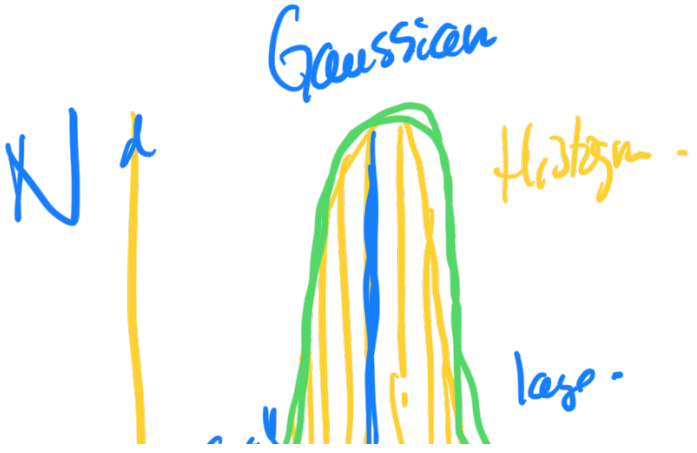
Physics 201 - Lecture 2

A1

1. Units in Equations
2. Measuring things (Uncertainty)
3. Scalars and Vectors
4. The Algebra of Scalars
5. The Algebra of Vectors

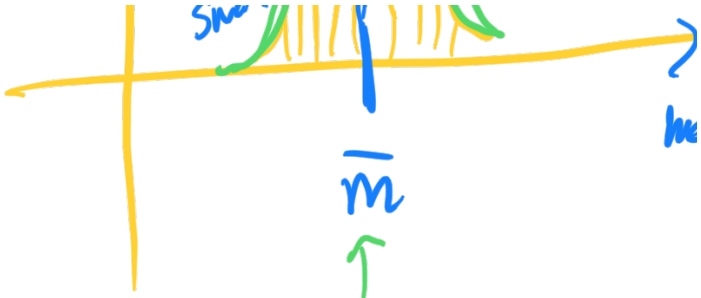
Question: I wonder how much the **average** apple weighs ... ???

Experiment:



0.237 kg

pounds



Nappels.

$M_{total\ apples} = M_{total}$

$= M_{basket}$

Total Mass of Things $= N_{things} * M_{thing}$

$M_{thing} = \frac{\text{Total Mass of Things.}}{N_{things}.}$

Data: $m_{apples} = 88\,kg$

$N_{apples} = 400$

$$m_{apple} = \frac{88\,kg}{400} = 0.22\,kg$$

$$\approx 220\,g \pm 5\%$$

Estimate of the "shape" of the Bell Curve.

$$\%\ error = \frac{1}{\sqrt{N_{this}}} = \frac{1}{\sqrt{400}}$$

statistical uncertainty.

$$= \frac{1}{20}$$

$$= 0.05$$

$\bar{m} = (0.220 \pm .011)\ kg$

Units

For ~ 20 years → Math with #'s only

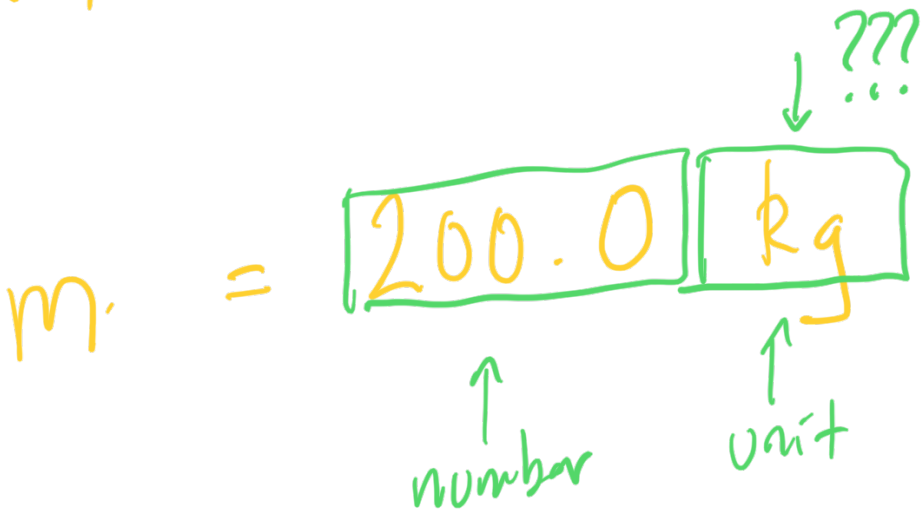
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$y = 2 + 3x + 4x^2 + 9x^3$$

