



Units and Measures in Wolfram|Alpha

*Physical dimension-based infrastructure for computing
with scientific data*

Michael Trott, Wolfram Alpha LLC

Scientific and Technical Data in Wolfram|Alpha

Use Data for (Real-Time) Computations

Units, Units, Units, ..., Measures, ...

Unit Conversions and Orders of Magnitude

Physical Quantities

Generalized Units

Unit and Physical Quantity Uses

Future (of units in Wolfram|Alpha)

Scientific and Technical Data in Wolfram|Alpha

Diverse data sets

'Object' data

Real-time data

Physical law data

Mathematical data

...

Data characteristics:

- all data are curated
- all data are properly structured
- interconnection of data
- all data are soon fully 'sliceable'
- potentially large in size (TB of data)

...

- **virtually all data are measured in units**

'Object' data

- chemicals (melting points, densities, ...)
- materials (conductivities, hardness, ...)
- food (calories, vitamin contents, ...)
- astronomical objects (distance, mass, ...)
- species (sizes, ages, ...)
- genetic data (sequences)

...



boiling point methanol vs propanol



Input interpretation:

Mathematica form

methanol

boiling point

N-propanol

Results:

methanol	64.7 °C (degrees Celsius)
N-propanol	97 °C (degrees Celsius)

Computed by: [Wolfram Mathematica](#)

[Source information »](#)

Download as: [PDF](#) | [Live Mathematica](#)

Real-time data

- weather (temperatures, air pressures, ...)
- earthquakes (magnitudes, wave characteristics, ...)
- UV radiation (UV indices, forecasts, ...)
- ...



recent earthquakes in europe > 4



Assuming Europe | Use [Europe with Russia and Turkey](#) or [Europe with Russia](#) instead

Input interpretation:

earthquakes Europe with magnitude > 4

Results:

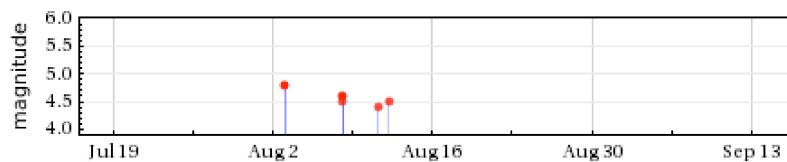
Last 2 months

Magnitude > 4

CDT



Timeline:



List:

Sort by magnitude

More

Show coordinates

Show metric

magnitude	time	location
4.8	Tue, Aug 3, 2010 02:40 am CDT (1.5 months ago)	12 mi ENE of Sardinia, Aitolia Kai Akamania, Greece
4.6	Sun, Aug 8, 2010 04:00 am CDT (1.3 months ago)	5 mi ESE of Nea Maditos, Thessaloniki, Greece

Physical law data

- effects, principles, laws, paradoxa, formulas, ...
- formulas, ...

Example: Pendulum

$T = 2\pi\sqrt{\frac{l}{g}}$		$f = \frac{1}{T}$
$v_{\max} = \sqrt{2gl(1 - \cos(\theta_0))}$		
T	period	
l	length	
θ_0	initial angle	
g	gravitational acceleration	
f	frequency	
v_{\max}	maximum speed	

⇔

$T = 4\sqrt{\frac{l}{g} K(\sin^2(\frac{\theta_0}{2}))}$		$f = \frac{1}{T}$
$v_{\max} = \sqrt{2gl(1 - \cos(\theta_0))}$		
T	period	
l	length	
θ_0	initial angle	
g	gravitational acceleration	
f	frequency	
v_{\max}	maximum speed	


 Calculate **period**

- length:
- initial angle:
- gravitational acceleration:

 Also include: [mass](#) | [moment of inertia](#)

Input interpretation:

 |

Small-oscillation pendulum:

Input values:

length	10 meters
initial angle	20° (degrees)
gravitational acceleration	1 g (standard acceleration due to gravity on the surface of the earth)

Result:

[Show formula](#) | [More](#)

period	6.345 seconds 0.1057 minutes
frequency	0.1576 Hz (hertz)
maximum speed	3.439 m/s (meters per second) 7.693 mph (miles per hour) 11.28 ft/s (feet per second)

Mathematical data

- named polyhedra, curves, knots, graphs, curves, surfaces, lamina, ... (areas, volumes, invariant polynomials, ...)
- mathematical identities (values, representations of special functions [$J_\nu(z)$, $P_n^m(x)$, ${}_2F_1(a, b, c; z), \dots$] and mathematical constants [π , e , γ , ...])
- mathematical conjectures, theorems, axioms

Even mathematical data need sometimes units, e.g. geometrical data



volume torus 2 inches, 3 inches

Assuming the input refers to a formula | Use "volume" as referring to chemical compounds instead

