PHYSICS
DURHAM JOHNSTON
AS and A LEVEL PHYSICS

Congratulations on choosing A-level physics. It is a challenging yet rewarding subject. We hope you will find it enjoyable and interesting.

What is Physics?

The word 'physics' comes from ancient Greek, literally meaning 'knowledge of nature'. It is the branch of science that studies matter, forces and energy to understand how everything in the universe behaves. If you are the type of person that is always asking 'Why?' then physics is for you!

Why should you study physics?

Using a few basic principles, theories and laws, you will become capable of explaining events and occurrences that you have never come across before. This ability to predict how the physical world works is a powerful tool not only to scientific research and industry but also to you, enabling you to 'think on your feet'. This makes physicists valued both for what they know and how they apply their knowledge

An A-level in physics is useful for when applying for virtually any higher education courses whether they are arts or science based. It will not tie you down to do physics forever. If you are already interested in a particular aspect of physics e.g. electronics, medical physics, astronomy etc or applied physics i.e. engineering then do not feel that you have to specialise now, higher education institutions will teach your specialism from the beginning.

Career opportunities

Physics A-level is a requirement of the majority of physical sciences and engineering courses in higher education. Physicists find employment in many scientific areas, such as engineering, renewable energy, astronomy, space exploration, meteorology and climate change, aeronautics, the automotive industry, electronics, laboratory work, radiography, medicine, veterinary science, telecommunications, forensic science, armed forces and nanotechnology.

Outside of science, physicists are valued in many other careers because of their skills in analysing information and solving complex problems, and their high levels of numeracy and computer literacy. Many physicists find employment in banking, insurance, accountancy, software and computing.

Minimum Course Entry Requirements

- **6-6 in combined science or equivalent, or level 6 in separate physics**
- **6 in GCSE maths or equivalent**
  A level maths is an ideal companion subject, though not essential. Every year a handful of pupils study physics without maths.

Exam Board and Course

OCR [Oxford Cambridge and RSA Examinations], Physics A (H156/H556)

All students will be taught the AS physics content in year 12. This will allow them to sit the two AS exams at the end of the year.
The remaining content, which is necessary for the A level qualification, is taught in year 13. To obtain an A level, students will sit three exams covering all the work from year 12 and 13. If sitting the A level, any mark obtained at AS in year 12 is disregarded. The grade depends solely upon the marks achieved in the three year 13 exams.
Pupils need to pass a teacher assessed set of practical of tasks in order to achieve a Practical Endorsement in Physics. Though it does not carry any marks contributing to a final grade, many universities require the Practical Endorsement as an entry requirement.

AS Level Specification (H156)

Year 12 modules:

1. Development of practical skills.
2. Foundations of physics.
3. Forces and motion.
4. Electron, waves and photons.

Year 12 exams:

- Breadth in Physics
- Depth in Physics.
  Both 1 hour 30 minutes, both assessing all material.

A Level Specification (H556)

Year 13 modules:

1. Development of practical skills.
5. Newtonian world and astrophysics.
6. Particles and medical physics.
   (Content taught in modules 2, 3 and 4 is also used throughout year 13)

Year 13 exams:

- Modelling Physics (2 hours 15 minutes, 100 marks, assessing modules 1, 2, 3 and 5)
- Exploring Physics (2 hours 15 minutes, 100 marks, assessing modules 1, 2, 4 and 6)
- Unified Physics (1 hour 30 minutes, assessing all modules)

The first term of year 12 and transition material

You will be taught all year 12 modules concurrently by two teachers. One teacher will teach modules 2 and 3, the other teaching module 4.

The topics taught in the first term build upon work already covered at GCSE.

From modules 2 and 3:

- Physical quantities and units
- Making measurements and analysing data
- Nature of quantities
- Motion
- Forces in action
- Work, energy and power

From module 4:

- Charge and current
- Electrical energy, power and resistance
- Electrical circuits

Module 1 (practical skills) is taught throughout the course.

