Physics Reference Tables[1]

Contents:

Table A. Metric Prefixes

Factor		Prefix	Symbol
1 000 000 000 000 000 000 000 000	10^{24}	yotta	Y
1 000 000 000 000 000 000 000	10^{21}	zeta	Z
1 000 000 000 000 000 000	10^{18}	exa	E
1 000 000 000 000 000	10^{15}	peta	P
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^{9}	giga	G
1 000 000	10^{6}	mega	M
1 000	10^{3}	kilo	k
100	10^{2}	hecto	h
10	10^{1}	deca	da
1	10^{0}	—	—
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	μ
0.000 000 001	10^{-9}	nano	n
0.000 000 000 001	10^{-12}	pico	p
0.000 000 000 000 001	10^{-15}	femto	f
0.000 000 000 000 000 001	10^{-18}	atto	a
0.000 000 000 000 000 000 001	10^{-21}	zepto	z
0.000 000 000 000 000 000 000 001	10^{-24}	yocto	y

[1] some data from: The University of the State of New York, The State Education Department. Albany, NY: Reference Tables for Physical Setting/Physics, 2006 Edition.
http://www.p12.nysed.gov/apda/reftable/physics-rt/physics06tbl.pdf
and SparkNotes: SAT Physics website. http://www.sparknotes.com/testprep/books/sat2/physics/

Table B. Physical Constants

Description	Symbol	More Precise Value	Rounded Value
universal gravitational constant	G	$6.673\,84 \times 10^{-11}\ \frac{\text{N·m}^2}{\text{kg}^2}$	$6.67 \times 10^{-11}\ \frac{\text{N·m}^2}{\text{kg}^2}$
acceleration due to gravity at sea level	g	$9.806\,65\ \frac{\text{m}}{\text{s}^2}$	$9.8\ \frac{\text{m}}{\text{s}^2}$
speed of light in a vacuum	c	$299\,792\,458\ \frac{\text{m}}{\text{s}}$	$3.00 \times 10^{8}\ \frac{\text{m}}{\text{s}}$
mass of the Earth	$m_{\oplus}$	5.9722×10^{24} kg	6.0×10^{24} kg
mass of the Moon	$m_{☽}$	7.3477×10^{22} kg	7.3×10^{22} kg
mean radius of the Earth	$r_{\oplus}$	6.371×10^{6} m	6.4×10^{6} m = 6 400 km
mean radius of the Moon	$r_{☽}$	1.737×10^{6} m	1.7×10^{6} m = 1 700 km
mean distance from Earth to Moon	$d_{\oplus ☽}$	3.844×10^{8} m	3.8×10^{8} m = 380 000 km
mean distance from Earth to Sun	$d_{\oplus \odot}$	1.496×10^{11} m	1.5×10^{11} m = 150 000 000 km
electrostatic constant	k	$8.987\,552 \times 10^{9}\ \frac{\text{N·m}^2}{\text{C}^2}$	$8.99 \times 10^{9}\ \frac{\text{N·m}^2}{\text{C}^2}$
elementary charge	e	$1.602\,176 \times 10^{-19}$ C	1.6×10^{-19} C
1 coulomb (C)		$6.241\,510 \times 10^{18}$ elementary charges	6.24×10^{18} elementary charges
1 electron volt (eV)		$1.602\,176 \times 10^{-19}$ J	1.6×10^{-19} J
Planck's constant	h	$6.626\,068 \times 10^{-34}$ J·s	6.6×10^{-34} J·s
1 universal mass unit (u)		931.494 MeV	931 MeV
Avogadro's constant	N_A	$6.022\,141 \times 10^{23}\ \text{mol}^{-1}$	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Boltzmann's constant	k_B	$1.380\,650 \times 10^{-23}\ \frac{\text{J}}{\text{K}}$	$1.38 \times 10^{-23}\ \frac{\text{J}}{\text{K}}$
gas constant	R	$8.314\,462\ \frac{\text{J}}{\text{mol·K}}$	$8.31\ \frac{\text{J}}{\text{mol·K}}$
standard atmospheric pressure at sea level		101 325 Pa ≡ 1.01325 bar	100 000 Pa ≡ 1.0 bar
rest mass of the electron	m_e	$9.109\,382 \times 10^{-31}$ kg	9.11×10^{-31} kg
rest mass of the proton	m_p	$1.672\,622 \times 10^{-27}$ kg	1.67×10^{-27} kg
rest mass of the neutron	m_n	$1.674\,927 \times 10^{-27}$ kg	1.67×10^{-27} kg

