Mathematical and Physical Formulae

(version 14.09.2022)

This collection of mathematical and physical formulae will NOT be available at the exam. The operators in cylindrical and spherical coordinates as well as the physical constants necessary for the solution of the exam will be written in the exam document. For all other formula in this collection and in the course slides, each student is responsible to prepare her/his own collection of formulas, in a two A4 sheets (four pages).

Conversion between cartesian, cylindrical, and spherical coordinates

Cartesian Cylindrical

$$\hat{\mathbf{x}} = \cos\varphi\hat{\mathbf{r}} - \sin\varphi\hat{\varphi} \qquad \hat{\mathbf{r}} = \frac{x\hat{\mathbf{x}} + y\hat{\mathbf{y}}}{\sqrt{x^2+y^2}}$$

$$\hat{\mathbf{y}} = \sin\varphi\hat{\mathbf{r}} + \cos\varphi\hat{\varphi} \qquad \hat{\varphi} = \frac{-y\hat{\mathbf{x}} + x\hat{\mathbf{y}}}{\sqrt{x^2+y^2}}$$

$$\hat{\mathbf{z}} = \hat{\mathbf{z}} \qquad \hat{\mathbf{z}} = \hat{\mathbf{z}}$$

$$x = r\cos\varphi \qquad r = \sqrt{x^2+y^2}$$

$$y = r\sin\varphi \qquad \varphi = \arctan\left(\frac{y}{x}\right)$$

$$z = z \qquad z = z$$

$$\frac{\partial\hat{\mathbf{r}}}{\partial r} = 0 \qquad \frac{\partial\hat{\mathbf{r}}}{\partial\varphi} = \hat{\varphi} \qquad \frac{\partial\hat{\mathbf{r}}}{\partial z} = 0$$

$$\frac{\partial\hat{\varphi}}{\partial r} = 0 \qquad \frac{\partial\hat{\varphi}}{\partial\varphi} = -\hat{\mathbf{r}} \qquad \frac{\partial\hat{\varphi}}{\partial z} = 0$$

$$\frac{\partial\hat{\mathbf{z}}}{\partial r} = 0 \qquad \frac{\partial\hat{\mathbf{z}}}{\partial\varphi} = 0 \qquad \frac{\partial\hat{\mathbf{z}}}{\partial z} = 0$$

Cartesian Spherical

$$\hat{\mathbf{x}} = \sin\theta\cos\varphi\hat{\mathbf{r}} + \cos\theta\cos\varphi\hat{\theta} - \sin\varphi\hat{\varphi} \qquad \hat{\mathbf{r}} = \sin\theta\left(\cos\varphi\hat{\mathbf{x}} + \sin\varphi\hat{\mathbf{y}}\right) + \cos\theta\hat{\mathbf{z}}$$

$$\hat{\mathbf{y}} = \sin\theta\sin\varphi\hat{\mathbf{r}} + \cos\theta\sin\varphi\hat{\theta} + \cos\varphi\hat{\varphi} \qquad \hat{\theta} = \cos\theta\left(\cos\varphi\hat{\mathbf{x}} + \sin\varphi\hat{\mathbf{y}}\right) - \sin\theta\hat{\mathbf{z}}$$

$$\hat{\mathbf{z}} = \cos\theta\hat{\mathbf{r}} - \sin\theta\hat{\theta} \qquad \hat{\varphi} = -\sin\varphi\hat{\mathbf{x}} + \cos\varphi\hat{\mathbf{y}}$$

$$x = r\sin\theta\cos\varphi \qquad r = \sqrt{x^2+y^2+z^2}$$

$$y = r\sin\theta\sin\varphi \qquad \theta = \arccos\left(\frac{z}{r}\right)$$

$$z = r\cos\theta \qquad \varphi = \arctan\left(\frac{y}{x}\right)$$

$$\frac{\partial \hat{\mathbf{r}}}{\partial r} = 0 \qquad \frac{\partial \hat{\mathbf{r}}}{\partial \theta} = \sin\varphi \hat{\theta} \qquad \frac{\partial \hat{\mathbf{r}}}{\partial \varphi} = \hat{\varphi}$$

