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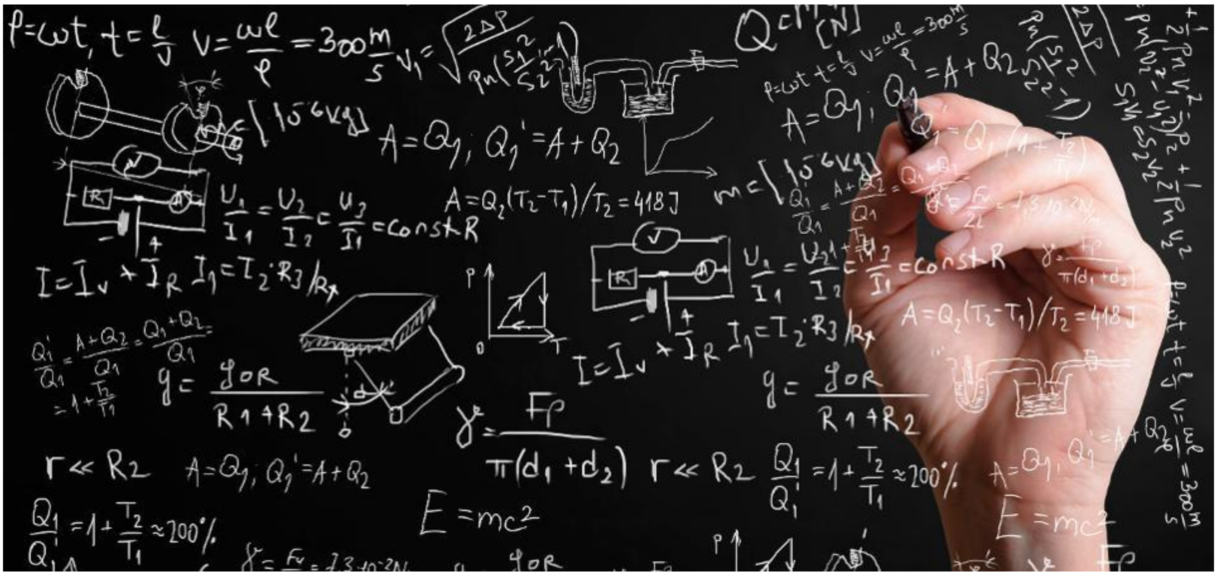

