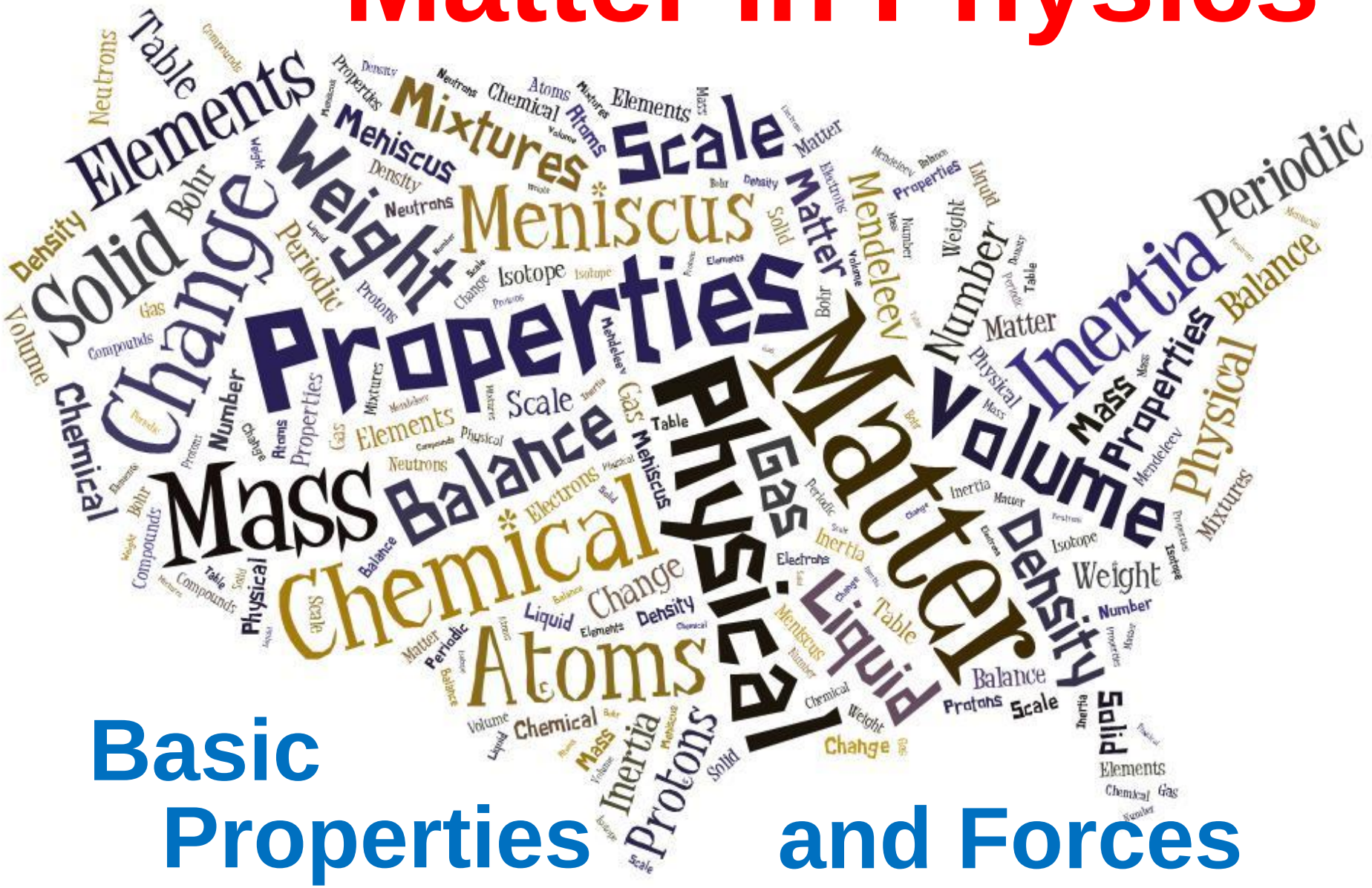
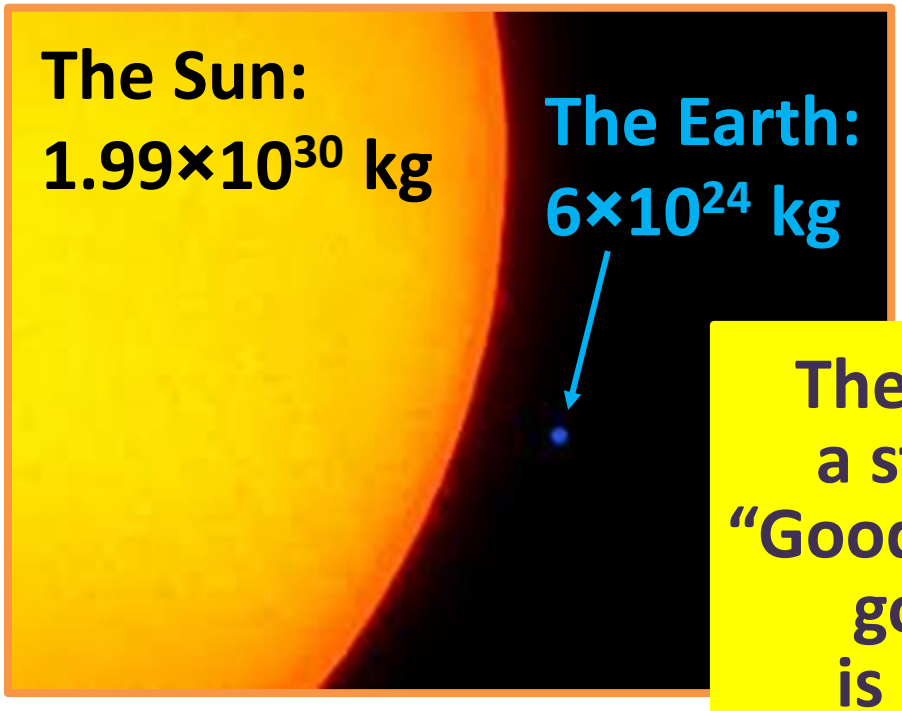
# Matter in Physics