Input information:

torus volume	
radius 1	2 inches
radius 2	3 inches

Result: More

volume	5.822 dm ³ (cubic decimeters) 0.005822 m ³ (cubic meters) 5822 cm ³ (cubic centimeters)
--------	--

Equation:

$V = 2 \pi^2 R_1 R_2^2$	
V	volume
R_1	radius 1
R_2	radius 2

Computed by: [Wolfram Mathematica](#) [Source information »](#) Download as: [PDF](#) | [Live Mathematica](#)

Astronomical object with "exotic" units



crab pulsar



Input interpretation:

Mathematica form

Crab Pulsar (pulsar)

Basic properties:

alternate names	B0531+21 J0534+2200 PSR B0531+21 PSR J0534+2200
discovery year	1968 (42 years ago)
pulsar type	spin-powered pulsar with pulsed emission from radio to infrared or higher frequencies
surveys	Arecibo Survey 4 Green Bank Fast Pulsar Survey

Distance and motion properties:

distance from Earth	6519 ly 1.999 kpc
proper motion right ascension	-14.7 mas/yr
proper motion declination	2 mas/yr
transverse velocity	140.67 km/s

Units »

Rotation properties:

[More](#)

rotation period	0.03308471603 s (barycentric)
rotation frequency	2.61147776×10^6 rev/day (barycentric) 2.60434756×10^6 angular speeds of the earth's rotation on its axis
rotation measure	-42.3 rad/m^2
spin down age	1240 yr
spin down age corrected for proper motion	1240 yr
glitch count	12 (in 42 years)

rotation period | 0.0330847

[Units »](#)

Radiation properties:

[More](#)

pulse width at 50% peak	3 ms
pulse width at 10% peak	4.7 ms
spin down energy loss rate	4.6×10^{31} W
dispersion measure	56.791 pc/cm ³
temporal broadening	1.51×10^{-6} s
energy flux measured at Earth	1.2×10^{38} erg/(kpc ² s)
magnetic field at light cylinder	98 T 980 000 G
mean flux density at 400 MHz	646 mJy
mean flux density at 1400 MHz	14 mJy
surface magnetic dipole corrected for proper motion	3.78×10^8 T 3.78×10^{12} G
surface magnetic flux density	3.78×10^8 T 3.78×10^{12} G
radio luminosity 400 MHz	2584 mJkpc ²
radio luminosity 1400 MHz	56 mJkpc ²
measured spectral index	-3.1

[Units »](#)

Use Data for (Real-Time) Computations

Why not just store everything?

- time-dependent data
- combinatorial explosion of product sets
- free parameters in applications

Calculating with data \Leftarrow **calculating with units**

Real-time computed data

- astronomical objects
- geo-distances
- ...



what is the distance from mars to venus



Input interpretation:

Mars (planet)

distance

Venus (planet)

Current result:

1.744 AU (astronomical units)

Value:

2.609×10^8 km (kilometers)

2.609×10^{11} meters

162.1 million miles

Comparison as distance:

$\approx 1.7 \times$ mean Earth-Sun distance (≈ 1 AU)

Corresponding quantities:

Light travel time t in vacuum from $t = x/c$:

15 minutes

Light travel time t in an optical fiber $t = 1.48x/c$:

21 minutes

Solar radiation pressure from $P = L_{\odot}/(c4\pi r^2)$:

1.5 μ Pa (micropascals)

Data analysis

- averages, distributions
- correlations
- genetic data look-ups
- ...

Wiedemann-Franz law



thermal conductivity metals vs electrical conductivity metals



Input interpretation:

Mathematica form

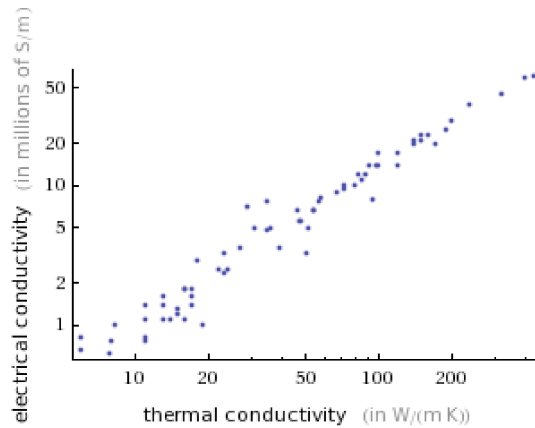
metallic elements thermal conductivity |
metallic elements electrical conductivity

Results:

thermal conductivity	40 W/(mK) (watts per meter kelvin difference) (median)
electrical conductivity	5.3×10^6 S/m (siemens per meter) (median)

Scatter plot:

Log-log plot ▾



Units »

Computed by: [Wolfram Mathematica](#)

[Source information »](#)

Download as: [PDF](#) | [Live Mathematica](#)

Units, Units, Units, ..., Measures, ...