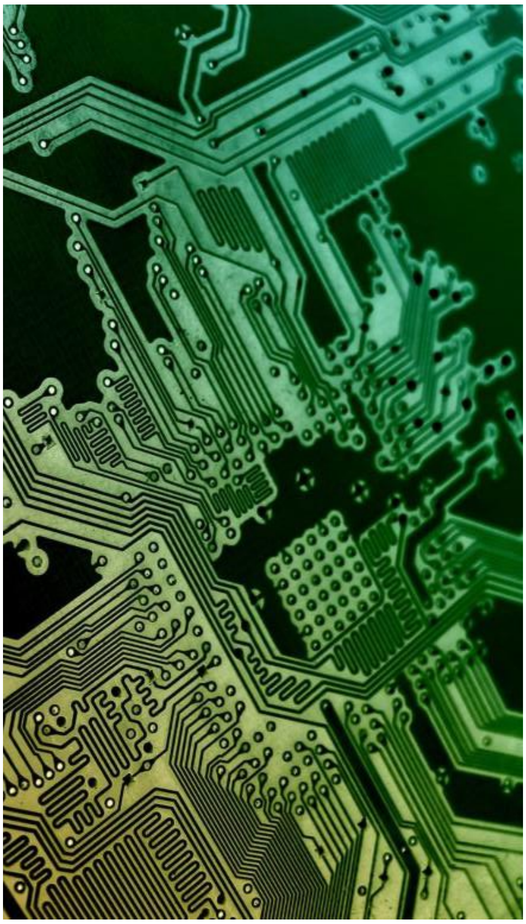

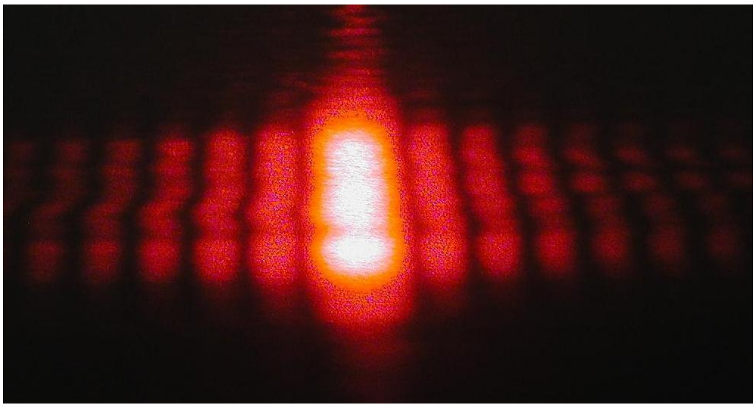

Physics Welcome Pack

You're studying AS or A-level Physics, **congratulations**!

Studying physics after your GCSEs really develops your practical and mathematical skills. If you enjoy experimenting in the lab, you'll love it. At first, you may find the jump in demand from GCSE a little daunting, but if you follow the tips and advice in this guide, you'll soon adapt. I recommend you keep this somewhere safe, as you may like to refer to the information inside throughout your studies.

Studying Physics A-level makes you very lucky… and desirable

As physicists, you will explore the fundamental nature of almost everything we know of. You will study everything from the fundamental particles that build matter, to the galaxies that make up the universe itself. You will be joining a discipline where you will get to enter a world deep beneath the surface of normal human experience. Even if you don't decide to work in physics, studying it still develops useful and transferable skills for other careers. You'll develop research, problem solving and analytical skills, alongside teamwork and communication. Universities and business regard all of these very highly.

Your future begins here, now.

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

- Physics
- Mathematics
- Mechanical Engineering
- Computer Science
- Civil Engineering
- Economics
- Business

Studying Physics at A-level or degree level opens up all sorts of career opportunities, making you one of the most employable group of people in society. Some potential career paths include:

- 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, mechanical or civil engineer
- Electrical engineer
- Product/process development scientist
- Systems developer
- Public relations
- Human resources
- Management

You can also move into engineering, astrophysics, chemical physics, nanotechnology, renewable energy and so many more.

With physics, your opportunities are endless and infinite.

Don't lose sight of your future ambitions during your A-level course. Actively speak to your teachers about your plans for your future. They can support you in many ways by linking your learning directly to your interests and career plans, highlighting higher education and work experience opportunities and assisting you with UCAS applications alongside interview and PAT (Physics Aptitude Test) preparation.

The Basics

Exam board and course information

AQA AS Physics (7407). AQA A-level Physics (7408).

https://filestore.aqa.org.uk/resources/physics/specifications/AQA-7407-7408-SP-2015.PDF

Equipment

Students of Physics are expected to bring the following to every lesson:

- An A4 folder, to be kept well organised by specification heading and inspected every half term
- A4 lined paper to make notes on
- Plastic wallets for handouts
- Plastic wallet/A4 envelope folder for homework assignments
- Pen, pencil, ruler (30 cm is best), protractor, compasses
- Scientific calculator

What you can expect in this course

As physicists, you will explore the fundamental nature of almost everything we know of. You will study everything from the fundamental particles that build matter, to the galaxies that make up the universe itself. You will be joining a discipline where you will get to enter a world deep beneath the surface of normal human experience. Even if you don't decide to work in physics, studying it still develops useful and transferable skills for other careers. You'll develop research, problem solving and analytical skills, alongside teamwork and communication. Universities and business regard all of these very highly. As a physicist studying A Level Physics you will receive:

- A range of resources to help you learn effectively and stay organised
- Lots of opportunity to share your ideas and challenge each other
- Many opportunities to solve complex problems individually and as a group
- Tuition on practical skills
- Opportunity to apply practical skills in a wide variety of physical experimentation situations
- Homework tasks which help you to progress
- Excellent examination preparation

Expectations of all students

- Excellent attendance and punctuality
- A positive attitude and good concentration in lessons
- Turning up fully-equipped to all lessons on time
- Homework completed on time and to the best of your ability; any homework completed on a computer should be printed by you *before* the lesson unless you are given directions to the contrary.
- Taking on board feedback you are given and using it to improve your work
- Constant review and revision throughout the course
- Wider examination practice: you will need to complete many additional practice examination questions outside those directed within the course.
- It is expected that you will spend approximately 4-6 hours per week working on this subject outside lessons, through a mixture of homework, self-directed study and revision. The A-level Physics course is an academically rigorous course and time is at a premium, therefore most revision must be completed by you independently, outside of lessons.

Remember: there is a directly proportional relationship between your effort and your final grade.

In short, we expect 100% commitment. You will be treated like a young adult in lessons and you are expected to behave like one: with maturity, conscientiousness, politeness and common sense.

Subject content

The below units refer directly to the AQA specification, Sections 1 to 5 are designed to be covered in the first year of the A-level and cover AS subject content. Sections 6 to 8 alongside the optional module are designed to be covered in the second year of the A-level.

Alongside learning the subject content, you will build your mathematical skills, practical skills and learn how to deploy new apparatus and techniques.

1: Measurements and their errors

Content in this section is a continuing study for a student of physics. A working knowledge of the specified fundamental (base) units of measurement is vital. Likewise, practical work in the subject needs to be underpinned by an awareness of the nature of measurement errors and of their numerical treatment. The ability to carry through reasonable estimations is a skill that is required throughout the course and beyond.

Use of SI units and their prefixes

- Fundamental (base) units
- Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units
- SI units derived
- Knowledge and use of the SI prefixes, values and standard form
- Prefixes: T, G, M, k, c, m, μ, n, p, f
- Convert between different units of the same quantity, eg J and eV, J and kW h

Limitation of physical measurements

- Random and systematic errors
- Precision, repeatability, reproducibility, resolution and accuracy
- Uncertainty: absolute, fractional and percentage uncertainties represent uncertainty in the final answer for a quantity
- Combination of absolute and percentage uncertainties
- Represent uncertainty in a data point on a graph using error bars
- Determine the uncertainties in the gradient and intercept of a straight-line graph

Estimation of physical quantities

- Orders of magnitude
- Estimation of approximate values of physical quantities

2: Particles and radiation

This section will introduce you both to the fundamental properties of matter, and to electromagnetic radiation and quantum phenomena. This topic provides a new interest and knowledge dimension beyond GCSE. Through a study of these topics, you will become aware of the way ideas develop and evolve in physics. You will appreciate the importance of international collaboration in the development of new experiments and theories in this area of fundamental research.

Particles

- Constituents of the atom
- Stable and unstable nuclei
- Particles, antiparticles and photons
- Particle interactions
- Classification of particles
- Quarks and antiquarks
- Applications of conservation laws

Electromagnetic radiation and quantum phenomena

- The photoelectric effect
- Collisions of electrons with atoms
- Energy levels and photon emission
- Wave-particle duality

3: Waves

GCSE studies of wave phenomena are extended through a development of knowledge of the characteristics, properties, and applications of travelling waves and stationary waves. Topics treated include refraction, diffraction, superposition and interference.

