

2021-2022

# TCOLC Sixth Form

Yr11 – 12 Transition Activities

Subject: Physics



City of Leicester College

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# So you are considering A Level Physics?

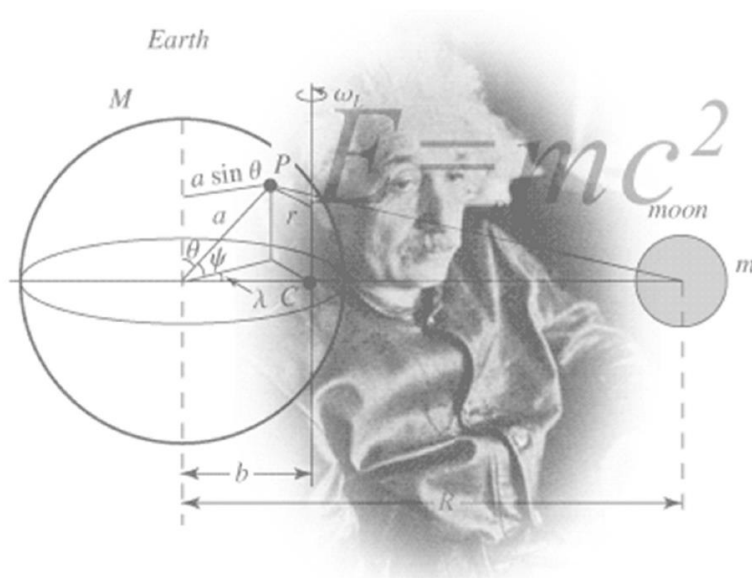


Figure 1 <http://scienceworld.wolfram.com/physics/images/main-physics.gif>

Welcome to Physics and thank you for choosing to study this subject at City of Leicester College.

This booklet introduces you to some of the mathematical tools we frequently use in Physics. Your success in Physics is often determined of how well you can apply these skills along with the knowledge of the subject in solving numerical problems.

You are expected to familiarise yourself with the content of the booklet and work out the exercises included on each topic. Print out the booklet and show your work and written notes. Bring it along in the first Physics lesson in September.

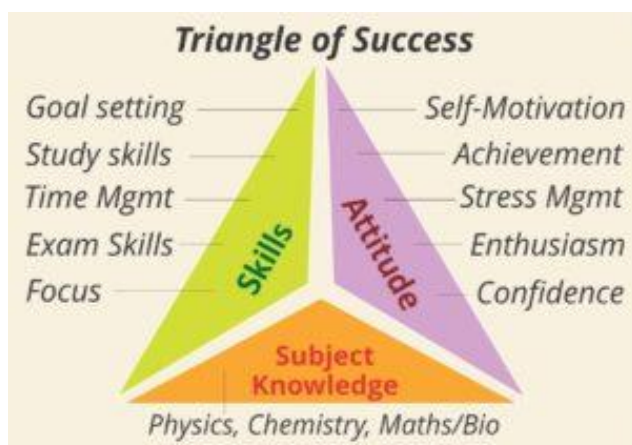
## Chapter 1. Introduction

### How to succeed in A Level Physics

The jump from GCSEs to AS Levels can be challenging for many students, and A Level Physics is no exception. In Y11, to some extent, you could get away with not having a deep understanding of the topics, but once you step into Y12 such superficial knowledge will not be good enough. You will also be faced with more calculations than GCSE science required of you. A Level Physics is one of the most rewarding and respected qualifications available and the success is within the reach of everyone who gets the pre-requisite GCSE grades.

So, what do you need to do to succeed? Here are a few ideas you could follow:

#### Aim to get to the top of the triangle leading to success



To be successful, you should have an approach for acquiring in-depth subject knowledge, have mastered the skills and attitude of success, after all this is the most critical stage, which can be career defining junction of life.

To be successful in Physics, don't stop until you understand the topic, and seek help from teachers and peers.