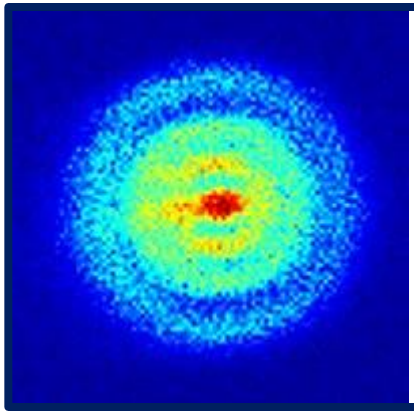



## Basic Properties and Forces

# **Mass** is the **amount of material** in an object

- **SI unit of mass is kg**



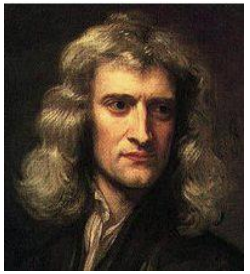



**The mass of a smallest atom, Hydrogen, is $1.67 \times 10^{-27}$ kg**

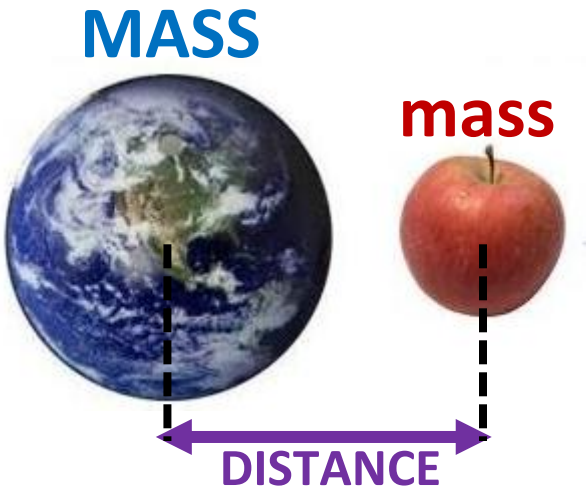
**The mass of a standard "Good Delivery" gold bar is 12.4 kg**

- Since **all atoms making up any object are composed of protons, neutrons and electrons**, mass is essentially defined by the **total amount of those particles in an object**.

