

Useful Data

M_e	Mass of the earth	5.98×10^{24} kg	
R_e	Radius of the earth	6.37×10^6 m	
g	Free-fall acceleration on earth	9.80 m/s ²	
G	Gravitational constant	6.67×10^{-11} N m ² /kg ²	
k_B	Boltzmann's constant	1.38×10^{-23} J/K	
R	Gas constant	8.31 J/mol K	
N_A	Avogadro's number	6.02×10^{23} particles/mol	
T_0	Absolute zero	-273°C	
σ	Stefan-Boltzmann constant	5.67×10^{-8} W/m ² K ⁴	
p_{atm}	Standard atmosphere	$101,300$ Pa	
v_{sound}	Speed of sound in air at 20°C	343 m/s	
m_p	Mass of the proton (and the neutron)	1.67×10^{-27} kg	
m_e	Mass of the electron	9.11×10^{-31} kg	
K	Coulomb's law constant ($1/4\pi\epsilon_0$)	8.99×10^9 N m ² /C ²	
ϵ_0	Permittivity constant	8.85×10^{-12} C ² /N m ²	
μ_0	Permeability constant	1.26×10^{-6} T m/A	
e	Fundamental unit of charge	1.60×10^{-19} C	
c	Speed of light in vacuum	3.00×10^8 m/s	
h	Planck's constant	6.63×10^{-34} J s	4.14×10^{-15} eV s
\hbar	Planck's constant	1.05×10^{-34} J s	6.58×10^{-16} eV s
a_B	Bohr radius	5.29×10^{-11} m	

Common Prefixes

Prefix	Meaning
femto-	10^{-15}
pico-	10^{-12}
nano-	10^{-9}
micro-	10^{-6}
milli-	10^{-3}
centi-	10^{-2}
kilo-	10^3
mega-	10^6
giga-	10^9
terra-	10^{12}

Conversion Factors

Length

1 in = 2.54 cm
1 mi = 1.609 km
1 m = 39.37 in
1 km = 0.621 mi

Velocity

1 mph = 0.447 m/s
1 m/s = 2.24 mph = 3.28 ft/s

Mass and energy

1 u = 1.661×10^{-27} kg
1 cal = 4.19 J
1 eV = 1.60×10^{-19} J

Time

1 day = 86,400 s
1 year = 3.16×10^7 s

Pressure

1 atm = 101.3 kPa = 760 mm of Hg
1 atm = 14.7 lb/in ²

Rotation

1 rad = $180^\circ/\pi = 57.3^\circ$
1 rev = $360^\circ = 2\pi$ rad
1 rev/s = 60 rpm

Mathematical Approximations

Binominal approximation: $(1 + x)^n \approx 1 + nx$ if $x \ll 1$

Small-angle approximation: $\sin \theta \approx \tan \theta \approx \theta$ and $\cos \theta \approx 1$ if $\theta \ll 1$ radian

Greek Letters Used in Physics

Alpha		α	Mu		μ
Beta		β	Pi		π
Gamma	Γ	γ	Rho		ρ
Delta	Δ	δ	Sigma	Σ	σ
Epsilon		ϵ	Tau		τ
Eta		η	Phi	Φ	ϕ
Theta	Θ	θ	Psi		ψ
Lambda		λ	Omega	Ω	ω

Astronomical Data

Planetary body	Mean distance from sun (m)	Period (years)	Mass (kg)	Mean radius (m)
Sun	—	—	1.99×10^{30}	6.96×10^8
Moon	3.84×10^8 *	27.3 days	7.36×10^{22}	1.74×10^6
Mercury	5.79×10^{10}	0.241	3.18×10^{23}	2.43×10^6
Venus	1.08×10^{11}	0.615	4.88×10^{24}	6.06×10^6
Earth	1.50×10^{11}	1.00	5.98×10^{24}	6.37×10^6
Mars	2.28×10^{11}	1.88	6.42×10^{23}	3.37×10^6
Jupiter	7.78×10^{11}	11.9	1.90×10^{27}	6.99×10^7
Saturn	1.43×10^{12}	29.5	5.68×10^{26}	5.85×10^7
Uranus	2.87×10^{12}	84.0	8.68×10^{25}	2.33×10^7
Neptune	4.50×10^{12}	165	1.03×10^{26}	2.21×10^7

