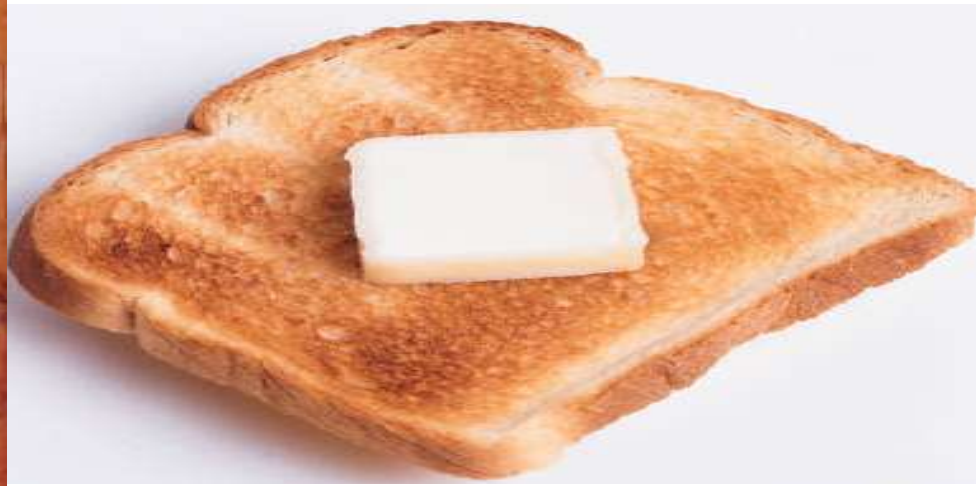
Measurement

….in France alone there were 23 temperature scales in use based on everything from the perfect temperature of a wine cellar to the melting point of butter.

- Up to the late 1700's, every country and/or town had their own way of measuring and comparing things…..



Measurement Activity

- Obtain Measuring Device #1
- Measure the width of YOUR desk.
- Obtain Measuring Device #2
- Repeat your measurement.

- Which device was “better” for measuring the floor tiles?
- Why was that device better?

- **In the late 1700's an international and uniform system of measuring was proposed by the French Academy of Sciences which they called the…..**