The following three aspects of **Study Habits** will set you towards the path of success

1. **Learn the material - bottom segment**
2. **Master it - middle segment**
3. **Create your own views/style - top segment**

#### 1. Learning the material

##### **Rule 1 - use the syllabus**

1. Make notes on each part of syllabus
2. Tick off each part of syllabus in colours – red: still not understand, orange: some idea, green: I understand
3. Check notes before exams to ensure you understand all aspects

4. Download key materials - exam board material etc

#### **Rule 2 - make notes during the term**

1. Use a note taking planner to assess which notes you understand and what is missing by creating a grid of notes received each week and a colour coded tick (red, orange, green) to show if you understand them or not
2. Anki – generates flash cards and questions for students if you type notes there

#### **Rule 3 - use a different folder for each subject**

1. Use loose leaf folders
  - One per subject which stays at home
  - One working folder which you bring to school and has the work in each subject being done that week
  - File the material from the working folder each weekUsing an exercise book means flicking back and forth, which limits memory. Using a folder allows you to slot notes into the relevant section

#### **Rule 4 - pay attention to space and colour in notes**

1. Do not write in full sentences; use abbreviations and key words
2. Have headings, sub headings, key points
3. Consider having headings and key words on the left of a page and the main points on the right
4. Use colour coding **Note** - Rewriting notes takes too much time

### **2. Mastering the material**

#### **Rule 1 - use a system of review**

1. Take notes
2. Review notes immediately
3. Review them 24 hours later
4. Review them continuously

#### **Rule 2 - use mind maps**

1. Images are easier to remember than words
2. Use the xmind website if you cannot draw mind maps - <http://www.xmind.net/>

#### **Rule 3 - Practise papers**

1. Minimum 3 per subject per exam
2. Do practice papers only in the run up to an exam, not revision notes.

### **3. Creating your own style to stand out**

#### **Independent work**

1. Use the syllabus
2. Ask the teacher
3. Complete extra reading
  - Consider Google scholar and Khan Academy
  - YouTube hosts some excellent Physics videos to learn the content
4. Look for depth, counter arguments/methods, quotes
5. Add extras in a different colour

## Chapter 2: General approaches to Physics problems

One of things that many people find disconcerting when studying Physics is the idea of having to deal with lots of complicated equations. On first sight, it can be very daunting to see a page full of funny looking letters and symbols but with practice you will see that this really is just to save us having to write words out over and over again (physicists like to work efficiently).

The purpose of this introductory unit is to help you develop the core skills needed to solve numerical problems which will make your AS Physics studies much more enjoyable and successful than they otherwise would be. Without these core skills solving problems becomes much more difficult if not impossible, a bit like trying to build a house with no wood or bricks. A bit of work before the course starts will pay huge dividends later and allow you to work and learn much more efficiently.

The key to success is to break numerical problems where calculations are necessary into smaller, simpler steps which can be followed every time.

The steps can be summarised as follows:-

**Step 1:** Write down the values of everything you are given and put a question mark next to what you are asked to work out.

**Step 2:** Convert all the values into SI units i.e. time in seconds, distances in metres and so on.

**Step 3:** Pick an equation that contains the values we know and the quantity we are trying to work out.

**Step 4:** Re-arrange the equation so what we are trying to work out is the subject.

**Step 5:** Insert the values into the equation including the units.

**Step 6:** Type it into our calculator to get the answer and quote the answer to a reasonable number of significant figures and with units

**Step 7:** Pause for one moment and think about if our answer is sensible.

With experience some of these steps can be done more quickly or in your head but you should always show your working. This is for several reasons:-

1. If you don't show your working, you will needlessly lose many marks in the exam (probably enough to drop your score by one whole grade, i.e. from B  $\rightarrow$  C).
2. It will help make the steps outlined above more apparent and easy to follow when tackling numerical problems.
3. It makes it easier for the teacher to see where you have gone wrong and therefore help you learn more quickly and effectively.

## Chapter 3: Physical Quantities/Units

When we first look at numerical problem in Physics then we need to be able to recognise what quantities we are given in the question. This can be made a lot easier if we know what quantity corresponds to the units given in the question. For example, if a question says someone's speed changes at a rate of  $5 \text{ ms}^{-2}$ , you need to be able to recognise that  $\text{ms}^{-2}$  is the unit of acceleration and so we know that we have been given an acceleration (even though the word acceleration wasn't used in the question).

### We can classify physical quantities as either

- (a) **Basic:** These are **fundamental** which are **defined** as being independent

There are seven basic quantities defined by the Systeme International d'Unites (SI Units). They have been defined for convenience not through necessity (force could have been chosen instead of mass). Once defined we can make measurements using the correct unit and measure with direct comparison to that unit.

Basic quantity	Unit	
	Name	Symbol
Mass	Kilogram	kg
Length	Metre	m
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of a substance	Mole	mol
Luminous intensity	Candela	cd

NOTE: Base units are also referred to as dimensions.