Progressive and stationary waves

- ☐ Progressive waves
- ☐ Longitudinal and transverse waves
- ☐ Principle of superposition of waves and formation of stationary waves

Refraction, diffraction and interference

- ☐ Interference
- ☐ Diffraction
- ☐ Refraction at a plane surface
- ☐ Total internal reflection

4: Mechanics and materials

Vectors and their treatment are introduced followed by development of the student's knowledge and understanding of forces, energy and momentum. The section continues with a study of materials considered in terms of their bulk properties and tensile strength.

Force, energy and momentum

- ☐ Scalars and vectors
- ☐ Moments
- ☐ Motion along a straight line
- ☐ Projectile motion
- ☐ Newton's laws of motion
- ☐ Momentum
- ☐ Work, energy and power
- ☐ Conservation of energy

Materials

- ☐ Bulk properties of solids
- ☐ The Young modulus

5: Electricity

This section builds on and develops earlier study of these phenomena from GCSE. It provides opportunities for the development of practical skills at an early stage in the course and lays the groundwork for later study of the many electrical applications that are important to society.

Current electricity

- ☐ Basics of electricity
- ☐ Current-voltage characteristics
- ☐ Resistivity
- ☐ Circuits
- ☐ Potential divider
- ☐ Electromotive force and internal resistance

6: Further mechanics and thermal physics

The earlier study of mechanics is further advanced through a consideration of circular motion and simple harmonic motion (the harmonic oscillator). A further section allows the thermal properties of materials, the properties and nature of ideal gases, and the molecular kinetic theory to be studied in depth.

Periodic motion

- ☐ Circular motion
- ☐ Simple harmonic motion (SHM)
- ☐ Simple harmonic systems
- ☐ Forces vibrations and resonance

Thermal physics

- ☐ Thermal energy transfer
- ☐ Ideal gases
- ☐ Molecular kinetic theory model

7: Fields and their consequences

The concept of field is one of the great unifying ideas in physics. The ideas of gravitation, electrostatics and magnetic field theory are developed within the topic to emphasise this unification. Many ideas from mechanics and electricity from earlier in the course support this and are further developed. Practical applications considered include: planetary and satellite orbits, capacitance and capacitors, their charge and discharge through resistors, and electromagnetic induction. These topics have considerable impact on modern society.

Gravitational fields

- ☐ Newton's law
- ☐ Gravitational field strength
- ☐ Gravitational potential
- ☐ Orbits of planets and satellites

Electric fields

- ☐ Coulomb's law
- ☐ Electric field strength
- ☐ Electric potential

Capacitance

- ☐ Capacitance
- ☐ Parallel place capacitor
- ☐ Energy stored by a capacitor
- ☐ Capacitor charge and discharge

Magnetic fields

- ☐ Magnetic flux density
- ☐ Moving charges in a magnetic field
- ☐ Magnetic flux and flux linkage
- ☐ Electromagnetic induction
- ☐ Alternating currents
- ☐ The operation of a transformer

8: Nuclear physics

This section builds on the work of Particles and radiation to link the properties of the nucleus to the production of nuclear power through the characteristics of the nucleus, the properties of unstable nuclei, and the link between energy and mass. You will become aware of the physics that underpins nuclear energy production and also of the impact that it can have on society.

Radioactivity

- Rutherford scattering
- α, β and γ radiation
- Radioactive decay
- Nuclear instability
- Nuclear radius
- Mass and energy
- Induced fission
- Safety aspects

9-13: Optional module

Within A-level Physics you will study an optional module. This will allow you to extend your broad knowledge to a specific applied setting, moving into the range covered within undergraduate degree courses. Your teacher will confirm the optional module you will be studying closer to the time of study.

9 Astrophysics

- Fundamental physical principles are applied to the study and interpretation of the Universe. You will gain deeper insight into the behaviour of objects at great distances from Earth and discover the ways in which information from these objects can be gathered. The underlying physical principles of the devices used are covered and some indication is given of the new information gained by the use of radio astronomy. The discovery of exoplanets is an example of the way in which new information is gained by astronomers.