# **Gravity** aka **gravitation**



is the universal **force of attraction** that acts **between any two or more objects that have mass**




$$\text{GRAVITY} = G \cdot \frac{\text{MASS} \cdot \text{mass}}{(\text{DISTANCE})^2}$$

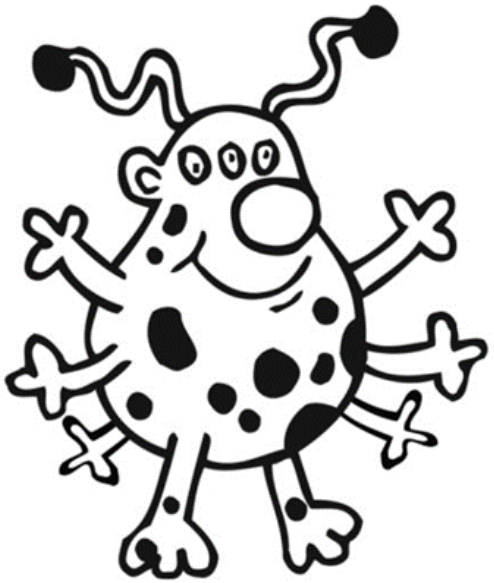
$$6.67 \times 10^{-11}\ \text{Nm}^2/\text{Kg}^2$$

"gravitation constant"

- **Gravity is generally a "weak" force…but massive objects create strong gravitational pull!**
- **Gravity has infinite range…but very distant objects experience very little attraction!**

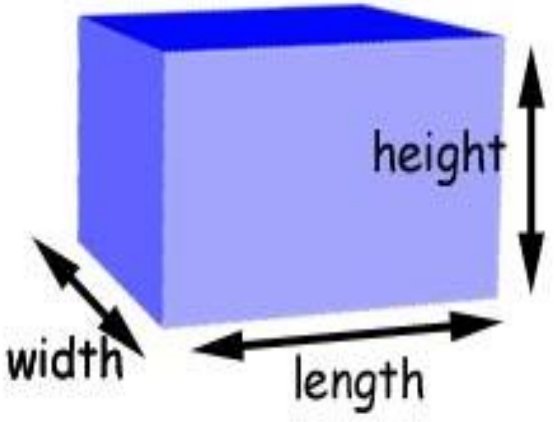
# Mass vs Weight

- **Mass** is the amount of material in an object (doesn't change).
- **Weight** is a measure of **how strongly *gravity* is pulling** on an object (decreases as elevation/distance increases).
- Note: on the Earth's surface, terms "weight" and "mass" are used interchangeably since we use a **weighing scale** to determine mass…

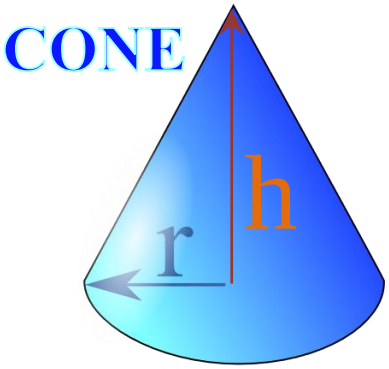


- Question: **What is the weight of a Martian on Mars and Moon if it weighs 50 kg on Earth?**
  - Gravity on Moon is 0.16 of Earth gravity; gravity on Mars is 0.38 of Earth gravity.
  - **Answer:** this Martian weighs 8.3 kg on Moon and 18.8 kg on Mars (the numbers shown by the scale), but **their mass is still 50 kg!!!**

