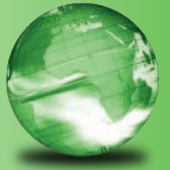


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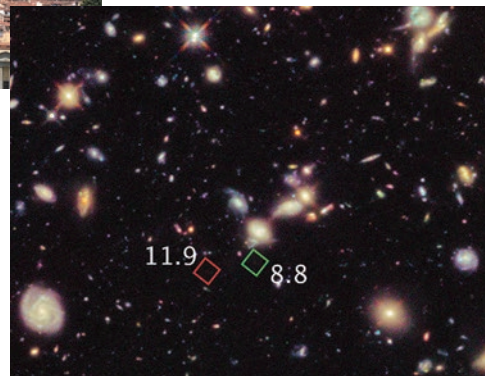
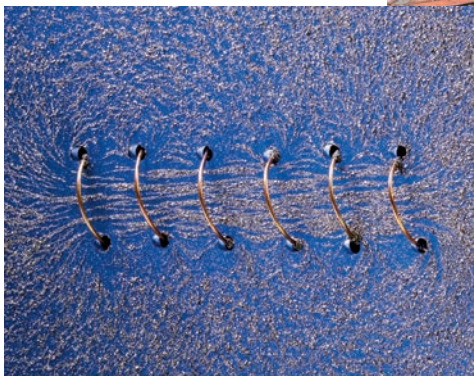


5th EDITION

# PHYSICS

for SCIENTISTS and ENGINEERS

with Modern Physics



DOUGLAS  
GIANCOLI



Fundamental Constants			
Quantity	Symbol	Approximate Value	Current Best Value <sup>†</sup>
Speed of light in vacuum	$c$	$3.00 \times 10^8$ m/s	$2.99792458 \times 10^8$ m/s
Gravitational constant	$G$	$6.67 \times 10^{-11}$ N · m <sup>2</sup> /kg <sup>2</sup>	$6.67430(15) \times 10^{-11}$ N · m <sup>2</sup> /kg <sup>2</sup>
Avogadro's number	$N_A$	$6.02 \times 10^{23}$ mol <sup>-1</sup>	$6.02214076 \times 10^{23}$ mol <sup>-1</sup>
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	$k$	$1.38 \times 10^{-23}$ J/K	$1.380649 \times 10^{-23}$ J/K
Charge on electron	$e$	$1.60 \times 10^{-19}$ C	$1.602176634 \times 10^{-19}$ C
Stefan-Boltzmann constant	$\sigma$	$5.67 \times 10^{-8}$ W/m <sup>2</sup> · K <sup>4</sup>	$5.670374419 \times 10^{-8}$ W/m <sup>2</sup> · K <sup>4</sup>
Permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}$ C <sup>2</sup> /N · m <sup>2</sup>	$8.8541878128(13) \times 10^{-12}$ C <sup>2</sup> /N · m <sup>2</sup>
Permeability of free space	$\mu_0$	$1.26 \times 10^{-6}$ T · m/A	$1.25663706212(19) \times 10^{-6}$ T · m/A
Planck's constant	$h$	$6.63 \times 10^{-34}$ J · s	$6.62607015 \times 10^{-34}$ J · s
Electron rest mass	$m_e$	$9.11 \times 10^{-31}$ 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	$m_p$	$1.6726 \times 10^{-27}$ kg = $1.00728$ u = $938.27$ MeV/ $c^2$	$1.67262192369(51) \times 10^{-27}$ kg = $1.007276466621(53)$ u
Neutron rest mass	$m_n$	$1.6749 \times 10^{-27}$ 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)		$1.6605 \times 10^{-27}$ kg = $931.49$ MeV/ $c^2$	$1.66053906660(50) \times 10^{-27}$ kg = $931.49410242(28)$ MeV/ $c^2$

<sup>†</sup>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		The Greek Alphabet					
Joule equivalent (1 cal)	4.186 J	Alpha	A	$\alpha$	Nu	N	$\nu$
Absolute zero (0 K)	-273.15°C	Beta	B	$\beta$	Xi	$\Xi$	$\xi$
Acceleration due to gravity at Earth's surface (avg.)	9.80 m/s <sup>2</sup> (= $g$ )	Gamma	$\Gamma$	$\gamma$	Omicron	O	$o$
Speed of sound in air (20°C)	343 m/s	Delta	$\Delta$	$\delta$	Pi	$\Pi$	$\pi$
Density of air (dry)	1.29 kg/m <sup>3</sup>	Epsilon	E	$\epsilon, \varepsilon$	Rho	P	$\rho$
Earth: Mass	$5.98 \times 10^{24}$ kg	Zeta	Z	$\zeta$	Sigma	$\Sigma$	$\sigma$
Radius (mean)	$6.38 \times 10^3$ km	Eta	H	$\eta$	Tau	T	$\tau$
Moon: Mass	$7.35 \times 10^{22}$ kg	Theta	$\Theta$	$\theta$	Upsilon	Y	$\upsilon$
Radius (mean)	$1.74 \times 10^3$ km	Iota	I	$\iota$	Phi	$\Phi$	$\phi, \varphi$
Sun: Mass	$1.99 \times 10^{30}$ kg	Kappa	K	$\kappa$	Chi	X	$\chi$
Radius (mean)	$6.96 \times 10^5$ km	Lambda	$\Lambda$	$\lambda$	Psi	$\Psi$	$\psi$
Earth–Sun distance (mean)	$149.60 \times 10^6$ km	Mu	M	$\mu$	Omega	$\Omega$	$\omega$
Earth–Moon distance (mean)	$384 \times 10^3$ km						

Values of Some Numbers			
$\pi = 3.1415927$	$\sqrt{2} = 1.4142136$	$\ln 2 = 0.6931472$	$\log_{10} e = 0.4342945$
$e = 2.7182818$	$\sqrt{3} = 1.7320508$	$\ln 10 = 2.3025851$	$1 \text{ rad} = 57.2957795^\circ$

Mathematical Signs and Symbols				Properties of Water	
$\propto$	is proportional to	$\leq$	is less than or equal to	Density (4°C)	$1.000 \times 10^3$ kg/m <sup>3</sup>
$=$	is equal to	$\geq$	is greater than or equal to	Heat of fusion (0°C)	334 kJ/kg (79.8 kcal/kg)
$\approx$	is approximately equal to	$\Sigma$	sum of	Heat of vaporization (100°C)	2260 kJ/kg (539.9 kcal/kg)
$\neq$	is not equal to	$\bar{x}$	average value of $x$	Specific heat (15°C)	4186 J/kg · C° (1.00 kcal/kg · C°)
$>$	is greater than	$\Delta x$	change in $x$	Index of refraction	1.33
$\gg$	is much greater than	$\Delta x \rightarrow 0$	$\Delta x$ approaches zero		
$<$	is less than	$n!$	$n(n-1)(n-2) \dots (1)$		
$\ll$	is much less than				

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