10 Medical physics

- Students with an interest in biological and medical topics are offered the opportunity to study some of the applications of physical principles and techniques in medicine. The physics of the eye and ear as sensory organs is discussed. The important and developing field of medical imaging, with both nonionising and ionising radiations is considered. Further uses of ionising radiation are developed in a section on radiation therapy.

11 Engineering physics

- This option offers opportunities for you to reinforce and extend the work of core units by considering applications in areas of engineering and technology. It extends your understanding in areas of rotational dynamics and thermodynamics. The emphasis in this option is on an understanding of the concepts and the application of physics. Questions can be set in novel or unfamiliar contexts, but in such cases the scene is set and any relevant required information is given.

12 Turning points in physics

- This option is intended to enable key concepts and developments in physics to be studied in greater depth than in the core content. Students will be able to appreciate, from historical and conceptual viewpoints, the significance of major paradigm shifts for the subject in the perspectives of experimentation and understanding. Many present-day technological industries are the consequence of these key developments and the topics in the option illustrate how unforeseen technologies can develop from new discoveries.

13 Electronics

- This option is designed for those who wish to learn more about modern electronic technologies as a development of their core work in electricity. A variety of discrete devices is introduced followed by discussions of both analogue and digital techniques ranging from the operational amplifier to digital signal processing. The option ends with a look at the issues surrounding data communication.

Study Skills

You can also find detail about study skills in your study skills booklet.

You can also find detail about practical skills in your Physics practical handbook. **You must review this carefully.**

Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures

Learning and recalling knowledge is very important in Physics and is assessed in you're a-level course. Throughout the course you will need to recall prior knowledge from GCSE study and from earlier in the course.

- **State** This is directly testing your subject knowledge.
- **Describe** This links subject knowledge from different parts of the course.

Study tip*: Try going through your notes in intervals. Returning to previous knowledge and linking ideas as you progress through the course is essential for success.*

Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: in a theoretical context; in a practical context; when handling qualitative data; when handling quantitative data

Simply recalling and stating facts is not sufficient at A-level. You will need to use your knowledge to explain a variety of situations including those that are theoretical, experimental and include data. This skill will be most heavily assessed during the course.

- **Explain** This is where you will link your understanding and knowledge to unfamiliar situations.
- **Calculate/show that** This is where you will have to apply theoretical or experimental quantitative data to calculate values of interest.

Study tip*: Practice as many examination questions as possible to familiarise yourself with as wide a variety of physical situations as possible. Practice, practice and more practice is crucial for success in Physics.*

Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: make judgements and reach conclusions; develop and refine practical design and procedures.

You will need to review information presented to you in order to make a judgement, reach a conclusion or adapt practical experimental designs. Drawing judgements from processed data is a vital skill in Physics.

- **Analyse** This is where you will consider data, process it and then draw a reasoned conclusion.
- **Comment/suggest** This is where you will have to make an adjustment to a practical design based upon analysis of evidence and data provided.

Study tip*: Continue linking your practical skills to your theoretical knowledge as you progress through the course.*

Mathematics

Mathematics is central to the study of Physics. Overall, at least 40% of the marks in assessments for physics will require the use of mathematical skills. It is strongly recommended that those studying A-level Physics also study A-level Mathematics and as such the two courses have been designed parallel to each other to support and reinforce shared teaching. If you do not study A-level Mathematics, your teacher will advise on additional opportunities for you to improve your mathematical skills and details for how you can join essential A-level Mathematics mechanics classes.

How should I revise for Physics?

Examination Question Practice

Practice, practice, practice! You can never do too many past examination questions in Physics. These will help you to apply your knowledge in a variety of ways and become familiar with the expected responses to Physics terminology.

Practical work

Continually review your practical notes and lab book. This will help you develop your analytical skills alongside your ability to apply experimental data in familiar and unfamiliar contexts.

Retrieval Practice

This is a learning strategy that aims to pull information from your memory. This usually involves recalling information you have previously studied.

