Order of Magnitude Estimation:

An estimation made to the nearest power of 10

Give an order of magnitude estimate for each of the following quantities.

1. The number of students enrolled at SEHS $\sim 10^3$
2. The number of teachers at SEHS $\sim 10^1$
3. The number of seconds in this period $\sim 10^3$
4. The height of the door in meters $\sim 10^0$
5. The thickness of the door in meters $\sim 10^{-2}$
6. The thickness of a piece of paper in meters $\sim 10^{-4}$

Ranges of magnitudes that occur in the universe:

Sizes: 10^{-15} m (subnuclear particles) to 10^{+25} m (extent of the visible universe)

Masses: 10^{-30} kg (electron mass) to 10^{+50} kg (mass of the universe)

Times: 10^{-23} s (passage of light across a nucleus) to 10^{+18} s (the age of the universe)

Size of an atom: $\mathring{A} = 10^{-10}$ m

Size of a proton: $\sim 10^{-15}$

Significant Figures, Decimal Places, and Scientific Notation

Decimal places – the number of digits after the decimal point

Significant figures (digits) –the digits that are known with certainty plus one digit whose value has been estimated in a measured value.

Measurement	Decimal Places	Significant Figures	Scientific Notation
4003 m		4	4.003×10^3 m
160 N		2	1.6×10^2 N
160. N		3	1.60×10^2 N
30.00 kg	2	4	3.000×10^1 kg
0.00610 m	5	3	6.10 10^{-3} m

Rules for determining significant figures:

1) Nonzero digits in a measurement are always significant.

2) Zeros that appear *before* a nonzero digit are *NOT* significant.

   Ex – 0.002 m (1 significant figure) and 0.13 g (2 s.f.).

3) Zeros that appear *between* nonzero digits are significant.

   Ex – 0.705 kg (3 s.f.) and 2006 km (4 s.f.).

4) Zeros that appear *after* a nonzero digit are significant *only* if:

   (a) followed by a decimal point

   Ex - 40 s (1 s.f.) and 20. m (2 s.f.).

   (b) they appear to the right of the decimal point.

   Ex – 37.0 cm (3 s.f.) and 40.00 m (4 s.f.).

Calculations with Significant Figures

Addition and Subtraction Rule

match decimal place

When adding or subtracting measured values, the operation is performed and the answer is rounded to the same **decimal place** as the value with the **fewest decimal places**.

Multiplication and Division Rule

match # of sig figs

When multiplying or dividing measured values, the operation is performed and the answer is rounded to the same number of **significant figures** as the value having the **fewest number of significant figures**.

Perform the following calculations and answer to the correct number of sig figs:

a) 11.44 m
5.00 m
0.11 m
+ 13.2 m
29.75

→ 29.8 m

b) Add 2.34 m, 35.7 m and 24 m

62 m

c) (0.304 cm) (73.84168 cm)

22.447.... cm^2

→ 22.4 cm^2

d) 0.1700 g ÷ 8.50 L

.0200 g/L or 2.00×10^{-2} g/L

Fundamental and Derived Units

The SI (International System) system of units defines seven fundamental units from which all other units are derived.

For example:

The **meter** is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second.

The **second** is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.

Fundamental Units

Quantity	Units	Symbol
Length	meter	[m]
Mass	kilogram	[kg]
Time	second	[s]
Electric current	Ampere	[A]
Temperature	Kelvin	[K]
Amount	mole	[mol]
Luminous intensity	candela	[cd]

Derived Units

New (derived) units can be named by combining the fundamental units.

a) What is the derived unit for *mass per length*? [kg/m]

b) What is the derived unit for *electric current times time*? [A·s]

c) What is the derived unit for *mass times length per time*? $[kg \frac{m}{s}]$

Note: Sometimes a derived unit will have a new name.

For example, $[kg \frac{m}{s^2}] = [N]$

Metric Prefixes and Conversions

Prefixes for Powers of Ten

PREFIX	SYMBOL	NOTATION
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

1. Convert 45.20 centimeters into meters.

Factor-Label Method for Converting Units

a) Write factors so units cancel leaving desired units.

b) Write "1" next to each prefixed unit.

c) Write the power of 10 (i.e.- the exponent) with each base unit.

2. Convert 1.9 A into microamps.

3. Convert 0.0340 pm into kilometers.

$$.0340\,\cancel{pm}\left(\frac{10^{-12}\,\cancel{m}}{1\,\cancel{pm}}\right)\left(\frac{1\text{ km}}{10^{3}\,\cancel{m}}\right) = .0340\times10^{-15}\text{ km}$$

$$3.40\times10^{-17}\text{ km}$$

4. Convert 12.8 cm^2 into m^2.

5. Convert 4700 kg/m^3 into g/cm^3

$$4700\,\frac{\cancel{kg}}{\cancel{m^3}}\left(\frac{10^{3}\text{ g}}{1\,\cancel{kg}}\right)\left(\frac{10^{-2}\,\cancel{m}}{1\text{ cm}}\right)\left(\frac{10^{-2}\,\cancel{m}}{1\text{ cm}}\right)\left(\frac{10^{-2}\,\cancel{m}}{1\text{ cm}}\right) = 4.7\ \frac{g}{cm^3}$$

6. Convert 55 mph into m/s. (1.0 mile ≈ 1.6 km)