

Physic formulary

School

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1 Constants[1]

Bohr radius	$a_0 = \frac{4\pi\epsilon_0\hbar^2}{m_e e^2} = \frac{\epsilon_0\hbar^2}{\pi m_e e^2} = \frac{\hbar}{m_e c \alpha} = 5.291\,772\,109\,03 \times 10^{-11} \text{ m}$
Velocity of light:	$c_0 = 299\,792\,458 \frac{\text{m}}{\text{s}}$
Elementary charge:	$e = 1.602\,176\,634 \times 10^{-19} \text{ C}$
Vacuum permittivity:	$\epsilon_0 = 8.854\,187\,812\,8 \times 10^{-12} \frac{\text{F}}{\text{m}}$
Permittivity of air:	$\epsilon_r = 1.000\,59$
Faraday constant	$F = 96\,485.332\,123\,3 \frac{\text{C}}{\text{mol}}$
Acceleration due to gravity:	$g = 9.806\,65 \frac{\text{m}}{\text{s}^2}$
Gravitational constant:	$G = 6.674\,30 \times 10^{-11} \frac{\text{m}^3}{\text{kg s}^2}$
Planck constant:	$h = 6.626\,070\,15 \times 10^{-34} \frac{\text{J}}{\text{Hz}}$
Boltzmann constant:	$k = 1.280\,649 \times 10^{-23} \frac{\text{J}}{\text{K}}$
Electron mass:	$m_e = 9.109\,383\,701\,5 \times 10^{-31} \text{ kg}$
	$m_e = 0.510\,998\,950\,00 \frac{\text{MeV}}{c_0^2}$
	$m_\mu = 1.883\,531\,627 \times 10^{-28} \text{ kg}$
Muon mass:	$m_\mu = 105.658\,375\,5 \frac{\text{MeV}}{c_0^2}$
	$m_\mu = 0.113\,428\,925\,9 \text{ Da}$
	$m_n = 1.674\,927\,498\,04 \times 10^{-27} \text{ kg}$
Neutron mass:	$m_n = 939.565\,420\,52 \frac{\text{MeV}}{c_0^2}$
	$m_p = 1.672\,621\,923\,69 \times 10^{-27} \text{ kg}$
Proton mass:	$m_p = 938.272\,088\,16 \frac{\text{MeV}}{c_0^2}$
	$\mu_0 = 1.256\,637\,062\,12 \times 10^{-6} \frac{\text{H}}{\text{m}}$
Vacuum permeability:	
Permeability of air:	$\mu_r = 1.000\,000\,37$

2 Other physical interrelationships

Visible spectrum:	380 nm to 750 nm	
Speed of sound under standart conditions:	$343 \frac{\text{m}}{\text{s}}$	
Dalton Da / unified atomic mass unit u:	Da/u	= $1.660\,539\,066\,60 \times 10^{-27} \text{ kg}$
Hydrogen mass:	m_{H}	= 1.007 84 Da to 1.008 11 Da
Atomic mass of helium ^4He	m_{He}	= 4.002 603 254 Da
Kilowatt-hour:	kW h	= $3.6 \times 10^6 \text{ J}$
Kilowatt-hour:	eV	= $1.602\,176\,634 \times 10^{-19} \text{ J}$
Pressure:	1 Pa	= $1 \frac{\text{N}}{\text{m}^2}$
Pressure:	1 bar	= 10^5 Pa
Absolute zero:	-273.15°C	= 0 K

3 Energy

Kinetic Energy

$$E_k = \frac{1}{2}mv^2$$

Potential Energy

$$U = mgh \quad (\text{gravitational})$$

$$U = \frac{1}{2} \cdot k \cdot x^2 \quad (\text{elastic})$$

$$U = \frac{1}{2} \cdot C \cdot V^2 \quad (\text{electric})$$

$$U = -mB \quad (\text{magnetic})$$

$$U = \int F(r) dr \quad (\text{general})$$

4 Motion

uniform linear motion

$$s(t) = vt \ (+s_0)$$

$$v(t) = \text{const.}$$

$$a(t) = 0$$

non-uniform linear motion

$$s(t) = \frac{1}{2}at^2 \ (+v_0 t + s_0)$$

$$v(t) = at \ (+v_0)$$

$$a(t) = \text{const.}$$

Circular motion

$$F_z = \frac{mv^2}{r} = m\omega^2 r$$

$$\omega = \frac{v}{r} = \frac{2\pi}{T} = \frac{\Delta\varphi}{\Delta t} \quad \varphi \text{ in rad}$$

$$f = \frac{1}{T}$$

5 Momentum

momentum itself		
$\vec{p} = m\vec{v}$		
$\vec{p} = \frac{h}{\lambda}$		photons
$\vec{p} = \sqrt{m_0^2 c_0^2 + \frac{E^2}{c_0^2}}$		general
relations to momentum		
$\sum_i m_i u_i = \sum_i m_i v_i$		conservation of momentum
$\Delta p = F \Delta t$		
$E_k = \int p dv$		