$$\frac{\partial \hat{\theta}}{\partial r} = 0 \qquad \frac{\partial \hat{\theta}}{\partial \varphi} = 0 \qquad \frac{\partial \hat{\theta}}{\partial \theta} = -\cos\varphi\hat{\varphi} - \sin\varphi\hat{\mathbf{r}}$$

$$\frac{\partial \hat{\varphi}}{\partial r} = 0 \qquad \frac{\partial \hat{\varphi}}{\partial \varphi} = -\hat{\mathbf{r}} \qquad \frac{\partial \hat{\varphi}}{\partial \theta} = \cos\varphi \hat{\theta}$$

Scalar and Vector product: general expression

$$\begin{aligned}
\mathbf{u} \cdot \mathbf{v} = (u_1\mathbf{i} + u_2\mathbf{j} + u_3\mathbf{k}) \cdot (v_1\mathbf{i} + v_2\mathbf{j} + v_3\mathbf{k}) = \\
(u_1\mathbf{i} \cdot v_1\mathbf{i}) + (u_1\mathbf{i} \cdot v_2\mathbf{j}) + (u_1\mathbf{i} \cdot v_3\mathbf{k}) + \\
(u_2\mathbf{j} \cdot v_1\mathbf{i}) + (u_2\mathbf{j} \cdot v_2\mathbf{j}) + (u_2\mathbf{j} \cdot v_3\mathbf{k}) + \\
(u_3\mathbf{k} \cdot v_1\mathbf{i}) + (u_3\mathbf{k} \cdot v_2\mathbf{j}) + (u_3\mathbf{k} \cdot v_3\mathbf{k})
\end{aligned}$$

$$\begin{aligned}
\mathbf{u} \times \mathbf{v} = (u_1\mathbf{i} + u_2\mathbf{j} + u_3\mathbf{k}) \times (v_1\mathbf{i} + v_2\mathbf{j} + v_3\mathbf{k}) = \\
(u_1\mathbf{i} \times v_1\mathbf{i}) + (u_1\mathbf{i} \times v_2\mathbf{j}) + (u_1\mathbf{i} \times v_3\mathbf{k}) + \\
(u_2\mathbf{j} \times v_1\mathbf{i}) + (u_2\mathbf{j} \times v_2\mathbf{j}) + (u_2\mathbf{j} \times v_3\mathbf{k}) + \\
(u_3\mathbf{k} \times v_1\mathbf{i}) + (u_3\mathbf{k} \times v_2\mathbf{j}) + (u_3\mathbf{k} \times v_3\mathbf{k})
\end{aligned}$$

Gradient, Divergence, Curl, Laplacian

Cartesian coordinates

$$
\begin{aligned}
\mathbf{A} &= A_y\hat{\mathbf{x}} + A_y\hat{\mathbf{y}} + A_z\hat{\mathbf{z}} \\
d\mathbf{l} &= dx\hat{\mathbf{x}} + dy\,\hat{\mathbf{y}} + dz\,\hat{\mathbf{z}} \\
d\mathbf{s} &= dy\,dz\,\hat{\mathbf{x}} + dx\,dz\,\hat{\mathbf{y}} + dx\,dy\,\hat{\mathbf{z}} \\
dV &= dx\,dy\,dz \\
\nabla &= \hat{\mathbf{x}}\frac{\partial}{\partial x} + \hat{\mathbf{y}}\frac{\partial}{\partial y} + \hat{\mathbf{z}}\frac{\partial}{\partial z} \\
\nabla f &= \frac{\partial f}{\partial x}\hat{\mathbf{x}} + \frac{\partial f}{\partial y}\hat{\mathbf{y}} + \frac{\partial f}{\partial z}\hat{\mathbf{z}} \\
\nabla \cdot \mathbf{A} &= \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z} \\
\nabla \times \mathbf{A} &= \left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right)\hat{\mathbf{x}} + \left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right)\hat{\mathbf{y}} + \left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right)\hat{\mathbf{z}} \\
\nabla^2 f &= \nabla \cdot \nabla f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} \\
\nabla^2 \mathbf{A} &= \nabla^2 A_x\hat{\mathbf{x}} + \nabla^2 A_y\hat{\mathbf{y}} + \nabla^2 A_z\hat{\mathbf{z}}
\end{aligned}
$$