# Volume

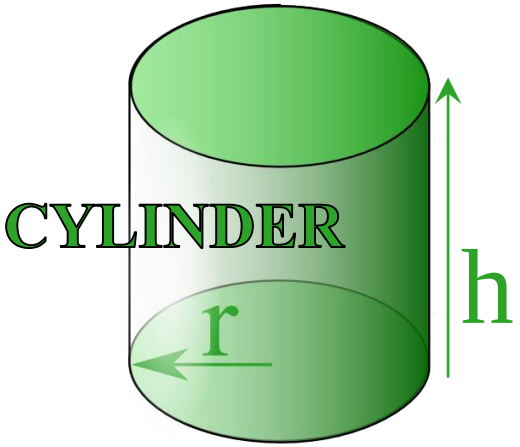



- **Volume** is the <u>amount of three-dimensional space that a substance or shape occupies or contains</u>.
- SI unit of volume is $m^3$ *(cubic meters)*
- $V_{\text{rectangular prism}}$ = length × width × height




$\left(\frac{1}{3}\right)\pi r^2 h$

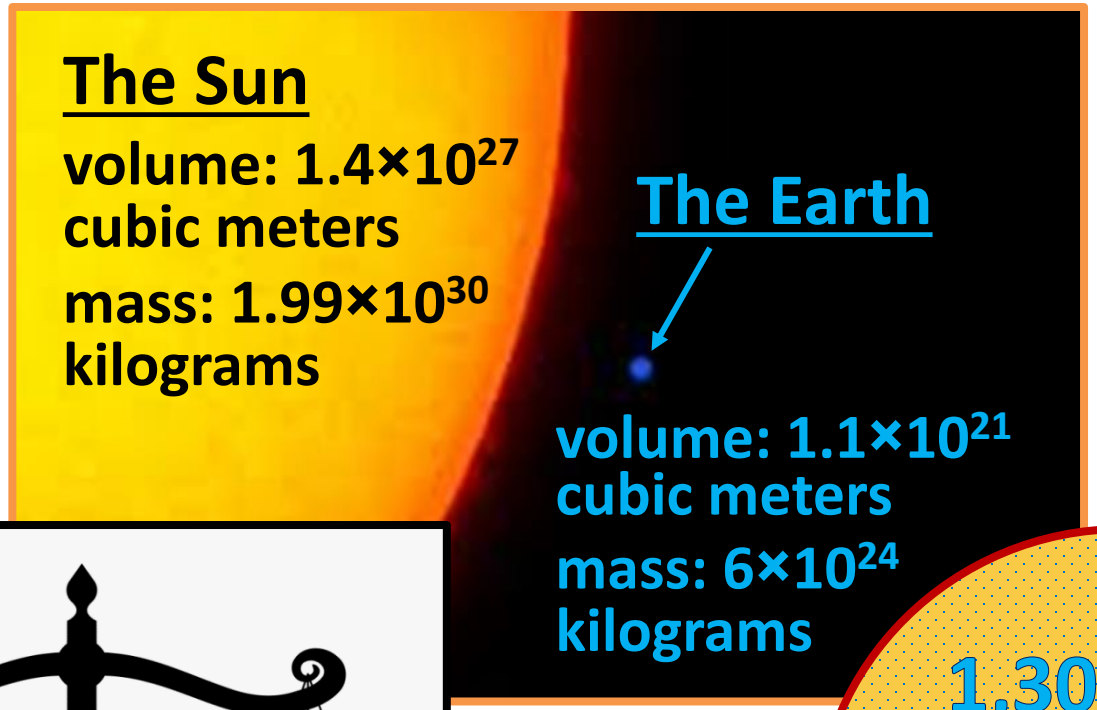

$\left(\frac{4}{3}\right)\pi r^3$

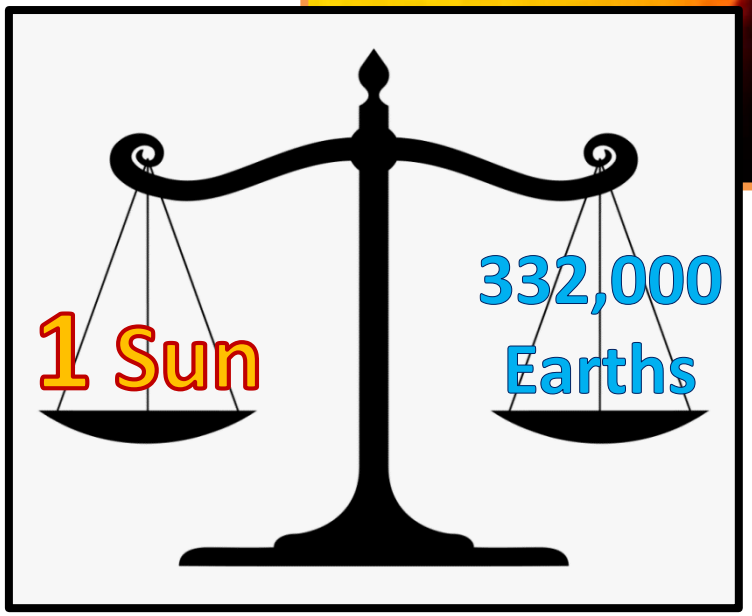



$\pi r^2 h$

**Where $r$ = radius, $h$ = height, and $\pi$ = 3.14**

# Sun and Earth comparison



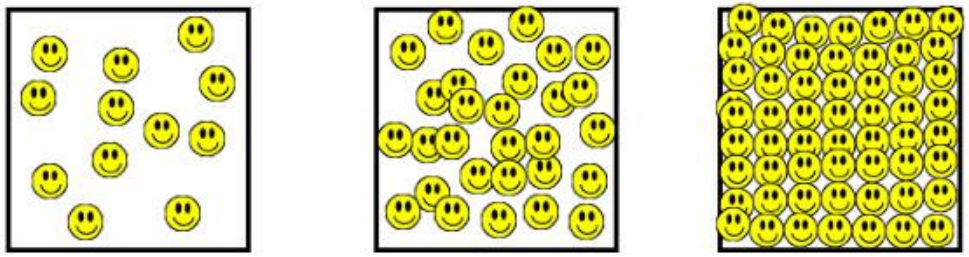

???