Table C. Approximate Coëfficients of Friction

Substance	Static (μ_s)	Kinetic (μ_k)	Substance	Static (μ_s)	Kinetic (μ_k)
rubber on concrete (dry)	0.90	0.68	wood on wood (dry)	0.25–0.5	0.30
rubber on concrete (wet)		0.58	wood on wood (wet)	0.2	
rubber on asphalt (dry)	0.85	0.67	wood on metal	0.3	
rubber on asphalt (wet)		0.53	wood on brick	0.6	
rubber on ice		0.15	wood on concrete	0.62	
steel on ice	0.03	0.01	Teflon on Teflon	0.04	
waxed ski on snow	0.14	0.05	Teflon on steel	0.04	
aluminum on aluminum	1.35		graphite on steel	0.1	
cast iron on cast iron	0.15	1.05	leather on wood	0.3–0.4	
steel on steel	0.57	0.74	leather on metal (dry)	0.6	
copper on steel	0.36	0.53	leather on metal (wet)	0.4	
diamond on diamond	0.1		glass on glass	0.9–1.0	0.4
diamond on metal	0.1–0.15		metal on glass	0.5–0.7	

Table D. Quantities, Variables and Units

Quantity	Variable	Unit Name	Unit	SI Equivalent
distance, length, height	d, λ, h	meter*	m	m
angle	θ	radian, degree	—, °	—
area	A	square metre	m^2	m^2
volume	V	cubic meter, liter	m^3, λ, L	m^3
time	t	second*	s	s
velocity	$\vec{v}$			
speed	s	meter/second	$\frac{m}{s}$	$\frac{m}{s}$
speed of light	c			
angular velocity	$\vec{u}$	radians/second	$\frac{1}{s}$	$\frac{1}{s}$
acceleration	$\vec{a}$	meter/second^2	$\frac{m}{s^2}$	$\frac{m}{s^2}$
acceleration due to gravity	$\vec{g}$			
mass	m	kilogram*	kg	kg
force	$\vec{F}$	newton	N	$\frac{kg\cdot m}{s^2}$
pressure	P	pascal	Pa	$\frac{kg}{m\cdot s^2}$
energy	E			
potential energy	U	joule	J	$\frac{kg\cdot m^2}{s^2}$
heat	Q			
work	W	newton-meter , joule	N·m , J	$\frac{kg\cdot m^2}{s^2}$
torque	$\vec{o}$	newton-meter	N·m	$\frac{kg\cdot m^2}{s^2}$
power	P	watt	W	$\frac{kg\cdot m^2}{s^3}$
momentum	$\vec{p}$	newton-second	N·s	$\frac{kg\cdot m}{s}$
impulse	$\vec{J}$			
moment of inertia	I	kilogram-meter^2	$kg\cdot m^2$	$kg\cdot m^2$
angular momentum	$\vec{L}$	newton-meter-second	N·m·s	$\frac{kg\cdot m^2}{s}$
frequency	f	hertz	Hz	s^{-1}
wavelength	λ	meter	m	m
period	T	second	s	s
index of refraction	n	—	—	—
electric current	$\vec{I}$	ampere*	A	A
electric charge	q	coulomb	C	A·s
electric potential	V	volt	V	$\frac{kg\cdot m^2}{A\cdot s^3}$
electrical resistance	R	ohm	Ω	$\frac{kg\cdot m^2}{A^2\cdot s^3}$
capacitance	C	farad	F	$\frac{A^2\cdot s^4}{m^2\cdot kg}$
electric field	$\vec{E}$	netwon/coulomb volt/meter	$\frac{N}{C}$, $\frac{V}{m}$	$\frac{kg\cdot m}{A\cdot s^3}$
magnetic field	$\vec{B}$	tesla	T	$\frac{kg}{A\cdot s^2}$
temperature	T	kelvin*	K	K
amount of substance	n	mole*	mol	mol
luminous intensity	I_v	candela*	cd	cd

* denotes S.I base unit

Table E. Mechanics Formulas and Equations

Kinematics (Distance, Velocity & Acceleration)	$\vec{d} = \Delta x = x - x_0$ $\vec{v} = \frac{\vec{d}}{t} = \frac{\Delta x}{t}$ $\Delta \vec{v} = \vec{v} - \vec{v}_0 = \vec{a}t$ $x - x_0 = \vec{d} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$ $\vec{v}^2 - \vec{v}_0^2 = 2\vec{a}d$
Forces & Dynamics	$\vec{F} = m\vec{a}$ $\vec{F}_g = m\vec{g}$ $F_g = \frac{Gm_1 m_2}{d^2}$ $F_f = \mu F_N$
Circular and Simple Harmonic Motion	$\vec{F}_s = -k\vec{x}$ $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$ $U_{spring} = \frac{1}{2}kx^2$ $T_{pendulum} = 2\pi\sqrt{\frac{L}{g}}$ $a_c = \frac{v^2}{r} = \omega^2 r$ $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $F_c = ma_c = \frac{mv^2}{r}$ $\vec{\tau} = \vec{r} \times \vec{F}$ $\tau = rF\sin\theta$
Momentum	$\vec{p} = m\vec{v}$ $\Sigma m_i \vec{v}_i = \Sigma m_f \vec{v}_f$ $\vec{J} = \Delta\vec{p} = \vec{F}_{net}\Delta t$ $\vec{L} = \vec{r} \times \vec{p}$ $L = rp\sin\theta$
Energy, Work & Power	$W = \vec{F} \bullet \vec{d} = Fd\cos\theta$ $U_g = mgh$ $E_k = \frac{1}{2}mv^2$ $E_k = \frac{p^2}{2m}$ $E_{total} = U + E_k + Q$ $W = \Delta E_k = -\Delta U$ $P = \frac{W}{t}$