You should complete the transition work provided below before the start of the course. There is work covering some of the maths skills you should have acquired at GCSE and need for year 12 physics, along with some revision of energy and electricity topics met at GCSE but covered again in more depth in year 12. **You do not need to print the work, but you should at least write answers to all questions on paper, with clear working shown when appropriate.**

As well as the transition work, if you wish to stimulate your interest in physics over the summer, try the following Youtube channels:

- Sixty Symbols
- Minutephysics
- Physics Girl

If you are already considering studying the physical sciences or engineering at university, we would advise you to start reading around your areas of interest. Evidence of a deeper understanding beyond the curriculum and a genuine passion for your subject is what makes candidates stand out at interview.

PHYSICS

Year 12 Physics Course Preparation
Some important maths and calculator skills

Name: ______________________________

Physics Year 12 Induction

Objectives:

- *To give you the skills needed for the successful study of physics at A level.*
- *To help you to identify areas in which you might need help.*

There are several areas in which students initially struggle at A level:

- Use of symbols
- Use of SI units
- Use of a calculator
- Use of formulae

These notes and activities are to help you to become confident with these basic skills, which will help the start of your physics studies to be more productive and enjoyable.

Using Symbols

An **equation** is a mathematical model that sums up how a system behaves. For example, we know that, if we have a current flowing through a wire and double the voltage, the current will double as well. We know that the quantities of current and voltage are related by the simple rule: $V = IR$

In physics problems we are given certain quantities and use them to find an unknown quantity with an equation.

Symbols

At GCSE you were often given equations in words: $distance = speed \times time$

At A level you will be provided with a data sheet in your examinations. The data sheet will provide you with equations that are given in **symbols.** The symbols all mean something; they are abbreviations. The symbols used in exams and most textbooks are those agreed by the Association of Science Education.

Some symbols are easy; ***V*** stands for voltage. Some are not so easy. ***I*** for current comes from the French *intensité du courant*, since it was a French physicist who first worked on it.

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

You will come across symbols written in Greek letters. The normal (Latin) alphabet has 26 characters.
The Greek alphabet adds another 24.

The Greek Alphabet

Greek	Name	Greek	Name
α	alpha	ν	nu
β	beta	ξ	xi
γ	gamma	ο	omicron
δ (Δ)	delta	π	pi
ε	epsilon	ρ	rho
ζ	zeta	σ (Σ)	sigma
η	eta	τ	tau
θ	theta	υ	upsilon
ι	iota	ϕ	phi
κ	kappa	χ	chi
λ	lambda	ψ	psi
μ	mu	ω (Ω)	omega

The ones in grey are the ones you will not generally come across in A-level. You will come across the others in the context of:

- Particles – many particles are given Greek letters, e.g. π meson.
- Physics equations, e.g. $v = f\lambda$

2. The wave equation is $v = f\lambda$. What do the symbols refer to?
v
f
λ

The most common uses of Greek letters are:

- α – as in alpha particle
- β – as in beta particle
- γ – as in gamma ray
- Δ – change in (□t is time interval)
- θ – angle
- π – 3.1415…
- μ – as in micro ($x10^{-6}$)

When you use an equation, you will need to know exactly what each term means. But do not worry; the terms will be explained when the formula is introduced to you.

Units

Physics formulae use **SI** (Système International) units

Many physics formulae will give you the right answer ONLY if you put the quantities in SI units. This means that you might have to convert them. You will often find units that are prefixed, for example kilometre. The table below shows you the commonest prefixes and what they mean:

Prefix	*Symbol*	*Meaning*	*Example*
pico	p	$\times 10^{-12}$	1 pF
nano	n	$\times 10^{-9}$	1 nF
micro	μ	$\times 10^{-6}$	1 μg
milli	m	$\times 10^{-3}$	1 mm
centi	c	$\times 10^{-2}$	1 cm
kilo	k	$\times 10^{3}$	1 km
mega	M	$\times 10^{6}$	1 MΩ
giga	G	$\times 10^{9}$	1 GWh

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.