All that can be measured must be measured in reference to some agreed-on yardstick.

Calculations with data require calculations with units.

- length, time, area, volume
- pressure, force, energy, electric current, ...
- since 1790: International System of Units
 - seven base units: meter, second, kilogram, kelvin, ampere, candela, mole (radian, steradian)

Most countries use the SI system today.



To deal with diverse data, one needs to handle units well!

Wolfram|Alpha knows tens of thousands of units

Knowing a unit means:

- numerical values and precision (c is exact, trusted digits of \hbar)
- relations to other units
- typical uses
- names, abbreviations, ...
- formatting

...

Unit Conversions and Orders of Magnitude

- default conversions
- default comparisons
- country-specific preferred units



200 US fluid ounces



Input interpretation:

200 fl oz (fluid ounces)

Unit conversions:

[More](#)

1.563 gallons

6.25 quarts

12.5 pints

25 cups

360.9 in³ (cubic inches)

Comparisons as volume:

≈ 0.26 × molar volume (1 mol molar volume constants)

≈ volume of blood in a typical human (≈ 5 L)

Comparisons as volume of food or beverage:

≈ 1.9 × US can size 10 (105 fl oz)

≈ 3.6 × US can size 5 (7 cups)

≈ 6.2 × US can size 3 (4 cups)

Interpretations:

[More](#)

volume

volume of food or beverage

Basic unit dimensions:

[length]³

Corresponding quantities:

Radius r of a sphere from $V = 4\pi r^3/3$:

0.3681 feet

4.417 inches

11.22 cm (centimeters)

Edge length a of a cube from $V = a^3$:

0.5933 feet

7.12 inches

18.08 cm (centimeters)

Mass m of water from $m = \rho V$:

13 lb (pounds)

5.9 kg (kilograms)

(assuming water density $\approx 1000 \text{ kg/m}^3$)

Molecules N of water from $N = \rho V/MW$:

1.977×10^{26} molecules

(assuming water density $\approx 1000 \text{ kg/m}^3$)



120 kV



Input interpretation:

120 kV (kilovolts)

Unit conversions:

0.12 MV (megavolts)

120 000 V (volts)

400.3 statV (statvolts)
(unit officially deprecated)400.3 esus of potential difference
(unit officially deprecated)

Comparisons as electric potential difference:

 $\approx (0.5 \text{ to } 0.8) \times$ high voltage US power line voltage (138 000 to 230 000 V) $\approx (0.2 \text{ to } 1.2) \times$ typical stun gun voltage (100 000 to 600 000 V) $\approx 0.8 \times$
typical miniature Van de Graaff generator generated voltage ($\approx 150\,000$ V)

Interpretations:

electric potential difference

[More](#)

Basic unit dimensions:

 $[\text{mass}] [\text{length}]^2 [\text{time}]^{-3} [\text{current}]^{-1}$

Corresponding quantities:

Radius r of a 1 meter long copper wire carrying 1 ampere current from

$$\Delta\phi = I\rho L/(\pi r^2):$$

$$2.1 \times 10^{-7} \text{ meters}$$

(assuming resistivity of copper $\approx 1.72 \times 10^{-8} \Omega \cdot \text{m}$)

$$\text{Radius } r \text{ of a 1 meter long copper wire carrying 1 ampere current from } \Delta\phi = I\rho L/(\pi r^2):...$$

Relativistic velocity v of an electron after traversal of this potential difference $m_0\gamma v^2/2 = e\Delta\phi$:

$$0.61 c \text{ (speeds of light)}$$

Energy E from $E = e\Delta\phi$:

$$120 \text{ keV (kiloelectronvolts)}$$

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)



4 arpents



Assuming Louisiana arpent areas for "arpents" | Use [Arkansas arpent areas](#) or [French arpent lengths](#) instead

Input interpretation:

4 Louisiana arpent areas

Unit conversions:

147 456 ft² (square feet)

0.0137 km² (square kilometers)

13 699 m² (square meters)

1.37 hectares

3.385 acres

Comparisons:

≈ (0.25 ≈ 1/4) × area of the base of the Great Pyramid of Giza (≈ 55 000 m²)

≈ 1.9 × area of a FIFA –sanctioned international match soccer field
(7700 to 9600 yd²)

≈ (1 to 3) × area of a FIFA –sanctioned soccer field (5000 to 13 000 yd²)

Interpretation:

area

Basic unit dimensions:

[length]²

Corresponding quantities:

Radius r of a circle from $A = \pi r^2$:

216.6 feet

66.03 meters

Radius r of a sphere from $A = 4\pi r^2$:

108.3 feet

33.02 meters

Edge length a of a square from $A = a^2$:

384 feet

0.07273 miles

117 meters

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)



12.3 queenquoons



Input interpretation:

12.30 QQn (queenquoons)

Unit conversions:

[More](#)

1.971×10^{18} C (coulombs)

1.971×10^{17} abC (abcoulombs)
(unit officially deprecated)

5.908×10^{27} statC (statcoulombs)
(unit officially deprecated)

5.908×10^{27} Fr (franklins)

5.908×10^{27} esus of charge
(unit officially deprecated)

Interpretations:

[More](#)

electric charge

Basic unit dimensions:

[time] [current]

Corresponding quantities:

Current I caused by the charge flowing in one second from $I = Q/t$:

1.971×10^{18} A (amperes)

Force F between like charges 1 cm apart from $F = Q^2/(4\pi\epsilon_0 r^2)$:

3.49×10^{50} N (newtons)

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

Physical constants (CODATA)





Input Interpretation:

c (speed of light in vacuum)

Value:

[Show exact value](#)

299 792 km/s (kilometers per second)

2.998×10^8 m/s (meters per second)

186 282 mi/s (miles per second)

6.706×10^8 mph (miles per hour)

1 Planck speed

Comparison:

$\approx 2.4 \times$ speed of light in diamond ($\approx 1.24 \times 10^8$ m/s)

Interpretation:

speed

Basic unit dimensions:

[length] [time]⁻¹

Corresponding quantity:

Slowness from $S = 1/v$:

3.336×10^{-9} s/m (seconds per meter)

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

Calculations with units



0.008 (electron charge)^3/hbar



Assuming multiplication | Use [a list](#) instead

Assuming reduced Planck constants for "hbar" | Use [hctobars](#) instead

Input interpretation:

$$0.008 \frac{(e \text{ (electron charge)})^3}{\hbar \text{ (reduced Planck constant)}}$$

Result:

$3.12 \times 10^{-28} \text{ s}^4 \text{ A}^3 / (\text{g m}^2)$ (second to the fourth amperes cubed per gram meter squared)

Unit conversions:

$1.947 \times 10^{-6} \text{ A eV/V}^2$ (ampere electronvolts per volt squared)

$3.12 \times 10^{-25} \text{ A J/V}^2$ (ampere joules per volt squared)

1.263 a_{FN} (first Fowler–Nordheim constants)

Interpretation:

first Fowler–Nordheim constant unit

Basic unit dimensions:

$[\text{mass}]^{-1} [\text{length}]^{-2} [\text{time}]^4 [\text{current}]^3$

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

Physical Quantities

Length, time, area, volume, pressure, force, energy, ...

Wolfram|Alpha knows thousands of physical quantities

- typical units (N·m as torque vs energy; eV versus BTU)
- relation between physical quantities



pressure



Assuming "pressure" is a physical quantity | Use as a formula or a weather property or a word or a financial entity instead

Input interpretation:

physical quantity pressure

Basic dimensions:

$[\text{mass}] [\text{length}]^{-1} [\text{time}]^{-2}$

Standard unit for pressure:

Pa (pascal)

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

Bird's-eye view on the space of physical quantity dimensions

Physical quantities of given dimensions

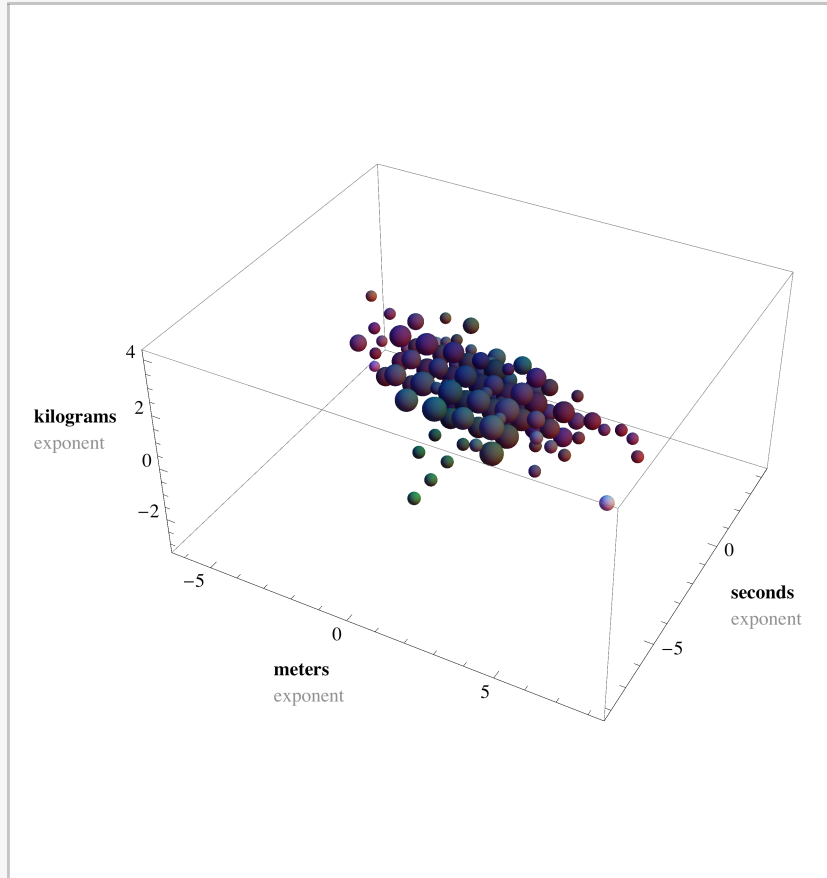
plot dimensions

base units
(dimensions)

meter (m)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
second (s)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
kilogram (kg)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ampere (A)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
kelvin (K)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
candela (cd)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
moles (mol)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
radian (rad)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
steradian (ster)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

show only nonvanishing exponents

show exponents near origin



Dimensional analysis

Taylor's estimation of the energy released in the first detonated atomic bomb



pressure, mass density, energy, time, length



Input interpretation:

physical quantity | pressure |
 physical quantity | mass density | | physical quantity | energy | |
 physical quantity | time | | physical quantity | length

Basic dimensions:

pressure	$[\text{mass}] [\text{length}]^{-1} [\text{time}]^{-2}$
mass density	$[\text{mass}] [\text{length}]^{-3}$
energy	$[\text{mass}] [\text{length}]^2 [\text{time}]^{-2}$
time	$[\text{time}]$
length	$[\text{length}]$

Standard units:

pressure	Pa (pascal)
mass density	kg/m^3 (kilogram per cubic meter)
energy	J (joule)
time	second
length	meter

Dimensionless combinations:

$$\frac{[\text{length}]^3 [\text{pressure}]}{[\text{energy}]}$$

$$\frac{[\text{pressure}]^5 [\text{time}]^6}{[\text{energy}]^2 [\text{mass density}]^3}$$

Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

Generalized Units

Real world data contain often more than just units that can be reduced to the seven (nine) SI units. They also contain:

Currencies

Counting units


Commodities

Substances

Scales and Industrial measures

Currencies

- \$, €, ¥, ... (e.g. \$/kg)
- time-dependent conversion factors



convert dollar/ounce to euro/kg
☰

Assuming kilograms for "kg" | Use [kilograms-force](#) instead

Input interpretation:

convert \$1/oz t (US dollars per troy ounce) to euros per kilogram

Result:

€ 24.58 kg⁻¹ (euros per kilogram) (at current quoted rate)

Unit conversions: [More](#)

€ 11.15 per lb (euros per pound)

€ 22 296.97 per sh tn (euros per short ton)

Currency conversions: [World currencies](#)

USD	\$ 32.15 kg ⁻¹ (US dollars per kilogram)
JPY	¥2759.12 kg ⁻¹ (Japanese yen per kilogram)
GBP	£ 20.56 kg ⁻¹ (British pounds per kilogram)
CNY	¥ 216.11 kg ⁻¹ (Chinese yuan per kilogram)
CAD	C\$ 33 kg ⁻¹ (Canadian dollars per kilogram)
INR	₹ 1483.07 kg ⁻¹ (Indian rupees per kilogram)
RUB	1006.81 py6/kg (Russian rubles per kilogram)
CHF	Fr. 32.63 kg ⁻¹ (Swiss francs per kilogram)

Computed by: [Wolfram Mathematica](#)
[Source information](#) »
Download as: [PDF](#) | [Live Mathematica](#)

Counting units

- people, women, men, marriages, boys, girls, children, teenagers, ... (e.g. marriages per year)
- samples, pages, ...



400 pages 

Input interpretation:
400 generic pages (in English)

Conversions:

1.22 × 10 ⁶ characters (1.22 MB (megabytes)) (assuming 5.1 characters per word and 1 space between each word)
200 000 words
18 000 lines


Times: [More](#)

typical typing	56 hours
typical speaking	22 hours
silent reading	12 hours

Computed by: [Wolfram Mathematica](#) Download as: [PDF](#) | [Live Mathematica](#)

Commodities

- bushels, ...



Assuming US bushels for "bushels" | Use UK bushels or more ▾ instead

New to Wolfram|Alpha? ✕

Input Interpretation:

20 bu (US bushels)

Unit conversions:

80 pecks

704.8 L (liters)

186.2 gallons

0.7048 m³ (cubic meters)

704781 cm³ (cubic centimeters)

Comparisons:

≈ (0.008 to 0.01) × 40-foot equivalent unit

≈ (0.01 to 0.03) × 20-foot equivalent unit

≈ (0.031 ≈ 1/32) × standard volume (1000)

Interpretation:

volume

Basic unit dimensions:

[length]³

Corresponding quantities:

Radius *r* of a sphere from $V = 4\pi r^3/3$:

1.811 feet

21.73 inches

55.21 cm (centimeters)

32-pound bushels (bottom onion sets, cotton, green peas in pod, oats)

60-pound bushels (alfalfa, cowpeas, dried peas, flax, Irish potatoes, soybeans, vetch, wheat)

46-pound bushels

70-pound bushels (ear corn, ear popcorn)

80-pound bushels (lime)

30-pound bushels (top onion sets)

34-pound bushels (malted barley, rice, oats in Canada)

35-pound bushels (Japanese barnyard millet)

47-pound bushels (green apples)

48-pound bushels (barley, broom corn seed, cucumbers, quinces, unboiled corn meal)

50-pound bushels (forage sorghum, hickory nuts, millet, parsnips, rape seed, rutabagas, rye meal, sorghum seed, sweet potatoes, walnut)

52-pound bushels (buckwheat)

55-pound bushels (turnips)

12-pound bushels (spinach)

14-pound bushels (grass)

20-pound bushels (bran, charcoal, shorts)

22-pound bushels (green peanuts)

24-pound bushels (dried apples, green beans, string beans, wax beans)

33-pound bushels (cranberries, dried peaches, osage orange seed, unhulled sweet clover seed)

40-pound bushels (emmer, gooseberries, spelt)

58-pound bushels (pears)

28-pound bushels (Sudan grass)

44-pound bushels (hemp seed)


45-pound bushels (rough rice, timothy grass)

56-pound bushels (rye, shelled corn, shelled popcorn, sorghum, tomatoes)

57-pound bushels (onions)

Substances

- CO₂, CH₄, ... (e.g. MtCO₂/MWh) [noncommutative conversions]


WolframAlpha[™] computational...
knowledge engine

2ktCO₂/MWh
=

Input interpretation:
2 ktCO₂/MWh (metric kilotons of carbon dioxide per megawatt hour)

Unit conversion:
2 tCO₂/kWh (metric tons of carbon dioxide per kilowatt hour)

Comparisons:

≈ (1 to 3) ×
average emission for electrical energy generation from burning hard coal
(0.7 to 1.4 tCO₂/kWh)

≈ (2 to 5) ×
average emission for electrical energy generation from burning natural gas
(0.4 to 0.9 tCO₂/kWh)

≈ 6.7 × 2006 California average emission for electrical energy
(≈ 300 kgCO₂/kWh)

Interpretation:
carbon dioxide per energy

Computed by: [Wolfram Mathematica](#)
Download as: [PDF](#) | [Live Mathematica](#)

Scales and Industrial measures

- Beaufort scale, earthquake magnitudes, screw sizes, ...



seismic moment magnitude 8



Calculate **equivalent energy**

Input information:

seismic moment magnitude

seismic moment magnitude 8

Seismic moment magnitude:

[Show formula](#) | [More](#)

equivalent energy	4.2×10^{18} J (joules) 4.2×10^{25} ergs 2.6×10^{37} eV (electronvolts)
equivalent mass of TNT	1×10^9 metric tons 1 Gt (metric gigaton) 1000 Mt (metric megatons)
seismic moment	1.3×10^{21} J (joules) 1.3×10^{28} ergs 7.9×10^{39} eV (electronvolts)

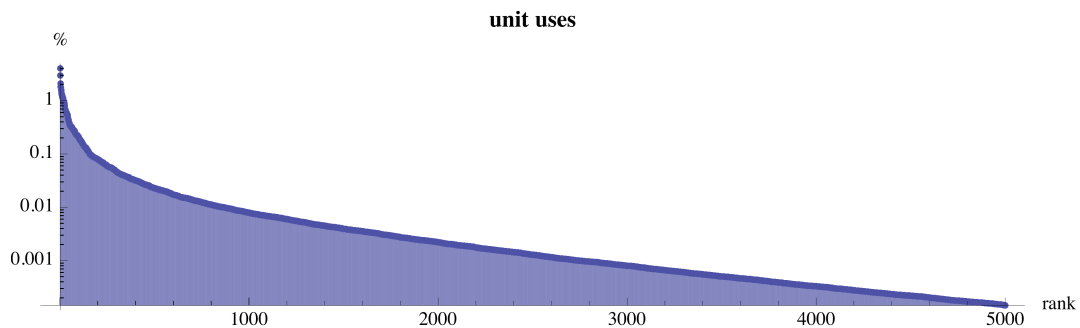
Computed by: [Wolfram Mathematica](#)

Download as: [PDF](#) | [Live Mathematica](#)

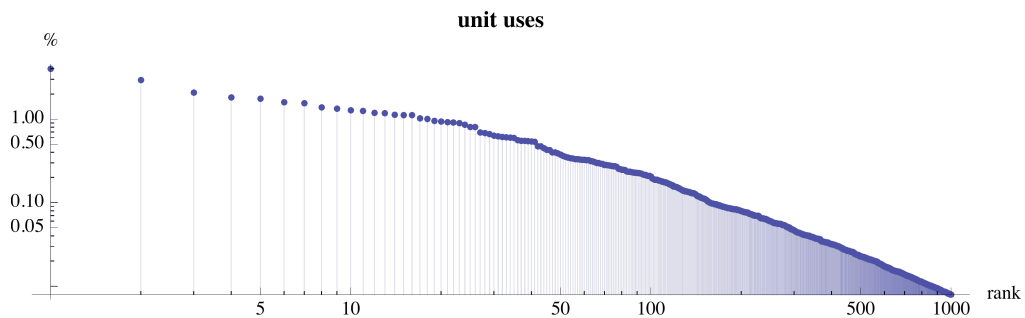
Unit and Physical Quantity Uses

Overall unit uses

Often users have their own unit preferences. (country specific)



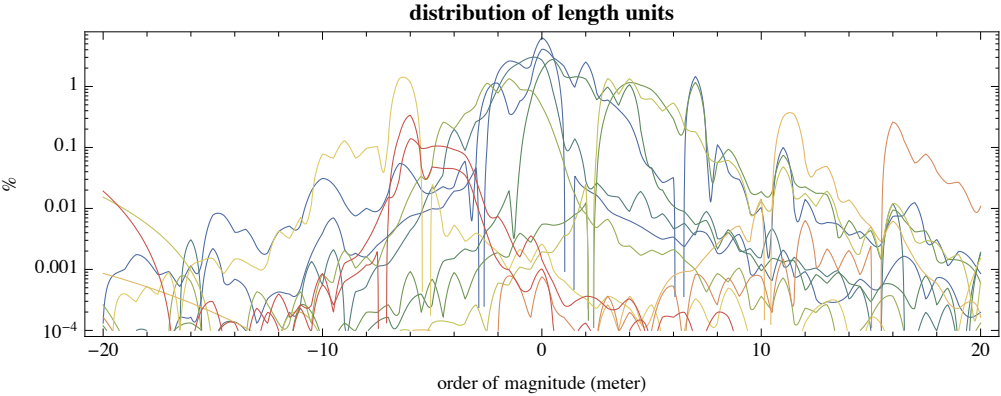
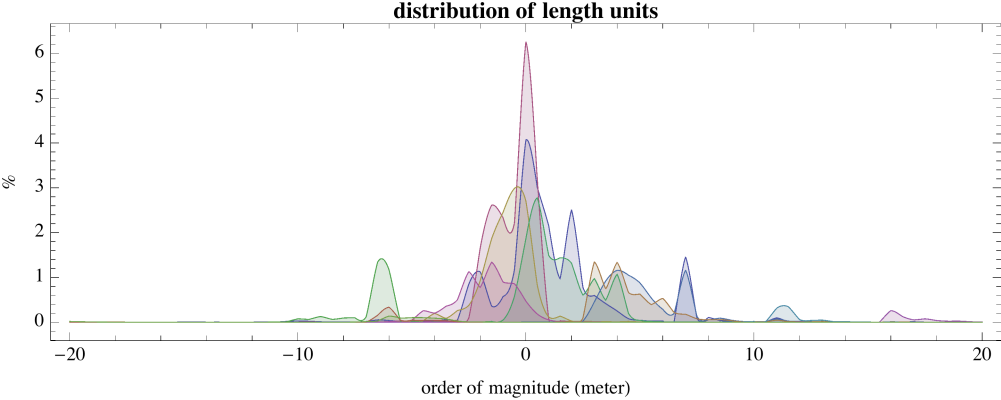
approximate Zipf law



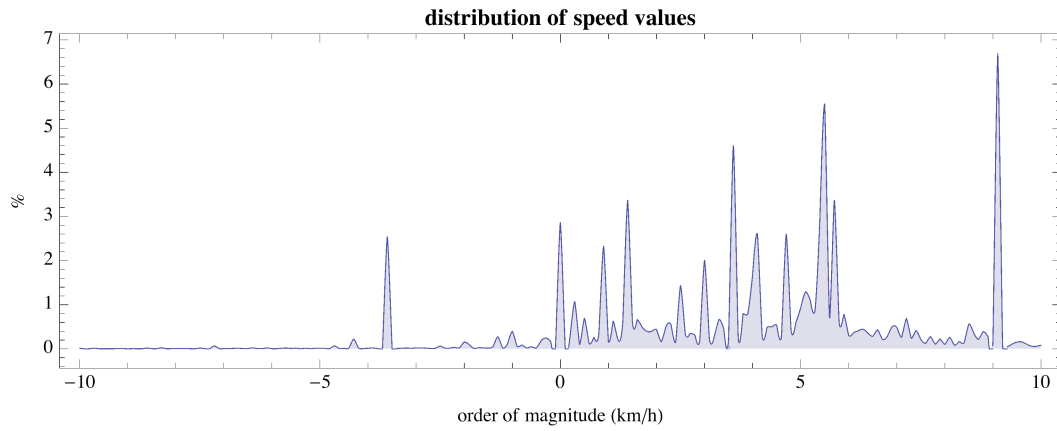
Overall physical quantity uses

physical quantity	percentage
length	30.00
time	27.00
volume	11.00
speed	8.80
temperature	6.10
frequency	3.50
plane angle	3.40
area	3.10
electric current	1.30
amount	0.88
acceleration	0.71
molarity	0.66
electric charge	0.56
voltage	0.52
slowness	0.46
flow	0.42
angular velocity	0.28

Scale dependence of length unit uses



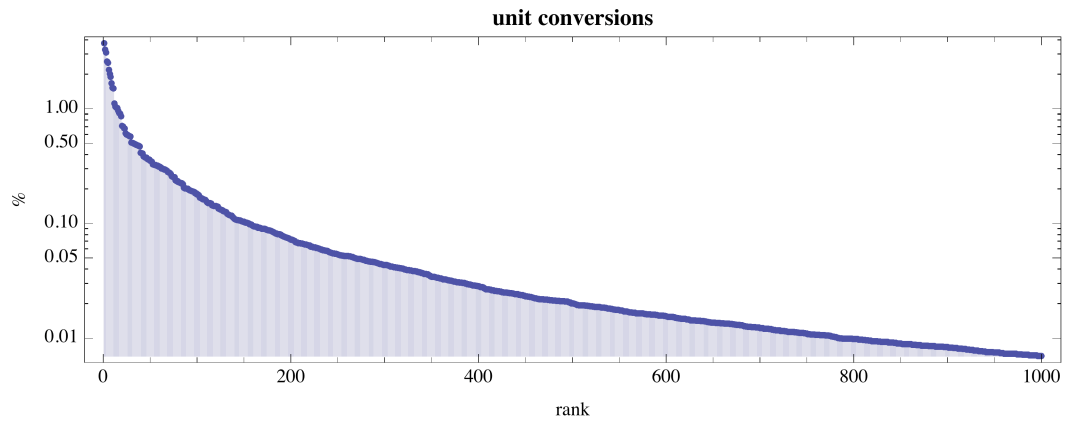
Speed units



Anthropological values

speed value	percentage
75 miles per hour	5.1
340.3 meters per second	4.4
10 meters per second	4.0
88 miles per hour	3.1
1 meters per second	2.7
10 centimeters per second	2.5
4 miles per hour	2.2
150 meters per minute	2.1
45 miles per hour	2.0
30 miles per hour	2.0
72 miles per hour	1.7
46 kilometers per hour	1.4
5 meters per second	1.2
$3. \times 10^7$ meters per second	1.2
340.29 meters per second	1.2
2.5 meters per second	1.0
1.25 meters per second	1.0
70 miles per hour	1.0
60 miles per hour	0.9
15 miles per hour	0.9

Unit conversions



Future (of units in Wolfram|Alpha)

- International units

- Japanese, Portuguese, ...

- Historical units (what is their “exact” value?)

- Babylonian, Egyptian, ...
- Medieval European units

(in 1790 about 40,000 different volume, mass, and length measures were used in France 🤖)

- realization changes over time; soon all quantum-based (1m in 1791 = 0.9998 m in 2010)

- Generalized conversions

- $\text{cm} \rightarrow \text{eV}$, $\text{kg} \rightarrow \text{eV}$ (multiply by $\hbar^\alpha c^\beta G^\gamma \dots$)
- pint \rightarrow kg (for sugar, milk, ...)

- Unit system

- cgs, cgs-esu, cgs-emu
- Atomic, Planck, Stoney, Astronomical, ...