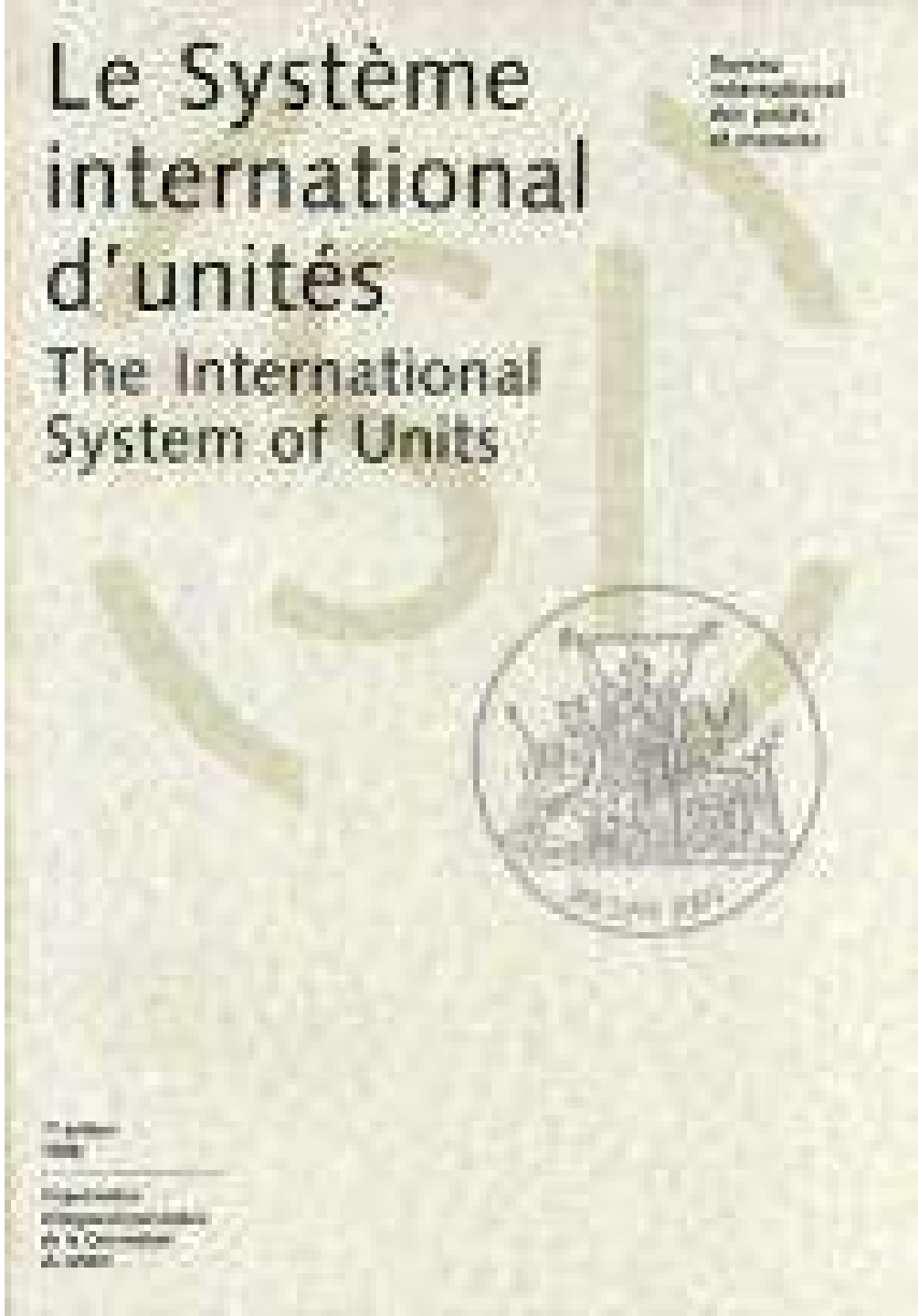
Systemé International des Unités

or as they are known today simply as…..

SI Units

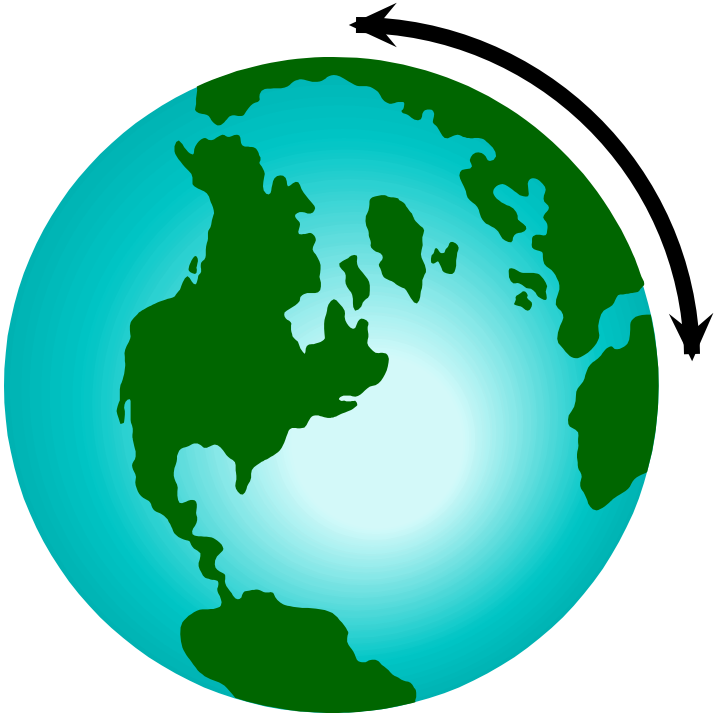
- Every physical quantity used today is compared to or measured by a **standard** or **base unit**

- At the 1971 General Conference on Weights and Measures seven (7) quantities were defined as the basis for all physical quantities.



1. Length…

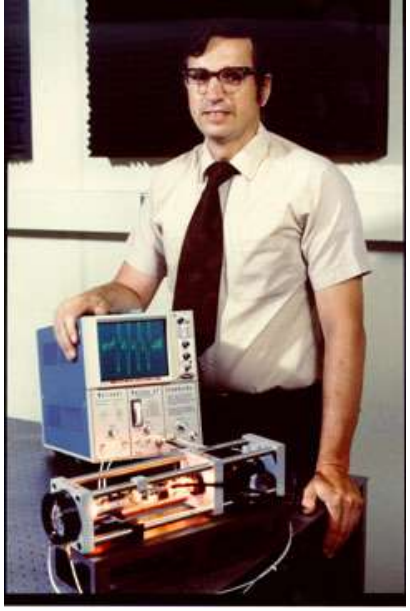
METER(m)…from Greek word "*metron*" (meaning "to measure")



- **(1792)Originally one ten-millionth ($1/10^7$) the distance from North Pole to equator along longitude line through Paris**

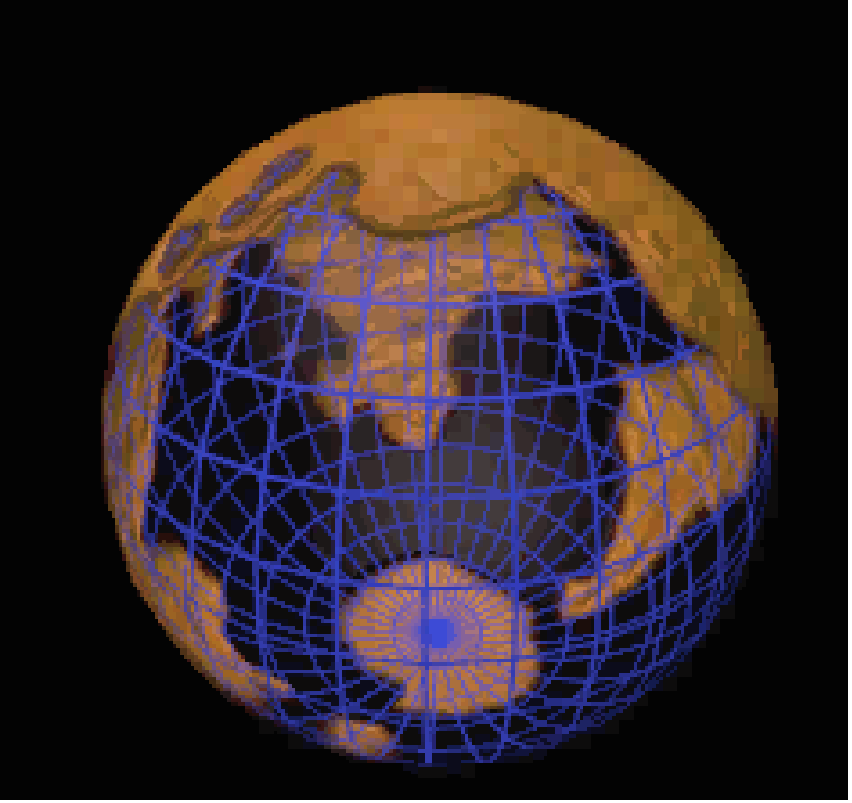
- **(1880) Platinum-Iridium Bar created to represent length**
- **Original "stick" known as *Meter of the Archives* kept in vault**

•(1960) Need for more precision changes definition to 1,650,763.73 wavelengths of specific orange-red light emitted from the Krypton-86 isotope



•(1983)More precision available and needed…meter redefined as distance light travels in a vacuum in 1/299,792,458 of a second

So precise, the inch, foot, and mile are defined in terms of the meter…..1 foot(ft)=0.305 meters

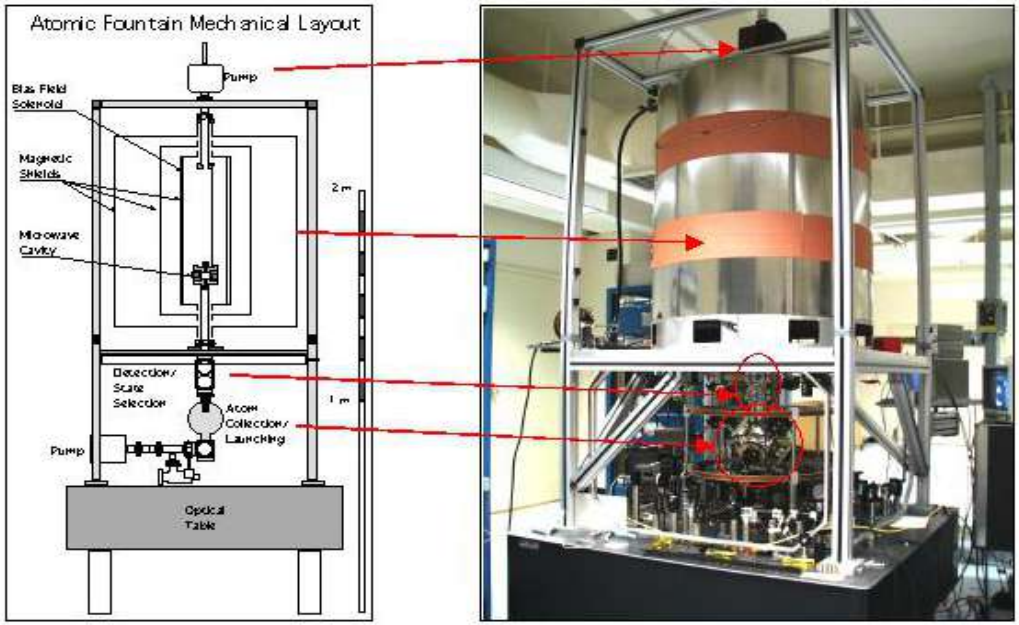


2. Time…

SECOND(s): Originally defined (1792) as 1/86,400 of ave. solar day (noon to noon)

- **(1967)Redefined by radiation frequency of Cesium-133 atom ….used in atomic clocks that are accurate to 3 millionths of a second per year**

(1999)Cesium-133 atomic fountain clock developed….
…..accurate to within 1 second every 20 million years!



As of 2010 the accuracy of the fountain clock has been improved to within 1 second every 100 million years!

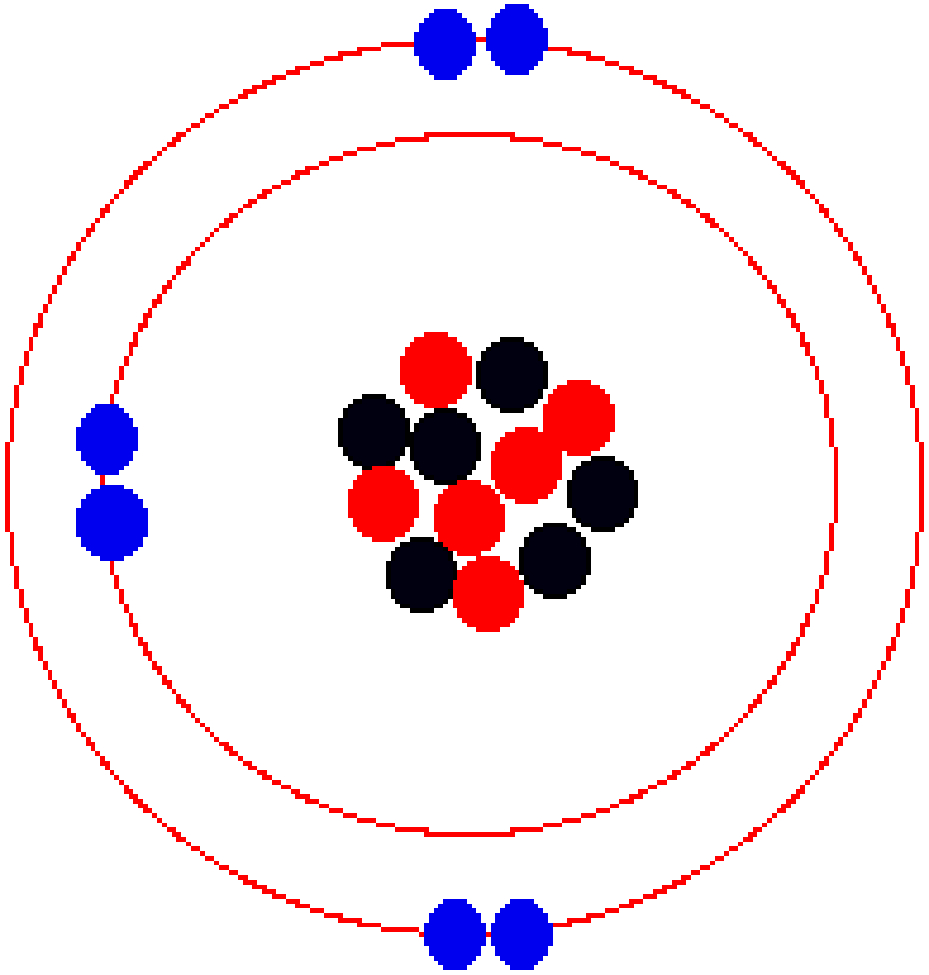
3. Mass…

KILOGRAM(kg): Originally called the "grave" (from gravity) it was the mass of water occupying a 1/10 m X 1/10 m X 1/10 m of a meter cube (def. of a volume standard – The Liter)

- **(1889) Physical platinum-iridium cylinder created 3.9 cm in diameter and 3.9 cm high and kept in vault at International Bureau of Weights and Measures**

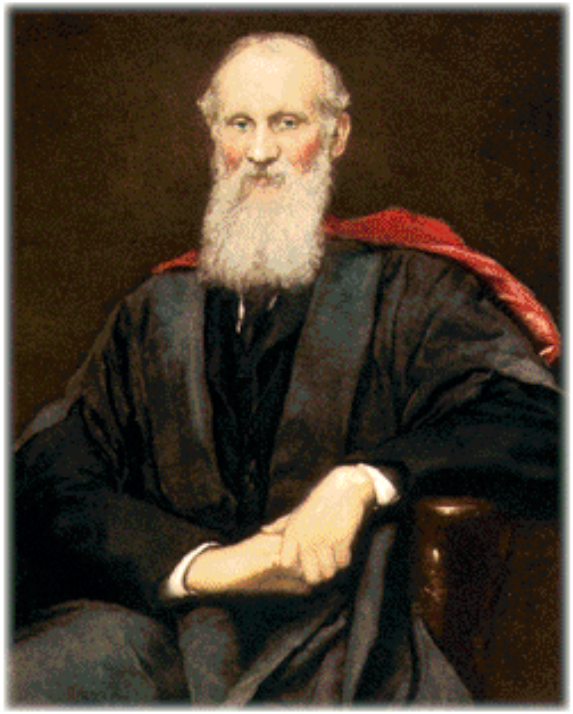
- **U.S.A. has own version in vault (National Institute of Standards and Technology –NIST- Washington, D.C.) that has been compared to original only twice since 1889.**

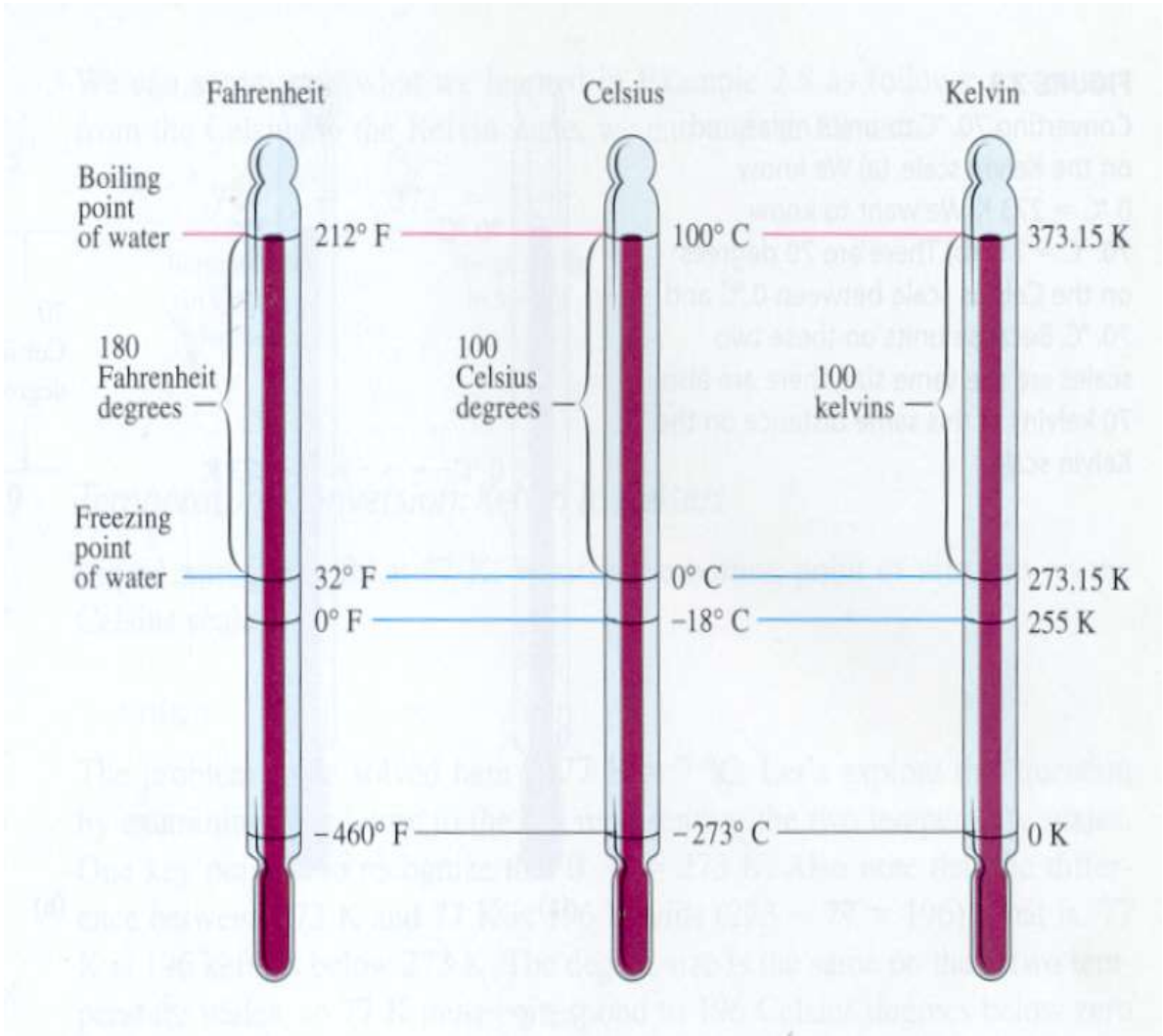
***ATOMIC MASS UNIT (u): (second mass standard)**
***Carbon-12 atom**
(used for very small masses on the atomic level where kilogram not practical)



4. Temperature…

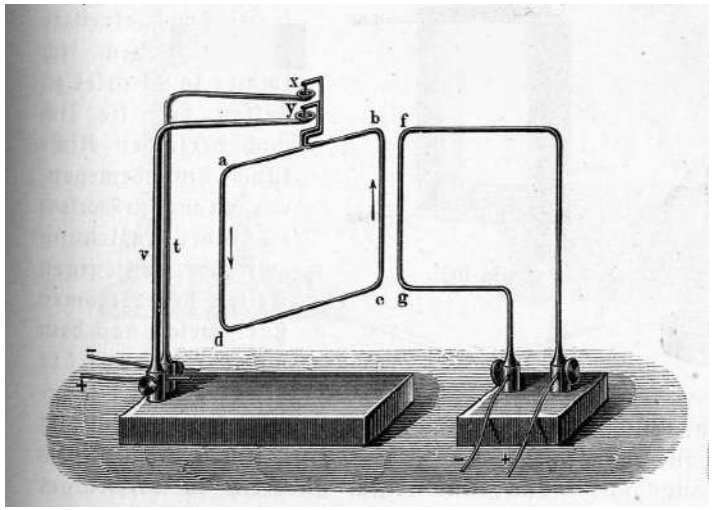
KELVIN (K): (1967) Developed by Lord William Thomson Kelvin based on absolute zero