Converting areas and volumes causes a lot of problems.

Area:

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

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

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

Standard Form

Standard form consists of a number between 1 and 10 multiplied by a **power** of 10. For big numbers and very small numbers standard form is very useful.

You should have found that very small numbers entered into a calculator are read as 0, unless they are entered as standard form. The following number is shown in standard form:

$$\mathbf{3.28 \times 10^5}$$
$$= 3.28 \times 100\,000 = 328\,000$$

Look at this number:

$$4\ 505\ 000\ 000\ 000\ 000\ 000$$

Start counting from here to get the power of 10.

We find that there are 18 digits after the first digit, so we can write the number in standard form as:

$$4.505 \times 10^{18}$$

For fractions we count how far back the first digit is from the decimal point:

$$0.00000342$$

In this case it is six places from the decimal point, so it is:

$$3.42 \times 10^{-6}$$

A negative power of ten (negative index) means that the number is a fraction, i.e. between 0 and 1.

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

There is no hard and fast rule as to when to use standard form in an answer. Basically if your calculator presents an answer in standard form, then use it. Generally use standard form for:

- numbers greater than 100 000
- numbers less than 0.001

When doing a **conversion** from one unit to another, for example from millimetres to metres, consider it perfectly acceptable to write:

$$15 \text{ mm} = 15 \times 10^{-3} \text{ m}$$

Using a Calculator

A **scientific calculator** is an essential tool in Physics, just like a chisel is to a carpenter. 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.

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.

Use the standard form button at the bottom of the number pad. It is either:

EXP or $\text{x } 10^{x}$

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

2	.	3	1	EXP	7

Or

2	.	3	1	$\times 10^x$	7

Do **NOT** key it in like this:

2	.	3	1	×	1	0	EXP	7

This will give you 2.31×10^8. Misuse of the calculator will always cost marks.

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 3 significant figures. Three significant figures is claiming accuracy to about one part in 1000. 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 or 3 significant figures. So our answer above could be written as:

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) $\frac{3.40\times10^{-3}\times6.02\times10^{23}}{235}$	
(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) $45sin10^0$	

Some other tips on use of calculators:

- Take one step at a time and write intermediate results.
- It is easy to make a mistake such as pressing the × key rather than the ÷ key. It is a good idea to do the calculation again as a check.
- As you get more experienced, you will get a feel for what is a reasonable answer. 1000 N is a reasonable force that a car would use to accelerate; 2×10^{-10} N is most certainly not.

Transposition of Formulae

The **transposition** (or **rearrangement**) of formulae is a skill that is essential for successful study of Physics. A wrong transposition of a formula will lead to a **physics error** in the exam and you will lose all the marks available in that part of the question. (However, if you use your incorrect answer correctly in subsequent parts, your error will be carried forward and you will gain the credit.)

Some students find rearrangement difficult and it hampers their progress and enjoyment of the subject. They try to get round it by learning all the variants of a formula, which is a waste of brain power.

It is far better to get into the habit of rearranging formulae from the start. The best thing to do is to practise.

Key Points:

- What you do on one side you have to do on the other side. It applies whether you are working with numbers, symbols, or both.
- Do not try to do too many stages at once.

Transposing Simple Formulae

Simple formulae are those that consist of three quantities, taking the form $A = BC$. A typical example is $V = IR$

Suppose we are using the equation $V = IR$ and wanted to know *I*.

We want to get rid of the R on the RHS so that I is left on its own. So we divide both sides by *R* which gives us:

$$\frac{V}{R} = \frac{IR}{R}$$

The *R*s on the RHS cancel out because *R*/*R* = 1. So we are left with:

$$\frac{V}{R} = I$$

It does not matter which way the equation ends up, as long as it is rearranged properly.