- (b) **Derived:** These are obtained by multiplication or division of the basic units **without** numerical factors. For example:

Derived quantity	Unit	
	Name	Symbols used
Volume	Cubic metre	$\text{m}^3$
Velocity	Metre per second	$\text{ms}^{-1}$
Density	Kilogram per cubic metre	$\text{kgm}^{-3}$

Some derived SI units are complicated and are given a simpler name with a unit defined in terms of the base units.

**Farad (F)** is given as  $\text{m}^2\text{kg}^{-1}\text{s}^4\text{A}^2$       **Watt (W)** is given as  $\text{m}^2\text{kgs}^{-3}$

A table of quantities with their units is shown on the next page along with the most commonly used symbols for both the quantities and units.

**!!! Note that in GCSE we wrote units like metres per second in the format of m/s but in A-level it is written as  $\text{ms}^{-1}$ , and this is the standard way units are written at university level Physics.**

Quantity	Quantity	SI Unit	Unit Symbol
Length	L or l	Metre	m
Distance	s	Metre	m
Height	h	Metre	m
Thickness (of a Wire)	d	Metre	m
Wavelength	$\lambda$	Metre	m
Mass	m or M	kilogram	kg
Time	t	second	s
Period	T	second	s
Temperature	T	Kelvin	K
Current	I	Ampere	A
Potential Difference	V	Volt	V
Area	A	Metres squared	$\text{m}^2$
Volume	V	Metres cubed	$\text{m}^3$
Density	$\rho$ (Rho)	Kilograms per metre cubed	$\text{kg m}^{-3}$
Force	F	Newton	N
Initial Velocity	u	Metres per second	$\text{ms}^{-1}$
Final Velocity	v	Metres per second	$\text{ms}^{-1}$
Energy	E	Joule	J
Kinetic Energy	$E_k$	Joule	J
Work Done	W	Joule	J
Power	P	Watt	W
Luminosity	L	Watt	W
Frequency	f	Hertz	Hz
Charge	Q	Coulomb	C
Resistance	R	Ohm	$\Omega$
Electromotive Force	$\epsilon$ (Epsilon)	Volt	V
Resistivity	$\rho$	Ohm Metre	$\Omega\text{m}$
Work Function	$\phi$	Joule	J
Momentum	p	kilogram metres per second	$\text{kg ms}^{-1}$
Specific Charge		Coulombs per kilogram	$\text{C kg}^{-1}$
Planck's Constant	h	Joule seconds	Js
Gravitational Field Strength	g	Newtons per kilogram	$\text{N kg}^{-1}$

**This table needs to be memorised – once you know this it will significantly improve your ability to answer numerical questions. It is so important that we will test you on this very early on in Year 12.**





$$1 \text{ pc} = 3.09 \times 10^{16} \text{ m}$$

$$h = 6.63 \times 10^{-34} \text{ Js}$$

So this is a much shorter way of writing these numbers!

To put a list of large numbers in order is difficult because it takes time to count the number of digits and hence determine the magnitude of the number.

For more information visit: [www.bbc.co.uk/education/guides/zc2hsbk/revision](http://www.bbc.co.uk/education/guides/zc2hsbk/revision)

### Exercise

1. Write 2530 in standard form.
2. Write 280 in standard form.
3. Write 0.77 in standard form.
4. Write 0.0091 in standard form.
5. Write 1 872 000 in standard form.
6. Write 12.2 in standard form.
7. Write  $2.4 \times 10^2$  as a normal number.
8. Write  $3.505 \times 10^1$  as a normal number.
9. Write  $8.31 \times 10^6$  as a normal number
10. Calculate, giving answers in standard form,
  - a)  $(3.45 \times 10^{-5} + 9.5 \times 10^{-6}) \div 0.0024$
  - b)  $2.31 \times 10^5 \times 3.98 \times 10^{-3} + 0.0013$

## Chapter 5: Converting Units to SI Units

Some common non-SI units that you will encounter during Year 12 Physics:-

Quantity	Quantity	Alternative Unit	Unit Symbol	Value in SI Units
Energy	E	electron volt	eV	$1.6 \times 10^{-19}$ J
Charge	Q	charge on electron	e	$1.6 \times 10^{-19}$ C
Mass	m	atomic mass unit	u	$1.67 \times 10^{-27}$ J
Mass	m	tonne	t	$10^3$ kg
Time	t	hour	hr	3,600 s
Time	t	year	yr	$3.16 \times 10^7$ s
Distance	d	miles	miles	1,609 m
Distance	d	astronomical unit	AU	$3.09 \times 10^{11}$ m
Distance	d	light year	ly	$9.46 \times 10^{15}$ m
Distance	d	parsec	pc	$3.09 \times 10^{16}$ m

**It is essential that you recognise these units and also know how to change them to SI units and back again. A lot of marks can be lost if you are not absolutely competent doing this.**

When you are converting from these units to SI units you need to multiply by the value in the right hand column. When you convert back the other way you need to divide.

