2.1. SYSTÈME INTERNATIONAL D'UNITÉS

In the past, many countries followed their own system of measurement and units. To avoid inconveniences that would result from this difference, a common scientific system of units of measurements became necessary. In 1968, a group of scientists from different countries met at '**the conférence Générale des Poids et des Mesures (CGPM)' (General Conference on Weight and Measures). The system they recommended came to be known** as 'système International d'Unités' (International System of units) shortened to **S.I. units.** The system uses seven base units and all others units are derived from these base units by multiplying or dividing one unit by another without introducing a numerical factor.

2.1.1. NAMES AND SYMBOLS FOR BASE S.I. UNITS.

Physical quantity	Name of Si base unit	Symbol for unit
Length	Metre	m
Mass	Kilogramme	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

Table 2.1: Base quantities and units

2.1.2. DERIVED UNITS

Most of the units commonly used are a combination of the basic units. There are given in the table below

Quantity	Unit	Symbol
Velocity	metre per second	m/s
Acceleration	Metre per second squared	m/s^2
Force	Newton	N or $kg\cdot m/s^2$
Energy	Joule	J or $kg\cdot m^2/s^2$
Frequency	Hertz	Hz
Angle	Radian	rd
Area	Square metre	m^2
Volume	Cubic metre	m^3
Density	Kilogramme per cubic metre	Kg/m^3
Momentum	Kilogramme metre per second	Kg·m/s
Pressure	Pascal	Pa
Power	Watt	W or N·m/s
Electric charge	Coulomb	C
Potential difference	Volt	V
Resistance	Ohm	Ω
Capacitance	Farad	F

Table 2.2: Derived quantities and units

2.1.3. PREFIXES

When the value of a physical measurement is written in standard form a system of prefixes has been created to simplify discussion of these measurements.

For example, 10,000m may be written as $1.0 \times 10^4 m$. We could also write this quantity as $10 \times 10^3 m$. In the prefix system 10^3 is called '**kilo'** to the unit '**metre'.** We may then write 10000m as **'10 kilometres'** or '**10km'.**

List of some of the most common prefixes used with S.I. units.

Power of ten	Prefix	Symbol	Decimal equivalence

10^{-18}	Atto	**A**	**0.000000000000000001**
10^{-15}	femto	**f**	**0. 000000000000001**
10^{-12}	pica	**p**	**0. 000000000001**
10^{-9}	nano	**n**	**0. 000000001**
10^{-6}	Micro	**M**	**0. 000001**
10^{-3}	Milli	**M**	**0. 001**
10^{-2}	Centi	**C**	**0. 01**
10^{-1}	Deci	**D**	**0. 1**
1	None	**None**	**1**
10^{1}	Deca	**Da**	**10**
10^{2}	Hecta	**H**	**100**
10^{3}	Kilo	**K**	**1000**
10^{6}	Mega	**M**	**1000000**
10^{9}	Giga	**G**	**1000000000**
10^{12}	Tera	**T**	**1000000000000**

Table 2.3: S.I. units more common prefixes:

2.1.4. SCIENTIFIC NOTATION

Many of the numbers that will be dealt with are either very small or very large. Often these numbers are expressed in powers of ten. We call this system of representing numbers "***the scientific notation*** or ***standard form"***. Scientific notation is a way to assess the order of magnitude and to visually decrease the zeros that are got in the answer to some problems. It also may help us to compare very large (or very small numbers)

In science, we often work with very large or very small numbers. For example, in geology, the age of the Earth = 4,600,000,000 years old, or, in chemistry, one a.m.u. = 0.00000000000000000000000000166 kilograms. It seems like a lot of work to keep track of all those zeros. Fortunately, we can easily keep track of zeros and compare the size of numbers with scientific notation.

Scientific notation allows us to reduce the number of zeros that we see while still keeping track of them for us. For example, the age of the Earth (see above) can be written as 4.6×10^{9} years. This means that this number has 9 places after the decimal place - filled with zeros unless a number comes after the decimal when writing scientific notation. So 4.6×10^{9} years represents 4600000000 years.

Very small numbers use the same type of notation only the exponent on the 10 is usually a negative number. For example, 0.00000000000000000000000000166 kg (the weight of one atomic mass unit (a.m.u.)) would be written 1.66×10^{-27}using scientific notation. A negative number after the 10 means that we count places before the decimal point in the scientific notation. You can count how many numbers are between the decimal point in the first number and the second number and it should equal 27.

More examples:

300,000,000 = 3×10^{8}

0.0016 = 1.6×10^{-3}

4200 = 4.2×10^{3}

0.235 2.35×10^{-1}

2.1.5. ROUNDING OFF NUMBERS

e.g.: 683 = 680 → rounded off to the nearest ten

683 = 700 → rounded off to the nearest hundred

9.3 = 9 → rounded off to the nearest whole number

5.7 = 6 → rounded off to the nearest whole number

6.83 = 6.8 → rounded off to one decimal place

0.006348 = 0.01 → rounded off to two decimal places.

2.1.6. SIGNIFICANT FIGURES

If a number is very large or has infinite number of digits, then this number is made simpler by only referring to a specified number of digits. i.e. a specified number of **'significant figures'.**

Significant Figures refer to the number of digits used to express a measured or calculated quantity. By using significant figures, we can show how precise a number is. If we express a number beyond the place to which we have actually measured (and are therefore certain of), we compromise the integrity of what this number is representing. It is important after learning and understanding significant figures to use them properly throughout your scientific career.

Precision: A measure of how closely individual measurements agree with one another.
Accuracy: Refers to how closely individual measurements agree with the correct or true value.

Digits that are Significant

1. Non-zero digits are always significant.
2. Any zeros between two non-zero digits are significant.
3. A final zero or trailing zeros in the decimal portion ***ONLY*** are significant.

Examples:

How many significant figures are in: 1. 12.548, **2.** 0.00335, **3.** 504.70, **4.** 4000?

1. There are 5. All numbers are significant.
2. There are 3. The zeros are simply placeholders and locate the decimal. They are not trailing zeros. They are not significant.
3. There are 5. The two zeros are not simply placeholders. One is between two significant digits and the other is a final, trailing zero in the decimal portion. Hence, they are both significant.
4. This is a bit confusing. It is somewhere between 1 and 4. In order to clarify, we need to convert this to scientific notation. If it were 4×10^3, there is one significant figure. If it were 4.000×10^3, then there are 4 significant figures.

Rules for Using Significant Figures

- For addition and subtraction, the answer should have the same number of decimal places as the term with the fewest decimal places.
- For multiplication and division, the answer should have the same number of significant figures as the term with the fewest number of significant figures.
- In multi-step calculations, you may round at each step or only at the end.
- Exact numbers, such as integers, are treated as if they have an infinite number of significant figures.

- In calculations, round up if the first digit to be discarded is greater than 5 and round down if it is below 5. If the first discarded digit is 5, then round up if a nonzero digit follows it, round down if it is followed by a zero.

Examples:

3. **Addition and Subtraction. 12.793 + 4.58 + 3.25794 = 20.63094**

- With significant figures it is **20.63** since **4.58** has 2 decimal places, which is the least number of decimal places.

4. **Multiplication and Division.** $\mathbf{56.937 \div 0.46 = 130.29782609}$

- With significant figures, the final value should be reported as $\mathbf{1.3 \times 10^2}$ since **0.46** has only 2 significant figures. Notice that **130** would be ambiguous, so scientific notation is necessary in this situation.

Examples of rounding to the correct number of significant figures with a 5 as the first non-significant figure

- **Round 4.7475 to 4 significant figures:** 4.7475 becomes 4.748 because the first non-significant digit is 5, and we round the last significant figure up to 6 to make it even.
- **Round 4.7465 to 4 significant figures:** 4.7465 is 4.746 because the first non-significant digit is 5 and since the last significant digit is even, we leave it alone.

2.1.7. ROUNDING OFF TO SIGNIFICANT FIGURES

The number of significant figures in a number is found by counting all the digits from the first non-zero digit on the left.

Leading zeros are *not* significant figures. Trailing zeros are significant figures *only* when they occur after the decimal point.

Let us look at a two situations below:

1. 765.430 has six significant figures. You start counting from the 7 which is the first non-zero digit on the left. The trailing zero is a significant figure; if it were not, it would not be necessary to include it.
2. 0.04321 has four significant figures. The leading zeros are essential to give the magnitude of the number. The first non-zero digit on the left is 4 and counting the significant digits then gives us a total of four.

