Scientific Toolkit

Auburn Mountainview: Physics

Karl Steffin, 2001

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Its all Greek to me

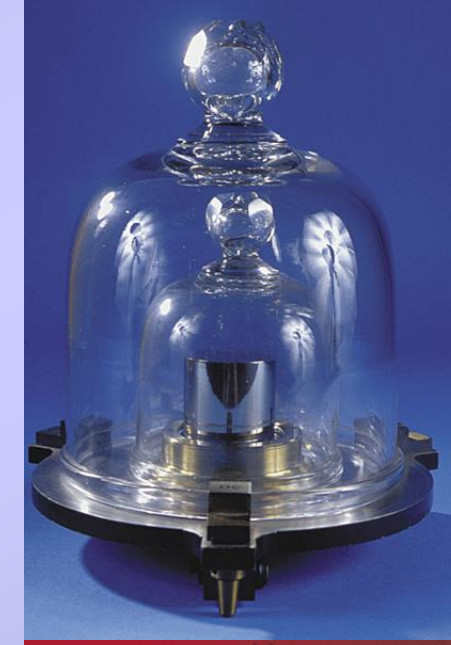
	Letter	Name		Letter	Name
1	A α	alpha	13	N ν	nu
2	B β	beta	14	Ξ ξ	xi
3	Γ γ	gamma	15	O ο	omicron
4	Δ δ	delta	16	Π π	pi
5	E ε	epsilon	17	P ρ	rho
6	Z ζ	zeta	18	Σ σ	sigma
7	H η	eta	19	T τ	tau
8	Θ θ	theta	20	Y υ	upsilon
9	I ι	iota	21	Φ φ	phi
10	K κ	kappa	22	X χ	chi
11	Λ λ	lambda	23	Ψ ψ	psi
12	M μ	mu	24	Ω ω	omega

Units

- **Physics uses commonly accepted units of measure**
  - **International System of Units (SI)**
- **There are two types of scientific units:**
  - **Base: seven fundamental.**
  - **Derived: mathematically combined.**
    - **Ex: Energy (Joules) which is a derived from Force (Newton) · Distance (Meter)**
      - **So 1.00-Joule = 1.00-Newton·Meter**

Base Units

- Mass: Kilogram-kg
- Length/Width/Height: Meter-m
- Time: Second-s
- Chemical Amount: Mole-mol
- Temperature: Kelvin-K
- Electric Current: Ampere-A
- Luminous Intensity: Candela-cd



Common Derived Units

- **Speed/Velocity: m/s**
- **Acceleration: m/s^2**
- **Force: Newton → $kg \cdot m/s^2$**
- **Pressure: Pascal → N/m^2**
- **Energy: Joule → $N \cdot m$**
- **Power: Watts → J/s**
- **Frequency: Hertz → 1/s**

Mass and Density

- **Mass**: quantity of matter in an object (kg)
- **Volume**: quantity of space that matter occupies (m^3)
- **Density**: the relationship between mass and volume of an object (kg/m^3)

For any substance $\rho = m/V$.

Density Example

- **What mass of water is needed to fill an Olympic size pool (50-m x 25-m, 3-m deep)?**
- **To set up a problem use the GUESS method.**
  - **Given: Highlight/Write what is given. (Right Side)**
  - **Unknown: Highlight/Write what is unknown (RS)**
  - **Equation: Find and write an equation (Left Side)**
  - **Substitute: Givens into the equation (LS)**
  - **Solve: Use algebra to isolate the unknown.**
- **Answer is rewritten in a box (bottom right)**

Density Example

- **What mass of water is needed to fill an Olympic size pool (50-m x 25-m, 3-m deep)?**

$$\rho = \frac{m}{V}$$

$$V = l \cdot w \cdot h$$
$$V = 50 - m \cdot 25 - m \cdot 3 - m$$
$$V = 3750 - m^3$$

ρ= 1000-kg/m^3
m= ?
V= 3750-m^3
l= 50-m
w= 25-m
h= 3-m

$$1000 - \frac{kg}{m^3} = \frac{m}{3750 - m^3}$$

$$m = 3,750,000 - kg$$

m = 3.75 x 10^6-kg

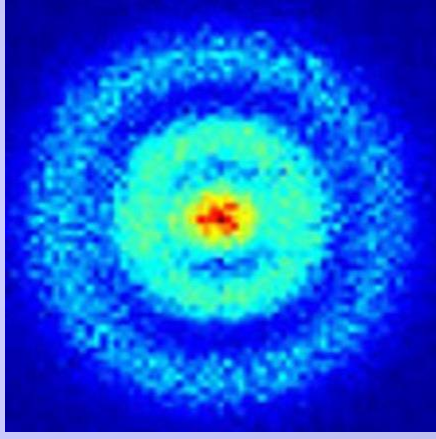
To put it into context:
The mass of a 747 is 162,400 kg
3750000/162400 = 23
The mass of the water is equal to…

23 747's!

Scientific Notation (SN)

- **Scientific Notation (Base 10) is used to simplify very big and small numbers.**
- **3,250,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000-kg (estimated mass of universe) and 0.0000000001-m (size of an atom) can both be simplified with Scientific Notation.**

Scientific Notation (SN)



- **Scientific Notation uses exponents (x 10 ^{x}).**
- **Width of the universe ≈ 93 billion light years:**
  - **879,800,000,000,000,000,000,000,000-m can be simplified by moving the decimal 26 places to the left.**
  - **This is written as 8.80 x 10^{26}-m.**
- **Width of a Hydrogen atom ≈ 0.000 000 000 11-m:**
  - **Simplify by moving the decimal 10 places to the right.**
  - **This is written as 1.10 x 10^{-10}-m (aka: Angstrom).**

Scientific Notation (SN)

- **Large #: Count decimal movement to the left.**
  - **These numbers have a positive exponent**
- **Small #: Count decimal movement to the right.**
  - **These numbers have a negative exponent**
- **In class numbers with a magnitude larger than 9,999 *or* starting with a decimal must be in Scientific Notation.**
  - **Exception: percentages & ratios (EA, μ, MA, IMA)**

SN Examples (with 3 Significant Digits)

$12,345 – 1.2345 \times 10^{4}$	1.23×10^{4}
$6,789,012 – 6.789012 \times 10^{6}$	6.79×10^{6}
$3,456 – 3.456 \times 10^{3}$	3.46×10^{3}
$78,901,234 – 7.8901234 \times 10^{7}$	7.89×10^{7}
$98.76 – 9.876 \times 10^{1}$	9.88×10^{1}
$0.000\ 000\ 01 – 1 \times 10^{-8}$	1.00×10^{-8}
$0.001\ 027 – 1.027 \times 10^{-3}$	1.03×10^{-3}

Scientific Notation and Math

- $a \times 10^{c} + b \times 10^{c} = (a + b) \times 10^{c}$
- $a \times 10^{c} - b \times 10^{c} = (a - b) \times 10^{c}$
- $a \times 10^{c} \bullet b \times 10^{d} = a \bullet b \times 10^{(c + d)}$

$4 \times 10^{5} \bullet 2 \times 10^{3}$ $\quad 4 \bullet 2 \times 10^{(5 + 3)}$ $\quad 8.00 \times 10^{8}$

$3 \times 10^{6} \bullet 5 \times 10^{-3}$ $\quad 15 \times 10^{(6 + (-3))}$ $\quad 1.50 \times 10^{4}$

- $a \times 10^{c} / b \times 10^{d} = a / b \times 10^{(c - d)}$

$\frac{11 \times 10^{7}}{2 \times 10^{4}}$ $\quad \frac{11}{2} \times 10^{7-4}$ $\quad 5.50 \times 10^{3}$

$\frac{3 \times 10^{3}}{9 \times 10^{5}}$ $\quad \frac{3}{9} \times 10^{3-5}$ $\quad .5 \times 10^{-2}$ $\quad 5 \times 10^{-2-1}$ $\quad 5.00 \times 10^{-3}$