*Distance from earth

Typical Coefficients of Friction

Material	Static μ_s	Kinetic μ_k	Rolling μ_r
Rubber on dry concrete	1.00	0.80	0.02
Rubber on wet concrete	0.30	0.20	0.002
Steel on steel (dry)	0.80	0.60	0.002
Steel on steel (lubricated)	0.10	0.05	
Wood on wood	0.50	0.20	
Wood on snow	0.12	0.06	
Ice on ice	0.10	0.03	

Coefficients of Thermal Expansion

Material	α ($^{\circ}\text{C}^{-1}$)
Aluminum	2.3×10^{-5}
Brass	1.9×10^{-5}
Concrete	1.2×10^{-5}
Steel	1.1×10^{-5}
Invar	0.09×10^{-5}
Material	β ($^{\circ}\text{C}^{-1}$)
Gasoline	9.6×10^{-4}
Mercury	1.8×10^{-4}
Ethyl alcohol	1.1×10^{-4}

Heats of Transformation

Substance	T_m (°C)	L_f (J/kg)	T_b (°C)	L_v (J/kg)
Water	0	3.33×10^5	100	22.6×10^5
Nitrogen (N ₂)	-210	0.26×10^5	-196	1.99×10^5
Ethyl alcohol	-114	1.09×10^5	78	8.79×10^5
Mercury	-39	0.11×10^5	357	2.96×10^5
Lead	328	0.25×10^5	1750	8.58×10^5

Properties of Materials

Substance	ρ (kg/m ³)	c (J/kgK)
Air at STP*	1.29	
Ethyl alcohol	790	2400
Gasoline	680	
Glycerin	1260	
Mercury	13,600	140
Oil (typical)	900	
Seawater	1030	
Water	1000	4190
Aluminum	2700	900
Copper	8920	385
Gold	19,300	129
Ice	920	2090
Iron	7870	449
Lead	11,300	128
Silicon	2330	703

*Standard temperature (0°C) and pressure (1 atm)

Thermal Conductivities

Material	k (W/mK)
Diamond	2000
Silver	430
Copper	400
Aluminum	240
Iron	80
Stainless steel	14
Ice	1.7
Concrete	0.8
Glass	0.8
Styrofoam	0.035
Air (20°C, 1 atm)	0.023

Molar Specific Heats of Gases

Gas	C_p (J/mol K)	C_v (J/mol K)
Monatomic Gases		
He	20.8	12.5
Ne	20.8	12.5
Ar	20.8	12.5
Diatomic Gases		
H ₂	28.7	20.4
N ₂	29.1	20.8
O ₂	29.2	20.9

Resistivity and Conductivity of Conductors

Metal	Resistivity (Ω m)	Conductivity ($\Omega^{-1} \text{m}^{-1}$)
Aluminum	2.8×10^{-8}	3.5×10^7
Copper	1.7×10^{-8}	6.0×10^7
Gold	2.4×10^{-8}	4.1×10^7
Iron	9.7×10^{-8}	1.0×10^7
Silver	1.6×10^{-8}	6.2×10^7
Tungsten	5.6×10^{-8}	1.8×10^7
Nichrome	1.5×10^{-6}	6.7×10^5
Carbon	3.5×10^{-5}	2.9×10^4

Indices of Refraction

Material	Index of refraction
Vacuum	1 exactly
Air	1.00
Water	1.33
Ethyl alcohol	1.36
Oil	1.46
Glass	1.50
Plastic	1.59
Diamond	2.42

Elastic Properties of Materials

Substance	Young's modulus (N/m ²)	Bulk modulus (N/m ²)
Steel	20×10^{10}	16×10^{10}
Copper	11×10^{10}	14×10^{10}
Aluminum	7×10^{10}	7×10^{10}
Concrete	3×10^{10}	–
Wood (Douglas fir)	1×10^{10}	–
Plastic (polystyrene)	0.3×10^{10}	–
Mercury	–	3×10^{10}
Water	–	0.2×10^{10}