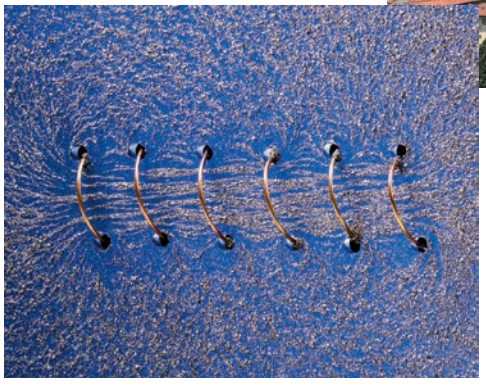
GLOBAL EDITION

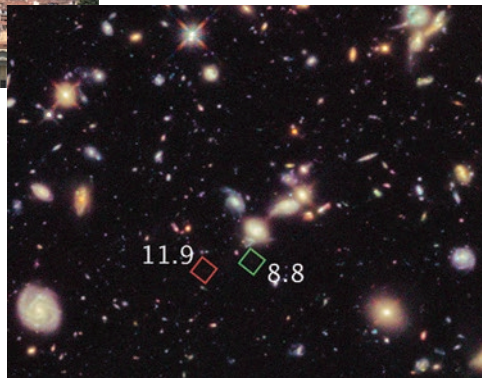
5th EDITION

PHYSICS

for SCIENTISTS and ENGINEERS

with Modern Physics





DOUGLAS
GIANCOLI

Fundamental Constants

Quantity	Symbol	Approximate Value	Current Best Value[†]
Speed of light in vacuum	c	3.00×10^8 m/s	2.99792458×10^8 m/s
Gravitational constant	G	6.67×10^{-11} N · m^2/kg^2	$6.67430(15) \times 10^{-11}$ N · m^2/kg^2
Avogadro's number	N_A	6.02×10^{23} mol^{-1}	$6.02214076 \times 10^{23}$ mol^{-1}
Gas constant	R	8.314 J/mol · K = 1.99 cal/mol · K = 0.0821 L · atm/mol · K	8.314462618 J/mol · K
Boltzmann's constant	k	1.38×10^{-23} J/K	1.380649×10^{-23} J/K
Charge on electron	e	1.60×10^{-19} C	$1.602176634 \times 10^{-19}$ C
Stefan-Boltzmann constant	σ	5.67×10^{-8} W/m^2 · K^4	$5.670374419 \times 10^{-8}$ W/m^2 · K^4
Permittivity of free space	ϵ_0	8.85×10^{-12} C^2/N · m^2	$8.8541878128(13) \times 10^{-12}$ C^2/N · m^2
Permeability of free space	μ_0	1.26×10^{-6} T · m/A	$1.25663706212(19) \times 10^{-6}$ T · m/A
Planck's constant	h	6.63×10^{-34} J · s	$6.62607015 \times 10^{-34}$ J · s
Electron rest mass	m_e	9.11×10^{-31} kg = 0.000549 u = 0.511 MeV/c^2	$9.1093837015(28) \times 10^{-31}$ kg = $5.48579909065(16) \times 10^{-4}$ u
Proton rest mass	m_p	1.6726×10^{-27} kg = 1.00728 u = 938.27 MeV/c^2	$1.67262192369(51) \times 10^{-27}$ kg = 1.007276466621(53) u
Neutron rest mass	m_n	1.6749×10^{-27} kg = 1.008665 u = 939.57 MeV/c^2	$1.67492749804(95) \times 10^{-27}$ kg = 1.00866491595(49) u
Atomic mass unit (1 u)		1.6605×10^{-27} kg = 931.49 MeV/c^2	$1.66053906660(50) \times 10^{-27}$ kg = 931.49410242(28) MeV/c^2

[†]Numbers in parentheses indicate one-standard-deviation experimental uncertainties in final digits (2019, new SI). Values without parentheses are exact (i.e., defined quantities).

Other Useful Data

Joule equivalent (1 cal)	4.186 J
Absolute zero (0 K)	−273.15°C
Acceleration due to gravity at Earth's surface (avg.)	9.80 m/s^2 (= g)
Speed of sound in air (20°C)	343 m/s
Density of air (dry)	1.29 kg/m^3
Earth: Mass	5.98×10^{24} kg
Radius (mean)	6.38×10^3 km
Moon: Mass	7.35×10^{22} kg
Radius (mean)	1.74×10^3 km
Sun: Mass	1.99×10^{30} kg
Radius (mean)	6.96×10^5 km
Earth–Sun distance (mean)	149.60×10^6 km
Earth–Moon distance (mean)	384×10^3 km

The Greek Alphabet

Alpha	A	α	Nu	N	ν
Beta	B	β	Xi	Ξ	ξ
Gamma	Γ	γ	Omicron	O	o
Delta	Δ	δ	Pi	Π	π
Epsilon	E	ϵ, ε	Rho	P	ρ
Zeta	Z	ζ	Sigma	Σ	σ
Eta	H	η	Tau	T	τ
Theta	Θ	θ	Upsilon	Υ	υ
Iota	I	ι	Phi	Φ	ϕ, φ
Kappa	K	κ	Chi	X	χ
Lambda	Λ	λ	Psi	Ψ	ψ
Mu	M	μ	Omega	Ω	ω

Values of Some Numbers

$\pi = 3.1415927$	$\sqrt{2} = 1.4142136$	$\ln 2 = 0.6931472$	$\log_{10} e = 0.4342945$
$e = 2.7182818$	$\sqrt{3} = 1.7320508$	$\ln 10 = 2.3025851$	1 rad = 57.2957795°

Mathematical Signs and Symbols

$\propto$	is proportional to	$\leq$	is less than or equal to
$=$	is equal to	$\geq$	is greater than or equal to
$\approx$	is approximately equal to	$\sum$	sum of
$\neq$	is not equal to	$\bar{x}$	average value of x
$>$	is greater than	Δx	change in x
$\gg$	is much greater than	$\Delta x \to 0$	Δx approaches zero
$<$	is less than	$n!$	$n(n-1)(n-2) \ldots (1)$
$\ll$	is much less than		

Properties of Water

Density (4°C)	1.000×10^3 kg/m^3
Heat of fusion (0°C)	334 kJ/kg (79.8 kcal/kg)
Heat of vaporization (100°C)	2260 kJ/kg (539.9 kcal/kg)
Specific heat (15°C)	4186 J/kg · C° (1.00 kcal/kg · C°)
Index of refraction	1.33

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Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents