

2 Units of Physics

2.1 SI Units

Symbol	Name of unit	Definition	Quantity measured
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Basic Units

m	metre	see CU - 2.2	length
kg	kilogram	see CU - 2.2	mass
s	second	see CU - 2.2	time
A	ampere	see CU - 2.2	electric current
K	kelvin	see CU - 2.2	thermodynamic temperature
cd	candela	see CU - 2.2	luminous intensity
mol	mole	see CU - 2.2	amount of substance

Supplementary Units

rad	radian	see CU - 2.2	plane angle
sr	steradian	see CU - 2.2	solid angle

Derived Units

Hz	hertz	1 Hz = 1 s ⁻¹	frequency
N	newton	1 N = 1 kg m/s ²	force
J	joule	1 J = 1 Nm	energy
W	watt	1 W = 1 J/s	power
Pa	pascal	1 Pa = 1 N/m ²	pressure
V	volt	1 V = 1 W/A	voltage
C	coulomb	1 C = 1 As	electric charge
Ω	ohm	1 Ω = 1 V/A	resistance
F	farad	1 F = 1 C/V	capacitance
H	henry	1 H = 1 Ωs	inductance
S	siemens	1 S = 1 A/V	electric conductance
Wb	weber	1 Wb = 1 Vs	magnetic flux
T	tesla	1 T = 1 Wb/m ²	magnetic flux density
°C	degree Celsius	1 °C = 1 K*	temperature
Bq	becquerel	1 Bq = 1 s ⁻¹	radioactivity
Gy	gray	1 Gy = 1 J/kg	absorbed dose of ionizing radiation

* 1 °C = 1 K is for temperature differences, 0 °C = 273.15 K.

Symbol	Name of unit	Definition	Quantity measured
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Sv	sievert	1 Sv = 1 J/kg	dose equivalent
lm	lumen	1 lm = 1 cd · sr	light flux
lx	lux	1 lx = 1 lm/m ²	illuminance

Additional Units

ℓ, L	litre	$1 \ell = \frac{1}{1000} \text{ m}^3 = 1 \text{ dm}^3$	volume
min	minute	1 min = 60 s	time
h	hour	1 h = 60 min	time
d	day	1 d = 24 h	time
t	ton(metric)	1 ton = 1 000 kg	mass
°	degree	$1^\circ = \frac{\pi}{180} \text{ rad}$	plane angle
'	minute	$1' = \frac{1^\circ}{60}$	plane angle
"	second	$1'' = \frac{1'}{60}$	plane angle
g	gon	$1 \text{ g} = \frac{\pi}{200} \text{ rad}$	plane angle
bar	bar	1 bar = 10 ⁵ Pa	pressure

2.2 Definition of SI Units

Definition of Basic Units

1 metre = the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second. (17th CGPM, 1983, Resolution 1)

1 kilogram = the mass of the international prototype of the kilogram. (3rd CGPM, 1901)

1 second = the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom. (13th CGPM, 1967, Resolution 1)

1 ampere = that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to $2 \cdot 10^{-7}$ newton per metre of length. (9th CGPM, 1948)

1 kelvin = the fraction $1/273.16$ of the thermodynamic temperature of the triple point of water. (13th CGPM, 1967)

1 candela = the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency $540 \cdot 10^{12}$ hertz and that has a radiant intensity in that direction of $1/683$ watt per steradian. (16th CGPM, 1948)

1 mole = the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. (14th CGPM, 1971)

Definition of Supplementary Units

1 radian = the size of the plane angle between two radii in a circle which on the circumference cuts an arc with the length of the radius.

1 steradian = the size of a solid angle for a cone which has its apex at the centre of a sphere and cuts a surface of this sphere with an area which is equal to the area of a square with a side that has the same length as the radius of the sphere.

2.3 Conversion Factors of Non-SI Units

Many of the units below have been annexed to the SI system as multiple units, in which cases the conversion factors are exact by definition.

<i>Length</i>	1 Å (ångström) = 10^{-10} m
	1 XU (x-unit) = $1.002\ 08\ m\text{Å} = 1.002\ 08 \cdot 10^{-13}$ m
	1 fermi = 10^{-15} m
	1 au (atomic unit) = $1\ bohr = 1\ a_0 = 0.529\ 177\ \text{Å}$
	1 AU (astronomical unit) = $1.495\ 978\ 70 \cdot 10^{11}$ m
	(The astronomical unit is sometimes abbreviated ua.)
	1 light-year* = $9.460\ 55 \cdot 10^{15}$ m = $6.32 \cdot 10^4$ AU
	1 pc (parsec) = $3.0857 \cdot 10^{16}$ m = $2.062\ 65 \cdot 10^5$ AU = 3.262 light-year
	1 nautical mile = 1852 m
	1 English mile = 1609.344 m
	1 yard = 0.9144 m
	1 ft (foot) = 12 in (inches) = 0.3048 m
	1 in (inch) = 2.54 cm
	1 Swedish "for" = 0.296 90 m