### Example

The nearest star (other than the Sun) to Earth is Proxima Centauri at a distance of 4.24 light years.

What is this distance expressed in metres?

$$4.24 \text{ light years} = 4.24 \times 9.46 \times 10^{15} \text{ m} = 4.01 \times 10^{16} \text{ m}$$

What is this distance expressed in parsecs?

$$4.01 \times 10^{16} \text{ m} = 4.01 \times 10^{16} / 3.09 \times 10^{16} \text{ m} = 1.30 \text{ pc}$$

### Exercise

Convert the following quantities:-

1. What is 13.6 eV expressed in joules?
2. What is a charge of 6e expressed in coulombs?
3. An atom of Lead-208 has a mass of 207.9766521 u, convert this mass into kg.

4. What is  $2.39 \times 10^8$  kg in tonnes?
5. It has been 44 years since England won the World Cup, how long is this in seconds?
6. An TV program lasts 2,560s, how many hours is this?
7. The semi-major axis of Pluto's orbit around the Sun is  $5.91 \times 10^{12}$  m, what is this distance in AU?

### Converting Speeds

Things get a little more complicated when you have to convert speeds. For example, if Usain Bolt runs at an average speed of  $10.4 \text{ ms}^{-1}$ , what is this speed in miles per hour?

First, we will change from  $\text{ms}^{-1}$  to  $\text{miles s}^{-1}$ :-

$$10.4 \text{ ms}^{-1} = 10.4 / 1609 \text{ miles s}^{-1} = 6.46 \times 10^{-3} \text{ miles s}^{-1}$$

Now we have to change from  $\text{miles s}^{-1}$  to  $\text{miles hr}^{-1}$

$$6.46 \times 10^{-3} \text{ miles s}^{-1} = 6.46 \times 10^{-3} \times 3,600 \text{ miles hr}^{-1} = 23.3 \text{ miles hr}^{-1}$$

Notice that in last line we had to multiply by the number of seconds in an hour. This is because you would go further in an hour than you would in a second. If you find this hard to understand sometimes you can multiply by the conversion factor and divide by it and see which value is sensible. Let's see what would have happened if we had divided by 3,600:-

$$6.46 \times 10^{-3} \text{ miles s}^{-1} = 6.46 \times 10^{-3} / 3,600 \text{ miles hr}^{-1} = 1.80 \times 10^{-6} \text{ miles hr}^{-1}$$

Do you think Usain Bolt was running at a speed of about 2 millionths of a mile an hour? This is clearly wrong so we would have realised that we needed to multiply by 3,600.

### Exercise

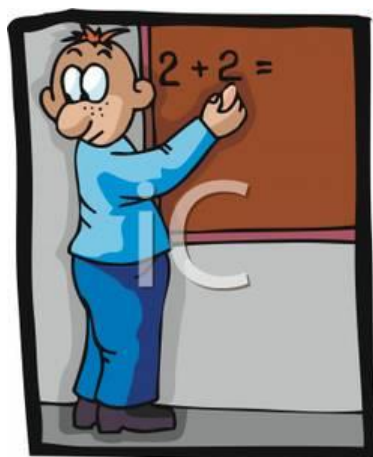
1. Convert  $0.023 \text{ kms}^{-1}$  into  $\text{ms}^{-1}$ .
2. Express  $3456 \text{ m hr}^{-1}$  into  $\text{km hr}^{-1}$
3. What is  $30 \text{ miles hr}^{-1}$  in  $\text{ms}^{-1}$ ?
4. What is  $50 \text{ ms}^{-1}$  in  $\text{miles hr}^{-1}$ ?
5. Convert  $33 \text{ km hr}^{-1}$  into  $\text{ms}^{-1}$ .
6. Express  $234 \text{ miles hr}^{-1}$  in  $\text{km hr}^{-1}$ .