- Δ = change
- Σ = sum
- d = distance (m)
- $\vec{d}$ = displacement (m)
- $\vec{x}$ = position (m)
- t = time (s)
- $\vec{v}$ = velocity $\left(\frac{m}{s}\right)$
- $\bar{v}$ = average velocity $\left(\frac{m}{s}\right)$
- $\vec{a}$ = acceleration $\left(\frac{m}{s^2}\right)$
- a_c = centripetal acceleration
- $\vec{F}$ = force (N)
- F_f = magnitude of force due to friction (N)
- $\vec{F}_g$ = force due to gravity (N)
- F_N = normal force (N)
- F_c = centripetal force (N)
- m = mass (kg)
- $\vec{g}$ = acceleration due to gravity $\left(\frac{m}{s^2}\right)$
- G = universal gravitational constant $\left(\frac{N \cdot m^2}{kg^2}\right)$
- r = radius (m)
- $\vec{r}$ = radius (vector)
- μ = coefficient of friction
- θ = angle (°, rad)
- ω = angular velocity $\left(\frac{rad}{s}\right)$
- k = spring constant $\left(\frac{N}{m}\right)$
- $\vec{x}$ = displacement of spring (m)
- L = length of pendulum (m)
- $\vec{\tau}$ = torque (N · m)
- E_k = kinetic energy (J)
- U = potential energy (J)
- h = height (m)
- Q = heat (J)
- P = power (W)
- W = work (N · m)
- T = (time) period (Hz)
- $\vec{p}$ = momentum (N · s)
- $\vec{J}$ = impulse (N · s)
- $\vec{L}$ = angular momentum (N · m · s)

Table F. Heat and Thermal Physics Formulas and Equations

Temperature	$°F = 1.8(°C) + 32$ $K = °C + 273.15$	
Heat	$Q = m C_p \Delta T$ $Q_{melt} = m \Delta H_{fus}$ $Q_{boil} = m \Delta H_{vap}$ $C_p - C_v = R$ $\Delta L = \alpha L_i \Delta T$ $\Delta V = \beta V_i \Delta T$ $\frac{Q}{t} = -kA\frac{\Delta T}{L}$ $PV = Nk_B T = nRT$ $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$	
Thermodynamics	$\Delta U = \Delta Q + \Delta W$	

Δ = change
°F = Fahrenheit temperature (°F)
°C = Celsius temperature (°C)
K = Kelvin temperature (K)
Q = heat (J, kJ)
m = mass (kg)
C = specific heat capacity $\left(\frac{kJ}{kg \cdot °C}\right)$ (C_p = const. pressure; C_v = const. volume)
T = temperature (K)
t = time (s)
L = length (m)
k = coëfficient of thermal conductivity $\left(\frac{J}{m \cdot s \cdot °C}, \frac{W}{m \cdot °C}\right)$
V = volume (m^3)
α = linear coëfficient of thermal expansion ($°C^{-1}$)
β = volumetric coëfficient of thermal expansion ($°C^{-1}$)
P = presure (Pa)
n = number of moles (mol)
R = gas constant $\left(\frac{J}{mol \cdot K}\right)$
U = internal energy (J)
W = work (N · m)