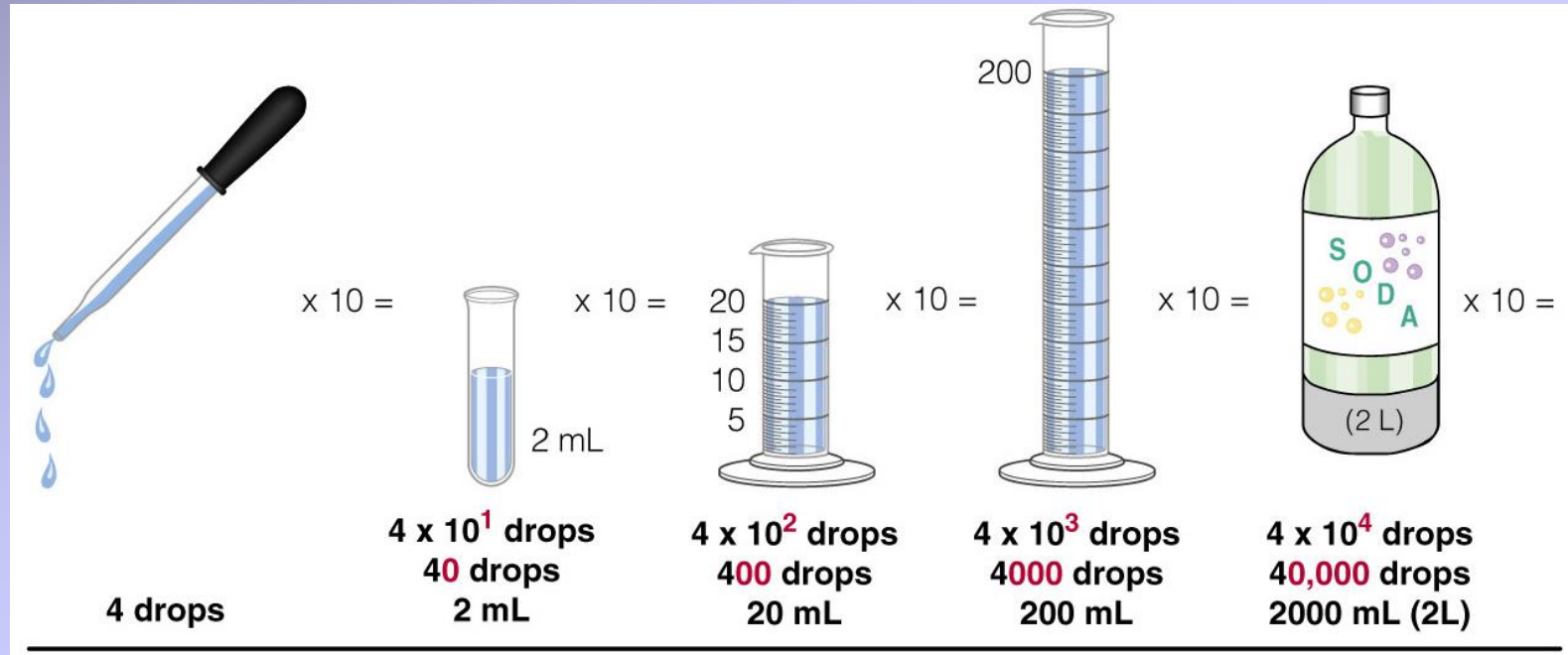
Scientific Notation Base 3

- **There is a shortcut if the exponent is a multiple of 3.**

10^{3}:Kilo-k	10^{-3}:milli-m
10^{6}:Mega-M	10^{-6}:micro-μ
10^{9}:Giga-G	10^{-9}:nano-n
10^{12}:Tera-T	10^{-12}:pico-p
10^{15}:Peta-P	10^{-15}:femto-f
10^{18}:Exa-E	10^{-18}:atto-a

