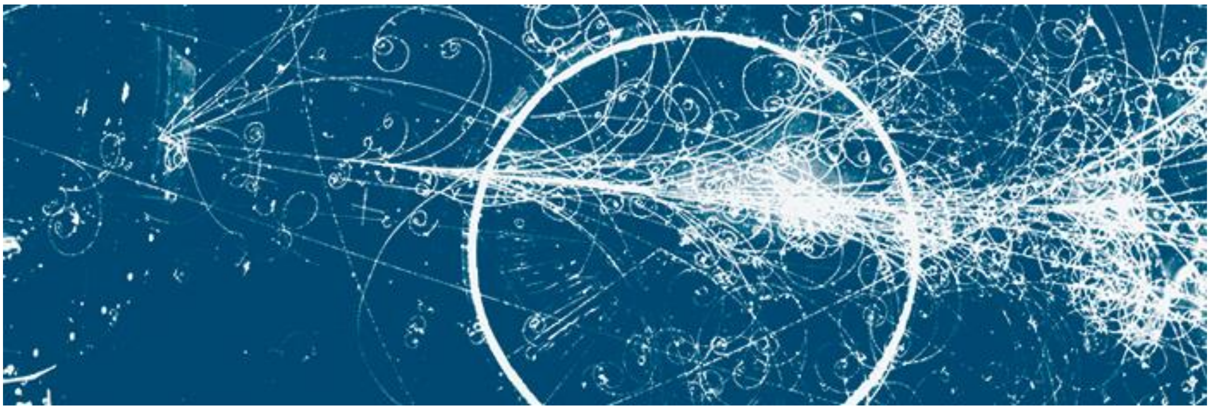


Physics Handbook

Physics is **THE most fascinating subject** to study at A-level! Physicists explore the fundamental nature of almost everything we know of. They study everything from the fundamental particles that build matter, to the galaxies that make up the universe itself. Join them to enter a world deep beneath the surface of normal human experience!

Physics is known as a **facilitating subject** – this means that it helps **keep your options open** as it's highly regarded as preparation for lots of different courses. Businesses and universities really value the subject because of the **transferrable skills** it gives you. You'll develop research, problem solving and analytical skills, alongside teamwork and communication.

Possible degree options

According to bestcourse4me.com the top seven degree courses taken by students who have A-level Physics are:

- Mathematics
- Physics
- Mechanical engineering
- Computer science
- Civil engineering
- Economics
- Business

Career opportunities

Studying Physics at A-level or degree level opens up all sorts of career opportunities.

- Geophysicist/field seismologist
- Healthcare scientist, medical physics
- Higher education lecturer or secondary school teacher
- Radiation protection practitioner
- Research scientist (physical sciences)
- Scientific laboratory technician
- Meteorologist
- Structural or Acoustic engineer
- Product/process development scientist
- Systems developer
- Technical author

You can also move into engineering, astrophysics, chemical physics, nanotechnology, renewable energy and more. With physics, the opportunities are endless!

The course

Year 12

1 Measurements and their errors (taught within all other topics)
2 Particles and radiation
3 Waves
4 Mechanics and materials
5 Electricity

Year 13

1 Measurements and their errors (taught within all other topics)
6 Further mechanics and thermal physics
7 Fields and their consequences
8 Nuclear physics
9 Optional topics. You will study one of these: Turning points in physics.

Exams

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: Optional topic- Turning Points
Assessed • written exam: 2 hours • 85 marks • 34% of A-level Questions	Assessed • written exam: 2 hours • 85 marks • 34% of A-level Questions	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.

Practical Endorsement

You will also have to complete 12 required practicals to demonstrate that you have a range of practical skills. 15% of the marks in available in the exams are based on practical skills.

Organisation

Folders

It is so important that you get organised from the beginning! You will need lined paper, a folder and dividers.

You will need to arrange your folder into the following:

- Lesson notes divided into different topics
- HW
- Study work section
- Tests section
- Further reading section

If a different arrangement suits you better that is fine- but ensure you know where everything is and can produce it if asked!

Study periods

You will have one study period for physics per week. You will be set work for this and it will be checked each week.

'Free' periods

It is so important to use this time wisely!! For every hour you spend in the classroom, you spend another outside of that studying. That is 4-5 hours per week!

What can you do?