Thermal Properties of Selected Materials

Substance	Melting Point (°C)	Boiling Point (°C)	Heat of Fusion ÄH_{fus} $\left(\frac{kJ}{kg}\right)$	Heat of Vaporization ÄH_{vap} $\left(\frac{kJ}{kg}\right)$	Specific Heat Capacity C_p $\left(\frac{kJ}{kg \cdot °C}\right)$ at 25°C	Thermal Conductivity k $\left(\frac{J}{m \cdot s \cdot °C}\right)$ at 25°C	Coefficients of Expansion at 20°C	
							Linear á ($°C^{-1}$)	Volumetric â ($°C^{-1}$)
air (gas)	—	—	—	—	1.012	0.024	—	—
aluminum (solid)	659	2467	395	10460	0.897	250	2.3×10^{-5}	6.9×10^{-5}
ammonia (gas)	−75	−33.3	339	1369	4.7	0.024	—	—
argon (gas)	−189	−186	29.5	161	0.520	0.016	—	—
carbon dioxide (gas)	−78		574		0.839	0.0146	—	—
copper (solid)	1086	1187	134	5063	0.385	401	1.7×10^{-5}	5.1×10^{-5}
brass (solid)	—	—	—	—	0.380	120	1.9×10^{-5}	5.6×10^{-5}
diamond (solid)	3550	4827	10 000	30 000	0.509	2200	1×10^{-6}	3×10^{-6}
ethanol (liquid)	−117	78	104	858	2.44	0.171	2.5×10^{-4}	7.5×10^{-4}
glass (solid)	—	—	—	—	0.84	0.96–1.05	8.5×10^{-6}	2.55×10^{-5}
gold (solid)	1063	2660	64.4	1577	0.129	310	1.4×10^{-5}	4.2×10^{-5}
granite (solid)	1240	—	—	—	0.790	1.7–4.0		
helium (gas)	—	−269	—	21	5.193	0.142	—	—
hydrogen (gas)	−259	−253	58.6	452	14.30	0.168	—	—
iron (solid)	1535	2750	289	6360	0.450	80	1.18×10^{-5}	3.33×10^{-5}
lead (solid)	327	1750	24.7	870	0.160	35	2.9×10^{-5}	8.7×10^{-5}
mercury (liquid)	−39	357	11.3	293	0.140	8	6.1×10^{-5}	1.82×10^{-4}
paraffin wax (solid)	46–68	~300	~210	—	2.5	0.25	—	—
silver (solid)	962	2212	111	2360	0.233	429	1.8×10^{-5}	5.4×10^{-5}
steam (gas) @ 100°C			—	2260	2.080	0.016	—	—
water (liq.) @ 25°C	0	100	334		4.181	0.58	6.9×10^{-5}	2.07×10^{-4}
ice (solid) @ −10°C				—	2.11	2.18	—	—

Table H. Electricity & Magnetism Formulas & Equations

Electrostatic Charges & Electric Fields	$F_e = \frac{kq_1q_2}{r^2}$ $\vec{F}_e = q\vec{E}$ $V = \frac{W}{Q} = Ed$ $U_E = qV = \frac{kq_1q_2}{r}$ $W = qEd$ $I = \frac{\Delta Q}{t}$	Δ = change $\vec{F}_e$ = force due to electric field (N) k = electrostatic constant $\left(\frac{N \cdot m^2}{C^2}\right)$ q = point charge (C) Q = charge (C) $\vec{E}$ = electric field V = voltage = electric potential difference (V) W = work (N · m) d = distance (m) $\vec{I}$ = current (A) t = time (s) R = resistance (Ω) P = power (W) Q_H = heat (J) ρ = resistivity (Ω · m) λ = length (m) A = cross-sectional area (m^2) U = potential energy (J) C = capacitance (F) $\vec{v}$ = velocity of moving charge $\left(\frac{m}{s}\right)$ $\vec{B}$ = magnetic field (T)
Circuits	$V = IR$ $P = VI = I^2R = \frac{V^2}{R}$ $W = Q_H = Pt = VIt = I^2Rt = \frac{V^2t}{R}$ $R = \frac{\rho\lambda}{A}$ $U_{capacitor} = \frac{1}{2}QV = \frac{1}{2}CV^2$	
Series Circuits	$I = I_1 = I_2 = I_3 = \ldots$ $V = V_1 + V_2 + V_3 + \ldots$ $R_{eq} = R_1 + R_2 + R_3 + \ldots$ $\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ $P_{total} = P_1 + P_2 + P_3 + \ldots$	
Parallel Circuits	$I = I_1 + I_2 + I_3 + \ldots$ $V = V_1 = V_2 = V_3 = \ldots$ $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ $C_{total} = C_1 + C_2 + C_3 + \ldots$ $P_{total} = P_1 + P_2 + P_3 + \ldots$	
Magnetism	$\vec{F} = q(\vec{v} \times \vec{B})$ $F = qvB\sin\theta$ $\vec{F} = \lambda(\vec{I} \times \vec{B})$ $F = \lambda IB\sin\theta$	
Electromagnetic Induction	$\frac{\text{emf in primary}}{\text{emf in secondary}} = \frac{\text{\# turns in primary}}{\text{\# turns in secondary}}$	