Wave number

1 kayser = $1\ cm^{-1}$

1 barn = $10^{-28}\ m^2$

1 Swedish "runland" = $4\ 936\ m^2$

1 acre = $4\ 046.86\ m^2$

1 ha (hectare) = $10\ 000\ m^2$

1 in² (square inch) = $0.645\ 16 \cdot 10^{-3}\ m^2$

1 ft² (square foot) = $92.903\ 04 \cdot 10^{-3}\ m^2$

1 yd² (square yard) = $0.836\ 127\ 36\ m^2$

1 square mile = $2.589\ 988\ 1 \cdot 10^6\ m^2$

Volume

1 barrel (British) = 163.66 ℓ

1 barrel (US petroleum) = 158.987 294 958 ℓ

1 barrel (US liq) = 119.24 ℓ

1 gallon (British) = 4.546 09 ℓ

1 gallon (US liq) = 3.785 411 784 ℓ

1 pint (British) = 20 Brit. fluid ounces = 0.568 25 ℓ

1 pint (US dry) = 0.550 60 ℓ

1 pint (US liq) = 16 US fluid ounces = 0.473 16 ℓ

1 cu in (cubic inch) = 0.016 387 064 ℓ

1 cu ft (cubic foot) = 28.316 847 ℓ

1 cu yd (cubic yard) = 0.764 554 86 m³

Plane angle

1° = $\pi/180$ rad = $1/57.2958$ rad = $0.017\ 453\ 3$ rad

1' (minute) = $\pi/10\ 800$ rad = $0.290\ 888\ 21 \cdot 10^{-3}$ rad

1" (second) = $\pi/648\ 000$ rad = $4.848\ 136\ 8 \cdot 10^{-6}$ rad

1 gon = $\pi/200$ rad = $15.707\ 963 \cdot 10^{-3}$ rad

1 tropical year (solar year) = $31.556\ 925\ 974 \cdot 10^6$ s = $365.242\ 198\ 78$ d

1 sidereal year (stellar year) = $31.558\ 150 \cdot 10^6$ s = $365.256\ 37$ d

Time

1 calendar year = 365 d = 8 760 h = 31.536 · 10⁶ s

1 leap-year = 366 d = 8784 h = 31.6224 · 10⁶ s

1 au (atomic unit) = 2.418 884 · 10⁻¹⁷ s

1 mph (mile per hour) = 1.609 344 km/h = 0.447 04 m/s

1 knot = 1.852 km/h = 0.514 44 m/s

1 km/h = 1/3.6 m/s = 0.277 777 8 m/s

1 ft/s = 0.3048 m/s

Speed

1 u (atomic mass constant, atomic mass unit) = $1.66054 \cdot 10^{-27}$ kg

1 au (atomic unit) = $1\ m_e = 9.109\ 38 \cdot 10^{-31}$ kg

1 lb (pound) = 16 oz. (ounces) = 0.453 592 37 kg

1 stone = 14 lbs = 6.350 293 18 kg

1 slug = 0.453 592 37 · 9.806 65/0.3048 kg = 14.593 903 kg

1 metric ton = 1 000 kg

Mass

* A corresponding unit, 1 beard-second = 10^{-8} m, has been suggested for microscopic distances. One beard-second is the distance which a standard beard in a standard face grows in one second. Its chances of ever becoming an established unit in physics seem rather slim though.

