

# Unit 0. Units and Basic Maths

Y12

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## 1 Standard Units and Basic Maths

### 1.1 Review of symbols

Symbol	Meaning
$\approx$	Approximately equal
$\neq$	Not equal, different
$\sum$	Sum of a series of numbers
$\prod$	Product of a series of numbers
$\int$	Integral operation
$\Delta$	Augment, difference in an interval
$\propto$	Proportional
$d$ or $\partial$	Derivative
$\infty$	Infinity
$ x $	Modulus of $x$
$\vec{x}$	Vector $x$

## 1.2 Base units

How many units do you think you really need in Physics? 10? 20? 100?... [Guess](#)

**Base units:** decided by scientific community, they are the minimum quantity needed to describe all other magnitudes.

BASIC QUANTITY	UNIT NAME	UNIT SYMBOL
mass	kilogram	kg
time	second	s
length	metre	m
electric current	ampere	A
temperature	kelvin	K
amount of substance	mole	mol
light intensity	candela	cd

Figure 1: Basic units

**SI units:** the internationally decided units for each base unit, revised periodically to increase precision, ease of use, etc:

- $kg$  (prototype)
- $s$  ( $9 \cdot 10^9 \Delta C_{groundlevel}$ )
- $m$  (distance light in  $\frac{1}{3} \cdot 10^8 s$ )
- $A$  (current for  $2 \cdot 10^{-7} \frac{N}{m}$  1m apart)
- $K$  ( $273.16^{-1} waters^{s-l-g}$ )
- $mol$  (atoms  $0.012 kg, {}^{12}C$ )
- $cd$  ( $10^{-3} \frac{W}{rad^2}$ , intensity of a  $5 \cdot 10^{14} Hz$  light).

**Derived units:** the rest, p.e.:

- $\frac{m}{s}$  or  $m \cdot s^{-1}$
- $N$ , Newton
- $J$ , Jules
- $W$ , Watts
- $Hz$ , Hertz
- $C$ , Coulombs
- $V$ , Volts
- $\Omega$ , Ohms
- ...

Units can be added *power prefixes*. You must know nano up to giga.

Careful with time above seconds! (not x10)

DERIVED QUANTITY	UNIT NAME	UNIT SYMBOL	BASE UNITS EQUIVALENT
force	newton	N	$\text{kg m s}^{-2}$
energy (work)	joule	J	$\text{kg m}^2 \text{s}^{-2}$
power	watt	W	$\text{kg m}^2 \text{s}^{-3}$
frequency	hertz	Hz	$\text{s}^{-1}$
charge	coulomb	C	A s
voltage	volt	V	$\text{kg m}^2 \text{s}^{-3} \text{A}^{-1}$
resistance	ohm	$\Omega$	$\text{kg m}^2 \text{s}^{-3} \text{A}^{-2}$

Figure 2: Derived units

FACTOR	NAME	SYMBOL	FACTOR	NAME	SYMBOL
$10^1$	deca-	da	$10^{-1}$	deci-	d
$10^2$	hecto-	h	$10^{-2}$	centi-	c
$10^3$	kilo-	k	$10^{-3}$	milli-	m
$10^6$	mega-	M	$10^{-6}$	micro-	$\mu$
$10^9$	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
$10^{21}$	zetta-	Z	$10^{-21}$	zepto-	z
$10^{24}$	yotta-	Y	$10^{-24}$	yocto-	y

Figure 3: Decimal system

### 1.3 Maths Revision

You should know already...

- $360^\circ = 2\pi \text{ rad} \rightarrow 30^\circ = 2\pi \cdot \frac{30}{360} \text{ rad}$
- **Vectors:**  $(2, 3)$  means 2 in the  $x$  direction, 3 in the  $y$  direction.
- **Trigonometry:** *SOH CAH TOA*

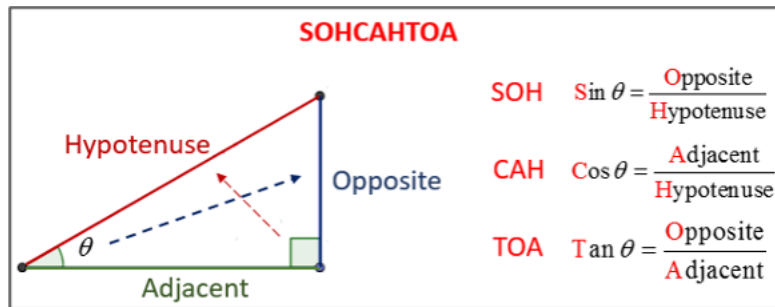


Figure 4: SOH CAH TOA

- **Graphs:**

Gradient: slope of a graph  $m = \frac{\Delta y}{\Delta x}$

– Line equation:  $y = ax + b$ , where  $b$  is the gradient or slope.