- Read the material from the textbook relevant to lessons you have just been to, adding any useful notes and making sure you still understand the ideas covered
- Complete any practice questions in the textbook
- Learn key vocabulary and definitions
- Wider reading of science news articles- for example you may wish to have the BBC science news bookmark on your phone
- Practise exam questions
- Correct and redo any HW/test questions that you got wrong

Expectations and guidance

Required Practicals

There are 12 required practicals that must be completed over the 2 year course:

1. Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string
2. Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating
3. Determination of g by a free-fall method
4. Determination of the Young modulus by a simple method
5. Determination of resistivity of a wire using a micrometre, ammeter and voltmeter
6. Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it
7. Investigation into simple harmonic motion using a mass-spring system and a simple pendulum
8. Investigation of Boyle's (constant temperature) law and Charles's (constant pressure) law for a gas
9. Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC
10. Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance
11. Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction
12. Investigation of the inverse-square law for gamma radiation

Required Practical Report

Each required practical will require a short report to be written to include the following elements:

- **Aim**: the purpose of the experiment. What are we trying to find out?
- **Variables**: independent, dependent and control variables identified
- A **diagram of apparatus**, with any variables labelled
- A clear **table** of results, correctly headed
- A clear **graph** of results, with any gradients clearly calculated
- **Analysis:** to explain to features of the table/graph relating to the aim of the experiment and/or y = mx + c
- **Evaluation:** a consideration as to the uncertainty/%uncertainty or %difference from expected value

Tables

Drawing a table is an important skill that you will have to demonstrate if you are to pass the practical element of the course. Here are the criteria we will be looking for:

1. Independent variable in first column
2. Control variable can either be recorded in the table or a separate comment to the effect that it was controlled at a specific value.
3. Dependent variable and repeats with mean in the next columns – repeats not necessarily required.
4. Processed data (that you calculate from your collected data) in the end columns of the table
5. All columns headed with quantity and unit
6. No units in the body of the table
7. Precision /resolution of instruments used and maintained throughout- all numbers within a column to the same number of decimal places.
8. Mean values don't generate extra or lose significant figures.

1. 3. 4. 5.

Mass/kg	Frequency 1 /Hz	Frequency 2 /Hz	Frequency mean /Hz	Tension /N
0.100	32.63	33.22	32.93	0.981
0.200	45.25	44.66	44.96	1.962
0.300	56.02	55.46	55.74	2.943
0.400	67.99	68.35	68.17	3.924
0.500	75.30	72.78	74.04	4.905
0.600	80.42	81.54	80.98	5.886

Length of the wire: 0.500m

6. 7. 8.

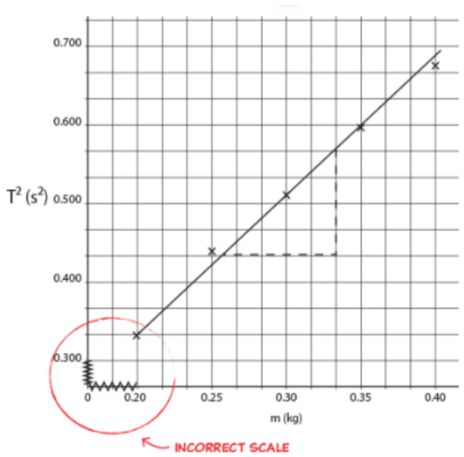
2.

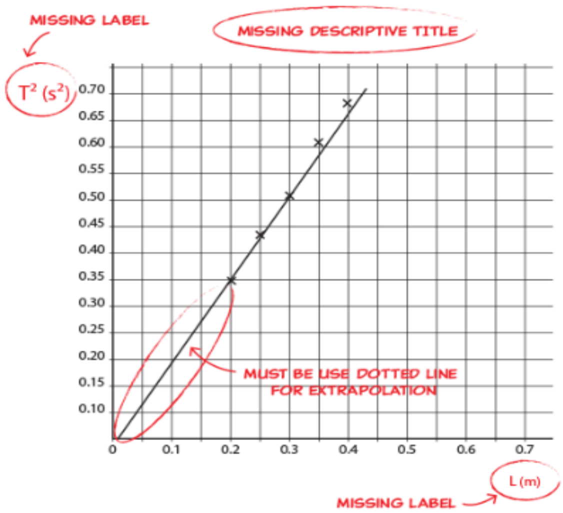
Graphs

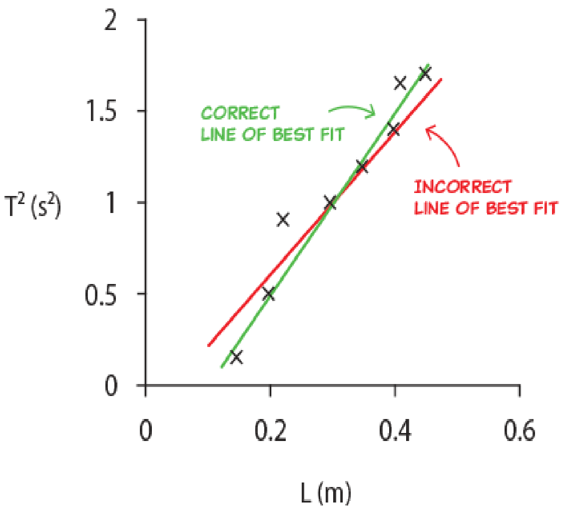
Drawing a graph is another important skill that you will have to demonstrate if you are to pass the practical element of the course. Here are the criteria we will be looking for:

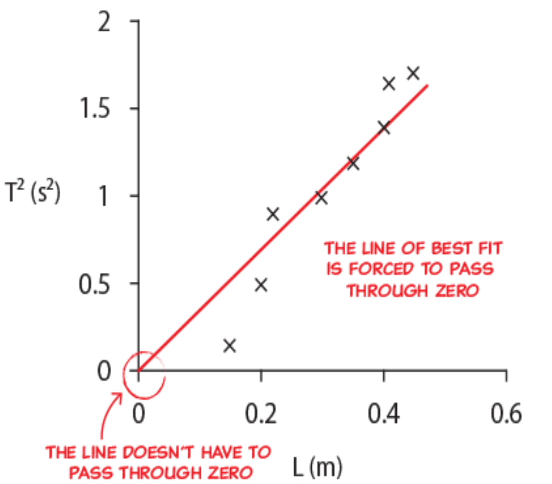
1. Axes labelled clearly with units
2. Axes divided into equal increments
3. If a mean has been calculated plot this and not each set of data
4. Points accurately plotted using neat crosses, not dots
5. A smooth line or curve of best fit drawn, with roughly an equal number of points on either side
6. If you are extrapolating your line of best fit (extending it beyond your plotted points), this should be drawn as a dotted line
7. Think carefully whether you line of best fit should pass through he origin
8. If the gradient is to be calculated lines should be drawn of at least 7cm in length

Some common mistakes:









Significant figures

1. All non-zero numbers are significant (meaning they count as sig figs)
613 has three sig figs
123456 has six sig figs

2. Zeros located between non-zero digits are significant (they count)
5004 has four sig figs
602 has three sig figs
6000000000000002 has 16 sig figs!

3. Trailing zeros (those at the end) are significant only if the number contains a decimal point; otherwise they are insignificant (they don't count)
5.640 has four sig figs
120000.0 has six sig figs
120000 has two sig figs – unless you're given additional information in the problem

For example If the mass of a vehicle is quoted as 1000 kg we do not know how many significant figures this is as we need the zeros to establish a place value. The quoted values in the table below are all the same in terms of their magnitude.

Quoted value	Number of SF	Precision
1000	?	?
1.0×10^3	2 SF	Nearest 100 kg
1.00×10^3	3 SF	Nearest 10 kg
1.000×10^3	4SF	Nearest 1 kg

4. Zeros to left of the first nonzero digit are insignificant (they don't count); they are only placeholders!
0.000456 has three sig figs
0.052 has two sig figs
0.000000000000000000000000000000000052 also has two sig figs!