Density	1 ton (UK, in US long ton) = 1.016 046 908 8 · 10 ³ kg 1 sh tn (short ton, US) = 0.907 184 74 · 10 ³ kg 1 cwt (hundred-weight) = 50.802 345 44 kg 1 sh cwt (short hundred-weight, US) = 45.359 237 kg 1 carat (metric) = 200 mg 1 amagat = 0.040 96 mole · dm ⁻³ (ideal gas at STP) 1 lb/ft ³ = 16.0185 kg/m ³ 1 lb/in ³ = 27.6799 · 10 ³ kg/m ³
Temperature	x K = (x - 273.15) °C (degrees Celsius) x °C = (x · 9/5 + 32) °F (degrees Fahrenheit) x °R (degrees Rankine) = (x - 459.67) °F (0 °R = 0 K) x °Réaumur = 1.25 · x °C
Energy	1 eV (electron volt) = 1.602 1765 · 10 ⁻¹⁹ J 1 Ry (rydberg) = 2.1799 · 10 ⁻¹⁸ J = 13.605 692 eV 1 au (atomic unit) = 1 H (hartree) = 2 Ry = 4.359 · 10 ⁻¹⁸ J 1 erg = 10 ⁻⁷ J 1 kWh = 3.6 · 10 ⁶ J 1 kcal = 1 000 cal = 4 186.8 J (= energy needed to raise the temperature of 1 kg of water from 14.5 °C to 15.5 °C when the pressure is 1 atm) 1 kcal/mol = 4.336 · 10 ⁻² eV/molecule 1 kiloton TNT = 4.18 · 10 ¹² J 1 Btu (British thermal unit) = 1 055.06 J 1 Q = 1 000 quad = 10 ¹⁸ Btu = 1.055 06 · 10 ²¹ J 1 hk (horsepower, metric) = 75 kpm/s = 735.50 W 1 hp (horsepower, UK and US) = 550 ft · lbf/s = 745.70 W
Power	1 au (atomic unit) = 1 ħ = 1.054 571 6 · 10 ⁻³⁴ J/s
Angular momentum	1 dyn = 10 ⁻⁵ N
Force	1 kp (kilopond) = 9.806 65 N (conventional value) 1 lbf (pound force) = 4.4482 N = 0.453 59 kp 1 torr (mm Hg) = 1.333 22 · 10 ² Pa 1 atm = 760 torr = 1.013 25 · 10 ⁵ Pa 1 bar = 10 ⁵ Pa 1 at = 1 kp/cm ² = 9.806 65 · 10 ⁴ Pa 1 psi (pound force per square inch, lbf/in ²) = 6.8948 · 10 ³ Pa
Pressure	1 B (bel) = (ln 10)/2 Np (neper) = 1.151 29 Np 1 dB (decibel) = (ln 10)/20 Np = 0.115 129 Np
Logarithmic units	1 P (poise) = 1 dyn s/cm ² = 0.1 N s/m ² (viscosity) 1 St (stokes) = 1 cm ² /s = 10 ⁻⁴ m ² /s (kinematic viscosity)
Viscosity	

Electric dipole moment	1 au (atomic unit) = 1 e a ₀ = 8.478 35 · 10 ⁻³⁰ Cm 1 D (debye) = 10 ⁻¹⁸ esu = 3.335 64 · 10 ⁻³⁰ Cm
Magnetic flux density	1 G (gauss) = 10 ⁻⁴ T 1 gamma = 10 ⁻⁵ G = 10 ⁻⁹ T
Magnetic flux	1 Mx (maxwell) = 10 ⁻⁸ Wb
Magnetizing field	1 oersted = 10 ³ /4π A/m
Magnetic dipole moment	1 au (atomic unit) = 1 eħ/m _e = 2 μ _B = 1.8548 · 10 ⁻²³ Am ² (= J/T)
Activity	1 Ci (curie) = 3.7 · 10 ¹⁰ Bq (= 3.7 · 10 ¹⁰ s ⁻¹) 1 Rd (rutherford) = 10 ⁶ Bq
Exposure	1 R (röntgen) = 2.58 · 10 ⁻⁴ C/kg air (1 R ≈ 10 ⁻² Sv)
Absorbed dose	1 rad = 10 ⁻² Gy (= 10 ⁻² J/kg)
Dose equivalent	1 rem = 10 ⁻² Sv (= 10 ⁻² J/kg)
Luminous intensity	1 hefner = 0.90 cd
Luminance	1 sb (stilb) = 10 ⁴ cd/m ² 1 asb (apostilb) = 1/π cd/m ² 1 cd/ft ² = 10.763 91 cd/m ²
Photometric brightness	1 lambert = 10 ⁴ /π cd/m ²
Gas exposure	1 L (langmuir) = 10 ⁻⁶ torr · s = 1.33 · 10 ⁻⁴ Pa · s
Gas fluence	1 ex = 10 ¹⁸ m ⁻² (suggested unit to replace the langmuir in surface physics)
Concentration of a solution	1 M (molarity) = 1 mole of a solute per litre solution 1 m (molality) = 1 mole of solute per kilogram solvent

2.4 Conversion Factors of Certain Units

Mass - Energy	1 kg	2 u	3 J	4 eV
	1	6.022 142 · 10 ²⁶	8.987 552 · 10 ¹⁶	5.609 589 · 10 ³⁵
	1.660 539 · 10 ⁻²⁷	1	1.492 418 · 10 ⁻¹⁰	9.314 940 · 10 ⁸
	1.112 650 · 10 ⁻¹⁷	6.700 537 · 10 ⁹	1	6.241 510 · 10 ¹⁸
	1.782 662 · 10 ⁻³⁶	1.073 544 · 10 ⁻⁹	1.602 176 · 10 ⁻¹⁹	1