Example

Write the following values correct to the number of significant figures given beside each.

(a) 723.6792 (4 sig figs)

(b) 0.0763 (1 sig fig)

(c) 6382 (2 sig figs)

Answers

(a) 723.6792: First count four digits from the left. This gives 723.6
Now look at the next digit.
This is 7 which indicates that the number is actually closer to 723.7 than 723.6
Rounding to four significant figures gives 723.7

(b) 0.0763: Counting from the first non-zero digit on the left, we have 0.07 Now examine the next digit.
This is 6 which indicates that the number is closer to 0.08 than 0.07 Rounding to one significant figure gives 0.08

(c) 6382: Counting from the left, the first two significant figures are 6 and 3 The next digit is 8 so we would round up the 3 to 4 This gives a value of 6400 to two significant figures.

More examples:

$6.83 \times 10^2 = 6.8 \times 10^2$ When rounded off to two significant figures.

$9.27 \times 10^2 = 9.3 \times 10^2$ When rounded off to two significant figures.

0.030034 = 3.003×10^{-2} when rounded off to four significant figures.

2.2. PROCEDURE FOR SOLVING PROBLEMS INVOLVING SI UNITS, SCIENTIFIC NOTATION AND SIGNIFICANT FIGURES

- Identify numerical values.
- Convert them to SI units.
- Write them in scientific notation.
- Substitute figures in formula.
- Separate into decimal numbers and powers of 10.
- Calculate the answer.
- Decide on the appropriate number of significant figures. This should not exceed the number of significant figures in the data given.
- Give value to appropriate number of significant figures.
- Convert into meaningful units.

EXERCISES 2.1

1. Convert:
   a. 10 milligrams to grams
   b. 10^{-4} megagrams to micrograms
   c. 50MHz to µHz
2. From the list below, select:
   A. Two fundamental quantities
   B. Two non SI units:

   Velocity, temperature, day, length, Ampere, inch, luminous intensity.

3. Convert the following units and write the answer to the suitable significant number of figure
   A. 234kg +20g = B. 0.5µm + 15m=

4. Complete the following table referring to the SI system of prefixes:

Prefixes	Symbol	Value	Factor
Pica			
		0.001	
	K		
			10^9

Table 2.4:

6. Complete the following table with SI units or quantities and say whether they are basic or derived.

Quantities	Units	Symbols	Type
Amount of substance			
	Kilogram per metre^3		
		Ω	
	Ampere		

Table 2.5:

7. Determine the basic unit form of the quantity, using the defining formula:
   A. $Pressure = \frac{Force}{Area}$
   B. $Force = Mass \times Acceleration$
   C. $If\ given\ Work = Force\ \times Distance$ and $Power = \frac{Work}{Time}$. Determine the fundamental unit form of the quantity "Power"

8. Suppose you want to hit the centre of this circle with a paint ball gun. Which of the following are considered accurate? Precise? Both? Neither?

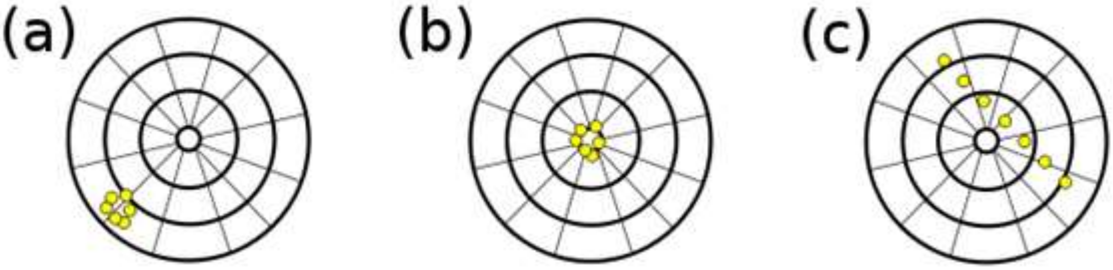

Figure 2.1:

9. What is the value of 79,487 rounded off to:
   (i) The nearest ten
   (ii) The nearest hundred
   (iii) The nearest thousand