Step 2 of Science: Collect Data.

Physical Quantities ← measure.

mass, time, temp, density, volume, ...



N = 400 apples

apples — dimensionless

$$m_{apple} = \frac{m_{total}}{N_{apples}} = \frac{88\ kg}{400\ apples}$$

$$= 0.22\ kg/apple.$$

Equations:

✓ 3 apples = 2 apples + 1 apple

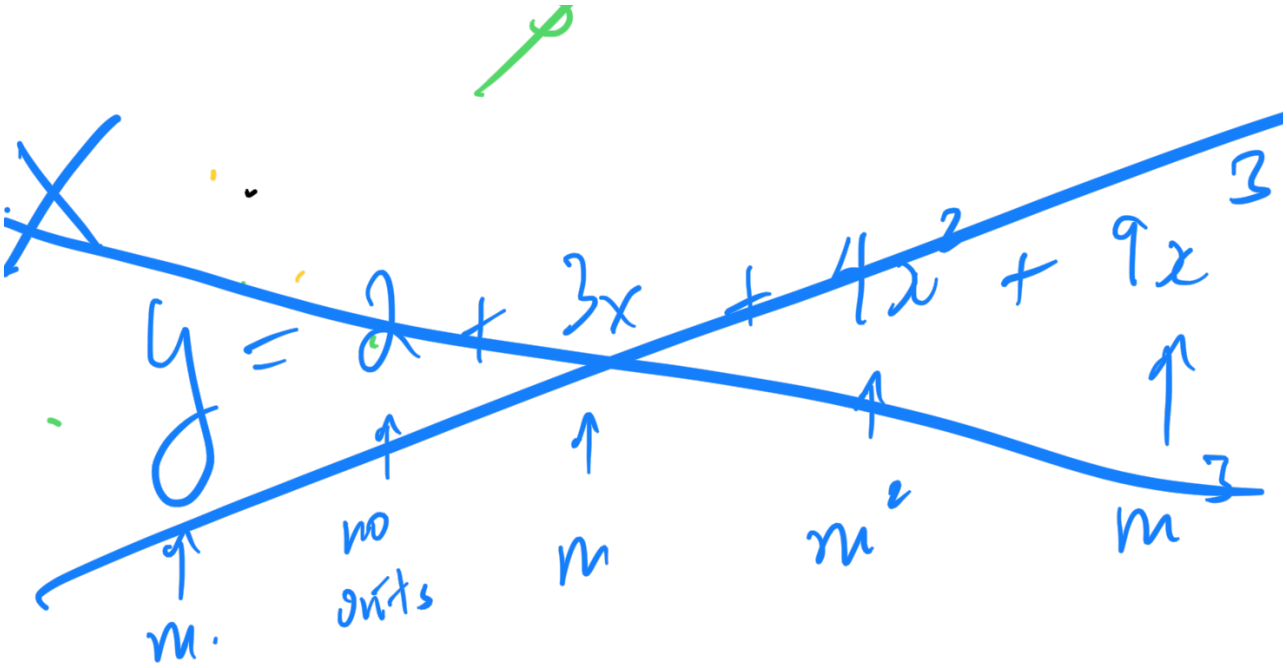
✗ $?_0$ = 2 apples + 1 cat

Distance travelled with constant acc.

