Physical quantities in the electricity and magnetism

Note: Abbreviations of the **scalar** quantities are presented in *italic* (*q*, *I*, *U*..), abbreviations of the **vector** quantities are presented in **bold** (**E**, **B**, ..)

The natural phenomenon or property → the human-derived imagination of it	**Physical quantity describing it**	**Abbreviation and definition formula**	**Measuring unit in the SI system of units**	**Abbreviation and definition of the unit**
The property of the body **to participate** in the electromagnetic interaction.	charge	q, Q basic quantity	coulomb	$1\text{C} = 1\text{A}\cdot 1\text{s}$
The **state of directed motion** of the charged particles → the net charge of the free carriers (charged particles) penetrating the cross section of the wire in the time unit.	current	$I = \frac{Q}{t}$, $i = \frac{\mathrm{d}q}{\mathrm{d}t}$	ampere	1 A basic unit of SI
The ability of the electric field to exert a **force** onto the body possessing positive **unit charge**. This ability is often measured via the **work** done by the electric field in the process of the unit displacement of the positive unit charge.	electric field strength	$\mathbf{E} = \frac{\mathbf{F}}{q}$	volt per meter	$1\frac{\text{V}}{\text{m}} = 1\frac{\text{N}}{\text{C}}$
The **process** occurring in the electric field → the **work** done by the electric field in the **process** of displacement of a positive **unit charge** from one point to the another.	voltage	$U = \frac{W}{q}$	volt	$1\,\text{V} = \frac{1\,\text{J}}{1\,\text{C}}$
The **situation** in some point of the electric field→ the potential energy of the body possessing positive **unit charge** placed in this point of the electric field.	potential	$V = \frac{E_p}{q}$	volt	$1\,\text{V} = \frac{1\,\text{J}}{1\,\text{C}}$
The **cyclic process** occurring in the electric field → the **work** done by the non-electric force (NEF) in the process of **cyclic** displacement of a positive **unit charge**. The NEF, acting in the **voltage source** separates the positive and negative charges and generates in such a way the electric field displacing the charge carriers outside the source.	electromotive force (EMF)	$\mathcal{E} = \frac{W_{NEF}}{q}$	volt	$1\,\text{V} = \frac{1\,\text{J}}{1\,\text{C}}$
	The EMF is a **sum** of all **voltages** along the closed path. These voltages can be always presented as the products of currents and resistances (Ohm's law).			
The presence of the "braking" forces acting onto the directed motion of the charged particles (current) in some conducting **body** → the **voltage** (*U*) needed for the generating of the **unit current** (*I*).	resistance	$R = \frac{U}{I}$	ohm	$1\,\Omega = \frac{1\,\text{V}}{1\,\text{A}}$
The current-resistive properties of the **substance** → the resistance (*R*) of the conducting body possessing **unit length** (*l*) and **unit** cross section **area** (*A*).	resistivity	$\rho = \frac{R\,A}{l}$	ohm-meter	$1\,\Omega\cdot\text{m} = \frac{1\,\Omega\cdot 1\text{m}^2}{1\,\text{m}}$
The effect of the **substance** on the electric field → the quantity showing how many times **weaker** is the electric field in the substance than in the vacuum.	relative permittivity	$\varepsilon_r = \frac{E_{\text{vacuum}}}{E_{\text{substance}}}$	no unit	–
The effect of the **substance** on the electric field → the product of the permittivity constant ε_0 and the relative permittivity ε_r of the substance.	absolute permittivity	$\varepsilon = \varepsilon_0\,\varepsilon_r$	farad per meter	$1\frac{\text{C}^2}{\text{N}\cdot\text{m}^2} = 1\frac{\text{F}}{\text{m}}$

