Physic formulary

School

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Contents

1 Constants[1]

Bohr radius	$a_0 = \frac{4\pi\varepsilon_0\hbar^2}{m_e e^2} = \frac{\varepsilon_0 h^2}{\pi m_e e^2} = \frac{\hbar}{m_e c\alpha} = 5.291\,772\,109\,03 \times 10^{-11}\,\mathrm{m}$
Velocity of light:	$c_0 = 299\,792\,458\,\frac{\mathrm{m}}{\mathrm{s}}$
Elementary charge:	$e = 1.602\,176\,634 \times 10^{-19}\,\mathrm{C}$
Vacuum permittivity:	$\varepsilon_0 = 8.854\,187\,812\,8 \times 10^{-12}\,\frac{\mathrm{F}}{\mathrm{m}}$
Permittivity of air:	$\varepsilon_r = 1.000\,59$
Faraday constant	$F = 96\,485.332\,123\,3\,\frac{\mathrm{C}}{\mathrm{mol}}$
Acceleration due to gravity:	$g = 9.806\,65\,\frac{\mathrm{m}}{\mathrm{s}^2}$
Gravitational constant:	$G = 6.674\,30 \times 10^{-11}\,\frac{\mathrm{m}^3}{\mathrm{kg\,s}^2}$
Planck constant:	$h = 6.626\,070\,15 \times 10^{-34}\,\frac{\mathrm{J}}{\mathrm{Hz}}$
Boltzmann constant:	$k = 1.280\,649 \times 10^{-23}\,\frac{\mathrm{J}}{\mathrm{K}}$
Electron mass:	$m_e = 9.109\,383\,701\,5 \times 10^{-31}\,\mathrm{kg}$
	$m_e = 0.510\,998\,950\,00\,\frac{\mathrm{MeV}}{{c_0}^2}$
Muon mass:	$m_\mu = 1.883\,531\,627 \times 10^{-28}\,\mathrm{kg}$
	$m_\mu = 105.658\,375\,5\,\frac{\mathrm{MeV}}{{c_0}^2}$
	$m_\mu = 0.113\,428\,925\,9\,\mathrm{Da}$
Neutron mass:	$m_n = 1.674\,927\,498\,04 \times 10^{-27}\,\mathrm{kg}$
	$m_n = 939.565\,420\,52\,\frac{\mathrm{MeV}}{{c_0}^2}$
Proton mass:	$m_p = 1.672\,621\,923\,69 \times 10^{-27}\,\mathrm{kg}$
	$m_p = 938.272\,088\,16\,\frac{\mathrm{MeV}}{{c_0}^2}$
Vacuum permeability:	$\mu_0 = 1.256\,637\,062\,12 \times 10^{-6}\,\frac{\mathrm{H}}{\mathrm{m}}$
Permeability of air:	$\mu_r = 1.000\,000\,37$

2 Other physical interrelationships

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

3 Energy

Kinetic Energy	
$E_{\text{k}} = \frac{1}{2}mv^2$	
Potential Energy	
$U = mgh$	(gravitational)
$U = \frac{1}{2} \cdot k \cdot x^2$	(elastic)
$U = \frac{1}{2} \cdot C \cdot V^2$	(electric)
$U = -mB$	(magnetic)
$U = \int F(r)\,\partial r$	(general)

4 Motion

uniform linear motion	
$s(t) = vt\ (+s_0\,)$	
$v(t) = const.$	
$a(t) = 0$	
non-uniform linear motion	
$s(t) = \frac{1}{2}at^2\,(+v_0\,t + s_0\,)$	
$v(t) = at\ (+v_0\,)$	
$a(t) = const.$	
circular motion	
$F_{\text{Z}} = \frac{mv^2}{r} = m\,\omega^2 r$	
$\omega = \frac{v}{r} = \frac{2\pi}{T} = \frac{\Delta\varphi}{\Delta t}$	φ in rad
$f = \frac{1}{T}$	

5 Momentum

momentum itself	
$\vec{p} = m\vec{v}$	
$\vec{p} = \frac{\hbar}{\lambda}$	photons
$\vec{p} = \sqrt{m_0^2 \mathrm{c_0}^2 + \frac{E^2}{\mathrm{c_0}^2}}$	general

relations to momentum	
$\sum_i m_i\, u_i = \sum_i m_i\, v_i$	conservation of momentum
$\Delta p = F \Delta t$	
$E_{\mathtt{k}} = \int p\, \partial v$	

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

Radial symmetric field	
$U = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$	
$U = -GMm\frac{1}{r}$	for $r_1 \to \infty$
$\vec{F}_g = -G\frac{Mm}{r^2}\hat{r}$	
$\vec{g} = \frac{\vec{F}_g}{m} = -G\frac{M}{r_2}\hat{r}$	
$\Delta\varphi = \frac{E}{m} = \gamma M\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$	

7.2 Electromagnetism

homogenous field
$E = q\vec{\mathbf{E}}d$
$\vec{F} = q\vec{\mathbf{E}}$
$\vec{\mathbf{E}} = \frac{\vec{F}}{q}$
$\mathbf{E} = \frac{V}{d}$
$V = \frac{E}{q} = \vec{\mathbf{E}}d$

Radial symetric field	
$U = -\frac{1}{4\pi\varepsilon_0\varepsilon_r}Qq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$	
$U = \frac{Qq}{4\pi\varepsilon_0}\frac{1}{r}$	for $r_1 \to \infty$
$\vec{F} = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{Qq}{r^2}\hat{r}$	
$\mathbf{E} = \frac{\vec{F}}{q} = \frac{1}{4\pi\varepsilon_0\varepsilon r}\frac{Q}{r^2}\hat{r}$	
$\varepsilon_0 = \frac{\sigma}{\varepsilon_r\mathbf{E}}$	const.

Capacitor	
$C = \frac{Q}{V} = \varepsilon_0 \varepsilon_r \frac{A}{d}$	Capcitance
$E = \frac{1}{2} C U^2$	Energy of Capacitor
$E = \frac{1}{2} \varepsilon_0 \varepsilon_r V \vec{\mathbf{E}}^2$	
$Q(t) = Q_0 e^{-\frac{1}{RC} t}$	Charge at time t, while charging
$I(t) = -\frac{Q_0}{RC} e^{-\frac{1}{RC} t}$	Current at time t, while charging
$I(t) = -I_0 e^{-\frac{1}{RC} t}$	
$V(t) = \frac{Q_0}{C} e^{-\frac{1}{RC} t}$	Voltage at time t, while charging
$V(t) = V_0 e^{-\frac{1}{RC} t}$	

Coil	
$L = \frac{\Phi}{I} = -\mu_0 \mu_r \frac{n^2 A}{l}$	Inductance
$\mathcal{E} = -L\dot{I}$	Induced Voltage
$B = \mu_0 \mu_r \frac{n}{l} I$	Magnetic flux density inside a coil
$V_L = -n\dot{\Phi}$	Electric potential of a coil when the magnetic field or the area interfused by the field changes
$V_L = V_0 e^{-\frac{R}{L} t}$	Electric potential of a coil when direct current is switched on
$V_R = V_0 \left(1 - e^{-\frac{R}{L} t}\right)$	Electric potential of an ohmic resistance when direct current is switched on
$V_L = -V_0 e^{-\frac{R}{L} t}$	Electric potential of a coil when direct current is switched off
$V_R = V_0 e^{-\frac{R}{L} t}$	Electric potential of an ohmic resistance when direct current is switched off

8 Units[2]

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

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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).
2. International System of Units (SI). https://physics.nist.gov/cuu/Units/units.html (2022).