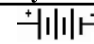
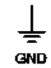
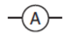
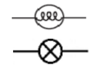
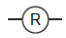
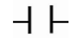
Table I. Symbols Used in Electrical Circuit Diagrams			
Component	**Symbol**	**Component**	**Symbol**
wire		battery	
switch		ground	
fuse		resistor	
voltmeter		variable resistor (potentiometer, rheostat, dimmer)	
ammeter		lamp (light bulb)	
ohmmeter		capacitor	
		diode	

Table J. Resistivities at 20°C	
Substance	**Resistivity** (Ù · m)
silver	1.59×10^{-8}
copper	1.72×10^{-8}
gold	2.44×10^{-8}
aluminum	2.82×10^{-8}
tungsten	5.60×10^{-8}
iron	9.71×10^{-8}
nichrome	1.50×10^{-6}
graphite	3×10^{-5} to 6×10^{-4}
germanium	0.001 to 0.5
silicon	0.1 to 60
glass	1×10^{9} to 1×10^{13}
rubber, hard	1×10^{13} to 1×10^{15}
quartz, fused	7.5×10^{17}

Table K. Waves & Optics		
Waves	$v = f\,ë$ $f = \frac{1}{T}$ $v_{\text{wave on a string}} = \sqrt{\frac{F_T}{\mu}}$ $f_{\text{doppler shifted}} = f\left(\frac{v_{\text{wave}} + v_{\text{detector}}}{v_{\text{wave}} + v_{\text{source}}}\right)$	v = velocity of wave $\left(\frac{m}{s}\right)$ f = frequency (Hz) ë = wavelength (m) T = (time) period (Hz) F_T = tension (force) on string (N) ì = elastic modulus of string θ_i = angle of incidence (°, rad) θ_r = angle of reflection (°, rad) n = index of refraction c = speed of light in a vacuum $\left(\frac{m}{s}\right)$ d_f = distance to the focus of a mirror or lens (m) r_c = radius of curvature of a spherical mirror (m) d_i = distance from the mirror or lens to the image (m) d_o = distance from the mirror or lens to the object (m) h_i = height of the image (m) h_o = height of the object (m) m = magnification
Reflection & Refraction	$\theta_i = \theta_r$ $n = \frac{c}{v}$ $n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\theta_{\text{critical}} = \arcsin\frac{n_2}{n_1}$ $\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{ë_1}{ë_2}$	
Mirrors & Lenses	$d_f = \frac{r_c}{2}$ $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{d_f}$ $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$	

