45th International Physics Olympiad
Astana, Kazakhstan
Theoretical Competition, Tuesday, 15 July 2014

List of fundamental constants

Speed of light in vacuum	$c = 299792458\ m \cdot s^{-1}$
Gravitational constant	$G = 6.67 \cdot 10^{-11}\ m^3 \cdot kg^{-1} \cdot s^{-2}$
Free fall acceleration	$g = 9.81\ m \cdot s^{-2}$
Avogadro constant	$N_A = 6.02 \cdot 10^{23}\ mol^{-1}$
Universal gas constant	$R = 8.31\ J \cdot K^{-1} \cdot mol^{-1}$
Boltzmann constant	$k = 1.38 \cdot 10^{-23}\ J \cdot K^{-1}$
Elementary charge	$e = 1.60 \cdot 10^{-19}\ C$
Electron rest mass	$m_e = 9.11 \cdot 10^{-31}\ kg$
Proton rest mass	$m_p = 1.67 \cdot 10^{-27}\ kg$
Reduced Planck constant	$\hbar = 1.05 \cdot 10^{-34}\ J \cdot s$
Permittivity of vacuum	$\varepsilon_0 = 8.85 \cdot 10^{-12}\ F \cdot m^{-1}$
Permeability of vacuum	$\mu_0 = 1.26 \cdot 10^{-6}\ H \cdot m^{-1}$

Useful mathematical formulas

$(1+x)^\alpha \approx 1 + \alpha x + \frac{1}{2}\alpha(\alpha-1)x^2$, where $|x| \ll 1$ and α being an arbitrary constant

$$\sin x \approx x - \frac{x^3}{3}, \text{ where } |x| \ll 1$$

$$\cos x \approx 1 - \frac{1}{2}x^2, \text{ where } |x| \ll 1$$

$\int x^n dx = \frac{x^{n+1}}{n+1} + C$, $n \neq -1$, with C being an arbitrary constant

$\int \frac{dx}{x-a} = \log|x-a| + C$, with C being an arbitrary constant

$$\cosh x = \frac{e^x + e^{-x}}{2}$$

$$\sinh x = \frac{e^x - e^{-x}}{2}$$

$$\cosh^2 x - \sinh^2 x = 1$$

$$\tanh x = \frac{\sinh x}{\cosh x}$$

$$(e^x)' = e^x$$

$$(\log x)' = \frac{1}{x}$$

$$(x^n)' = nx^{n-1}$$

$$u_t\big(x(t)\big) = u_x\big(x(t)\big)x_t(t)$$

$$\big(u(x)v(x)\big)' = u(x)'v(x) + u(x)v(x)'$$

$$\left(\frac{u(x)}{v(x)}\right)' = \frac{u(x)'v(x) - u(x)v(x)'}{v(x)^2}$$