Cylindrical coordinates

$$
\begin{aligned}
\mathbf{A} &= A_r\hat{\mathbf{r}} + A_\varphi\hat{\varphi} + A_z\hat{\mathbf{z}} \\
d\mathbf{l} &= dr\,\hat{\mathbf{r}} + r\,d\varphi\,\hat{\varphi} + dz\,\hat{\mathbf{z}} \\
d\mathbf{s} &= r\,d\varphi\,dz\,\hat{\mathbf{r}} + dr\,dz\,\hat{\varphi} + r\,dr\,d\varphi\,\hat{\mathbf{z}} \\
dV &= r\,dr\,d\varphi\,dz \\
\nabla &= \hat{\mathbf{r}}\frac{\partial}{\partial r} + \hat{\varphi}\frac{1}{r}\frac{\partial}{\partial \varphi} + \hat{\mathbf{z}}\frac{\partial}{\partial z} \\
\nabla f &= \frac{\partial f}{\partial r}\hat{\mathbf{r}} + \frac{1}{r}\frac{\partial f}{\partial \varphi}\hat{\varphi} + \frac{\partial f}{\partial z}\hat{\mathbf{z}} \\
\nabla \cdot \mathbf{A} &= \frac{1}{r}\frac{\partial\,(rA_r)}{\partial r} + \frac{1}{r}\frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z} \\
\nabla \times \mathbf{A} &= \left(\frac{1}{r}\frac{\partial A_z}{\partial \varphi} - \frac{\partial A_\varphi}{\partial z}\right)\hat{\mathbf{r}} + \left(\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r}\right)\hat{\varphi} + \frac{1}{r}\left(\frac{\partial\,(rA_\varphi)}{\partial r} - \frac{\partial A_r}{\partial \varphi}\right)\hat{\mathbf{z}} \\
\nabla^2 f &= \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial f}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 f}{\partial \varphi^2} + \frac{\partial^2 f}{\partial z^2} \\
\nabla^2 \mathbf{A} &= \left(\nabla^2 A_r - \frac{A_r}{r^2} - \frac{2}{r^2}\frac{\partial A_\varphi}{\partial \varphi}\right)\hat{\mathbf{r}} + \left(\nabla^2 A_\varphi - \frac{A_\varphi}{r^2} + \frac{2}{r^2}\frac{\partial A_r}{\partial \varphi}\right)\hat{\boldsymbol{\varphi}} + (\nabla^2 A_z)\hat{\mathbf{z}}
\end{aligned}
$$