Figure L. The Electcromagnetic Spectrum

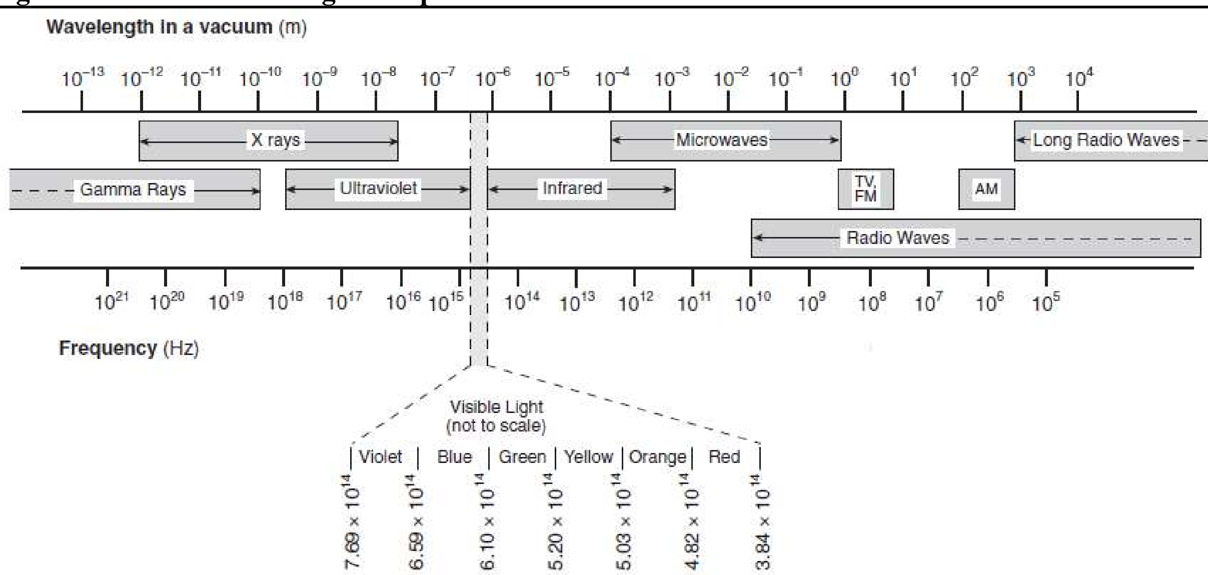


Table M. Properties of Water and Air

Temp. (°C)	Water: Density $\left(\frac{kg}{m^3}\right)$	Water: Speed of Sound $\left(\frac{m}{s}\right)$	Water: Vapor Pressure (Pa)	Air: Density $\left(\frac{kg}{m^3}\right)$	Air: Speed of Sound $\left(\frac{m}{s}\right)$
0	999.78	1 403	611.73	1.288	331.30
5	999.94	1 427	872.60	1.265	334.32
10	999.69	1 447	1 228.1	1.243	337.31
20	998.19	1 481	2 338.8	1.200	343.22
25	997.02	1 496	3 169.1	1.180	346.13
30	995.61	1 507	4 245.5	1.161	349.02
40	992.17	1 526	7 381.4	1.124	354.73
50	990.17	1 541	9 589.8	1.089	360.35
60	983.16	1 552	19 932	1.056	365.88
70	980.53	1 555	25 022	1.025	371.33
80	971.79	1 555	47 373	0.996	376.71
90	965.33	1 550	70 117	0.969	382.00
100	954.75	1 543	101 325	0.943	387.23

Table N. Absolute Indices of Refraction

Measured at $f = 5.09 \times 10^{14}$ Hz (yellow light)

Substance	Index of Refraction	Substance	Index of Refraction
air	1.000293	silica (quartz), fused	1.459
ice	1.309	plexiglass	1.488
water	1.3330	Lucite	1.495
ethyl alcohol	1.36	glass, borosilicate (Pyrex)	1.474
human eye, cornea	1.38	glass, crown	1.50–1.54
human eye, lens	1.41	glass, flint	1.569–1.805
safflower oil	1.466	sodium chloride, solid	1.516
corn oil	1.47	PET (#1 plastic)	1.575
glycerol	1.473	zircon	1.777–1.987
honey	1.484–1.504	cubic zirconia	2.173–2.21
silicone oil	1.52	diamond	2.417
carbon disulfide	1.628	silicon	3.96

Table O. Modern Physics Equations		
Energy	$E_{photon} = hf = \frac{hc}{\lambda} = pc$ $\lambda = \frac{h}{p}$ $E_{photon} = E_i - E_f$ $E = mc^2$	E = energy (J) h = Planck's constant (J · s) f = frequency (Hz) c = speed of light $\left(\frac{\text{m}}{\text{s}}\right)$ λ = wavelength (m) p = momentum (N · s) m = mass (kg) γ = Lorentz factor L = length (moving reference frame) L' = length (stationary reference frame) t = time (moving reference frame) t' = time (stationary reference frame) v = velocity $\left(\frac{\text{m}}{\text{s}}\right)$
Special Relativity	$\gamma = \frac{\Delta t'}{\Delta t} = \frac{L}{L'} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	