- **Solve unknown formulas:** P.e. solve  $u$ :

a.  $v^2 = u^2 + 2as \rightarrow v^2 - 2as = u^2 \rightarrow \sqrt{v^2 - 2as} = u$  done!

- **Combine formulas into new ones:** P.e. combine these three to calculate  $F$  without having to use  $a$  or  $s$ .

a.  $F = ma$ ;  $a = \frac{v^2 - u^2}{2s}$ ;  $s = \frac{d}{t}$  then

b.  $F = \frac{m(v^2 - u^2)}{2s}$  then

c.  $F = \frac{m(v^2 - u^2)}{2 \frac{d}{t}} = F = \frac{mt(v^2 - u^2)}{2d}$ .

- **Geometry:**

a. Area circle =  $\pi r^2$

b. Area square =  $base \cdot height$

c. Area triangle =  $\frac{base \cdot height}{2}$

d. Volume sphere =  $\frac{4}{3}\pi r^3$

e. ...

## 2 Scientific Notation

Scientific notation: using in your calculator.

[Watch this video.](#)

**Mini-practical:** Discover what method your calculator uses for dividing scientific notations ( $3.07 \cdot 10^4$ ,  $3.07^{04}$ ,  $3.07E4$ ).

- Design 20 operations you know (mentally) the answer of which include powers of ten. Eg  $\frac{9 \cdot 10^4}{3 \cdot 10^2} = 3 \cdot 10^2 = 300$ .
- Decide how your calculator works in scientific notation and formulate it as a hypothesis (“when I press... the calculator should do...”).
- Design a method to verify this hypothesis with a  $\frac{1}{20}$  (“significant”) reliability ( $\rightarrow$  you will need 20 operations, 19 of them must agree with the hypothesis for it to be declared true).
- Perform the method, and draw a conclusion.
- Compare with the calculators of other students (in case you ever need to borrow a calculator!).

## 3 Questions on Units and notation

1. Which of the following SI units equivalent to the volt?

- A - ampere per ohm
- B - coulomb per seconds
- C - joule per coulomb
- D - joule per second

(Total for question = 1 mark)

2. Which of the following expresses the volt in SI units?

- A -  $kg\ m^2s^{-2}C^{-1}$
- B -  $kg\ m^2s^{-3}C$
- C -  $kg\ m^2sA^{-1}$
- D -  $kg\ m^2s^{-3}A^{-1}$

(Total for question = 1 mark)

3. A student investigates how the resistance of a filament lamp varies during the first second after it is switched on. He decides to use a computer with data logging sensors take the readings. The best reason for this is that:

- A - A large number of readings can be taken
- B - The computer can calculate the resistance
- C - There is no human error
- D - There is no zero error

**(Total for question = 1 mark)**

4. The unit of potential is the volt. A correct alternative unit is:

- A -  $J A^{-1} s^{-1}$
- B -  $J A s^{-1}$
- C -  $J A s$
- D -  $J A^{-1} s$

**(Total for question = 1 mark)**

5. The unit of the time constant for a resistor-capacitor circuit is:

- A -  $\Omega F^{-1}$
- B -  $\Omega C$
- C -  $s$
- D -  $s F$

**(Total for question = 1 mark)**

6. Electric field strength can have the units:

- A -  $C m^{-1}$
- B -  $N C^{-1}$
- C -  $N V^{-1}$
- D -  $V m$

**(Total for question = 1 mark)**

7. A volt can be defined:

- A - A coulomb per joule
- B - A coulomb per second
- C - A joule per coulomb
- D - A joule per second

**(Total for question = 1 mark)**

8. An ampere can be expressed as:

A -  $C\ s^{-1}$

B -  $J\ C^{-1}$

C -  $V\ W^{-1}$

D -  $V\ \Omega$

**(Total for question = 1 mark)**

9. A unit for magnetic flux is the

A -  $Wb$

B -  $Wb\ m^2$

C -  $T$

D -  $T\ m^{-2}$

**(Total for question = 1 mark)**

### **3.1 Answers**

1.C ( $kg\ m^2sA^{-1}$ )

2.D

3.A (Human error is possible: eg not placing the sensor correctly)

4.A

5.C (time)

6.B (force on electric charge)

7.C

8.A

9.A (Wb - magnetism)