Spherical coordinates

$$
\begin{aligned}
\mathbf{A} &= A_r \hat{\mathbf{r}} + A_\theta \hat{\theta} + A_\varphi \hat{\varphi} \\
d\mathbf{l} &= dr\, \hat{\mathbf{r}} + r\, d\theta\, \hat{\theta} + r\, \sin\theta\, d\varphi\, \hat{\varphi} \\
d\mathbf{s} &= r^2 \sin\theta\, d\theta\, d\varphi\, \hat{\mathbf{r}} + r \sin\theta\, dr\, d\varphi\, \hat{\theta} + r\, dr\, d\theta\, \hat{\varphi} \\
dV &= r^2 \sin\theta\, dr\, d\theta\, d\varphi \\
\nabla &= \hat{\mathbf{r}} \frac{\partial}{\partial r} + \hat{\theta} \frac{1}{r} \frac{\partial}{\partial \theta} + \hat{\varphi} \frac{1}{r \sin\theta} \frac{\partial}{\partial \varphi} \\
\nabla f &= \frac{\partial f}{\partial r} \hat{\mathbf{r}} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{1}{r \sin\theta} \frac{\partial f}{\partial \varphi} \hat{\varphi} \\
\nabla \cdot \mathbf{A} &= \frac{1}{r^2} \frac{\partial \left(r^2 A_r\right)}{\partial r} + \frac{1}{r \sin\theta} \frac{\partial}{\partial \theta} \left(A_\theta \sin\theta\right) + \frac{1}{r \sin\theta} \frac{\partial A_\varphi}{\partial \varphi} \\
\nabla \times \mathbf{A} &= \frac{1}{r \sin\theta} \left(\frac{\partial}{\partial \theta} \left(A_\varphi \sin\theta\right) - \frac{\partial A_\theta}{\partial \varphi} \right) \hat{\mathbf{r}} + \frac{1}{r} \left(\frac{1}{\sin\theta} \frac{\partial A_r}{\partial \varphi} - \frac{\partial}{\partial r} \left(r A_\varphi\right) \right) \hat{\theta} + \frac{1}{r} \left(\frac{\partial}{\partial r} \left(r A_\theta\right) - \frac{\partial A_r}{\partial \theta} \right) \hat{\varphi} \\
\nabla^2 f &= \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial f}{\partial r} \right) + \frac{1}{r^2 \sin\theta} \frac{\partial}{\partial \theta} \left(\sin\theta \frac{\partial f}{\partial \theta} \right) + \frac{1}{r^2 \sin^2\theta} \frac{\partial^2 f}{\partial \varphi^2} \\
\nabla^2 \mathbf{A} &= \left(\nabla^2 A_r - \frac{2 A_r}{r^2} - \frac{2}{r^2 \sin\theta} \frac{\partial \left(A_\theta \sin\theta\right)}{\partial \theta} - \frac{2}{r^2 \sin\theta} \frac{\partial A_\varphi}{\partial \varphi} \right) \hat{\mathbf{r}} \\
&\quad + \left(\nabla^2 A_\theta - \frac{A_\theta}{r^2 \sin^2\theta} + \frac{2}{r^2} \frac{\partial A_r}{\partial \theta} - \frac{2 \cos\theta}{r^2 \sin^2\theta} \frac{\partial A_\varphi}{\partial \varphi} \right) \hat{\boldsymbol{\theta}} + \left(\nabla^2 A_\varphi - \frac{A_\varphi}{r^2 \sin^2\theta} + \frac{2}{r^2 \sin\theta} \frac{\partial A_r}{\partial \varphi} + \frac{2 \cos\theta}{r^2 \sin^2\theta} \frac{\partial A_\theta}{\partial \varphi} \right) \hat{\boldsymbol{\varphi}}
\end{aligned}
$$

Gauss and Stokes theorems

In the following, $\mathbf{A}$ is a well-behaved vector field, V is a three-dimensional volume with volume element, S is a closed two-dimensional surface bonding V, with a unit area element vector $d\mathbf{s}$ normal and outward to the surface:

$\oint_S \mathbf{A} \cdot d\mathbf{s} = \int_V (\nabla \cdot \mathbf{A})\, dV$ (Divergence (Gauss) theorem)

In the following, $\mathbf{A}$ is a well-behaved vector field, S is a two-dimensional surface having as contour the closed line C with line element $d\mathbf{l}$. The direction of the surface unit vector $d\mathbf{s}$ is defined by the right-hand-screw rule in relation to the sense of the line integral around C:

$\oint_C \mathbf{A} \cdot d\mathbf{l} = \int_S (\nabla \times \mathbf{A}) \cdot d\mathbf{s}$ (Curl (Stokes) theorem)

Line integral of a scalar field

For a scalar field f, the line integral along a piecewise smooth curve $\mathcal{C}$ is defined as:

$\int_{\mathcal{C}} f(\mathbf{r})dl = \int_a^b f(\mathbf{r}(t))\, |\dot{\mathbf{r}}(t)| dt$

where $\mathbf{r}$ is an arbitrary bijective parametrization of the curve $\mathcal{C}$ such that $\mathbf{r}(a)$ and $\mathbf{r}(b)$ give the endpoints of $\mathcal{C}$, $a < b$, and $\dot{\mathbf{r}}(t) = d\mathbf{r}/dt$. Line integrals of scalar fields over a curve $\mathcal{C}$ do not depend on the chosen parametrization $\mathbf{r}$ of $\mathcal{C}$.

