

Engineering Units and Constants Cheat Sheet

CODATA 2022 constants · NIST SP 811 conversions · SI prefixes

Exact SI constants

Speed of light in vacuum

$$c = 299\,792\,458 \text{ m/s}$$

CODATA 2022; exact (defines the SI)

Planck constant

$$h = 6.626\,070\,15 \times 10^{-34} \text{ J}\cdot\text{s}$$

CODATA 2022; exact (defines the SI)

Elementary charge

$$e = 1.602\,176\,634 \times 10^{-19} \text{ C}$$

CODATA 2022; exact (defines the SI)

Boltzmann constant

$$k = 1.380\,649 \times 10^{-23} \text{ J/K}$$

CODATA 2022; exact (defines the SI)

Avogadro constant

$$N_A = 6.022\,140\,76 \times 10^{23} \text{ mol}^{-1}$$

CODATA 2022; exact (defines the SI)

Derived and measured constants

Molar (universal) gas constant

$$R_u = N_A \cdot k = 8.314\,462\,618... \text{ J/(mol}\cdot\text{K)}$$

CODATA 2022; exact, shown truncated. = 8.314 kJ/(kmol·K)

Stefan–Boltzmann constant

$$\sigma = 5.670\,374\,419... \times 10^{-8} \text{ W/(m}^2\cdot\text{K}^4)$$

CODATA 2022; exact, shown truncated

Newtonian constant of gravitation

$$G = 6.674\,30 \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$$

CODATA 2022; measured, standard uncertainty $0.000\,15 \times 10^{-11}$

Standard acceleration of gravity

$$g_n = 9.806\,65 \text{ m/s}^2 = 32.174 \text{ ft/s}^2$$

Defined value (NIST SP 330); ft/s² value rounded

Standard atmosphere

$$1 \text{ atm} = 101\,325 \text{ Pa} = 14.696 \text{ psi}$$

Pa value defined (NIST SP 330); psi value rounded

Length, mass and force

Inch and foot

$$1 \text{ in} = 25.4 \text{ mm}; 1 \text{ ft} = 0.3048 \text{ m}$$

NIST SP 811; both exact

Pound mass

$$1 \text{ lbm} = 0.453\,592\,37 \text{ kg}$$

NIST SP 811; exact

Pound force

$$1 \text{ lbf} = 4.448\,222 \text{ N}; 1 \text{ kip} = 4.448\,222 \text{ kN}$$

NIST SP 811; 1 lbf = 1 lbm × g_n

Slug

$$1 \text{ slug} = 14.593\,90 \text{ kg} = 32.174 \text{ lbm}$$

NIST SP 811; 1 lbf = 1 slug·ft/s²

Pressure, energy and power

Pressure

$$1 \text{ psi} = 6.894\,757 \text{ kPa}; 1 \text{ ksi} = 6.894\,757 \text{ MPa}$$

NIST SP 811; 1 bar = 100 kPa exactly

Energy

$$1 \text{ Btu} = 1\,055.056 \text{ J}; 1 \text{ ft}\cdot\text{lbf} = 1.355\,818 \text{ J}$$

NIST SP 811; Btu is the International Table Btu

Power

$$1 \text{ hp} = 745.699\,9 \text{ W} = 550 \text{ ft}\cdot\text{lbf/s}$$

NIST SP 811; mechanical horsepower

Kilowatt-hour

$$1 \text{ kWh} = 3.6 \text{ MJ}$$

Exact: 1 000 W × 3 600 s

Temperature and prefixes

Absolute temperature

$$T(\text{K}) = T(^{\circ}\text{C}) + 273.15; T(^{\circ}\text{R}) = T(^{\circ}\text{F}) + 459.67$$

NIST SP 811; use absolute T in gas laws and Carnot

Celsius to Fahrenheit

$$T(^{\circ}\text{F}) = 1.8 \cdot T(^{\circ}\text{C}) + 32$$

Exact; a temperature difference of 1 K = 1.8 °R = 1.8 °F

SI prefixes

$$G 10^9 \cdot M 10^6 \cdot k 10^3 \cdot m 10^{-3} \cdot \mu 10^{-6} \cdot n 10^{-9}$$

NIST SP 330

Typical values (check your problem statement)

Water, about 20 °C

$$\rho \approx 998 \text{ kg/m}^3 \approx 62.3 \text{ lbm/ft}^3$$

Typical value; use 1 000 kg/m³ only if the problem says so

Air as an ideal gas

$$R = 0.287 \text{ kJ/(kg}\cdot\text{K)}; c_p = 1.005; k = 1.4$$

Typical room-temperature values (Çengel & Boles)

Structural steel

$$E \approx 200 \text{ GPa} \approx 29\,000 \text{ ksi}; G \approx 77 \text{ GPa}$$

Typical values (Gere & Goodno); alloys vary