$$\underbrace{y}_{m} = \underbrace{y_0}_{m} + \underbrace{v_0 t}_{m} + \underbrace{\frac{1}{2} a t^2}_{m}$$ ✓

- y: total distance
- y_0: initial position
- $v_0 t$: initial vel. × time
- $\frac{1}{2} a t^2$: $\frac{1}{2}$ × acc. × time × time

m, m/s, $m(s^2)/s^2$



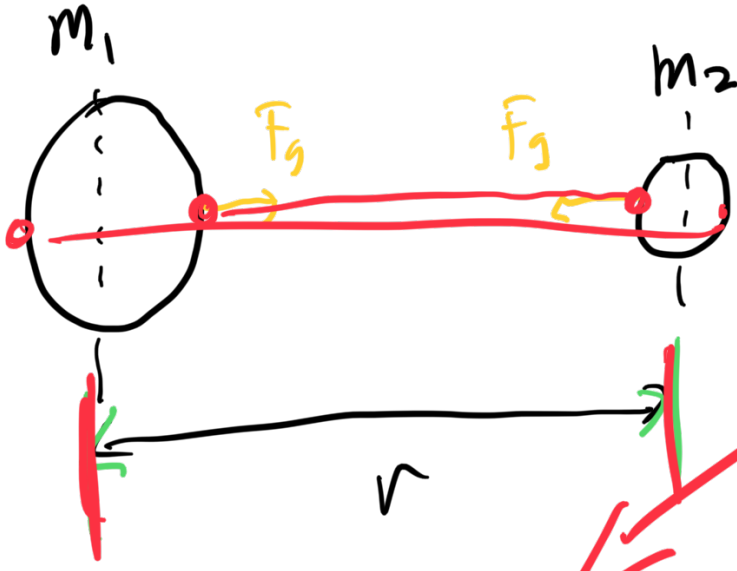
"All equations must make sense dimensionally."

units.

This helps you!! (A or B)

$$y = y_0 + v_0 t + \frac{1}{2} a t^2$$

Newton's Universal Law of Gravitation.



Invent Calculus.

kg kg

Law:

$$|\vec{F}_g| = G\frac{m_1 m_2}{r^2}$$

r^2: m^2

(Experiments)

Units? N

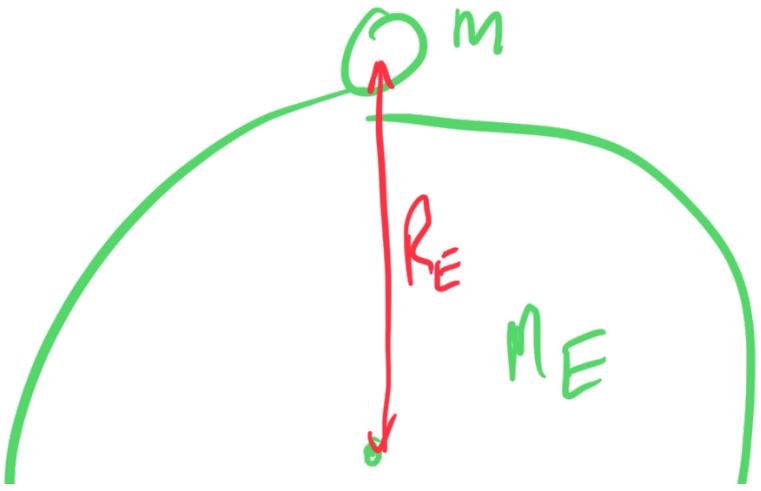
Newtons

$(kg \cdot m/s^2)$

$$N = [G] \cdot \frac{kg^2}{m^2}$$

$$[G] = \frac{N \cdot m^2}{kg^2}$$

$$G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$$



$$|F_g| = \frac{G \cancel{m} M_E}{R_E^2} = \cancel{m} \underbrace{g}_{9.8\,m/s^2}$$

$$g = \left(\frac{G \cdot M_E}{R_E^2} \right) = 9.8\,m/s^2$$