The electric field $\mathbf{E}_0$ generated by the charged body in the vacuum (without **substance**) if the body generates in the substance the electric field **E**.	electric induction	$\mathbf{D} = \varepsilon_0 \mathbf{E}_0 = \varepsilon \mathbf{E}$	coulomb per meter squared	$1 \frac{\mathrm{C}}{\mathrm{m}^2}$
The ability of the system of conducting bodies to create the **electric field** and to store the **charge** $\rightarrow$ the change of the **charge** of one conducting body divided by the change of the **voltage** between the bodies.	capacitance	$C = \frac{Q}{U} = \frac{\mathrm{d}q}{\mathrm{d}u}$	farad	$1\,\mathrm{F} = \frac{1\,\mathrm{C}}{1\,\mathrm{V}}$
The ability of the system of charged bodies to perform **work** $\rightarrow$ the energy stored in the capacitor possessing the capacitance C and the voltage U.	energy of the electric field	$E_e = \frac{C\,U^2}{2}$	joule	1 J = 1C · 1V
The ability of the magnetic field to exert a **force** onto the wire $\rightarrow$ the force exerted to the **unit current-length element** perpendicular to the magnetic field. The unit current-length element is the piece of wire carrying the unit current (1 A) and possessing the unit length (1 m).	magnetic induction	$B = \frac{F}{I\ l}$ $\mathrm{d}\mathbf{F} = I\,\mathrm{d}\mathbf{l} \times \mathbf{B}$	tesla	$1\,\mathrm{T} = \frac{1\,\mathrm{N}}{1\,\mathrm{A} \cdot 1\,\mathrm{m}}$
The ability of the magnetic field lines to **penetrate** some **surface** $\rightarrow$ the product of the magnetic induction B, the area of the surface A and the cosine of the angle β between the normal of the surface and the field lines.	magnetic flux	$\Phi = B\,A \cos\beta$ $\Phi = \mathbf{B} \cdot \mathbf{A}$	weber	1 Wb = 1T · 1m^2
The effect of the **substance** on the magnetic field $\rightarrow$ the quantity showing how many times **stronger** is the magnetic field in the substance than in the vacuum.	relative permeability	$\mu_r = \frac{B_{\text{substance}}}{B_{\text{vacuum}}}$	no unit	–
The effect of the **substance** on the magnetic field $\rightarrow$ the product of the permeability constant μ_0 and the relative permeability μ_r of the substance.	absolute permeability	$\mu = \mu_0\,\mu_r$	henry per meter	$1 \frac{\mathrm{N}}{\mathrm{A}^2} = 1 \frac{\mathrm{H}}{\mathrm{m}}$
The magnetic induction $\mathbf{B}_0$ generated by the current-carrying wire in the vacuum (without **substance**) if the wire generates in the substance the magnetic induction **B**.	magnetic field strength	$\mathbf{H} = \frac{\mathbf{B}_0}{\mu_0} = \frac{\mathbf{B}}{\mu}$	ampere per meter	$1 \frac{\mathrm{A}}{\mathrm{m}}$
The MMF is a **sum** of all **magnetic voltages** along the closed path. These voltages can be presented as the scalar products of magnetic field strengths **H** and small path lengths d$\boldsymbol{l}$ (considered as the vector quantities).	magnetomotive force (MMF)	$M = \oint_L \mathbf{H} \cdot \mathrm{d}\mathbf{l}$	ampere-turn	1 A-t
The current-loaded condition of the **substance** $\rightarrow$ the net **charge** of the free carriers (charged particles) penetrating the **unit area** of the cross section of the wire in the **time unit**.	current density	$\mathbf{J} = \frac{\mathrm{d}^2 q}{\mathrm{d}\mathbf{A} \cdot \mathrm{d}t}$	ampere per meter squared	$1 \frac{\mathrm{A}}{\mathrm{m}^2}$
The ability of the system of wires to create the **magnetic field** and to store the **current** $\rightarrow$ the change of the linked **magnetic flux** in the system divided by the change of the **current**.	inductance	$L = \frac{\Phi}{I} = \frac{\mathrm{d}\Phi}{\mathrm{d}i}$	henry	$1\,\mathrm{H} = \frac{1\,\mathrm{Wb}}{1\,\mathrm{A}}$
The ability of the system of current-carrying wires to perform **work** $\rightarrow$ the energy stored in the inductor possessing the inductance L and the current I.	energy of the magnetic field	$E_m = \frac{L\,I^2}{2}$	joule	1 J = 1Wb · 1A