}} \rightarrow$ SI unit of $H$: $1 \dfrac{\text{A}}{\text{m}}$ |

The **flux** of the field is the physical quantity describing the ability of the field lines to penetrate some surface. The vector quantity describing the field ($E$, $D$, $B$ or $H$) is the surface density of the flux. The flux itself is the scalar quantity by definition.

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| The **flux** of $D$ = electric induction $D$ × area $A$<br>$\Phi_D = D A \cos\beta = D_n A = \mathbf{D} \cdot \mathbf{A}$ (scalar product) | **Magnetic flux** = magnetic induction $B$ × area $A$<br>$\Phi = B A \cos\beta = \mathbf{B} \cdot \mathbf{A}$ SI unit **weber**: 1 Wb = 1T 1m$^2$ |
| **Gauss law** in the case of the **electrostatic** field: the flux of electric induction through the closed surface is equal to the algebraic sum of charges enclosed by this surface. The electrostatic field lines start from the positive charges and end at the negative ones. | **Gauss law** in the case of the **magnetostatic** field: the flux of magnetic induction through the closed surface is equal to zero. The magnetic field is the **solenoidal** one. The magnetic field lines are closed lines and they have neither initial nor final points. |
| **Faraday-Maxwell law**: the electromotive force along the closed line (the sum of all voltages along the line) in the case of electromagnetic induction is equal to the negative speed of change of the magnetic flux penetrating the surface enclosed by this line. | **Ampere-Maxwell law**: the magnetomotive force along the closed line (magnetic field strength × length of the line) is equal to the algebraic sum of currents flowing through the surface enclosed by this line. |
| **Gauss law:** All the charges located inside the closed surface contribute to the generation of electric field on this surface. | **Ampere-Maxwell law**: All the currents flowing through the surface enclosed by some line contribute to the generation of magnetic field on this line. |
| Gauss law: $\oint_A D_n \, dA = \sum_i q_i = \int_V \rho \, dV$ | Ampere-Maxwell law: $\oint_L H_l \, dl = \sum_i I_i$ |
| The ability of the system of bodies to create the electric field and to store the charge is described by **capacitance**<br>$C = \dfrac{q}{U}.$<br>The SI unit of capacitance is **farad** $1\,\text{F} = \dfrac{1\,\text{C}}{1\,\text{V}}.$ | The ability of the system of wires to create the magnetic field and store the current is described by **inductance**<br>$L = -\dfrac{\varepsilon_{self}}{\dfrac{\Delta I}{\Delta t}}$ ; $L = \dfrac{\Delta \Phi}{\Delta I}.$<br>The SI unit of inductance is **henry** $1\,\text{H} = \dfrac{1\,\text{Wb}}{1\,\text{A}}.$ |
| The **capacitor** is the system of bodies developed for obtaining a certain capacitance. | The **inductor** is the system of wires developed for obtaining a certain inductance. |
| The strength of the uniform electric field $E$ in the capacitor: $E = \dfrac{q}{\varepsilon A}$ | The induction of the uniform magnetic field $B$ in the long solenoid as an inductor: $B = \mu \dfrac{N}{l} I$ |
| The capacitance of the plate capacitor: $C = \dfrac{\varepsilon A}{d}$,<br>where $\varepsilon = \varepsilon_0 \varepsilon_r$ is the absolute permittivity of the substance between plates, $A$ – area of the one plate and $d$ – distance between plates. | The inductance of the long solenoid: $L = \mu \dfrac{N^2}{l} A$,<br>where $\mu = \mu_0 \mu_r$ is the absolute permeability of the substance inside the solenoid, $N$ – number of windings of the solenoid, $A$ – area of the one winding and $l$ – length of the solenoid. |
| The energy of the electric field in the capacitor<br>$E_e = \dfrac{C U^2}{2}$ | The energy of the magnetic field in the inductor<br>$E_m = \dfrac{L I^2}{2}$ |