Line integral of a vector field

For a vector field $\mathbf{A}$, the line integral along a piecewise smooth curve $\mathcal{C}$, in the direction of $\mathbf{r}$, is defined as:

$\int_{\mathcal{C}} \mathbf{A}(\mathbf{r}) \cdot d\mathbf{l} = \int_a^b \mathbf{A}(\mathbf{r}(t)) \cdot \dot{\mathbf{r}}(t) dt$

where $\mathbf{r}$ is an arbitrary bijective parametrization of the curve $\mathcal{C}$ such that $\mathbf{r}(a)$ and $\mathbf{r}(b)$ give the endpoints of $\mathcal{C}$, and $\dot{\mathbf{r}}(t) = d\mathbf{r}/dt$. Line integrals of vector fields are independent of the parametrization $\mathbf{r}$(t) in absolute value, but they do depend on its orientation. Specifically, a reversal in the orientation of the parametrization changes the sign of the line integral.

Vectorial identities

$\mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}$
$\mathbf{A} \cdot \mathbf{B} = \mathbf{B} \cdot \mathbf{A}$
$\mathbf{A} \times \mathbf{B} \times \mathbf{C} = (\mathbf{A} \cdot \mathbf{C})\, \mathbf{B} - (\mathbf{B} \cdot \mathbf{C})\, \mathbf{A}$
$(\mathbf{A} \times \mathbf{B}) \times \mathbf{C} = (\mathbf{A} \cdot \mathbf{C})\, \mathbf{B} - (\mathbf{B} \cdot \mathbf{C})\, \mathbf{A}$

Mechanics of fluids: main equations

Force on the unit of volume due to the pressure:
$\mathbf{f} = -\nabla P$

Continuity equation:
$\frac{\partial \rho}{\partial t} + (\nabla \cdot (\rho \mathbf{v})) = 0$ "Mass conservation in the unit of volume"

Bernoulli equation :
$\frac{1}{2}\rho v^2 + \rho g z + P = const$ "Energy conservation in the unit of volume"

Euler equation:
$-\nabla P + \rho \mathbf{g} = \rho(\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\mathbf{v})$ "Forces acting on the unit of volume"

Nevier-Stokes equation:
$-\nabla P + \rho \mathbf{g} + \eta \nabla^2 \mathbf{v} = \rho(\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\mathbf{v})$ "Forces acting on the unit of volume, in presence of viscosity"

Electromagnetism: main equations

Macroscopic Maxwell equations (differential and integral form)

$$\nabla \cdot \mathbf{D} = \rho_f \qquad \oint_S \mathbf{D} \cdot \mathrm{d}\mathbf{s} = \int_V \rho_f \,\mathrm{d}V$$

$$\nabla \cdot \mathbf{B} = 0 \qquad \oint_S \mathbf{B} \cdot \mathrm{d}\mathbf{s} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \oint_C \mathbf{E} \cdot \mathrm{d}\ell = -\int_S \frac{\partial \mathbf{B}}{\partial t} \cdot \mathrm{d}\mathbf{s}$$

$$\nabla \times \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t} \qquad \oint_C \mathbf{H} \cdot \mathrm{d}\ell = \int_S \mathbf{J}_f \cdot \mathrm{d}\mathbf{s} + \int_S \frac{\partial \mathbf{D}}{\partial t} \cdot \mathrm{d}\mathbf{s}$$

Microscopic Maxwell equations (differential and integral form)

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \qquad \oint_S \mathbf{E} \cdot \mathrm{d}\mathbf{s} = \frac{1}{\varepsilon_0} \int_V \rho \,\mathrm{d}V$$

$$\nabla \cdot \mathbf{B} = 0 \qquad \oint_S \mathbf{B} \cdot \mathrm{d}\mathbf{s} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \oint_C \mathbf{E} \cdot \mathrm{d}\ell = -\int_S \frac{\partial \mathbf{B}}{\partial t} \cdot \mathrm{d}\mathbf{s}$$