6 Electricity

General		
$I = \frac{\Delta Q}{\Delta t} = \frac{\partial Q}{\partial t} = \dot{Q}$		in A
$R = \frac{U}{I} = \rho \frac{l}{A}$		in Ω
$E = U \cdot Q$		
$P = \frac{\Delta E}{\Delta t} = UI$		in W Energy flow / "Power"

7 Fields

7.1 Newtonian gravitation

Homogeneous field

$$\begin{aligned}
 E &= mgh \\
 \vec{F}_g &= m\vec{g} \\
 \vec{g} &= \frac{\vec{F}_g}{m} \\
 \Delta\varphi &= \frac{E}{m} = gh
 \end{aligned}$$

Radial symmetric field

$$\begin{aligned}
 U &= GMm \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \\
 U &= -GMm \frac{1}{r} && \text{for } r_1 \rightarrow \infty \\
 \vec{F}_g &= -G \frac{Mm}{r^2} \hat{r} \\
 \vec{g} &= \frac{\vec{F}_g}{m} = -G \frac{M}{r^2} \hat{r} \\
 \Delta\varphi &= \frac{E}{m} = \gamma M \left(\frac{1}{r_1} - \frac{1}{r_2} \right)
 \end{aligned}$$

7.2 Electromagnetism

homogenous field

$$\begin{aligned}
 E &= q\vec{\mathbf{E}}d \\
 \vec{F} &= q\vec{\mathbf{E}} \\
 \vec{\mathbf{E}} &= \frac{\vec{F}}{q} \\
 \mathbf{E} &= \frac{V}{d} \\
 V &= \frac{E}{q} = \vec{\mathbf{E}}d
 \end{aligned}$$

Radial symetric field

$$\begin{aligned}
 U &= -\frac{1}{4\pi\epsilon_0\epsilon_r} Qq \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \\
 U &= \frac{Qq}{4\pi\epsilon_0} \frac{1}{r} && \text{for } r_1 \rightarrow \infty \\
 \vec{F} &= \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{Qq}{r^2} \hat{r} \\
 \mathbf{E} &= \frac{\vec{F}}{q} = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{Q}{r^2} \hat{r} \\
 \epsilon_0 &= \frac{\sigma}{\epsilon_r \mathbf{E}} && \text{const.}
 \end{aligned}$$

8 Units[2]

Derived quantity	Name	In terms of other SI units	Dimensions
electric charge, quantity of electricity	coulomb	$C = s A$	$T I$
capacitance	farad	$F = \frac{s^4 A^2}{m^2 kg}$	$T^4 L^{-2} M^{-1} I^2$
inductance	henry	$H = \frac{m^2 kg}{s^2 A^2}$	$T^{-2} L^2 M I^{-1}$
frequency	hertz	$Hz = \frac{1}{s}$	T^{-1}
energy, work, quantity of heat	joule	$J = \frac{m^2 kg}{s^2}$	$T^{-2} L^2 M$
force	newton	$N = \frac{m kg}{s^2}$	$T^{-2} L M$
electric resistance	ohm	$\Omega = \frac{m^2 kg A^2}{s^3}$	$T^{-3} L^2 M I^{-2}$
pressure, stress	pascal	$Pa = \frac{N}{m} = \frac{kg}{s^2 m}$	$T^{-2} L^{-1} M$
plane angle	radian	$rad = \frac{m}{m}$	
magnetic flux	weber	$T = \frac{Wb}{m^2} = \frac{kg}{s^2 A}$	$T^{-2} M I^{-1}$
electric potential difference, electromotive force	volt	$V = \frac{W}{A} = \frac{kg m^2}{s^3 A}$	$T^{-3} L^2 M I^{-1}$
power, radiant flux	watt	$W = \frac{J}{s} = \frac{m^2 kg}{s^3}$	$T^{-3} L^2 M$

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Bibliography

1. CODATA Internationally recommended 2018 values of the Fundamental Physical Constants. May 2019. <https://physics.nist.gov/cuu/Constants/index.html> (2022).
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