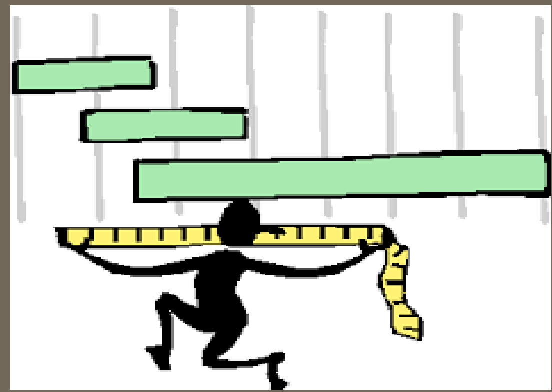
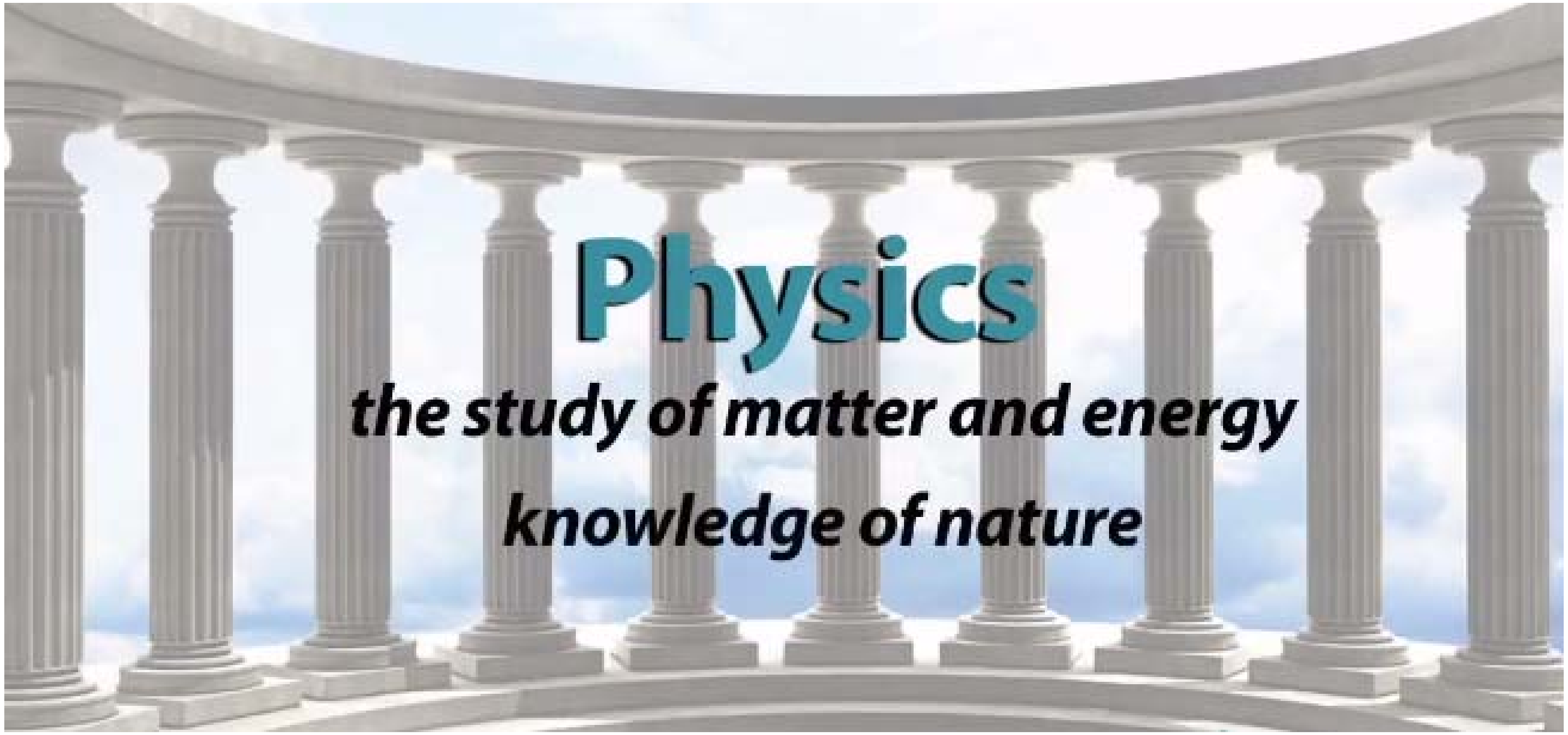


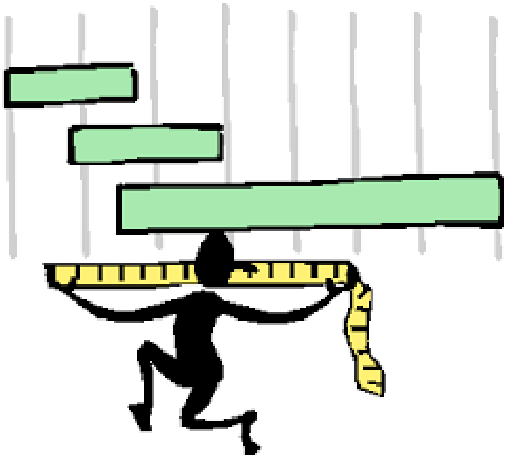
# Measurement

Meghdadi Fall 2016


Physics
the study of matter and energy
knowledge of nature

# Quantities and Units

**Quantity:**
**Anything than can be measured, such as *Length*, *Mass* or *Time***

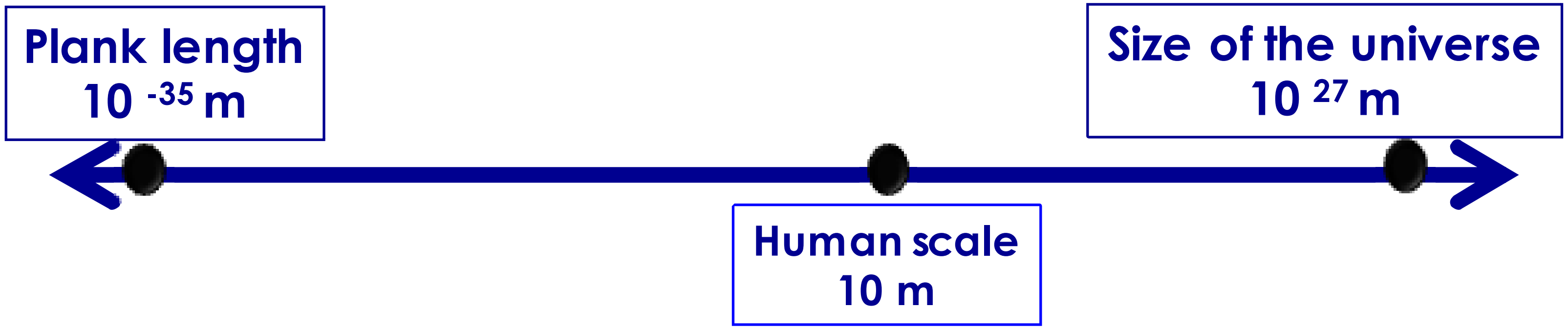


**Unit:**
**An invariable and accessible standard to measure a quantity.**

# Powers of ten

| Name | Common Notation | Math Notation | Exponent | Prefix |
|---|---|---|---|---|
| Quintillion | 1 000 000 000 000 000 000 | $10^{18}$ | 18 | Exa (E) |
| Quadrillion | 1 000 000 000 000 000 | $10^{15}$ | 15 | Peta (P) |
| Trillion | 1 000 000 000 000 | $10^{12}$ | 12 | Tera (T) |
| Billion | 1 000 000 000 | $10^{9}$ | 9 | Giga (G) |
| Million | 1 000 000 | $10^{6}$ | 6 | Mega (M) |
| Thousand | 1 000 | $10^{3}$ | 3 | kilo (k) |
| Hundred | 100 | $10^{2}$ | 2 | hecto (h) |
| Ten | 10 | $10^{1}$ | 1 | Deca (da) |
| One | 1 | $10^{0}$ | 0 | |
| One Tenth | 0.1 | $10^{-1}$ | -1 | deci (d) |
| One Hundredth | 0.01 | $10^{-2}$ | -2 | centi (c) |
| One Thousandth | 0.001 | $10^{-3}$ | -3 | milli (m) |
| One Millionth | 0.000 001 | $10^{-6}$ | -6 | micro ($\mu$) |
| One Billionth | 0.000 000 001 | $10^{-9}$ | -9 | nano (n) |
| One Trillionth | 0.000 000 000 001 | $10^{-12}$ | -12 | pico (p) |
| One Quadrillionth | 0.000 000 000 000 001 | $10^{-15}$ | -15 | femto (f) |
| One Quintillionth | 0.000 000 000 000 000 001 | $10^{-18}$ | -18 | atto (a) |

# Scaling universe by measuring the Lenght




The Scale of the Universe 2
Use the scroll bar
to zoom in and out.
Click on objects
to learn more.
By Cary Huang
Technical support by Michael Huang
Start

# Base quantities vs derived quantities

**Base quantities:**

1. Length
2. Time
3. Mass
4. Electric current
5. Temperature
6. Luminous intensity
7. Amount of substance

**Derived quantities**, such as *velocity* or *acceleration*, can be obtained in terms of base quantities.

# The International System of Units (French: Système International d'unités) SI

1. Metre for Length
2. Second for Time
3. Kilogram for Mass
4. Ampere for Electric current
5. Kelvin for Temperature
6. Candela for Luminous intensity
7. Mole for Amount of substance

# Measuring systems, unit conversion

| United States customary units USC | SI units |
|---|---|
| 1 foot (ft) | 0.3048 m |
| 1 yard (yd) = 3 ft | 0.9144 m |
| 1 mile (mi) = 5280 ft | 1.609344 km |
| 1 pound (lb) * | 453.59237 g |
| 1 ton = 2000 lb | 907.18474 kg |
| 32 Degrees Fahrenheit (°F)<br><br>*F=9/5 C + 32* | 0 °C = 273.15 °K |

* Be carefull, pound is the unit of ***weight***, while gram is the unit of ***mass***.

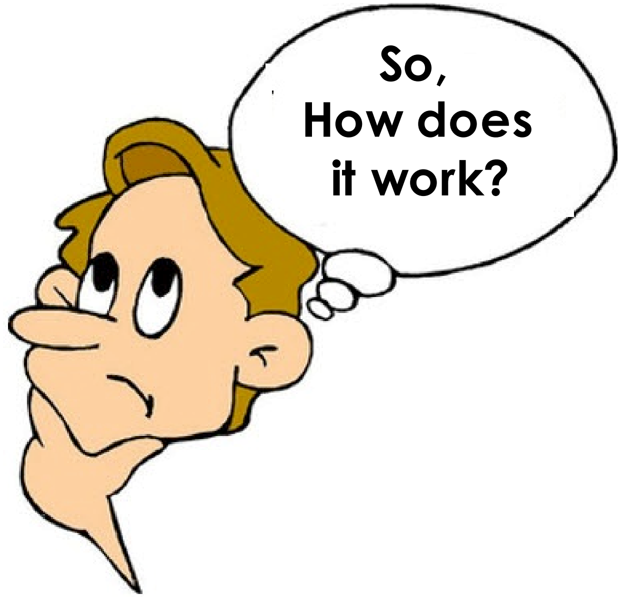
# Dimensional analysis

- The ***dimension*** of a quantity is its ***physical nature*** and can be defined in different units.

| quantity | dimension | unit |
|---|---|---|
| length | [L] | Meter<br>Foot<br>Yard<br>Mile |
| time | [T] | Second<br>Minute<br>Hour |
| mass | [M] | Kilogram |

1. We can divide or multiply any two quantities.

- ✓ [Velocity]=[L]/[T]
- ✓ [Force]=([M].[L])/[T]$^2$

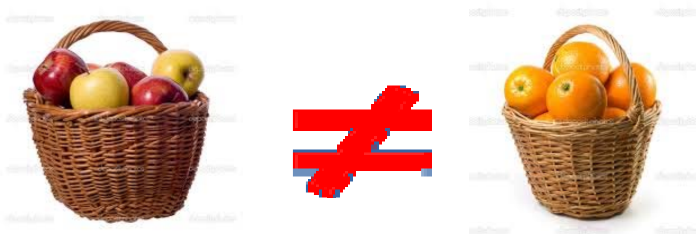



2. We can <u>NOT</u> add or subscribe two quantities with different dimensions.

~~[Velocity]+[Force]~~

✓ [Velocity]+[L]/[T]

3. Two sides of an equation should have the same dimension. you can not have apples in one side and oranges on the other side.



**Ex1. Finding the dimension of a quantity by using its formula.**

**Work= Force*Displacement** → $[Work]=[M].[L]/[T]^2 * [L]$

$[Work]=([M].[L]^2)/[T]^2$

**By having the formula you can *ALWAYS* find the dimension.**

## Ex2. Finding a formula for a quantity by using its dimension.

$t \sim m^{\alpha} \cdot h^{\beta} \cdot g^{\gamma}$

t: time of drop
m: mass of the ball
h: height of drop
g: gravitational acceleration of the Earth

$[T]=[M]^{\alpha} \cdot [L]^{\beta} \cdot [L]^{\gamma}/[T]^{2\gamma}$ → $\alpha=0$, $\beta+\gamma=0$, $1= -2\gamma$ → $t \sim \sqrt{(h/g)}$

$T = C\sqrt{(h/g)}$

C is a dimensionless constant
Which can be found by experiment.

What if you had chosen another group of quantities?

$t \sim m^{\alpha}.\ h^{\beta}.\ M_{Earth}^{\gamma}$

$[T]=[M]^{\alpha}.\ [L]^{\beta}.\ [M]^{\gamma}$

"t" would not be independent from "m" which is wrong.

One can ***NOT*** always find the correct formula by having the dimension.