

Chapter 18. Units of Measurement

The uniform use of units of measure facilitates broad catalog searches across archive systems. The PDS standard system for units, where applicable, is the *Systeme Internationale d'Unites* (SI). The default units for data elements in the *Planetary Science Data Dictionary* (PSDD) are determined as each element is defined and added to the dictionary. Specific unit definitions are also included in the PSDD.

In cases where more than one type of unit is commonly used for a given data element, an additional data element is provided to explicitly identify the corresponding unit.

SAMPLING_PARAMETER_RESOLUTION and SAMPLING_PARAMETER_UNIT are one such pair. The PDS allows exceptions to the SI unit requirement when common usage conflicts with the SI standard (e.g., angles which are measured in degrees rather than radians).

Both singular and plural unit names, as well as unit symbols, are allowed. The double asterisk (**) is used, rather than the caret (^), to indicate exponentiation. When the units associated with a value of a PDS element are not the same as the default units specified in the PSDD (or when explicit units are preferred), a unit expression is used with the value. These unit expressions are enclosed in angular brackets (< >) and follow the value to which they apply.

Examples

```
EXPOSURE_DURATION = 10 <SECONDS>
DECLINATION       = -14.2756 <DEGREES>
MASS              = 123 <kg>
MASS_DENSITY     = 123 <g/cm**3>
MAP_RESOLUTION   = 123 <PIXEL/DEGREE>
MAP_SCALE        = 123 <KM/PIXEL>
```

Note that in the above example, MASS_DENSITY is not expressed in the SI default unit of measurement for density (kg/m**3).

PDS recommends (in order of preference) that measurements be expressed using the default SI units of measurements, as defined in the following paragraphs. If it is not desirable to use the default SI unit of measurement, then the unit of measurement should be expressed using the SI nomenclature defined in the following paragraphs. If a unit of measurement is not defined by the SI standard, then a unit of measurement can be derived (e.g., pixels per degree, kilometers per pixel, etc.).

18.1 SI Units

The following summary of SI unit information is extracted from *The International System of Units*.

Base units — As the system is currently used, there are seven fundamental SI units, termed “base

units”:

| <u>QUANTITY</u> | <u>NAME OF UNIT</u> | <u>SYMBOL</u> |
|---------------------------|---------------------|---------------|
| length | meter | m |
| mass | kilogram | kg |
| time | second | s |
| electric current | ampere | A |
| thermodynamic temperature | kelvin | K |
| amount of substance | mole | mol |
| luminous intensity | candela | cd |

SI units are all written in mixed case; symbols are also mixed case except for those derived from proper names. No periods are used in any of the symbols in the international system.

Derived units — In addition to the base units of the system, a host of derived units, which stem from the base units, are also employed. One class of these is formed by adding a prefix, representing a power of ten, to the base unit. For example, a kilometer is equal to 1,000 meters, and a millisecond is .001 (that is, 1/1,000) second. The prefixes in current use are as follows:

| SI PREFIXES | | | | | |
|--------------------|---------------|---------------|---------------|---------------|---------------|
| <u>Factor</u> | <u>Prefix</u> | <u>Symbol</u> | <u>Factor</u> | <u>Prefix</u> | <u>Symbol</u> |
| 10**18 | exa | E | 10**-1 | deci | d |
| 10**15 | peta | P | 10**-2 | centi | c |
| 10**12 | tera | T | 10**-3 | milli | m |
| 10**9 | giga | G | 10**-6 | micro | |
| 10**6 | mega | M | 10**-9 | nano | n |
| 10**3 | kilo | k | 10**-12 | pico | p |
| 10**2 | hecto | h | 10**-15 | femto | f |
| 10**1 | deka | da | 10**-18 | atto | a |

Note that the kilogram (rather than the gram) was selected as the base unit for mass for historical reasons. Notwithstanding, the gram is the basis for creating mass units by addition of prefixes.

Another class of derived units consists of powers of base units and of base units in algebraic relationships. Some of the more familiar of these are the following:

| <u>QUANTITY</u> | <u>NAME OF UNIT</u> | <u>SYMBOL</u> |
|------------------|--------------------------|---------------|
| area | square meter | m**2 |
| volume | cubic meter | m**3 |
| density | kilogram per cubic meter | kg/m**3 |
| velocity | meter per second | m/s |
| angular velocity | radian per second | rad/s |
| acceleration | meter per second squared | m/s**2 |

| | | |
|------------------------------------|--------------------------------|------------------------------------|
| angular acceleration | radian per second squared | rad/s^2 |
| kinematic viscosity | square meter per second | m^2/s |
| dynamic viscosity | newton-second per square meter | $\text{N}\cdot\text{s}/\text{m}^2$ |
| luminance | candela per square meter | cd/m^2 |
| wave number | 1 per meter | m^{-1} |
| activity (of a radioactive source) | 1 per second | s^{-1} |

Many derived SI units have names of their own:

| <u>QUANTITY</u> | <u>NAME OF UNIT</u> | <u>SYMBOL</u> | <u>EQUIVALENT</u> |
|--|---------------------|---------------|-------------------------------------|
| frequency | hertz | Hz | s^{-1} |
| force | newton | N | $\text{kg}\cdot\text{m}/\text{s}^2$ |
| pressure (mechanical stress) | pascal | Pa | N/m^2 |
| work, energy, quantity of heat | joule | J | $\text{N}\cdot\text{m}$ |
| power | watt | W | J/s |
| quantity of electricity potential difference | coulomb | C | $\text{A}\cdot\text{s}$ |
| electromotive force | volt | V | W/A |
| electrical resistance | ohm | — | V/A |
| capacitance | farad | F | $\text{A}\cdot\text{s}/\text{V}$ |
| magnetic flux | weber | Wb | $\text{V}\cdot\text{s}$ |
| inductance | henry | H | $\text{V}\cdot\text{s}/\text{A}$ |
| magnetic flux density | tesla | T | Wb/m^2 |
| luminous flux | lumen | lm | $\text{cd}\cdot\text{sr}$ |
| illuminance | lux | lx | lm/m^2 |

Supplementary units are as follows:

| <u>QUANTITY</u> | <u>NAME OF UNIT</u> | <u>SYMBOL</u> |
|-----------------|---------------------|---------------|
| plane angle | radian | rad |
| solid angle | steradian | sr |

Use of figures with SI units — In the international system it is considered preferable to use only numbers between 0.1 and 1,000 in expressing the quantity associated with any SI unit. Thus the quantity 12,000 meters is expressed as “12 km”, not “12,000 m”. So too, 0.003 cubic centimeters is preferably written “3 mm³”, not “0.003 cm³”.

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