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \qquad \oint_C \mathbf{B} \cdot \mathrm{d}\ell = \mu_0 \int_S \mathbf{J} \cdot \mathrm{d}\mathbf{s} + \mu_0 \varepsilon_0 \int_S \frac{\partial \mathbf{E}}{\partial t} \cdot \mathrm{d}\mathbf{s}$$

Relationships between the auxiliary fields (always valid)

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P} \qquad \mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}$$

Additional relationships between the auxiliary fields in linear media

$$\mathbf{P} = \varepsilon_0 \chi_e \mathbf{E} \qquad \mathbf{M} = \chi_m \mathbf{H}$$

$$\mathbf{D} = \varepsilon \mathbf{E} \qquad \mathbf{H} = \frac{1}{\mu}\mathbf{B}$$

Lorentz force

$$\mathbf{F} = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$$

Potentials

$$\mathbf{E} = -\nabla V - \frac{\partial \mathbf{A}}{\partial t} \qquad \mathbf{B} = \nabla \times \mathbf{A}$$

$$V(\mathbf{r}, t) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(\mathbf{r}', t_r)}{|\mathbf{r} - \mathbf{r}'|} dV' \qquad \mathbf{A}(\mathbf{r}, t) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}(\mathbf{r}', t_r)}{|\mathbf{r} - \mathbf{r}'|} dV'$$

$$V(\mathbf{r}, t) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho_f(\mathbf{r}', t_r) - \nabla \cdot \mathbf{P}(\mathbf{r}', t_r)}{|\mathbf{r} - \mathbf{r}'|} dV' \qquad \mathbf{A}(\mathbf{r}, t) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}_f(\mathbf{r}', t_r) - \nabla \cdot \mathbf{M}(\mathbf{r}', t_r) + \frac{\partial \mathbf{P}}{\partial t}(\mathbf{r}', t_r)}{|\mathbf{r} - \mathbf{r}'|} dV'$$

