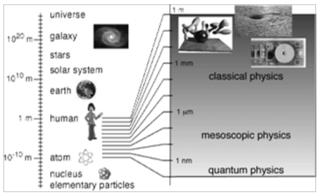
Lecture 2:

Astronomical & Biological Numbers



Astronomy 141 – Winter 2012

This lecture introduces basic notation and physical units we'll use during this course.

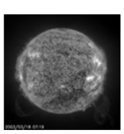
We will use Scientific Notation to express numbers large and small.

We will use the Metric System for units of length, mass, and temperature.

We use special units for expressing biological (very small) and astronomical (very large) scales.

Astronomical numbers are often very large.

Average distance of the Earth from the Sun:
149,597,870.691 kilometers



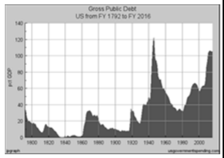
Mass of the Sun
1,989,100,000,000,000,000,000,000,000,000 kg

Age of the Earth:
4,600,000,000 years

Big Non-Astronomical Numbers

US National Debt as of
2011 Dec 29:

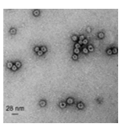
$15,125,898,976,397.19
($15.1 Trillion)



Number of OREO cookies
sold to date:

491,000,000,000
(491 Billion)

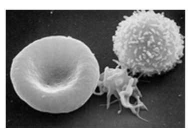
Biological numbers are very small



Virus particles
0.000000028 meters
0.00000000000001 grams

E. coli Bacteria
0.000002 meters
0.000000000001 grams

Human Blood Cells
0.00001 meters
0.000000001 grams



Scientific Notation is a compact way of expressing large and small numbers.

Use powers of 10 instead of many zeroes

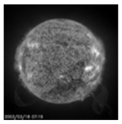
$$\boxed{1.9891} \times 10^{\boxed{30}}$$

__Mantissa__:
the significant digits
of the number

Exponent:
The power of 10
of the number

Examples:

Mass of the Sun

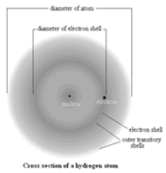


1,989,100,000,000,000,000,000,000,000,000 kg

1.9891×10^{30} kg

Diameter of a Hydrogen Atom
0.0000000000106 meters

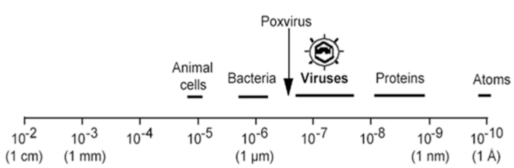
1.06×10^{-11} meters



Standard Prefixes are used to help us say some large numbers in a simple way.

10^{3} =	*kilo-*	(kilogram, kilometer)
10^{6} =	*mega-*	(megawatt, megayear)
10^{9} =	*giga-*	(gigabyte, gigayear)
10^{12} =	*tera-*	(terabyte, terawatt)
10^{15} =	*peta-*	(petabyte)
10^{-2} =	*centi-*	(centimeter)
10^{-3} =	*milli-*	(millimeter, millisecond)
10^{-6} =	*micro-*	(microsecond, micron)
10^{-9} =	*nano-*	(nanometer, nanogram)
10^{-12} =	*pico-*	(picogram, picometer)

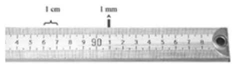
We need special size units for denoting the very small sizes of biological structures.



1 micron (µm) = 10^{-6} meters
Bacteria: 0.5-2 µm
Cells: 10s of µm
1 nanometer (nm) = 10^{-9} meters
Viruses: 10s to 100s of nm
Proteins: few nm

In the sciences we use the Metric System to express physical units.

Lengths in ***Meters***

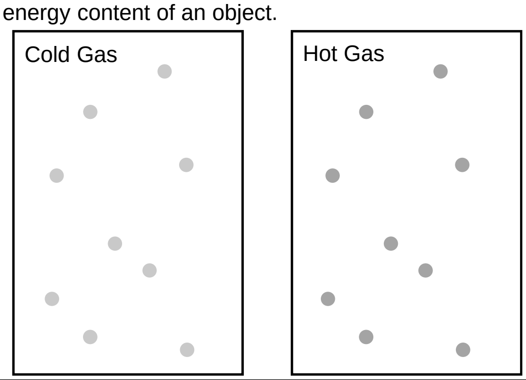


Masses in ***Kilograms***

Time in ***Seconds***

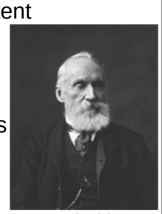
Temperature in ***Celsius*** or ***Kelvin***

Temperature is a measurement of the internal energy content of an object.



The Kelvin Scale is an absolute temperature scale that measures the thermal energy content of an object.

Twice the Internal Energy is
Twice the Temperature in Kelvins



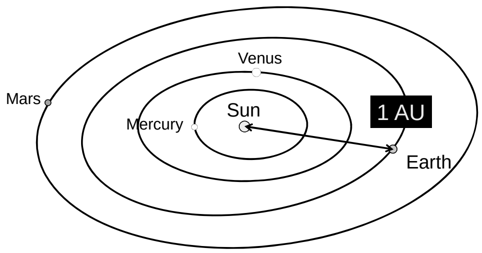
Lord Kelvin
(William Thompson)

Examples:

0 K = Absolute Zero (all motion stops)
273 K = pure water freezes (0º Celsius)
373 K = pure water boils (100º C)

The Astronomical Unit (AU) is the mean distance from the Earth to the Sun.

1 AU ≈ 1.496×10^8 kilometers



Use AUs for distances between planets

We use Light Years to express distances between the stars.

1 Light Year (ly) is the distance traveled by Light in 1 Year:

1 ly = 9.461×10^{12} kilometers
(63,240 AU)

The nearest stars are a little over 4 light years away.

Vast empty spaces in between…

Planetary and Stellar masses are measured relative to the Earth and Sun, respectively

1 Earth Mass = 1 M_{Earth}

5.9736×10^{24} kg

1 Solar Mass = 1 M_{sun}

1.9891×10^{30} kg

~333,000 M_{Earth}