Units and Prefixes

In the study of mechanics we come across many different quantities. Each quantity has its own units. We need to be able to work with these units.

The International System of Units

There are a number of different systems of units in use. However, only the modern metric system, known as the International System of Units (abbreviated SI from the French, Système International d'Unités) will be used in these leaflets. In nearly every mechanics problem we encounter the quantities mass, length and time. As shown in Table 1, the units of these quantities are defined to be kilograms, metres and seconds respectively; these are arbitrarily defined but have become accepted standard units. The units of many other quantities can be derived from physical laws. To illustrate this point consider the units of force in Table 1. The units of force are derived from Newton's second law (see mechanics sheet 2.2) which relates the quantity force ($\mathbf{F}$) to mass (m) and acceleration ($\mathbf{a}$) and can, for a body of constant mass, be expressed as $\mathbf{F} = m\mathbf{a}$. From this law we can determine what the units of force must be; acceleration is measured in units m s^{-2} and mass is measured in kg so force is measured in kg m s^{-2} which are called newtons (N) in mechanics.

Quantity	Dimensional Symbol	Unit	Symbol
Mass	M	kilogram	kg
Length	L	metre	m
Time	T	second	s
Force	F	newton	N (= m kg s^{-2})

Table 1: Fundamental quantities in mechanics

Prefixes

When a numerical unit is either very small or very large, the units used to define its size may be modified by using a prefix. A few of the prefixes used in the SI system of units are shown in Table 2. Each prefix represents a unit that, in most cases, moves the decimal point of a numerical quantity to every third place. There are 4 exceptions: the multiples deca and hecto and the submultiples centi and deci. In engineering and science the use of these prefixes is generally avoided, with the exception of some volume and area measurements.

Rules for the proper use of units and prefixes

1. A symbol is never written with a plural, s, as it may be confused with the unit for second, s.
2. Symbols are usually written in lower case unless they are named after individuals (for example, newton, N) or have a prefix larger than kilo, k (see Table 2).

 © mathcentre January 20, 2005

3. To avoid confusion with prefix symbols, quantities that are defined by several units that are multiples of one another are separated by a space. For example, compare m s (metre-second) and ms (milli-second) - there is no space between the prefix and the unit but there is between the two separate types of unit.

4. The exponent of a unit that has a prefix refers to both the unit and its prefix. For example, $\mu N^2 = (\mu N)^2 = \mu N \times \mu N$

5. Physical constants and numbers that have several digits on either side of the decimal point should be written with a space (rather than a comma) between every three digits. For example, 65 823.315 856.

6. Numbers used in calculations should be represented in terms of their base or derived units by converting all prefixes to powers of 10, with the final result expressed as a single prefix. For example 3145000000m should be written 3.145Gm.

7. Compound prefixes should be avoided. For example, kμs (kilo-micro-second) should be expressed as ms (milli-second) since 1kμs $= 1(10^3)(10^{-6})$s $= 1(10^{-3})$s $=$ 1ms.

8. The minute, hour and second are retained despite not being in decimal form, i.e. 1 minute = 60 seconds, not 10 seconds or 100 seconds.

9. Plane angular measurement is made in radians (rad). However, in many engineering mechanics problems degrees are often used, where 180° $= \pi$ rad.

Prefix	SI Symbol	Multiplier	Exponential
tera	T	1 000 000 000 000	10^{12}
giga	G	1 000 000 000	10^9
mega	M	1 000 000	10^6
kilo	k	1 000	10^3
hecto	h	100	10^2
deca	da	10	10^1
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000 001	10^{-6}
nano	n	0.000 000 001	10^{-9}
pico	p	0.000 000 000 001	10^{-12}

Table 2: Some prefixes used in mechanics.

Exercises

1. Write the following quantities in units with the appropriate prefixes:
a) 3142590 m b) 0.0000012 N c) 0.001 kg d) 987600 m e) 10022 N
2. Write the following quantities in units with only one prefix:
a) 2 Mpm b) 1.56 GkN c) 1.4 Tμs d) 1.08 GcN e) 18.56 cdam

Solutions

1. a) 3.14259 Mm b) 1.2 μN c) 1g d) 0.9876 Mm e) 10.022 kN
2. a) 2 μm b) 1.56 TN c) 1.4 Ms d) 10.8 MN e) 1.856 m

© **math**centre January 20, 2005