[Template:About](/wiki/Template:About" \o "Template:About) [Template:Infobox Unit](/wiki/Template:Infobox_Unit) The **joule** ([Template:IPAc-en](/wiki/Template:IPAc-en)), symbol **J**, is a [derived unit](/wiki/SI_derived_unit) of [energy](/wiki/Energy) in the [International System of Units](/wiki/International_System_of_Units).[[1]](#cite_note-1) It is equal to the energy transferred (or work done) to an object when a [force](/wiki/Force) of one [newton](/wiki/Newton_(unit)) acts on that object in the direction of its motion through a distance of one [metre](/wiki/Metre) (1 newton metre or N·m). It is also the energy dissipated as heat when an electric [current](/wiki/Current_(electricity)) of one [ampere](/wiki/Ampere) passes through a [resistance](/wiki/Resistance_(electricity)) of one [ohm](/wiki/Ohm) for one second. It is named after the English physicist [James Prescott Joule](/wiki/James_Prescott_Joule) (1818–1889).[[2]](#cite_note-2)[[3]](#cite_note-3)[[4]](#cite_note-4) In terms firstly of base [SI units](/wiki/International_System_of_Units) and then in terms of other SI units:

<math>\rm J = {}\rm \frac{kg \cdot m^2}{s^2} = N \cdot m = \rm Pa \cdot m^3={}\rm W \cdot s = C \cdot V</math>

where kg is the [kilogram](/wiki/Kilogram), m is the [metre](/wiki/Metre), s is the [second](/wiki/Second), N is the [newton](/wiki/Newton_(unit)), Pa is the [pascal](/wiki/Pascal_(unit)), W is the [watt](/wiki/Watt), C is the [coulomb](/wiki/Coulomb_(unit)), and V is the [volt](/wiki/Volt).

One joule can also be defined as:

* The work required to move an [electric charge](/wiki/Electric_charge) of one [coulomb](/wiki/Coulomb) through an [electrical potential difference](/wiki/Voltage) of one [volt](/wiki/Volt), or one '"coulomb volt" (C·V). This relationship can be used to define the volt.
* The work required to produce one [watt](/wiki/Watt) of [power](/wiki/Power_(physics)) for one [second](/wiki/Second), or one "watt second" (W·s) (compare [kilowatt hour](/wiki/Kilowatt_hour) - 3.6 megajoules). This relationship can be used to define the watt.

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## Usage[[edit](/index.php?title=(none)&action=edit&section=1)]

[Template:SI unit lowercase](/wiki/Template:SI_unit_lowercase)

## Confusion with newton-metre[[edit](/index.php?title=(none)&action=edit&section=2)]

[Template:Main](/wiki/Template:Main) In [angular mechanics](/wiki/Rotation_around_a_fixed_axis), [torque](/wiki/Torque) is analogous to the linear [Newtonian mechanics](/wiki/Newtonian_mechanics) parameter of force, [moment of inertia](/wiki/Moment_of_inertia) to [mass](/wiki/Mass), and [angle](/wiki/Angular_distance) to distance. Energy is the same in both systems. Thus, although the joule has the same dimensions as the newton-metre (1 J = 1 N·m = 1 kg·m2·s−2), these units are *not* interchangeable: the [CGPM](/wiki/CGPM) has given the unit of [energy](/wiki/Energy) the name "joule", but has not given the unit of [torque](/wiki/Torque) any special name, hence the unit of torque is known as the newton-metre (N·m) - a compound name derived from its constituent parts.<ref name=BIPM2/> Torque and energy are related to each other using the equation

<math>E= \tau \theta\ </math>

where *E* is the energy, *τ* is the torque, and *θ* is the angle moved (in [radians](/wiki/Radian)). Since radians are dimensionless, it follows that torque and energy have the same dimensions.

The use of newton-metres for torque and joules for energy is useful in helping avoid misunderstandings and miscommunications.<ref name=BIPM2/>

An additional solution is to realize that joules are scalars – they are the [dot product](/wiki/Dot_product) of a vector force and a vector displacement whereas torque is a vector. Torque is the [cross product](/wiki/Cross_product) of a distance vector and a force vector. Drawing a traditional vector arrow over "newton-metre" in a torque resolves the ambiguity.

## Practical examples[[edit](/index.php?title=(none)&action=edit&section=3)]

One joule in everyday life represents approximately:

* The energy required to lift a medium-size tomato (100 g) 1 meter vertically from the surface of the Earth.[[5]](#cite_note-5)\* The energy released when that same tomato falls back down to the ground.
* The energy required to accelerate a 1 kg mass at 1 m·s−2 through a 1 m distance in space.
* The [heat](/wiki/Heat) required to raise the temperature of 1 g of water by 0.24 K.[[6]](#cite_note-6)\* The typical energy released as heat by a person at rest every 1/60 second (approximately 17 ms).[[7]](#cite_note-7)\* The [kinetic energy](/wiki/Kinetic_energy) of a 50 kg human moving very slowly ([Template:Convert](/wiki/Template:Convert)).
* The kinetic energy of a 56 g tennis ball moving at [Template:Convert](/wiki/Template:Convert).[[8]](#cite_note-8)\* The kinetic energy of an object with mass 1 kg moving at √2 ≈ 1.4 m/s.
* The amount of electricity required to light a 1 watt [LED](/wiki/Light-emitting_diode) for 1 s.

Since the joule is also a watt-second and the common unit for electricity sales to homes is the kW·h (kilowatt-hour), a kW·h is thus 1000 (kilo) watt × 3600 seconds = 3.6 megajoules (MJ).

## Multiples[[edit](/index.php?title=(none)&action=edit&section=4)]

*For additional examples, see:* [*Orders of magnitude (energy)*](/wiki/Orders_of_magnitude_(energy))

|  |
| --- |
| [Template:SI multiples](/wiki/Template:SI_multiples) |

### Zeptojoule[[edit](/index.php?title=(none)&action=edit&section=5)]

The zeptojoule (zJ) is equal to one sextillionth (10−21) of one joule. 160 zeptojoules is equivalent to one [electronvolt](/wiki/Electronvolt).

### Nanojoule[[edit](/index.php?title=(none)&action=edit&section=6)]

The nanojoule (nJ) is equal to one billionth (10−9) of one joule. One nanojoule is about 1/160 of the [kinetic energy](/wiki/Kinetic_energy) of a flying mosquito.[[9]](#cite_note-9)

### Microjoule[[edit](/index.php?title=(none)&action=edit&section=7)]

The microjoule (μJ) is equal to one millionth (10−6) of one joule. The [Large Hadron Collider](/wiki/Large_Hadron_Collider) (LHC) produce collisions on the order of 1 microjoule (7 [TeV](/wiki/Electron_volt)) per particle.

### Millijoule[[edit](/index.php?title=(none)&action=edit&section=8)]

The millijoule (mJ) is equal to one thousandth (10−3) of a joule.

### Kilojoule[[edit](/index.php?title=(none)&action=edit&section=9)]

The kilojoule (kJ) is equal to one thousand (103) joules. Nutritional food labels in some countries express energy in kilojoules (kJ).

One square metre of the [Earth](/wiki/Earth) receives about 1.4 kilojoules of [solar radiation](/wiki/Sunlight#Solar_constant) every second in full daylight.<ref name=TSI>[Template:Cite web](/wiki/Template:Cite_web)</ref>

### Megajoule[[edit](/index.php?title=(none)&action=edit&section=10)]

The megajoule (MJ) is equal to one million (106) joules, or approximately the kinetic energy of a one megagram (tonne) vehicle moving at 160 km/h.

One [kilowatt hour](/wiki/Kilowatt_hour) of electricity is 3.6 megajoules.

### Gigajoule[[edit](/index.php?title=(none)&action=edit&section=11)]

The gigajoule (GJ) is equal to one billion (109) joules. 6 GJ is about the amount of potential [chemical energy](/wiki/Chemical_energy) in 160 L (approximately one US standard [barrel](/wiki/Barrel_of_oil_equivalent)) of oil, when combusted.[[10]](#cite_note-10)

### Terajoule[[edit](/index.php?title=(none)&action=edit&section=12)]

The terajoule (TJ) is equal to one trillion (1012) joules. About 63 TJ of energy was released by [the atomic bomb that exploded over Hiroshima](/wiki/Little_Boy).[[11]](#cite_note-11) The [International Space Station](/wiki/International_Space_Station), with a mass of approximately 450 [megagrams](/wiki/Megagram) and orbital velocity of 7.7 km/s,[[12]](#cite_note-12) has a [kinetic energy](/wiki/Kinetic_energy) of roughly 13 TJ.

### Petajoule[[edit](/index.php?title=(none)&action=edit&section=13)]

The petajoule (PJ) is equal to one quadrillion (1015) joules. 210 PJ is equivalent to about 50 megatons of TNT. This is the amount of energy released by the [Tsar Bomba](/wiki/Tsar_Bomba), the largest man-made nuclear explosion ever.

### Exajoule[[edit](/index.php?title=(none)&action=edit&section=14)]

The exajoule (EJ) is equal to one quintillion (1018) joules. The [2011 Tōhoku earthquake and tsunami](/wiki/2011_Tōhoku_earthquake_and_tsunami) in Japan had 1.41 EJ of energy according to its 9.0 on the [moment magnitude scale](/wiki/Moment_magnitude_scale). [Energy in the United States](/wiki/Energy_in_the_United_States) used per year is roughly 94 EJ.

### Zettajoule[[edit](/index.php?title=(none)&action=edit&section=15)]

The zettajoule (ZJ) is equal to one sextillion (1021) joules. The human [annual global energy consumption](/wiki/World_energy_resources_and_consumption) is approximately 0.5 ZJ.

### Yottajoule[[edit](/index.php?title=(none)&action=edit&section=16)]

The yottajoule (YJ) is equal to one septillion (1024) joules. This is approximately the amount of energy required to heat [all the water on Earth](/wiki/Water#On_Earth) by 1 °C. The thermal output of the [Sun](/wiki/Sun) is approximately 400 YJ per second.

## Conversions[[edit](/index.php?title=(none)&action=edit&section=17)]

[Template:Main](/wiki/Template:Main) 1 joule is equal to:

* [Template:Val](/wiki/Template:Val) (exactly)
* [Template:Val](/wiki/Template:Val)
* [Template:Val](/wiki/Template:Val) (gram calories)
* [Template:Val](/wiki/Template:Val) (food calories)
* [Template:Val](/wiki/Template:Val) [Template:Val](/wiki/Template:Val)
* [Template:Val](/wiki/Template:Val) (foot-poundal)
* [Template:Val](/wiki/Template:Val)
* [Template:Val](/wiki/Template:Val)
* [Template:Val](/wiki/Template:Val) (litre-atmosphere)
* [Template:Val](/wiki/Template:Val) (by way of [mass-energy](/wiki/Mass-energy) equivalence)
* [Template:Val](/wiki/Template:Val) (exactly)

Units defined exactly in terms of the joule include:

* 1 thermochemical [calorie](/wiki/Calorie) = 4.184 J<ref name=FAO>[The adoption of joules as units of energy](http://www.fao.org/docrep/meeting/009/ae906e/ae906e17.htm), FAO/WHO Ad Hoc Committee of Experts on Energy and Protein, 1971. A report on the changeover from calories to joules in nutrition.</ref>
* 1 International Table [calorie](/wiki/Calorie) = 4.1868 J[[13]](#cite_note-13)\* 1 watt hour = 3600 J (or 3.6 kJ)
* 1 kilowatt hour = [Template:Val](/wiki/Template:Val) (or 3.6 MJ)
* 1 watt second = [Template:Val](/wiki/Template:Val)
* 1 [ton TNT](/wiki/Ton_TNT) = [Template:Val](/wiki/Template:Val)

## See also[[edit](/index.php?title=(none)&action=edit&section=18)]

[Template:Wiktionary](/wiki/Template:Wiktionary)

* [Conversion of units of energy](/wiki/Conversion_of_units_of_energy)
* [Orders of magnitude (energy)](/wiki/Orders_of_magnitude_(energy))
* [Fluence](/wiki/Fluence)
* [International System of Units](/wiki/International_System_of_Units)
* [Watt second](/wiki/Watt_second)

## Notes and references[[edit](/index.php?title=(none)&action=edit&section=19)]

[Template:Reflist](/wiki/Template:Reflist)

[Template:SI units](/wiki/Template:SI_units) [Template:Footer energy](/wiki/Template:Footer_energy)

[Category:SI derived units](/wiki/Category:SI_derived_units) [Category:Units of energy](/wiki/Category:Units_of_energy) [Category:James Prescott Joule](/wiki/Category:James_Prescott_Joule)