Large and Small Numbers

Astronomers work with very large and very small numbers.

For example:

- The radius of the sun is 70,000,000,000 centimeters
- The mass of the sun is 20,000,000,000,000,000,000,000,000,000,000,000 grams
- The radius of a Hydrogen atom is 0.000,000,01 centimeters
- The mass of a Hydrogen atom is 0.000,000,000,000,000,000,000,001,6 grams

Such numbers are at best inconvenient to use
Scientific Notation

Scientists use a shorthand called scientific notation

Any number can be expressed as the product of two other numbers.

Usually, one of the numbers is a power of 10.

For example,

- $200 = 2 \times 100$ or $2 \times 10 \times 10$, or $2 \times 10^2$.
- $70,000,000,000 = 7 \times 10,000,000,000 = 7 \times 10^{10}$

Here, the 10 is called the *exponent*.

The exponent is the number of zeros which follow the initial number called the mantissa.
Scientific Notation

Numbers with absolute values less than 1:

The exponent is negative, because $10^{-n} = \frac{1}{10^n}$.

To get the exponent, count the number of zeros to the right of the decimal place, add 1, and then take the negative.

For example, $0.002 = 2 \times 0.001 = 2 \times 10^{-3}$.

Numbers between 1 and 10 have exponents of 0 because $10^0 = 1$. 
Significant Figures

1.234 \times 10^6 = 12.34 \times 10^5 = 0.1234 \times 10^7

By convention, we use a mantissa with one figure to the left of the decimal place (1.234 \times 10^6 is preferred).

The significant figures are the number of digits in the mantissa.

This number (1.234 \times 10^6 ) has 4 significant figures.

For most purposes in this course, 2 or 3 significant figures suffice.
Manipulating Numbers

Scientific notation simplifies manipulation of large and small numbers.

Suppose you wanted to determine the moment of inertia of the Sun. This is the product $MR^2$.

$I = 2 \times 10^{33} \times 7 \times 10^{10} \times 7 \times 10^{10}$

Multiply the mantissas ($2 \times 7 \times 7 = 98$)
Add the exponents ($33 + 10 + 10 = 53$)
$I = 98 \times 10^{53} = 9.8 \times 10^{54}$

For division, subtract the exponents
POWERS OF ONE
A MIND-EXPANDING LOOK AT OUR WORLD
Basic Units of Measurement
Distance

Centimeter (cm): 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2p10 and 5d5 of the krypton\(^{86}\) atom.

**Meter (m)**: 100 cm. Originally \(10^{-4}\) of the mean distance from the North Pole to the equator.

**Kilometer (km)**: \(10^3\) m.

**Angstrom Å**: \(10^{-10}\) m.

**Nanometer (nm)**: \(10^{-9}\) m.

**Micron (µm)**: \(10^{-6}\) m.

Inch: 2.54 cm; Mile: 1.62 km

**Longer Distances**

**Solar radius (R_☉)**: \(7 \times 10^{10}\) cm

**Astronomical Unit (AU)**: Earth-Sun distance = \(1.5 \times 10^{13}\) cm

**Light Year (ly)**: \(9.46 \times 10^{17}\) cm
Mass

**gram (gm)**: defined by the mass of a platinum-iridium cylinder stored in a vault in Paris.

**kilogram (kg)**: 1000 gm.

**Pound (lb)**: 454 gm

**Stone**: 14 lb.

**Solar mass (M_☉)**: $2 \times 10^{33}$ gm.
Time

**Second (s):** the duration of 9,192,631,770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of cesium\(^{133}\).

**Day (d):** 86,400 seconds. Mean rotation of the Earth

**Year (yr):** 365.2422 d. Approx \(\pi \times 10^7\) s. Orbital period of Earth
## Temperatures

<table>
<thead>
<tr>
<th>scale</th>
<th>Absolute zero</th>
<th>Water freezes</th>
<th>Water boils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kelvin (K)</td>
<td>0</td>
<td>273.15</td>
<td>373.15</td>
</tr>
<tr>
<td>Celsius (C)</td>
<td>-273.15</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Farenheit (F)</td>
<td>-456</td>
<td>32</td>
<td>212</td>
</tr>
</tbody>
</table>

1K = 1°C = \( \frac{9}{5} \) F; \( C=(F-32)\times\frac{5}{9} \)