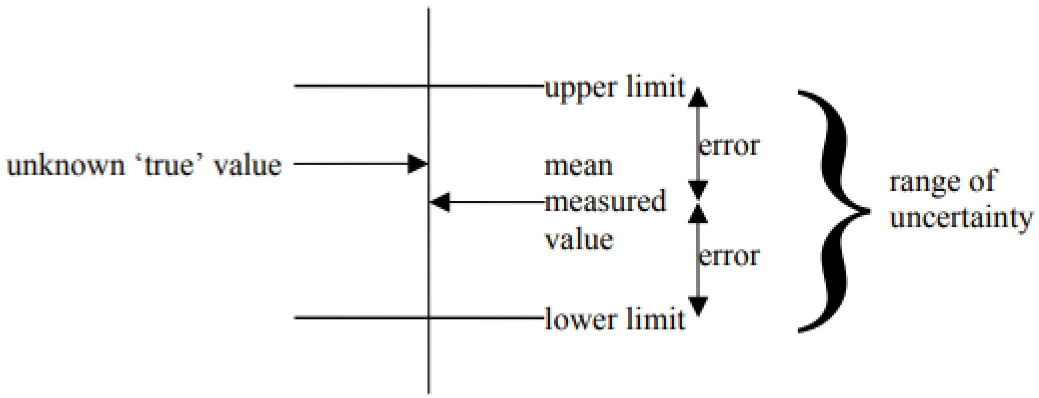
Why are they important?

You need to match the number of significant figures given to you in any answer you produce- this can earn you marks in exams! For example, if you are told that an objects mass was 3500kg and its velocity $7.5ms^{-1}$, you wouldn't then say that it had 98437.5J of kinetic energy! You would instead quote 98000J.

Uncertainty

A big deal in physics! We will consider this regularly when completing practicals.

All that any experimental procedure can do is to give a value for the result that we can say may be near the true value. We can never say that we know the true result, only that we have a result that may lie within a range of **uncertainty**. For example, as a result of a number of measurements we may have a best estimate of the true value for the acceleration due to gravity, g, of 9.9 ms^{-2} and also be confident that our uncertainty is ± 0.1 ms^{-2}, i.e. g is between 9.8 and 10.0 ms^{-2}. If we are lucky then there may be an accepted value (e.g. g = 9.81 ms^{-2}) with which we may compare our result. If the accepted value lies within our range of uncertainty then we have performed a good experiment.



1. **Precision**- this is the smallest non-zero reading an instrument can make- e.g. 1mm for a standard ruler. We may know our value for length of a block lies between say 12mm and 13mm, but we cannot say for certain where! We therefore say the precision of the ruler is +/- 1mm
2. **Uncertainty for one measurement-** tells you the region in which the actual result can be expected to lie. If you have only one measurement or reading, this will be determined by the precision of the instrument- so in our ruler example, the uncertainty is +/- 1mm
3. **Uncertainty for more than one measurement-** this is a tiny bit more complicated. If you use your ruler to measure a block more than once and get a value of 12mm and 15mm- the results are actually 3mm apart- so we know our true value could lie anywhere between +/- 1mm of 12mm and +/- 1mm of 15mm! **To calculate the uncertainty here you divide the range by 2**. So (15-12)/2 gives an uncertainty of +/- 1.5mm.
   ***the uncertainty can never be less than the precision of the instrument**
4. **Percentage uncertainty-** here we look at how much the uncertainty 'matters' for the measurement in question. For example- an uncertainty of +/- 1.5mm might not matter very much if you are measuring something very long (like 10m!), but it might matter a lot if measuring something small (10mm). To calculate percentage uncertainty, divide the uncertainty by the measured value and times by 100. Eg for our 10mm length: (1.5/10) x 100 = 15%. **There is a much more detailed explanation and work through from page 39 of the practical handbook (link below).**

Referencing

Students really hate this for some reason! But again- you need to show you can do this. Referencing is used whenever you have done research to support your own reports, to show where you have obtained your information and where you have used it in your report.

Referencing consists of two parts: 1) a pointer in the text, and 2) a list of numbered references **at the end** of your report.

For example:

One way to improve the method would be to complete the practical underwater[(1)]. This is because it will enable us to ensure that no air is escaping, as this would be obvious to see in the form of bubbles. If air was allowed to escape, n, the number of moles, would not be constant and data will therefore not be valid.

(1) Bishop, A.W., Blight, G.E., Geotechnique, 13, 177-197 (1963)

More guidance can be found here: https://www.citethisforme.com/harvard-referencing

Resources to help

AQA materials

- The **specification** – this explains exactly what you need to learn for your exams. https://filestore.aqa.org.uk/resources/physics/specifications/AQA-7407-7408-SP-2015.PDF
- **Practice exam papers** https://www.aqa.org.uk/subjects/science/as-and-a-level/physics-7407-7408/assessment-resources
- The **Practical handbook** explains the practical work you need to know https://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-PHBK.PDF
- **Formula sheet** https://filestore.aqa.org.uk/resources/physics/AQA-7408-SDB.PDF
- Maths skills support. https://www.aqa.org.uk/resources/science/as-and-a-level/teach/maths-skills-briefings

