

## SI

The International Systems of Units (SI) is a modernized version of the metric system. SI is at present the latest version of the original metric system first proposed in France in 1670 and improved many times since then.

The great advantage of the SI is that there is one and only one base unit for each physical quantity – the metre for length, the kilogram for mass, the second for time, etc. Units for all other mechanical quantities are derived from the base units. The derived units are definable by simple equations, such as:

Velocity = length per time

Force = mass x acceleration

Power = work or energy per time

Energy or work = force x distance

## SI Prefixes

| <i>Multiplication factors</i> | <i>Exponential</i>         | <i>Prefix</i> | <i>SI system</i> |
|-------------------------------|----------------------------|---------------|------------------|
| 1 000 000 000 000 000 000     | = 10 <sup>18</sup> = E+18  | exa           | E                |
| 1 000 000 000 000 000         | = 10 <sup>15</sup> = E+15  | peta          | P                |
| 1 000 000 000 000             | = 10 <sup>12</sup> = E+12  | tera          | T                |
| 1 000 000 000                 | = 10 <sup>9</sup> = E+09   | giga          | G                |
| 1 000 000                     | = 10 <sup>6</sup> = E+06   | mega          | M                |
| 1 000                         | = 10 <sup>3</sup> = E+03   | kilo          | k                |
| 100                           | = 10 <sup>2</sup> = E+02   | hecto         | h                |
| 10                            | = 10 <sup>1</sup> = E+01   | deca          | da               |
| 1                             | = 10 <sup>0</sup> = E+00   | UNIT          |                  |
| 0.1                           | = 10 <sup>-1</sup> = E-01  | deci          | d                |
| 0.01                          | = 10 <sup>-2</sup> = E-02  | centi         | c                |
| 0.001                         | = 10 <sup>-3</sup> = E-03  | milli         | m                |
| 0.000 001                     | = 10 <sup>-6</sup> = E-06  | micro         | μ                |
| 0.000 000 001                 | = 10 <sup>-9</sup> = E-09  | nano          | n                |
| 0.000 000 000 001             | = 10 <sup>-12</sup> = E-12 | pico          | p                |
| 0.000 000 000 000 001         | = 10 <sup>-15</sup> = E-15 | femto         | f                |
| 0.000 000 000 000 000 001     | = 10 <sup>-18</sup> = E-18 | atto          | a                |

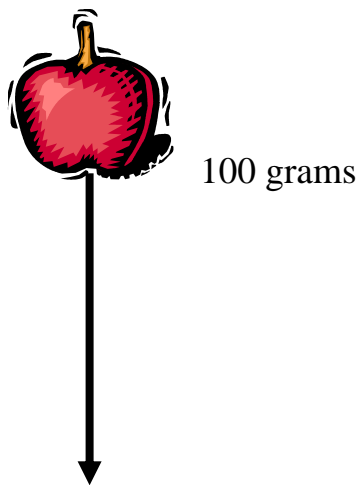
## Metre (m)



The first definition of the metre was in terms of the earth's circumference. The metre was to be constructed so that it would equal one ten-millionth of the distance from the North Pole to the equator along the meridian of the earth running near Dunkerque in France and Barcelona in Spain.

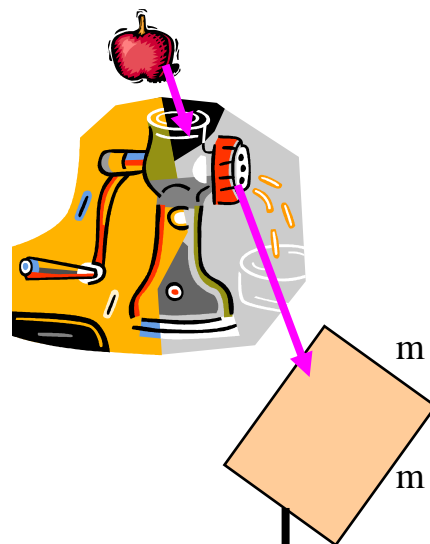
However a yarning existed among metricians to base the length of the metre on some fact of nature and so the metre (m) is now define as the length equal to 1 650 763.73 wave lengths in vacuum of the radiation corresponding to the transitions between the levels,  $2p_{10}$  and  $5d_5$  of the krypton-86 atom.

## Force



Force of 1 Newton (N)

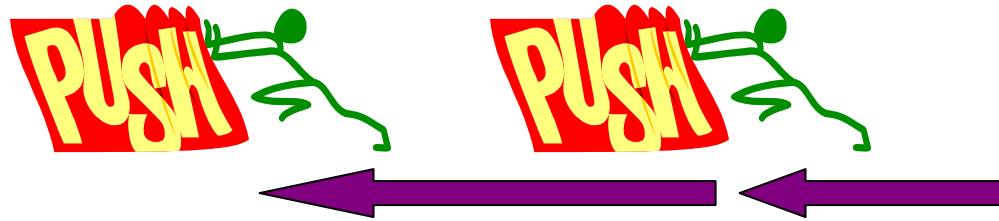
$$\begin{aligned} \text{Force} &= \text{mass} \times \text{acceleration} \\ &= 1 \text{ kg} \times 9.81 \text{ m/s}^2 \\ &= 9.81 \text{ N} \end{aligned}$$



Pressure of 1 Pascal (Pa)

It has been suggested that an apple (about 100 grams) tossed into the air strikes the hand, on falling, with a force of about one Newton (N). If the same apple is made into apple sauce and spread over an area of one square metre, the pressure exerted would be equal to 1 Pascal (Pa) or 1 Newton per square metre.

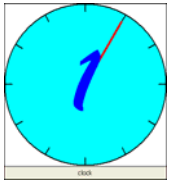
## Energy



$$\text{Work in joules} = \text{Distance in metres} \times \text{Force in newtons}$$

$$\begin{aligned} \text{Energy} &= \text{work done} \\ &= \text{force (N)} \times \text{distance (m)} \\ 1 \text{ J} &= 1 \text{ N.m} \end{aligned}$$

## Time



The base unit of time is the second. The definition is that the time 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.

## Mass (weight)

The base unit of mass is the kilogram (kg). The international prototype of the kilogram is a particular cylinder of platinum (90%)-iridium (10%) alloy, about 3.8 cm high and 3.8cm in diameter, which is preserved in a vault at Sèvres, France, by the International Bureau of Weights and Measures.

## Amount of substance

The amount of molecular substance is the mole, where one mole of any substance is the gram molecular weight of that material. For example, water (H<sub>2</sub>O);

$$\text{H}_2 = 2 \times 1.008 \text{ (atomic weight of hydrogen)} = 2.016 \text{ g}$$

$$\text{O} = 1 \times 16 \text{ (atomic weight of oxygen)} = 16 \text{ g}$$

$$1 \text{ mole of H}_2\text{O} = 18.016 \text{ g}$$

**Concentration** (of the amount of substance) is the mole per cubic meter (mol/m<sup>3</sup>)

## *Principle Conversation Factors*

|  |   |
|--|---|
| 1 atmosphere, physical (atm)<br>= 1.013 250 bar<br>= 760 mmHg (0 <sup>0</sup> C)<br>= 101.325 kPa<br>= 101 325 N/m <sup>2</sup><br>= 10.333 t/m <sup>2</sup><br>= 14.696 lbf/in <sup>2</sup> | 1 bar (bar) – unit of pressure<br>= 0.986 923 atm<br>= 750.06 mmHg (0 <sup>0</sup> C)<br>= 100 000 Pa<br>= 100 kPa<br>= 10 N/cm <sup>2</sup><br>= 10.197 tf/m <sup>2</sup>                                      |
| 1 calorie – International (Int cal)<br>= 4.186 8 J   | 1 calorie – dietetic (cal) – unit of energy<br>= 4.185 5 kJ   |
| 1 carat – metric (-) – unit of mass<br>= 200 mg  | 1 centimetre (cm) - unit of length<br>= 0.3937 in<br>= 10 mm<br>= 0.01 m  |
| 1 cubic centimetre (cm <sup>3</sup> )<br>= 0.001 L<br>= 1000 mL<br>= 0.035 195 fl oz (Cdn)<br>= 0.033 814 fl oz (US)<br>= 0.061 02 in <sup>3</sup>   | 1 cubic metre (m <sup>3</sup> ) – unit of volume<br>= 0.276 cord<br>= 1.308 yd <sup>3</sup><br>= 35.3147 ft <sup>3</sup><br>= 219.969 gal (cdn)<br>= 264.172 gal (US)<br>= 1000 kg<br>= 1 t<br>= 1 kL<br>= 1 Mg |
| 1 foot (ft) – unit of length<br>= 304.8 mm<br>= 30.48 cm<br>= 3.048 dm<br>= 0.3048 m   | 1 foot per minute (ft/min) – unit of velocity<br>= 5.08 mm/s<br>= 0.3048 m/min<br>= 18.288 m/h  |
| 1 foot pound-force (ft.lbf)<br>= 1.356 J   | 1 furlong (-) – unit of length<br>= 201.168 m   |
| 1 grain (gr) – unit of mass<br>= 64.798 91 mg  | 1 gray (Gy) – absorbed energy per mass<br>= 1 J/kg<br>= 100 rads  |
| 1 hectare (ha) – unit of area<br>= 100 ares<br>= 0.01 km <sup>2</sup><br>= 10 000 m <sup>2</sup><br>= 2.471 054 acres  | 1 inch (in) – unit of length<br>= 25.4 mm<br>= 2.54 cm<br>= 0.0254 m  |



|   |  |
|---|--|
| 1 newton (N) – unit of force<br>= 1 (kg.m)/S <sup>2</sup><br>= 101.97 gf<br>= 0.224 808 lbf                           | 1 newton per square metre (N/m <sup>2</sup> )<br>= 1 Pa<br>= 1 x 10 <sup>-2</sup> mbar<br>= 1 x 10 <sup>-5</sup> bar |
| 1 ounce (US fl oz)<br>= 29.537 mL   | 1 pint (US pt) – unit of capacity<br>= 0.473 176 L   |
| 1 pound per cubic inch (lb/in <sup>3</sup> )<br>= 27.679 g/cm <sup>3</sup><br>= 27.679 kg/l                           | 1 pound-force (lbf) – unit of force<br>= 4.448 22 N  |
| 1 pound-force per square inch (lbf/in <sup>2</sup> )<br>= 6.894 757 kPa   | 1 quart (US qt) – unit of volume<br>= 946.36 mL  |
| 1 square centimetre (cm <sup>2</sup> )<br>= 0.155 in <sup>2</sup><br>= 0.0001 m <sup>2</sup><br>= 100 mm <sup>2</sup> | 1 square mile (mi <sup>2</sup> ) – unit of area<br>= 258.9988 ha<br>= 2.589 988 km <sup>2</sup>                      |
| 1 ton long (ton)<br>= 1.016 047 t<br>= 1016.047 kg<br>= 1.12 tn   | 1 ton short (tn)<br>= 0.907 185 t<br>= 907.185 kg<br>= 0.892 857 ton   |
| 1 tonne (t)<br>= 1000 kg<br>= 0.984 207 ton<br>= 1.102 31 tn  | 1 ton-force short (tnf)<br>= 8.896 443 kN  |
| 1 ton-force per square inch (tnf/in <sup>2</sup> )<br>= 13.789 5 MPa  | 1 watt-hour (W.h) – unit of energy<br>= 3600 J<br>= 3.6 kJ   |
| 1 watt per square foot (W/ft <sup>2</sup> )<br>= 10.763 W/m <sup>2</sup>  | 1 yard (yd) – unit of length<br>= 91.44 cm<br>= 0.9144 m   |