- *Try creating flash cards from your notes*
- *Try regularly quizzing yourself to check your knowledge of a previous topic from a while ago*

Revision Guides

Your revision guide contains the *basic information* you need to know to pass your exams. You should learn the knowledge content in your revision guide.

- *Try creating your own version of the revision guide as a revision task. This could incorporate dual coding*
- *Quiz yourself on key pieces of knowledge (look, say, cover, write, check)*

Dual Coding

Turning text into images, symbols or diagrams. These are mental aids to help your learning as you have verbal and visual information at the same time.

- *Try summarising your Physics notes into images and key words to help you remember the content*

Self-Quizzing

Self-quizzing means testing yourself on your subject knowledge.

- *Try writing your own quizzes using your revision guide or based on your class notes*
- *You could swap quizzes with your classmates*

Videos and Podcasts

Visual aids can be really helpful for revision. Search YouTube, BBC iPlayer and Netflix for some helpful revision videos, documentaries and video lectures. Podcasts are easy to listen to whilst doing something you enjoy such as sport or drawing. *See the 'useful resources and taking your work further' section for some recommendations.*

Scheme of Work

This is an approximate outline only.

	Specification reference	Practical	Mathematics (focused)
Year 12 Autumn Term	1 Measurements and their errors. 2 Particles and radiation 3 Waves	Introduction to measurement. Required practical 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. Required practical 2: Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.	Arithmetic and numerical computation Handling data Graphs
Year 12 Spring Term	4 Mechanics and materials 5 Electricity	Required practical 3: Determination of g by a free-fall method. Required practical 4: Determination of the Young modulus by a simple method. Required practical 5: Determination of resistivity of a wire using a micrometer, ammeter and voltmeter. Required practical 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.	Algebra Geometry and trigonometry
Year 12 Summer Term	Revision, consolidation, AS Physics examination. 6.1 Further mechanics and thermal physics (periodic motion)	Required practical 7: Investigation into simple harmonic motion using a mass-spring system and a simple pendulum	Exponential and logarithmic functions
Year 13 Autumn Term	6.2 Further mechanics and thermal physics (thermal physics) 7 Fields and their consequences	Required practical 8: Investigation of Boyle's (constant temperature) law and Charles's (constant pressure) law for a gas. Required practical 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. Required practical 10: Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance. Required practical 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.	Use logarithmic plots to test exponential and power law variations Sketch relationships which are modelled by $y = e^{\pm x}$, and $y = \sin^2 x$, $y = \cos^2 x$ as applied to physical relationships.
Year 13 Spring Term	8 Nuclear physics 9-13 Optional module: astrophysics; medical physics; engineering physics; turning points in physics; electronics.	Required practical 12: Investigation of the inverse-square law for gamma radiation	Use logarithms in relation to quantities that range over several orders of magnitude
Year 13 Summer Term		Revision, consolidation and examination preparation.	

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Assessment

AS

Your AS grade in this subject will come from two examinations taken at the end of year 12. You may or may not be entered for AS certification. Discuss this further with your teacher.

Assessments

Paper 1	+	Paper 2
What's assessed Sections 1–5		**What's assessed** Sections 1–5
Assessed • written exam: 1 hour 30 minutes • 70 marks • 50% of AS		**Assessed** • written exam: 1 hour 30 minutes • 70 marks • 50% of AS
Questions 70 marks of short and long answer questions split by topic.		**Questions** Section A: 20 marks of short and long answer questions on practical skills and data analysis Section B: 20 marks of short and long answer questions from across all areas of AS content Section C: 30 multiple choice questions

A-level

Your final A-level grade in this subject will come from three examinations taken at the end of Year 13.

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
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.