Kerboodle website https://www.kerboodle.com/users/login

Here you will find the online textbooks and other resources. A guide for how to use this is found at the following link:

https://pfoa.sharepoint.com/sites/lsst/science/sitepages/physics.aspx?RootFolder=%2Fsites%2Flsst%2Fscience%2FPhysics%2FA%20level%20from%20September%202015%2FGuidance&FolderCTID=0x012000A3162560092EAF4EAAB58FBCCD0E0403&View=%7BA533A631%2D395A%2D4907%2D86AD%2DB0583E256D44%7D

Isaac physics website https://isaacphysics.org/

Here you will find lots of practice questions. We will also use this for setting study work and homework, so it is important you know how to use this. A guide for how to use this is found at the following link:

https://pfoa.sharepoint.com/sites/lsst/science/sitepages/physics.aspx?RootFolder=%2Fsites%2Flsst%2Fscience%2FPhysics%2FA%20level%20from%20September%202015%2FGuidance&FolderCTID=0x012000A3162560092EAF4EAAB58FBCCD0E0403&View=%7BA533A631%2D395A%2D4907%2D86AD%2DB0583E256D44%7D

YouTube

YouTube has thousands of Physics videos. Just be careful to look at who produced the video and why because some videos distort the facts. Check the author, date and comments – these help indicate whether the clip is reliable. If in doubt, ask your teacher.

Magazines

Focus, New Scientist or Philip Allan updates can help you put the physics you’re learning in context.

Useful reference material

Command words

Analyse- Interpret data to arrive at a conclusion.
Annotate- Add notation or labelling to a graph, diagram or other drawing.
Apply- Use information in a new context.
Calculate- Work out the value of something.

Comment	Make a judgement based on a value.
Compare	Identify similarities and/or differences.
Construct	Assemble a piece of equipment, usually in the context of ISA or EMPA test.
Deduce	Draw conclusions from information provided.
Derive	Obtain a relationship or equation from the manipulation of fundamental relationships and/or data.
Describe	Give an account of
Design	Set out how something will be done.
Determine	Use given data or information to obtain an answer.
Discuss	Present key points about different ideas or strengths and weaknesses of an idea.
Distinguish	List the differences between different items.
Draw	Produce a diagram.
Evaluate	Judge from available evidence.
Explain	Give reasons
Identify	Provide an answer from a number of alternatives.
Outline	Set out main characteristics.
Show	Provide structured evidence to reach a conclusion
Sketch	Draw approximately.
Solve	Arrive at answer using a numerical or algebraic method.
State	Express in clear terms.
Suggest	Present a possible case/solution.

The Greek alphabet

Α	α	alpha	Ν	ν	nu
Β	β	beta	Ξ	ξ	ksi
Γ	γ	gamma	Ο	ο	omicron
Δ	δ	delta	Π	π	pi
Ε	ε	epsilon	Ρ	ρ	rho
Ζ	ζ	zeta	Σ	ς or σ	sigma
Η	η	eta	Τ	τ	tau
Θ	θ	theta	Υ	υ	upsilon
Ι	ι	iota	Φ	ϕ	phi
Κ	κ	kappa	Χ	χ	chi
Λ	λ	lambda	Ψ	ψ	psi
Μ	μ	mu	Ω	ω	omega

Prefixes

Prefix	Symbol	Multiplication factor	
Tera	T	10^{12}	1 000 000 000 000
Giga	G	10^{9}	1 000 000 000
Mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1000
deci	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	µ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001

Practical Terms

Accurate	A measurement that is close to the true value.
Data	Information, in any form, that has been collected.
Precise	Measurements where repeated measurements show very little spread.
Prediction	A statement suggesting what may happen in the future.
Range	The spread of data, showing the maximum and minimum values of the data.
Repeatable	An experiment that gives the same results when the same experimenter uses the same method and equipment.
Reproducible	An experiment that gives the same results when a different person carries it out, or a different set of equipment or technique is used.
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	Physical, chemical or biological quantities or characteristics.
Control variable	A variable that is kept constant during an experiment.
Dependent variable	A variable that is measured as the outcome of an experiment.
Reading	The value found from a single judgement when using a piece of equipment
Measurement	The value taken as the difference between the judgements of two value