Not base 3 but commonly used→ 10^{-2}:centi-c

Base 10 Visual



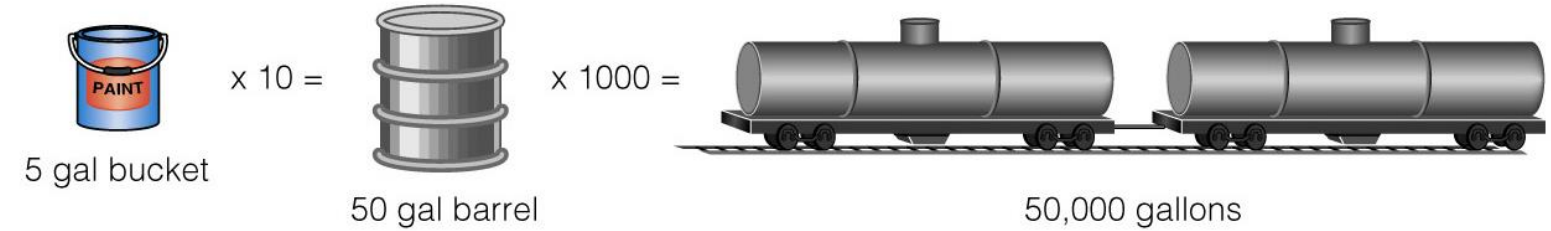
4 drops

4×10^1 drops
40 drops
2 mL

4×10^2 drops
400 drops
20 mL

4×10^3 drops
4000 drops
200 mL

4×10^4 drops
40,000 drops
2000 mL (2L)



5 gal bucket

50 gal barrel

50,000 gallons

4×10^5 drops
400,000 drops
20 liters

4×10^6 drops
4,000,000 drops
200 liters

4×10^9 drops
4,000,000,000 drops
200,000 liters

Scientific Notation Thoughts

- **Do not mix ‘base 3’ with longhand:**
  - **.0000102-m = 1.02×10^{-2} mm, *10.2-μm*, 1.02×10^{-5}-m**
- **For this class: always have one (and only one) number in front of the decimal point.**
  - **300 = 30×10^{1}, $.30 \times 10^{3}$, *.3 k*, 3.00×10^{2}**
- **Remember to round up if needed.**
  - **1555 = 1.55×10^{3}, 1.56×10^{3}**
  - **1099 = 1.09×10^{3}, 1.10×10^{3}**

SN and Calculators

- **Scientific calculators like TI use the EE: Enter Exponent (2nd+, or EXP) button for sci notation.**
  - **PE-MD-AS: solve $6 \times 10^4 / 10$.**
    - **Your calculator may do this $6 \times 10^{4/10}$ (15.07).**
    - **Pressing 6 EE 4 / 10 fixes this: (6E4)/10 (6000).**
  - **Never mix both: 6 x 10 E 4/10 = 60000.**
  - **Never use E in a final answer: 6E6 = 6.00×10^6.**

Conversions

- **Dimensional Analysis is a good way to convert to different units.**
  - **Units must be the same type (length, time…)**
  - **Place the old unit opposite where it currently is (numerator or denominator)**
  - **Place the new unit where the old unit currently is.**
  - **Use a conversion/truth table to fill in the appropriate numbers (some found on formula sheet).**

Conversions Example

- **How many centimeters in 1.5 feet?**

$$1.5\text{–ft} \times \frac{12\text{–}in}{1\text{–}ft} \times \frac{2.54\text{–}cm}{1\text{–}in} = \boxed{45.72\text{-cm}}$$

- **Convert 60-mph to m/s.**

$$60\text{–}\frac{mi}{hr} \times \frac{1609.34\text{–}m}{1\text{–}mi} \times \frac{1\text{–}hr}{3600\text{–}sec} = \boxed{26.82\text{–}\frac{m}{s}}$$

Class Conventions

- **For all tests, labs, assignments, homework…**
  - **Use GUESS Method (Draw a picture of the situation).**
  - **Use scientific notation for all numbers with a magnitude > 9999 or < 1. (Mistakes: 'SN' -1 pt)**
  - **All answers will be solved to the hundredth place. (Mistakes: 'SD' -1 pt)**
  - **Remember to use the appropriate units. (Mistakes: '6.00 ' -1 pt)**

Class Conventions

- **For all tests, homework…**
  - **All answers should be placed in a box or highlighted.**
  - **'CWA': if you can't solve part a: Fake it.**

a) **What is the density of a 68000-kg cube with a 2-m side?**
b) **Based on the chart do an error analysis.**

Substance	Density (kg/m^3)
Aluminum	2700
Brass	8400
Concrete	2080
Copper	8940

a) IDK
b) IDK

0

a) 2000 GUESS? Work? X
b) Concrete

CWA

$$\frac{2080 - 2000}{2080}$$

$.04 \times 100$

12

2000.00-kg/m^3

4.00 %