## Chapter 6: Prefixes & Converting Unit Magnitudes

### How to use and convert prefixes

Often in Physics, quantities are written using prefixes which is an even shorter way of writing numbers than standard form. For example instead of writing  $2.95 \times 10^{-9}$  m we can write 2.95 nm where n means nano and is a short way of writing  $\times 10^{-9}$ . Here is a table that shows all the prefixes you need to know in Year 12 Physics.

Prefix	Symbol	Name	Multiplier
femto	f	quadrillionth	$10^{-15}$
pico	p	trillionth	$10^{-12}$
nano	n	billionth	$10^{-9}$
micro	$\mu$	millionth	$10^{-6}$
milli	m	thousandth	$10^{-3}$
centi	c	hundredth	$10^{-2}$
deci	d	tenth	$10^{-1}$
deka	da	ten	$10^1$
hecto	h	hundred	$10^2$
kilo	k	thousand	$10^3$
mega	M	million	$10^6$
giga	G	billion <sup>†</sup>	$10^9$
tera	T	trillion <sup>†</sup>	$10^{12}$
peta	P	quadrillion	$10^{15}$



**Again, it is essential you know all of these to ensure that you don't lose easy marks when answering numerical problems.**

When you are given a variable with a prefix you must convert it into its numerical equivalent in standard form before you use it in an equation.

**FOLLOW THIS!** Always start by replacing the prefix symbol with its equivalent multiplier.

For example:  $0.16 \mu\text{A} = 0.16 \times 10^{-6} \text{A} = 0.00000016\text{A}$

$$3 \text{ km} = 3000\text{m} = 3 \times 10^3 \text{ m}$$

$$10 \text{ ns} = 10 \times 10^{-9} \text{ s} = 0.00000001 \text{ s}$$

**DO NOT** get tempted to follow this further (for example:  $0.16 \times 10^{-6} \text{A} = 1.6 \times 10^{-7} \text{A}$  and also  $10 \times 10^{-9} \text{s} = 10^{-8} \text{s}$ ) unless you are absolutely confident that you will do it correctly. It is always safer to stop at the first step ( $10 \times 10^{-9} \text{s}$ ) and type it like this into your calculator.

**NOW TRY THIS!**

$$1.4 \text{ kW} =$$

$$24 \text{ cm} =$$

$$46 \text{ pF} =$$

$$52 \text{ nm} =$$

$$10 \mu\text{C} =$$

$$340 \text{ GW} =$$

$$0.03 \text{ mA} =$$

$$43 \text{ M}\Omega =$$

### Converting between unit magnitudes for distances.

Convert the following: (Remember that milli =  $10^{-3}$  and centi =  $10^{-2}$ )

1. 5.46m to cm
2. 65mm to m
3. 3cm to m
4. 0.98m to mm
5. 34cm to mm
6. 76mm to cm

### Converting between unit magnitudes for areas and volumes

It's really important that when we convert areas and volumes that we don't forget to square or cube the unit.

#### Example

Let's take the example of converting a sugar cube of volume  $1 \text{ cm}^3$  into  $\text{m}^3$ .

If we just use the normal conversion, then  $1 \text{ cm}^3 = 1 \times 10^{-2} \text{ m}^3$  ← **Wrong Answer!**

STOP! Let's think about this one second:

Imagine in your head a box 1m by 1m by 1m, how many sugar cubes could you fit in there? A **lot** more than 100! That would only fill up one line along one of the bottom edges of the box! **So our answer must be wrong.**

What we have to do is do the conversion and then cube it, like this:-

$$1 \text{ cm}^3 = (1 \times 10^{-2} \text{ m})^3 = 1 \times 10^{-6} \text{ m}^3.$$

So this means we could fit a million sugar cubes in the box, which is right.

#### Exercise

1. What is  $5.2 \text{ mm}^3$  in  $\text{m}^3$ ?
2. What is  $24 \text{ cm}^2$  in  $\text{m}^2$ ?
3. What is  $34 \text{ m}^3$  in  $\mu\text{m}^3$ ?
4. What is  $0.96 \times 10^6 \text{ m}^2$  in  $\text{km}^2$ ?
5. Convert  $34 \text{ Mm}^3$  into  $\text{pm}^3$ .

## Chapter 7: Re-arranging Equations

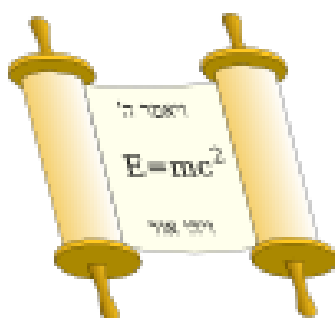
The first step in learning to manipulate an equation is your ability to see how it is done once and then repeat the process again and again until it becomes second nature to you.

In order to show the process once I will be using letters rather than physical concepts.

You can rearrange an equation  $a = b \times c$  with

$$b \text{ as the subject} \quad b = \frac{a}{c}$$

$$\text{or } c \text{ as the subject} \quad c = \frac{a}{b}$$



Any of these three symbols  $a, b, c$  can be itself a summation, a subtraction, a multiplication, a division, or a combination of all. So, when you see a more complicated equation, try to identify its three individual parts  $a, b, c$  before you start rearranging it.

### Worked examples

Equation	First Rearrangement	Second Rearrangement
$v = f \times \lambda$	$f = \frac{v}{\lambda}$	$\lambda = \frac{v}{f}$
$T = \frac{1}{f}$	$1 = T \times f$	$f = \frac{1}{T}$
$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$	$1 = v \times \left( \frac{1}{u} + \frac{1}{f} \right)$	$v = \frac{1}{\frac{1}{u} + \frac{1}{f}}$

**THINK!** As you can see from the third worked example, not all rearrangements are useful. In fact, for the lens equation only the second rearrangement can be useful in problems. So, in order to improve your critical thinking and know which rearrangement is the most useful in every situation, you must practise with as many equations as you can.

**NOW TRY THIS!**

From now on the multiplication sign will not be shown, so  $a = b \times c$  will be simply written as  $a = bc$

Equation	First Rearrangement	Second Rearrangement
(Power of lens) $P = \frac{1}{f}$	$1 =$	$f =$
(Magnification of lens) $m = \frac{v}{u}$	$v =$	$u =$
(refractive index) $n = \frac{c}{v}$	$c =$	$v =$
(current) $I = \frac{\Delta Q}{\Delta t}$		
(electric potential) $V = \frac{\Delta E}{\Delta Q}$		
(power) $P = \frac{\Delta E}{\Delta t}$		
(power) $P = VI$		
(conductance) $G = \frac{I}{V}$		
(resistance) $R = \frac{V}{I}$		
(resistance) $R = \frac{1}{G}$		
(power) $P = I^2 R$		
(power) $P = \frac{V^2}{R}$		
(stress) $\sigma = \frac{F}{A}$	$F =$	$A =$
(strain) $\varepsilon = \frac{x}{l}$	$x =$	$l =$

**Further Rearranging Practice**

- $a = bc$ ,  $b = ?$
- $a = b/c$ ,  $b = ?$ ,  $c = ?$



3.  $a = b - c, c=?$
4.  $a = b + c, b=?$
5.  $a = bc + d, c=?$
6.  $a = b/c - d, c=?$
7.  $a = bc/d, d=?, b=?$
8.  $a = (b + c)/d, c=?$
9.  $a = b/c + d/e, e=?$

## Chapter 8: Using Your Calculator

### Quick Exercise

- Evaluate:-using your calculator.

$$\frac{30}{5 \times 3} = ?$$

What answer did you get? 18? If you did it may surprise you to know that you are wrong. Nope – there’s nothing wrong with your calculator we just need to establish exactly how it works.

### Order of Operations

Your calculator has a rule to decide which operation to do first which is summarised by the word BODMAS, which stands for the order in which operations are done:-

1. B - Brackets first
2. O - Orders (ie Powers and Square Roots, etc.)
3. DM - Division and Multiplication (left-to-right)
4. AS - Addition and Subtraction (left-to-right)

So if we type in the numbers like this:-

$30 \div 5 \times 3 = 6 \times 3 = 18$  ← Left to Right is the conventional order and is what your calculator does.

But if we use brackets we can get the right answer:-

$$30 \div (5 \times 3) = 30 \div 15 = 2$$

Note that the fact that the 5 and 3 are put on the bottom implies they should be multiplied first.

You will need to be able to use your calculator correctly and be familiar with scientific notation, such as standard form, brackets etc.

e.g.  $3\,670\,000 = 3.67 \times 10^6$   
 $0.0\,000\,367 = 3.67 \times 10^{-4}$

To enter  $3.67 \times 10^6$  into your calculator press: 3.67 exp 6

**Note that  $10^8$  means  $1 \times 10^8$  and so must be keyed in as 1 exp 8 not 10 exp 8!**



**As a result when I write out what I know I write out  $1 \times 10^8$  to remind myself to do this.**

**Exercise A** Always give your answer in standard form,  
 e.g.  $7.0 \times 10^{-3}$  and not as  $7.0^{-3}$ , which is how it is displayed on the calculator.

Your answer should have the same amount of significant figures as the question.

1.  $(7.5 \times 10^3) \times 24 =$
2.  $(6.2 \times 10^{-5}) \times (5.0 \times 10^{-3}) =$
3.  $(1.4 \times 10^5) \times (2.0 \times 10^4) =$
4.  $4.5 \times 10^3 / 7.0 \times 10^4 =$
5.  $4.3 \times 10^{-6} / 6.0 \times 10^3 =$

**Exercise B** In each case, find the value of “y”.

1.  $y = (7.5 \times 10^3)^2$
2.  $y = \frac{(1.3 \times 10^3) \times (1.6 \times 10^{-4})}{(6.6 \times 10^6) + (3.27 \times 10^{-3})}$
3.  $y = \frac{(5.6 \times 10^{-4})^2 \times (7.8 \times 10^8)}{(6.6 \times 10^{-11}) \times (9.1 \times 10^{-2})^2}$
4.  $y = \sqrt{\frac{(4.12 \times 10^3) + (6.5 \times 10^2)}{(2.3 \times 10^4) \times (8.1 \times 10^2)}}$

## Chapter 9: Significant Figures

At A level you will be expected to use an appropriate number of significant figures in your answers. The number of significant figures you should use is the same as the number of significant figures in the data you are given. You can never be more precise than the data you are given so if that is given to 3 significant your answer should be too. E.g. Distance = 8.24m, time = 1.23s therefore speed = 6.75m/s

The website below summarises the rules and how to round correctly.

<http://www.purplemath.com/modules/rounding2.htm>

You can lose a mark if you quote too many significant figures in an answer. It is not as bad as leaving off a unit when answering a question – but why lose marks needlessly when you don't have to?

### The Rules

1. All non-zero digits are significant.
2. In a number without a decimal point, only zeros BETWEEN non-zero digits are significant. e.g. significant in 12001 but not in 12100
3. In a number with a decimal point, all zeros to the right of the right-most non-zero digit are significant. 12.100 → 5 s.f.

### Examples

39.389 → 5 s.f.    120000000000000 → 2 s.f.    3400.000 → 7 s.f.

34224000 → 5 s.f.    200000.0004 → 10 s.f.

### Exercise 1-How many significant figures are the following numbers quoted to?

1. 224.4343
2. 0.00000000003244654
3. 3442.34
4. 200000
5. 43.0002
6. 24540000
7. 543325
8. 23.5454353
9. 4.0000000000
10. 4456001

**Exercise 2 – For the numbers above that are quoted to more than 3 s.f., convert the number to standard form and quote to 3 s.f.**

### Using a Reasonable Number of S.F.

Try to use the same s.f. as those provided in the question or just one more.

**Example:**

Let's say we were faced with this question:

A man runs 110 metres in 13 seconds, calculate his average speed.

Distance = 110 m

Time = 13 s

Speed = Distance/Time = 110 metres / 13 seconds

=8.461538461538461538461538461538 m/s

**This is a ridiculous number of significant figures!**

=8.46 m/s seems acceptable (3 s.f.) because the figures we were given in the question we given to 2 s.f, so we've used just one more than that in our answer.

If in doubt quote answers to 3 s.f. in the exam – this is normally close enough to what they are looking for.

## Chapter 10: Example Numerical Problems

### A Step by Step Guide on Tackling a Numerical Problem

This example may look lengthy, but that's because I am describing every step that I do in my head. **Only the yellow shaded bits will end up written down on my paper.**

Let's try Q2(a) from the worksheet given out in class:-

The question says:-

Speed of electromagnetic radiation in free space ( $c$ ) =  $3.00 \times 10^8 \text{ m s}^{-1}$   
Planck's constant ( $h$ ) =  $6.63 \times 10^{-34} \text{ J s}$

2. Calculate the energies of a quantum of electromagnetic radiation of the following wavelengths:

(a) gamma rays wavelength  $10^{-3} \text{ nm}$

**Step 1:** Write down the values of everything you are given and put a question mark next to what you are asked to work out:-

$c = 3.00 \times 10^8 \text{ ms}^{-1}$   
 $h = 6.63 \times 10^{-34} \text{ Js}$   
 $\lambda = 10^{-3} \text{ nm}$   
 $E = ?$