$$t_r = t - \frac{|\mathbf{r} - \mathbf{r}'|}{c}$$

Name	**Symbol**	**Value**	**Unit**
Number π	π	3.14159265358979323846	
Number e	e	2.71828182845904523536	
Euler's constant	$\gamma=\lim\limits_{n\to\infty}\left(\sum\limits_{k=1}^{n}1/k-\ln(n)\right)=0.5772156649$		
Elementary charge	e	$1.60217733\cdot10^{-19}$	C
Gravitational constant	G,κ	$6.67259\cdot10^{-11}$	$\mathrm{m^3kg^{-1}s^{-2}}$
Fine-structure constant	$\alpha=e^2/2hc\varepsilon_0$	$\approx 1/137$	
Speed of light in vacuum	c	$2.99792458\cdot10^{8}$	m/s (def)
Permittivity of the vacuum	ε_0	$8.854187\cdot10^{-12}$	F/m
Permeability of the vacuum	μ_0	$4\pi\cdot10^{-7}$	H/m
$(4\pi\varepsilon_0)^{-1}$		$8.9876\cdot10^{9}$	$\mathrm{Nm^2C^{-2}}$
Planck's constant	h	$6.6260755\cdot10^{-34}$	Js
Dirac's constant	$\hbar=h/2\pi$	$1.0545727\cdot10^{-34}$	Js
Bohr magneton	$\mu_{\rm B}=e\hbar/2m_{\rm e}$	$9.2741\cdot10^{-24}$	$\mathrm{Am^2}$
Bohr radius	a_0	0.52918	Å
Rydberg's constant	Ry	13.595	eV
Proton Compton wavelength	$\lambda_{\rm Cp}=h/m_{\rm p}c$	$1.3214\cdot10^{-15}$	m
Reduced mass of the H-atom	$\mu_{\rm H}$	$9.1045755\cdot10^{-31}$	kg
Stefan-Boltzmann's constant	σ	$5.67032\cdot10^{-8}$	$\mathrm{Wm^{-2}K^{-4}}$
Wien's constant	$k_{\rm W}$	$2.8978\cdot10^{-3}$	mK
Molar gasconstant	R	8.31441	$\mathrm{J\cdot mol^{-1}\cdot K^{-1}}$
Avogadro's constant	$N_{\rm A}$	$6.0221367\cdot10^{23}$	$\mathrm{mol^{-1}}$
Boltzmann's constant	$k=R/N_{\rm A}$	$1.380658\cdot10^{-23}$	J/K
Electron mass	$m_{\rm e}$	$9.1093897\cdot10^{-31}$	kg
Proton mass	$m_{\rm p}$	$1.6726231\cdot10^{-27}$	kg
Neutron mass	$m_{\rm n}$	$1.674954\cdot10^{-27}$	kg
Elementary mass unit	$m_{\rm u}=\frac{1}{12}m(^{12}_{6}\mathrm{C})$	$1.6605656\cdot10^{-27}$	kg
Nuclear magneton	$\mu_{\rm N}$	$5.0508\cdot10^{-27}$	J/T
Diameter of the Sun	$D_\odot$	$1392\cdot10^{6}$	m
Mass of the Sun	$M_\odot$	$1.989\cdot10^{30}$	kg
Rotational period of the Sun	$T_\odot$	25.38	days
Radius of Earth	$R_{\rm A}$	$6.378\cdot10^{6}$	m
Mass of Earth	$M_{\rm A}$	$5.976\cdot10^{24}$	kg
Rotational period of Earth	$T_{\rm A}$	23.96	hours
Earth orbital period	Tropical year	365.24219879	days
Astronomical unit	AU	$1.4959787066\cdot10^{11}$	m
Light year	lj	$9.4605\cdot10^{15}$	m
Parsec	pc	$3.0857\cdot10^{16}$	m
Hubble constant	H	$\approx(75\pm25)$	$\mathrm{km\cdot s^{-1}\cdot Mpc^{-1}}$

The SI units

Basic units

Quantity	Unit	Sym.
Length	metre	m
Mass	kilogram	kg
Time	second	s
Therm. temp.	kelvin	K
Electr. current	ampere	A
Luminous intens.	candela	cd
Amount of subst.	mol	mol

Extra units

Plane angle	radian	rad
solid angle	sterradian	sr

Derived units with special names

Quantity	Unit	Sym.	Derivation
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$kg \cdot m \cdot s^{-2}$
Pressure	pascal	Pa	$N \cdot m^{-2}$
Energy	joule	J	$N \cdot m$
Power	watt	W	$J \cdot s^{-1}$
Charge	coulomb	C	$A \cdot s$
El. Potential	volt	V	$W \cdot A^{-1}$
El. Capacitance	farad	F	$C \cdot V^{-1}$
El. Resistance	ohm	Ω	$V \cdot A^{-1}$
El. Conductance	siemens	S	$A \cdot V^{-1}$
Mag. flux	weber	Wb	$V \cdot s$
Mag. flux density	tesla	T	$Wb \cdot m^{-2}$
Inductance	henry	H	$Wb \cdot A^{-1}$
Luminous flux	lumen	lm	$cd \cdot sr$
Illuminance	lux	lx	$lm \cdot m^{-2}$
Activity	bequerel	Bq	s^{-1}
Absorbed dose	gray	Gy	$J \cdot kg^{-1}$
Dose equivalent	sievert	Sv	$J \cdot kg^{-1}$

Prefixes

yotta	Y	10^{24}	giga	G	10^{9}	deci	d	10^{-1}	pico	p	10^{-12}
zetta	Z	10^{21}	mega	M	10^{6}	centi	c	10^{-2}	femto	f	10^{-15}
exa	E	10^{18}	kilo	k	10^{3}	milli	m	10^{-3}	atto	a	10^{-18}
peta	P	10^{15}	hecto	h	10^{2}	micro	μ	10^{-6}	zepto	z	10^{-21}
tera	T	10^{12}	deca	da	10	nano	n	10^{-9}	yocto	y	10^{-24}