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# ASTRONOMY 121: SUPPLEMENT I

## A. POWERS OF TEN

Because of the large *range* of scales involved in astronomy, we will need to make extensive use of the standard scientific **powers of ten notation**.

In this convenient and compact notation, large (or small) numbers are expressed as a regular decimal number multiplied by ten raised to an integer positive (or negative) power.

> For example, the speed of light is twenty-nine billion nine hundred million centimeters per second or: $c = 29,900,000,000$ cm/sec. It would be very awkward to have to write out such a large number for computations. But in powers of ten notation, this becomes:
>
> $$c = 2.99 \times 10^{10} \text{ cm/sec}$$
>
> ...much more tractable.

The exponent of ten in this notation is the number of times 10 must be multiplied by itself:

$10 = 10^1$ $\quad$ $1{,}000 = 10 \times 10 \times 10 = 10^3$ $\quad$ $1{,}000{,}000 = 1000 \times 1000 = 10^6$ etc.

Negative exponents indicate values smaller than 1 and represent the number of times that $\frac{1}{10}$ must be multiplied by itself:

$0.1 = \frac{1}{10} = 10^{-1}$ $\quad$ $0.001 = 1/1000 = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 10^{-3}$ etc

Thus, in powers of ten notation,

$35{,}000 = 3.5 \times 10^4$ $\quad$ $0.00035 = 3.5 \times 10^{-4}$.

Note that:

one thousand = $10^3$, $\quad$ one million = $10^6$, $\quad$ one billion = $10^9$

and that the following prefixes (usually applied to units of length, time, energy, or mass) indicate particular powers of ten:

| | | |
|---|---|---|
| **milli** = $10^{-3}$ | **micro** = $10^{-6}$ | **nano** = $10^{-9}$ |
| **kilo** = $10^3$ | **mega** = $10^6$ | **giga** = $10^9$ |

## B. SPECIAL SYMBOLS

Astronomy is an "order of magnitude" science. That is, we often cannot measure quantities of interest to better than a factor of ten in accuracy. For this reason, the "approximate" symbol ($\approx$ or $\sim$) is used more often than the "equals sign":

$x \approx 20$ means "x is approximately equal to 20".

Other mathematical symbols we will occasionally use as shorthand include:

$<$ "is less than"

$>$ "is greater than"

*wrt* "with respect to"

$\Rightarrow$ "implies"

$\Uparrow$ "increases"

$\Downarrow$ "decreases"

$\exists$ "there is"

@ "at"

Examples:

$L \Uparrow \Rightarrow T \Downarrow$ means "if L increases then T decreases"

@ 1200°, $x > y$ means "at 1200 degrees, x is greater than y".

Some astronomical symbols:

$\odot$ stands for the Sun $\oplus$ stands for the Earth

Commonly used symbols for other quantities:

$n$ for neutron

$p$ for proton

$e$ or $e^-$ for electron

$c$ for speed of light

$\lambda$ for wavelength of electromagnetic wave

$\nu$ for frequency of electromagnetic wave