7. Rearrange these equations:		
Equation	***Subject***	***Answer***
$V = IR$	R	
$p = mv$	v	
$\rho = \frac{m}{V}$	m	
$Q = CV$	C	

Formulae with Four Terms

8. Rearrange these equations:		
Equation	***Subject***	***Answer***
$pV = nRT$	V	
$E_p = mg\Delta h$	Δh (*Δh* is a single term	
$V = \frac{-Gm}{r}$	G	
$\lambda = \frac{ax}{D}$	D	

Equations with + or -

If there are terms which are added or subtracted, we need to progress like this:

$$Ek = hf - \Phi$$

We want to find *h*.

To get rid of the □ term we need to add it to both sides of the equation:

$$Ek + \Phi = hf - \Phi + \Phi$$
$$Ek + \Phi = hf$$

Now we can get rid of the *f* on the RHS by dividing the whole equation by *f*:

$$\frac{(Ek + \Phi)}{f} = \frac{hf}{f}$$

Which gives us our final result of:

$$h = \frac{(Ek + \Phi)}{f}$$

9. Rearrange these equations:		
Equation	***Subject***	***Answer***
$v = u + at$	t	
$E = V + Ir$	r	

Now mark your work. Ensure that it is ticked and that you have written up your corrections.

ANSWERS

1. What are the meanings for these symbols?
a *acceleration*
v *velocity*
F *force*
t *time*
Q *amount of charge*

2. The wave equation is $= f\lambda$. What do the symbols refer to?
v *speed*
f *frequency*
λ *wavelength*

3. Convert the following quantities to SI units:	
15 cm	*0.15 m*
3 km	*3000 m*
35 mV	*0.035 V*
220 nF	*2.2×10^{-7} F*

4. Convert the following:
1 m^2 = *1 000 000 mm^2 (1 x 10^6 mm^2)*
45 000 mm^2 = *0.045 m^2*
6 000 000 cm^3 = *6 m^3*

5. Convert these numbers to standard form:
86 = 8.6×10^1
381 = 3.81×10^2
45300 = 4.53×10^4
1 500 000 000 = 1.5×10^9
0.03 = 3.0×10^{-2}
0.00045 = 4.5×10^{-4}
0.0000000782 = 7.82×10^{-8}

6. Use your calculator to do the following calculations. Write your answers to no more than **three** significant figures.	
(a) $\frac{3.4\times10^{-3}\times6.0\times10^{23}}{235}$	8.71×10^{18}
(b) $\frac{27.3^2-24.8^2}{\sqrt{38}}$	21.1
(c) 1.4509^3	3.05

(d) $sin\, 56.4^0$	0.833
(e) Reciprocal of 2.34×10^5	4.27×10^{-6}
(f) $45sin10^0$	7.81

7. Rearrange these equations:		
$V = IR$	R	$R = \frac{V}{I}$
$p = mv$	v	$v = \frac{p}{m}$
$\rho = \frac{m}{V}$	m	$m = \rho V$
$Q = CV$	C	$C = \frac{Q}{V}$

8. Rearrange these equations:		
$pV = nRT$	V	$V = \frac{nRT}{p}$
$E_p = mg\Delta h$	Δh (Δh is a single term)	$\Delta h = \frac{E_p}{mg}$
$V = \frac{-Gm}{r}$	G	$G = -\frac{Vr}{m}$
$\lambda = \frac{ax}{D}$	D	$D = \frac{ax}{\lambda}$

9. Rearrange these equations:		
$v = u + at$	t	$t = \frac{v - u}{a}$
$E = V + Ir$	r	$r = \frac{E - V}{I}$

Reflection on the transition work and the AS physics course you are about to undertake:

Which exercises I found the easiest and why?
Which exercises I found the hardest and why?
Concerns I have about the AS Physics course in Year 12: