Physics A-level

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Year 11 Summer Work

September 2020

Key Information

AQA Physics A

Exams: June 2022 (A-level)
Specification code: 7408

A-level

Assessments

Paper 1	Paper 2	Paper 3
What's assessed Sections 1–5 and 6.1 (Periodic motion)	**What's assessed** Sections 6.2 (Thermal Physics), 7 and 8 Assumed knowledge from sections 1 to 6.1	**What's assessed** Section A: Compulsory section: Practical skills and data analysis Section B: Students enter for **one** of sections 9, 10, 11, 12 or 13
Assessed • written exam: 2 hours • 85 marks • 34% of A-level	**Assessed** • written exam: 2 hours • 85 marks • 34% of A-level	**Assessed** • written exam: 2 hours • 80 marks • 32% of A-level
Questions 60 marks of short and long answer questions and 25 multiple choice questions on content.	**Questions** 60 marks of short and long answer questions and 25 multiple choice questions on content.	**Questions** 45 marks of short and long answer questions on practical experiments and data analysis. 35 marks of short and long answer questions on optional topic.

Tasks for the Summer Break

1. **Complete all questions in this workbook.**
2. **There will be work set that needs to be completed by time you get back to school in September 2020.**

Introduction

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 Year 12 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 → 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.

Standard Form

You may well already be familiar with Standard Form from GCSE Maths, but just in case you aren't or could do with refreshing your memory then this chapter will explain what it is and why we use it.

Why use standard form? Standard form is used to make very large or very small numbers easier to read. Standard form also makes it easier to put large or small numbers in order of size.

In Physics, we often deal with quantities that are either really large, such as a parsec

1 pc = 30,900,000,000,000,000 m

Or really small like Planck's Constant:-

h= 0.000000000000000000000000000000000663 Js

Now, it would be tiresome to write out numbers like this over and over again and so we use a different notation known as standard form. Standard form shows the magnitude (size) of the number as powers of ten. We write a number between 1 and 10 and then show it multiplied by a power of 10.

For example

	1.234×10^{4}	1.234×10^{-4}
This means	1.234 x (10 x 10 x 10 x 10)	1.234 x(1 ÷ 10 ÷ 10 ÷ 10 ÷ 10)
Which is	12340	0.0001234

Let's see some more examples.

$0.523 = 5.23 \times 10^{-1}$ (note that $\times 10^{-1}$ means divide 5.23 by 10)

$52.3 = 5.23 \times 10^{1}$ (note that $\times 10^{1}$ means multiply 5.23 by 10)

$523 = 5.23 \times 10^{2}$ (note that $\times 10^{2}$ means multiply 5.23 by 100)

$5230 = 5.23 \times 10^{3}$ (note that $\times 10^{3}$ means multiply 5.23 by 1000)

$0.00523 = 5.23 \times 10^{-3}$ (note that $\times 10^{-3}$ means divide 5.23 by 1000)

Note that the sign (positive or negative) in the index tells you whether you are dividing or multiplying; a positive number means you are multiplying and a negative number means you are dividing. The number tells you how many times you are either dividing or multiplying by 10. So 1.60×10^{-19} means take the number 1.60 and divide it by 10 nineteen times (divide by 10^{19}) i.e. move the decimal point 19 places to the left.

And to go back to our examples from above:-

1 pc = 3.09×10^{16} m

h= 6.63×10^{-34} 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.

1. Put these numbers in order of size,

5239824 , 25634897 , 5682147 , 86351473 , 1258964755, 142586479, 648523154

But it is easier to order large numbers when they are written in standard form.

2. Put these numbers in order of size,

5.239×10^6 , 2.563×10^7 , 5.682×10^6 , 8.635×10^7 , 1.258×10^9, 1.425×10^8 , 6.485×10^8

You can see that it is easier to work with large numbers written in standard form. To do this we must be able to convert from one form into the other.

3. Convert these numbers into normal form.

a) 5.239×10^3

b) 4.543×10^4

c) 9.382×10^2

d) 6.665×10^6

e) 1.951×10^2

f) 1.905×10^5

g) 6.005×10^3

5. Convert these numbers to standard form:
86
381
45300
1 500 000 000
0.03
0.00045
0.0000000782

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 ms^{-2}, you need to be able to recognise that 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	m^3
Velocity	Metre per second	ms^{-1}
Density	Kilogram per cubic metre	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 $m^{-2}kg^{-1}s^4A^2$ **Watt** (W) is given as m^2kgs^{-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 ms^{-1}, and this is the standard way units are written at university level Physics.

Quantity	Quantity	SI Unit	Unit
Length	L or l	Metre	m
Displacement	s	Metre	m
Height	h	Metre	m
Thickness (of a Wire)	d	Metre	m
Wavelength	λ	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	m^2
Volume	V	Metres cubed	m^3
Density	ρ	Kilograms per metre	$kg\ m^{-3}$
Force	F	Newton	N
Initial Velocity	u	Metres per second	ms^{-1}
Final Velocity	v	Metres per second	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	Ω
Electromotive Force	ε	Volt	V
Resistivity	ρ	Ohm Metre	Ωm
Work Function	φ	Joule	J
Momentum	p	kilogram metres per	$kg\ ms^{-1}$
Specific Charge		Coulombs per kilogram	$C\ kg^{-1}$
Planck's Constant	h	Joule seconds	Js
Gravitational Field	g	Metre per second	ms^{-2}
Gravity	g	Metre per second	ms^{-2}
Acceleration	a	Metre per second	ms^{-2}

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. What are the meanings for these symbols?
a
v
F
t
Q

The Greek Alphabet is incomplete, find the correct symbols.

Greek	***Name***	***Greek***	***Name***
	alpha		nu
	beta		pi
	gamma		rho
	delta		sigma
	epsilon		tau
	eta		phi
	theta		chi
	lambda		psi
	mu		omega

A lot of physics equations have the Greek alphabet.

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 2.95×10^{-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	µ	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†	10^{9}
tera	T	trillion†	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 µA = 0.16×10^{-6} A = 0.00000016A

3 km = 3000m = 3×10^{3} m

10 ns = 10×10^{-9} s = 0.00000001 s

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

NOW TRY THIS!

1.4 kW =

24 cm =

46 pF =

52 Gbytes =

10 μC =

340 MW =

0.03 mA =

43 kΩ =

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

When converting, it is perfectly acceptable to write the number and the conversion factor. For example:

$$250 \text{ nm} = 250 \times 10^{-9} \text{ m} = 2.5 \times 10^{-7} \text{ m}$$

3. Convert the following quantities to SI units:	
15 cm	
3 km	
35 mV	
220 nF	

When you write out your answer, you must **always** put the correct **unit** at the end. The number 2500 on its own is meaningless; 2500 J gives it a meaning.

Failure to put units in loses 1 mark in the exam, which is 2 %. Repeated across a paper, it can mean the difference of two grades.

Converting areas and volumes causes a lot of problems.

Area:

$$1m^2 \neq 100cm^2$$

$$\mathbf{1m^2 = 100cm \times 100cm = 10,000cm^2 = 10^4cm^2}$$

Volume:

$$\mathbf{1m^3 = 100cm \times 100cm \times 100cm = 1000,000cm^3 = 10^6cm^3}$$

4. Convert the following:
1 m^2 = mm^2
45 000 mm^2 = m^2
6 000 000 cm^3 = m^3

Using calculator

You can convert your number to prefix form by pressing 

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 as the subject $b = \dfrac{a}{c}$

or c as the subject $c = \dfrac{a}{b}$

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.

<u>Worked examples</u>

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

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 Find the question mark by rearranging

1. a = bc , b=?

2. 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=?

Using a Calculator

A **scientific calculator** is an essential tool in Physics, just like a chisel is to a cabinet-maker. All physics exams assume you have a calculator, and you should always bring a calculator to every lesson. They are not expensive, so there is no excuse for not having one.

The calculator should be able to handle:

- **standard form**;
- **trigonometrica**l functions;
- **angles** in **degrees** and **radians**;
- **natural logarithms** and **logarithms to the base 10**.

Most scientific calculators have this and much more.

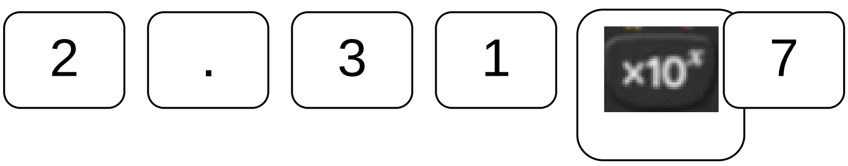
There are no hard and fast rules as to what calculator you should buy:

- Get one that you are happy with.
- Make sure it is accurate; we have known some calculators to get an answer plain wrong!
- Avoid machines that need a hefty instruction manual.
- For the exam, there are certain types of calculator that are NOT allowed, for example those with QWERTY keypads.   Make sure that your calculator is an allowable type.

We are assuming that you know the basic functions of your calculator, but we need to draw your attention to a couple of points on the next page.

***Misuse of the EXP key*:**

Suppose we have a number like 2.31×10^7. You key it in like this:



Too Many Significant Figures

Consider this calculation: $V_{rms} = \frac{13.6}{\sqrt{2}}$

Your calculator will give the answer as V_{rms} = 9.6166526 V

There is no reason at all in A-level Physics to write any answer to any more than 4 significant figures. Four significant figures is claiming accuracy to about one part in 10000. Blindly writing your calculator answer is claiming that you can be accurate to one part in 100 million, which is absurd.

The **examination mark schemes** give answers that are either 2, 3 or 4 significant figures. So our answer above could be written as:

V_{rms} = 9.617 V (4 s.f.)

V_{rms} = 9.62 V (3 s.f.)

V_{rms} = 9.6 V (2 s.f.)

Do any **rounding** up or down at the end of a calculation. If you do any rounding up or down in the middle, you could end up with rounding errors.

6. Use your calculator to do the following calculations. Write your answers to **three** significant figures.

	ANSWER
(a) $\frac{3.4\times10^{-3}\times6.0\times10^{23}}{235}$	
(b) $\frac{27.3^2-24.8^2}{\sqrt{38}}$	
(c) 1.4509^3	
(d) $\sin 56.4^0$	
(e) Reciprocal of 2.34×10^5	
(f) $45\sin10^0$	

GCSE Physics Knowledge

The main topics at AS Physics are:

- Particles and radiation
- Electromagnetic radiation
- Electricity
- Mechanics
- Materials
- Waves
- Practical skills

On the following pages create a mind map or revision notes on all you can remember from GCSE.

Particle and Radiation

Electromagnetic radiation

Electricity

Mechanics

Materials

Waves

Important vocabulary for practical work

There are many words used in practical work. You will have come across most of these words in your GCSE studies. It is important that you are using the right definition for each word. The activity on the next page tests your understanding of terms used in practical work.

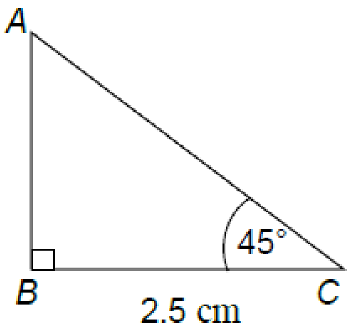
Activity 6

Join the boxes to link the word to its definition.

Accurate	A statement suggesting what may happen in the future.
Data	An experiment that gives the same results when a different person carries it out, or a different set of equipment or technique is used.
Precise	A measurement that is close to the true value.
Prediction	An experiment that gives the same results when the same experimenter uses the same method and equipment.
Range	Physical, chemical or biological quantities or characteristics.
Repeatable	A variable that is kept constant during an experiment.
Reproducible	A variable that is measured as the outcome of an experiment.
Resolution	This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.
Uncertainty	The interval within the true value can be expected to lie.
Variable	The spread of data, showing the maximum and minimum values of the data.
Control variable	Measurements where repeated measurements show very little spread.
Dependent variable	Information, in any form, that has been collected.

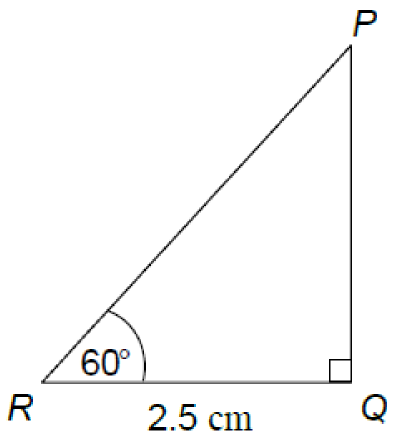
Activity 10: Use sine, cosine and tangent

1 (a) Work out the length of *AB*.



(Not drawn accurately)

(b) Work out the length of *PR*.



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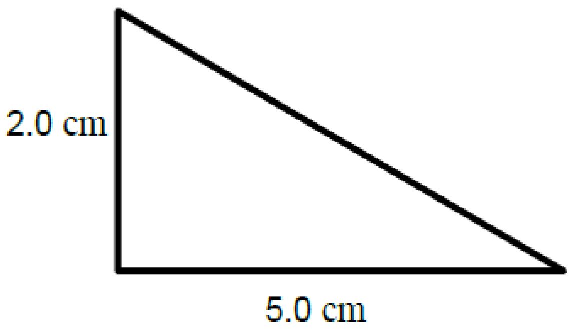
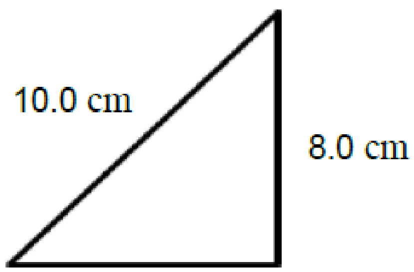
Activity 11: Pythagoras's theorem

Work out the lengths of the unlabelled sides.





Activity 13: Rearranging formulas

1. Rearrange $y = 2x + 3$ to make x the subject.

2. Rearrange $C = 2\pi r$ to make r the subject.

3. Rearrange $E = \frac{1}{2}mv^2$ to make v the subject.

4. Rearrange $s = ut + \frac{1}{2}at^2$ to make u the subject.

5. Rearrange $s = ut + \frac{1}{2}at^2$ to make a the subject.

6. Rearrange $\omega = \frac{v}{r}$ to make r the subject.

7. Rearrange $T = 2\pi\sqrt{\frac{v}{r}}$ to make r the subject.

8. Rearrange $v = \omega\sqrt{A^2 - x^2}$ to make x the subject.

Note: in science, subscripts are often used to label quantities. So in the following two examples, there are two masses, m_1 and m_2. The 1 and 2 are part of the quantity and should be kept with the m.

9. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make m_2 the subject.

10. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make r the subject.