**Commented [CJP1]:** These were given at the top of the sheet.

**Commented [CJP2]:** The wavelength was given in the question.

**Commented [CJP3]:** We are trying to work out the energy.

**Step 2:** Convert all the values into SI units i.e. time in seconds, distances in metres and so on:-

$c = 3.00 \times 10^8 \text{ ms}^{-1}$   
 $h = 6.63 \times 10^{-34} \text{ Js}$   
 $\lambda = 10^{-3} \text{ nm}$   
 $E = ?$

**Commented [CJP4]:** These are already in SI units.

**Commented [CJP5]:** This is in nanometres and needs converting to metres.

**Commented [CJP6]:** If all the other quantities are in SI units then this will come out in SI units which for Energy is Joules (J)

From the table I handed out in class:-

$$\text{nm} = 10^{-9} \text{ m}$$

So now replace nm with  $10^{-9} \text{ m}$ :-

$$\begin{aligned}\lambda &= 10^{-3} \text{ nm} \\ &= 10^{-3} \times 10^{-9} \text{ m} \\ &= 10^{-12} \text{ m} \\ &= 1 \times 10^{-12} \text{ m}\end{aligned}$$

**Commented [CJP7]:** Writing "1 x" might look pointless but it will help to remind us to type it into our calculators correctly later on.

So our list of known values becomes:-

$$\begin{aligned}c &= 3.00 \times 10^8 \text{ ms}^{-1} \\h &= 6.63 \times 10^{-34} \text{ Js} \\ \lambda &= 10^{-3} \text{ nm} = 1 \times 10^{-12} \text{ m} \\ E &= ?\end{aligned}$$

*Step 3: Pick an equation that contains the values we know and the quantity we are trying to work out:-*

So we want an equation with  $c$ ,  $h$ ,  $\lambda$  and  $E$  in it. This looks like a job for the photon energy equation:

$$E = \frac{hc}{\lambda}$$

*Step 4: Re-arrange the equation so what we are trying to work out is the subject.*

We got lucky this time, the thing we are trying work out is the Energy,  $E$ , and that is already the subject, so no re-arranging to do!

*Step 5: Insert the values into the equation including the units:-*

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \text{ Js} \times 3.00 \times 10^8 \text{ ms}^{-1}}{1 \times 10^{-12} \text{ m}}$$

*Step 6: Type it into our calculator to get the answer and quote the answer to a reasonable number of significant figures:-*

Answer in the calculator:

$$E = 1.989 \times 10^{-13} \text{ J}$$

The values for  $h$  and  $c$  were quoted to 3 significant figures, the value for  $\lambda$  was only quoted to 1 s.f. but it's not clear whether this actually was an exact value or rounded to 1 s.f.. Quoting our answer to 3 significant figures seems reasonable. (If in doubt, quote to 3 significant figures, you won't be too far wrong.)

$$E = 1.99 \times 10^{-13} \text{ J (3.s.f.)}$$

*Step 7: Pause for one moment and think about if our answer is sensible.*

This comes with practice and experience. The first time I tried this calculation out I got an answer of  $1.989 \times 10^{-37} \text{ J}$ . Photon energies for the visible part of the electromagnetic spectrum

are about  $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$  and gamma rays are more energetic so I knew I must have made a mistake somewhere to get such a small energy.

Looking back over my working, I could see that I had accidentally used a value of  $1 \times 10^{12} \text{ m}$  for the wavelength,  $\lambda$ , instead of the correct value of  $1 \times 10^{-12} \text{ m}$ .

After a few practice questions, you can do the same and in the exam it is reassuring when you calculate an answer and know that it looks about right.

## Chapter 11: Checking Equations using Dimensions

You can check an equation you have written by examining the base units on both sides of that equation. If you have an extra base unit on one side then your equation is wrong!

### Now try these

1. a. In the equation below,  $c$  represents the speed of water waves in a shallow tank of depth  $d$  and  $g$  is the acceleration due to gravity.

$$c = (g \cdot d)^{1/2}$$

Show from an analysis of the units that the equation is dimensionally consistent.

b. Assuming  $g = 9.8 \text{ ms}^{-2}$ , calculate the speed of the waves if the depth of the water is 1 cm.

c. What depth of water would be required to double the speed of the waves from the value calculated in part a?

d. Would the speeds be any different if the experiment was carried out on the surface of the moon?

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