Figure P. Quantum Energy Levels

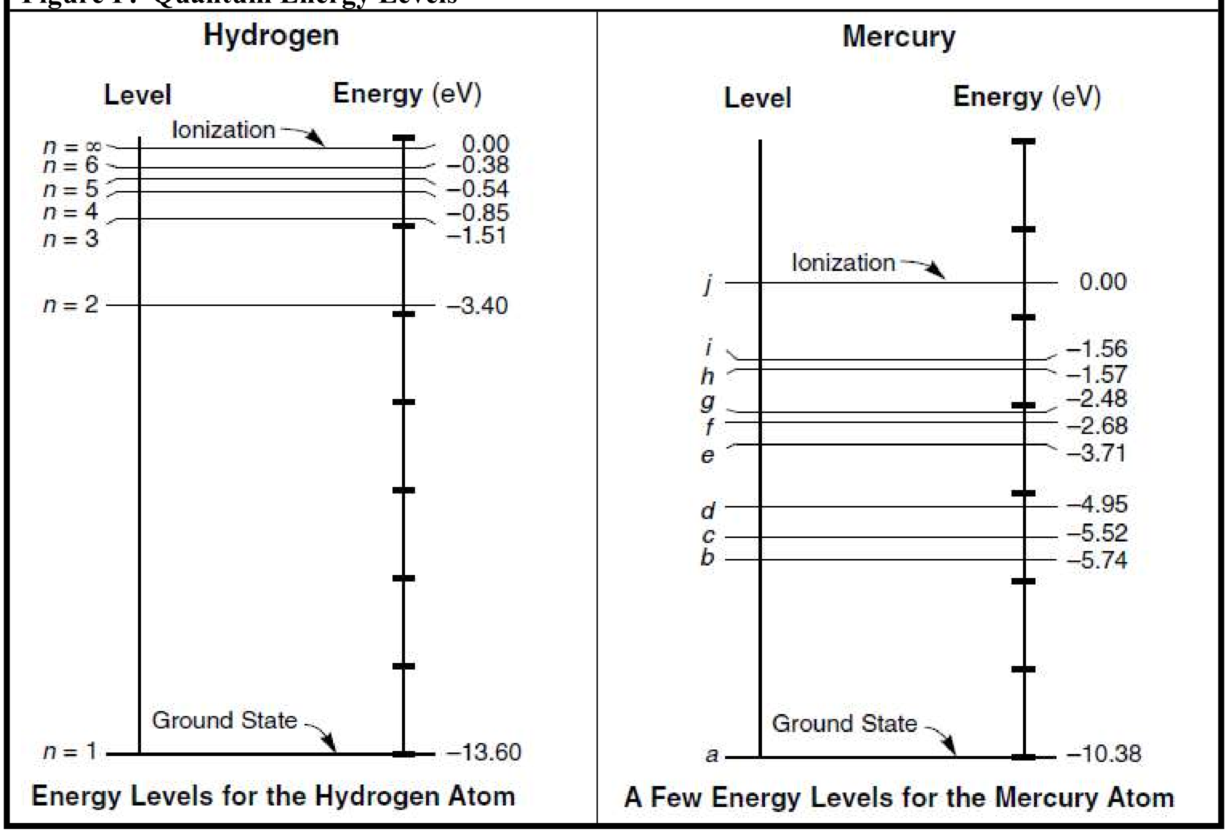


Figure Q. Particle Classification

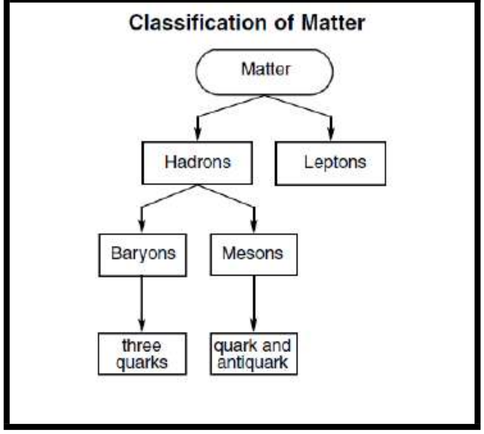


Figure R. Particle Sizes

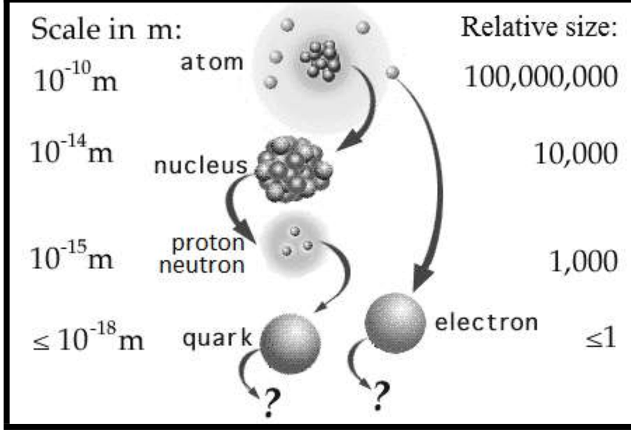


Table S. Particle Data

Quarks				
Particle / Antiparticle	**Symbols**	**Mass (MeV)**	**Charge**	**Spin**
up /anti-up	u / $\underline{u}$	1.5–4.0	$+\frac{2}{3}$	$\frac{1}{2}$
down /anti-down	d / $\underline{d}$	3.5–8.0	$-\frac{1}{3}$	$\frac{1}{2}$
charm / anti-charm	c / $\underline{c}$	1160–1500	$+\frac{2}{3}$	$\frac{1}{2}$
strange / anti-strange	s / $\underline{s}$	80–130	$-\frac{1}{3}$	$\frac{1}{2}$
top / anti-top	t / $\underline{t}$	171 000–176 000	$+\frac{2}{3}$	$\frac{1}{2}$
bottom / anti-bottom	b / $\underline{b}$	4200 or 4680	$-\frac{1}{3}$	$\frac{1}{2}$

Leptons				
Particle / Antiparticle	**Symbols**	**Mass (MeV)**	**Charge**	**Spin**
electron / positron	e / $\underline{e}$	0.511	−1	$\frac{1}{2}$
electron neutrino / electron antineutrino	ν_e / $\underline{\nu}_e$	< 2.2	0	$\frac{1}{2}$
muon / anti-muon	μ / $\underline{\mu}$	105.7	−1	$\frac{1}{2}$
muon neutrino / muon antineutrino	ν_μ / $\underline{\nu}_\mu$	< 0.170	0	$\frac{1}{2}$
tau / anti-tau	τ / $\underline{\tau}$	1777	−1	$\frac{1}{2}$
tau neutrino / tau antineutrino	ν_τ / $\underline{\nu}_\tau$	< 15.5	0	$\frac{1}{2}$

