1.3.3 Electricity and magnetism

Name	*Symbol*	*Definition*	*SI unit*	*Notes*
quantity of electricity, electric charge	Q		C	
charge density	ρ	$\rho = Q/V$	C m^{-3}	
surface charge density	σ	$\sigma = Q/A$	C m^{-2}	
electric potential	V, φ	$V = \mathrm{d}W/\mathrm{d}Q$	V, J C^{-1}	
electric potential difference	$U, \Delta V, \Delta\varphi$	$U = V_2 - V_1$	V	
electromotive force	E	$E = \int(\boldsymbol{F}/Q)\cdot \mathrm{d}\boldsymbol{s}$	V	
electric field strength	$\boldsymbol{E}$	$\boldsymbol{E} = \boldsymbol{F}/Q = -\nabla V$	V m^{-1}	
electric flux	Ψ	$\Psi = \int \boldsymbol{D}\cdot \mathrm{d}\boldsymbol{A}$	C	(1)
electric displacement	$\boldsymbol{D}$	$\boldsymbol{D} = \varepsilon \boldsymbol{E}$	C m^{-2}	
capacitance	C	$C = Q/U$	F, C V^{-1}	
permittivity	ε	$\boldsymbol{D} = \varepsilon \boldsymbol{E}$	F m^{-1}	
permittivity of vacuum	ε_0	$\varepsilon_0 = \mu^{1} c^{2}$	F m^{-1}	
relative permittivity	ε_r	$\varepsilon_r = \varepsilon/\varepsilon_0$	1	(2)
dielectric polarization (dipole moment per volume)	$\boldsymbol{P}$	$\boldsymbol{P} = \boldsymbol{D} - \varepsilon_0 \boldsymbol{E}$	C m^{-2}	
electric susceptibility	χ_e	$\chi_e = \varepsilon_r - 1$	1	
electric dipole moment	$\boldsymbol{p}, \boldsymbol{\mu}$	$\boldsymbol{p} = \Sigma Q_i \boldsymbol{r}_i$	C m	(3)
electric current	I, i	$I = \mathrm{d}Q/\mathrm{d}t$	A	

(1) d$\boldsymbol{A}$ is a vector element of area.

(2) This quantity was formerly called dielectric constant.

(3) When a dipole is composed of two point charages Q and $-Q$ separated by a distance r, the direction of the dipole vector is taken to be from the negative to the positive charge. The opposite convention is sometimes used, but is to be discouraged. The dipole moment of an ion depends on the choice of the origin.

Name	*Symbol*	*Definition*	*SI unit*	*Notes*
electric current density	$\boldsymbol{j}, \boldsymbol{J}$	$I = \int \boldsymbol{j} \cdot \mathrm{d}\boldsymbol{A}$	$\mathrm{A\ m^{-2}}$	(1)
magnetic flux density, magnetic induction	$\boldsymbol{B}$	$\boldsymbol{F} = Q\, \boldsymbol{v} \times \boldsymbol{B}$	T	(4)
magnetic flux	$\boldsymbol{\Phi}$	$\boldsymbol{\Phi} = \int \boldsymbol{B} \cdot \mathrm{d}\boldsymbol{A}$	Wb	(1)
magnetic field strength	$\boldsymbol{H}$	$\boldsymbol{B} = \mu \boldsymbol{H}$	$\mathrm{A\ m^{-1}}$	
permeability	μ	$\boldsymbol{B} = \mu \boldsymbol{H}$	$\mathrm{N\ A^{-2}}$, $\mathrm{H\ m^{-1}}$	
permeability of vacuum	μ_0	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\ m^{-1}}$	$\mathrm{H\ m^{-1}}$	
relative permeability	μ_r	$\mu_r = \mu / \mu_0$	1	
magnetization (magnetic dipole moment per volume)	$\boldsymbol{M}$	$\boldsymbol{M} = \boldsymbol{B}/\mu_0 - \boldsymbol{H}$	$\mathrm{A\ m^{-1}}$	
magnetic susceptibility	$\chi, \kappa, (\chi_m)$	$\chi = \mu_r - 1$	1	(5)
molar magnetic susceptibility	χ_m	$\chi_m = V_m \chi$	$\mathrm{m^3\ mol^{-1}}$	
magnetic dipole moment	$\boldsymbol{m}, \boldsymbol{\mu}$	$E_p = -\boldsymbol{m} \cdot \boldsymbol{B}$	$\mathrm{A\ m^2}$, $\mathrm{J\ T^{-1}}$	
electric resistance	R	$R = U/I$	Ω	(6)
conductance	G	$G = 1/R$	S	(6)
loss angle	δ	$\delta = \varphi_I - \varphi_U$	1, rad	(7)
reactance	X	$X = (U/I) \sin\delta$	Ω	
impedance, (complex impedance)	Z	$Z = R + \mathrm{i}X$	Ω	
admittance, (complex admittance)	Y	$Y = 1/Z$	S	
susceptance	B	$Y = G + \mathrm{i}B$	S	
resistivity	ρ	$\rho = E/j$	Ω m	
conductivity	κ, γ, σ	$\kappa = 1/\rho$	$\mathrm{S\ m^{-1}}$	
self-inductance	L	$E = -L(\mathrm{d}I/\mathrm{d}t)$	H	
mutual inductance	M, L_{12}	$E_1 = L_{12}(\mathrm{d}I_2/\mathrm{d}t)$	H	

(4) This quantity is sometimes loosely called magnetic field.

(5) The symbol χ_m is sometimes used for magnetic susceptibility, but it should be reserved for molar magnetic susceptibility.

(6) In a material with reactance $R = (U/I) \cos\delta$, and $G = R/(R^2 + X^2)$.

(7) φ_I and φ_U are the phases of current and potential difference.