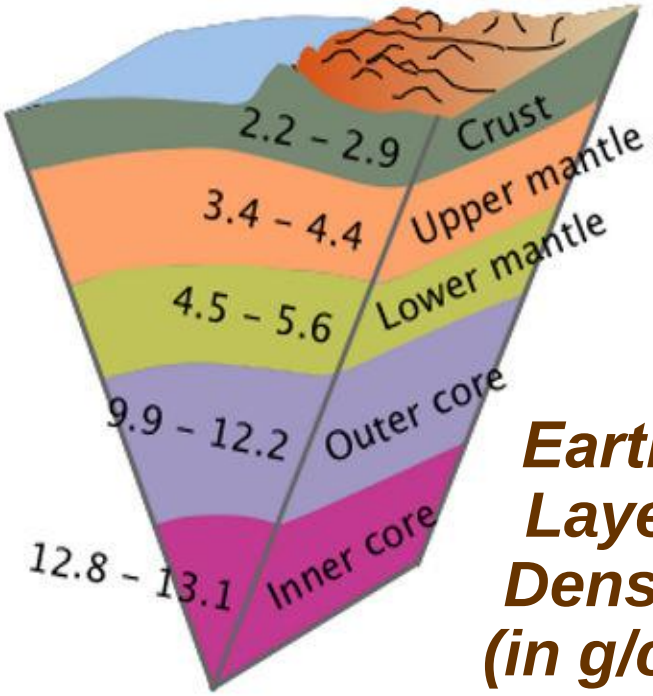
1,300,000 Earths can fit inside 1 Sun

# Density

- **Density is a measure of <u>how much matter (particles!) is contained in a unit of volume</u>:**

  - **density = $\frac{\text{mass}}{\text{volume}}$**
  - **SI unit is $kg/m^3$**






***Earth's Layers Density (in $g/cm^3$)***

- **The density of a material varies with temperature and pressure** (this variation is typically small for solids and liquids but much greater for gases).
  - **In general, lowering the temperature results in density increase**
  - **Increasing the pressure also results in density increase**