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
Δ	Augment, difference in an interval
$\propto$	Proportional
d or ∂	Derivative
∞	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 $0.012kg$, ^{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, Hertzs
- C, Coulombs
- V, Volts
- Ω, 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	$kg\,m\,s^{-2}$
energy (work)	joule	J	$kg\,m^2\,s^{-2}$
power	watt	W	$kg\,m^2\,s^{-3}$
frequency	hertz	Hz	s^{-1}
charge	coulomb	C	$A\,s$
voltage	volt	V	$kg\,m^2\,s^{-3}\,A^{-1}$
resistance	ohm	Ω	$kg\,m^2\,s^{-3}\,A^{-2}$

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-	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
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...

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

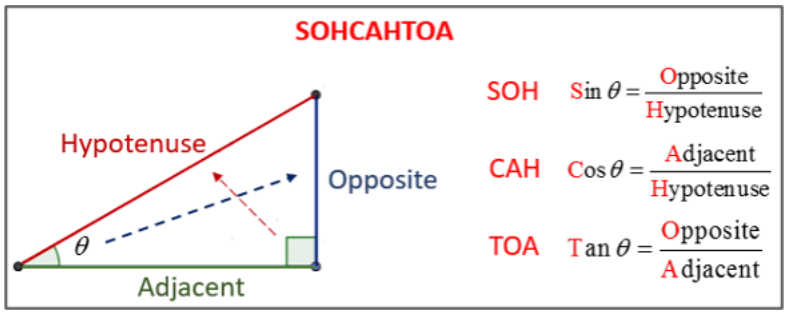

Figure 4: SOH CAH TOA

- **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 - $kg\ m^2 s^{-2} C^{-1}$

B - $kg\ m^2 s^{-3} C$

C - $kg\ m^2 s A^{-1}$

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

(**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 ake 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 - $J\ As^{-1}$

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 - ΩF^{-1}

B - ΩC

C - s

D - $s\ F$

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

6. Electric field strenght 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 ($kg\ m^2 sA^{-1}$)

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)