Bosons				
Force Particle	**Symbols**	**Mass (MeV)**	**Charge**	**Spin**
photon	y	0	0	1
gluon	g	0	0	1
"Z" boson	Z	91 200	0	1
"W" boson	W^- / W^+	80 400	±1	1

Table T. Fluid Mechanics Formulas and Equations

Density & Pressure	$P = \frac{F}{A}$ $\rho = \frac{m}{V}$ $P = P_0 + \rho g h$ $A_1 v_1 = A_2 v_2$ $P + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}$	Δ = change ρ = density $\left(\frac{kg}{m^3}\right)$ m = mass (kg) V = volume (m^3) P = presure (Pa) g = acceleration due to gravity $\left(\frac{m}{s^2}\right)$ h = height or depth (m) A = area (m^2) v = velocity of fluid $\left(\frac{m}{s}\right)$ F = force (N) n = number of moles (mol) R = gas constant $\left(\frac{J}{mol \cdot K}\right)$ N = number of molecules k_B = Boltzmann's constant $\left(\frac{J}{K}\right)$ T = temperature (K) M = molar mass $\left(\frac{g}{mol}\right)$ μ = molecular mass (kg) K = kinetic energy (J) W = work ($N \cdot m$)
Forces, Work & Energy	$PV = Nk_B T = nRT$ $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ $K_{molecular} = \frac{3}{2} k_B T$ $v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3k_B T}{\mu}}$ $W = -P\Delta V$ $F_B = \Delta\rho\, V_d\, g$	

Table U. Geometry & Trigonometry Formulas

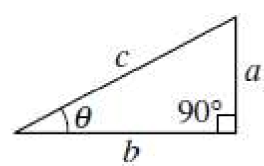
Triangles	$A = \frac{1}{2} bh$ $c^2 = a^2 + b^2 - 2ab\cos\theta$	 a, b, c = length of a side of a triangle θ = angle A = area C = circumference S = surface area V = volume b = base h = height λ = length w = width r = radius
Right Triangles	$c^2 = a^2 + b^2$ $\sin\theta = \frac{a}{c} = \frac{\text{opposite}}{\text{hypotenuse}}$ $\cos\theta = \frac{b}{c} = \frac{\text{adjacent}}{\text{hypotenuse}}$ $\tan\theta = \frac{a}{b} = \frac{\text{opposite}}{\text{adjacent}}$ $b = c\cos\theta$ $a = c\sin\theta$	
Rectangles, Parallelograms and Trapezoids	$A = \bar{b}h$	
Rectangular Solids	$V = \lambda w h$	
Circles	$C = 2\pi r$ $A = \pi r^2$	
Cylinders	$S = 2\pi r\lambda + 2\pi r^2 = 2\pi r(\lambda + r)$ $V = \pi r^2 \lambda$	
Spheres	$S = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$	

Table V. Some Exact and Approximate Conversions

Length	1 cm	~	width of a small paper clip		
	1 inch (in.)	≡	2.54 cm		
	length of a dollar bill	=	6.14 in.	=	15.6 cm
	12 in.	≡	1 foot (ft.)	~	30 cm
	3 ft.	≡	1 yard (yd.)	~	1 m
	1 m	=	0.3048 ft.	=	39.37 in.
	0.6 mi.	~	1 km		
	5,280 ft.	≡	1 mile (mi.)	~	1.6 km
Mass/ Weight	1 small paper clip	~	1 gram (g)		
	1 penny (1983–present)	=	2.5 g		
	1 nickel (5¢ coin)	=	5 g		
	1 oz.	~	30 g		
	1 pound (lb.)	≡	16 oz.	~	454 g
	1 pound (lb.)	~	4.45 N		
	1 ton	≡	2000 lb.	~	1 tonne
	1 tonne	≡	1000 kg	~	1.1 ton
Volume	1 pinch	=	≤ $^1/_8$ teaspoon (tsp.)		
	1 mL	~	10 drops		
	1 tsp.	~	5 mL	~	60 drops
	3 tsp.	≡	1 tablespoon (Tbsp.)	~	15 mL
	2 Tbsp.	≡	1 fluid ounce (fl. oz.)	~	30 mL
	8 fl. oz.	≡	1 cup (C)	~	250 mL
	2 C	≡	1 pint (pt.)		
	2 pt.	≡	1 quart (qt.)	~	1 L
	4 qt.	≡	1 gallon (gal.)	~	3.8 L
Speed	1 $^{m}/_{s}$	~	2.24 $^{mi.}/_{h}$		
	60 $^{mi.}/_{h}$	~	100 $^{km}/_{h}$	~	30 $^{m}/_{s}$