5. Substance Amount

MOLE (mol): Number of atoms in 0.012 kg of the carbon-12



6. Electric Current

AMPERÉ (A): amount of electrical current that produces 2 X10^{-7} N of force between 2 parallel conductors 1 meter apart

7. Luminous Intensity

CANDELA (cd): Luminous intensity emitted from frozen platinum at constant pressure

- **All other physical quantities and units are combinations of the 7 base units called…**

…..DERIVED UNITS.

Speed:

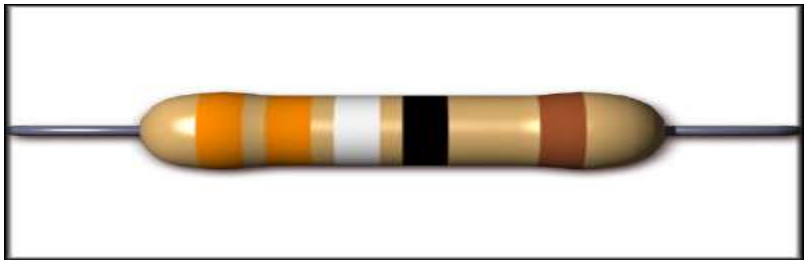
meters/second (m/s)

Volume:

m X m X m (m^3)

Resistance:

(kg X m^2)/(A^2 X s^3) Ohm (Ω)



***SI Unit system also referred to as METRIC system**

OR

M-K-S System for…..meter-kilogram-second

OR

C-G-S System for….centimeter-gram-second

***Our system known as British Engineering System (English System) OR**

F-P-S System for….foot-pound-second

(British have switched to almost all metric)

WHATEVER SYSTEM IS USED, YOU MUST RESPECT THE NUMBER WITH A UNIT!

***NO NAKED NUMBERS !**

Scientific Notation (powers of 10)

See video

Biology 10^{10} …. Chemistry 10^{15} …. **Physics 10^{40}**

Note on Significant figures

*Your answers are only as good as your measuring device and thus only accurate to the least number of digits of the values used.

*Don't give "calculator answers"!

Significant Figures

Digits that are *always significant*:

1. Non-zero digits (9 cm has one sig fig).
2. Zeroes between two significant digits (902 cm has three sig fig's).
3. All *final* zeroes to the *right* of a decimal point (902.0 cm has four sig fig's).

Digits that are *never significant*:

4. Leading zeroes to the right of a decimal point. (0.009 cm has only one significant digit.)
5. Final zeroes in a number that does not have a decimal point (900 cm has one sig fig), BUT…..

**Most text books treat 900 cm as exactly 900 cm meaning 3 sig figs!*

Calculation Rules

Rules for addition/subtraction

The answer to contain the same **number of decimal places** as the least precise measurement used in the calculation.

456.367963
- 452.1 — *least number of decimal places (limiting term)*

4.267963 — *initial answer (must be rounded off to one decimal place)*

Final answer: 4.3

Rules for multiplication/division

The answer to contain the same **number of sign. figs.** as the least precise measurement used in the calculation.

72.5674 — *six sign. figs*

x 3.34 — *three sign. figs (limiting term)*

242.3751160 — *initial answer (must be rounded off to three sign. figs.)*

Final answer: 242 or 2.42×10^2

CAUTION!

When doing unit conversions, the number of sig fig's you start with is how many you end with! *You don't get a more detailed measurement by converting!

What is the kilogram?

Common Scientific Notations Used

Large Scale……

Kilo (k)= x 10^3
mega (M)= x 10^6
giga (G)= x 10^9

Small Scale…..

Centi (c)= x 10^{-2}
milli (m)= x 10^{-3}
micro (μ)= x 10^{-6}
nano (n)= x 10^{-9}
pico (p)= x 10^{-12}

*See book appendix/
cover for more!

Next up…..
Mini-Lab
“SI Estimation”