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Assessment objectives

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.	*AO1 is assessed in all exams*
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data.	*AO2 is assessed in all exams*
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: • make judgements and reach conclusions • develop and refine practical design and procedures.	*AO3 is assessed in all exams*

Weighting of assessment objectives for A-level Physics

Assessment objectives (AOs)	Component weightings (approx %)			Overall weighting (approx %)
	Paper 1	Paper 2	Paper 3	
AO1	34	32	31	33
AO2	38	53	35	42
AO3	28	15	32	25
Overall weighting of components	34	34	32	100

40% of the overall assessment of A-level Physics will contain mathematical skills equivalent to Level 2 or above.

At least 15% of the overall assessment of A-level Physics will assess knowledge, skills and understanding in relation to practical work.

Assessment during course

Throughout the course, you will be assessed in the following ways:

- Weekly examined questions
- Knowledge quizzes
- Online learning assignments
- Ongoing assessment in class, including in discussions and group calculations
- During practical work via the Common Practical Assessment Criteria (CPAC) – see Physics practical handbook for further information
- End of unit assessments, which will be a combination of all type of examination question

Tracking your progress

Note on target grades: these are generated automatically by an organisation called LPUK, based on national averages about what people with similar GCSE grades to you go on to achieve in sixth form ***if they push themselves****. They are* ***not what you will automatically get****, they are* ***not necessarily what you will be predicted on your UCAS or any other applications*** *and they are absolutely* ***not the maximum you can achieve****. What you achieve in sixth form will depend on* ***how much work you put in****. Your target grade is intended to be something for you to work towards: for you to try to do as good as or better than.*

Your LPUK target grade:

Major assessments will be tracked here

Date	Assessment title	Mark/grade	Focus for improvement
Y12 Term 1	1 Measurements and their errors.		
Y12 Term 1	2 Particles and radiation		
Y12 Term 1	3 Waves		
Y12 Term 2	4 Mechanics and materials		
Y12 Term 2	5 Electricity		
End of Y12	AS Physics Examination		
Y12 Term 3	6.1 Periodic motion		
Y13 Term 1	6.2 Thermal physics		
Y13 Term 1	7 Fields and their consequences		
Y13 Term 2	8 Nuclear physics		
Y13 Term 2	9-13 Optional module		
	A-level mock examination		
	A-level mock examination		
	A-level mock examination		

Useful resources and taking your work further

With Sixth Form studies, there is no such thing as "finished all your work". See Mr Squires' (less) important course information pack to find a variety of things to read, watch, do and listen to.

Below details resources which may be useful to you during your studies:

AQA Website

The AQA website is a great place to start. The Physics webpages are aimed at teachers, but you may find them useful too (https://www.aqa.org.uk/subjects/science/as-and-a-level/physics-7407-7408). Information includes:

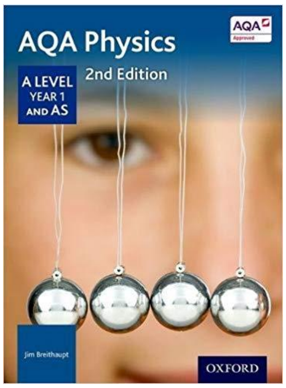
- The specification – this explains exactly what you need to learn for your exams (https://filestore.aqa.org.uk/resources/physics/specifications/AQA-7407-7408-SP-2015.PDF).
- Practice exam papers (https://www.aqa.org.uk/subjects/science/as-and-a-level/physics-7407-7408/assessment-resources)
- Lists of command words and subject specific vocabulary – so you understand the words to use in exams (https://www.aqa.org.uk/resources/science/as-and-a-level/physics-7407-7408/teach/command-words)
- Practical handbooks explain the practical work you need to know (https://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-PHBK.PDF)
- Past papers from the old specification. Some questions won't be relevant to the new AS and A-level, so please check with your teacher.
- Maths skills support.

Institute of Physics (IOP)

The IOP do everything from research like that taking place at CERN to lobbying MPs. You'll find lots of handy resources on their website at http://www.iop.org/tailored/students/

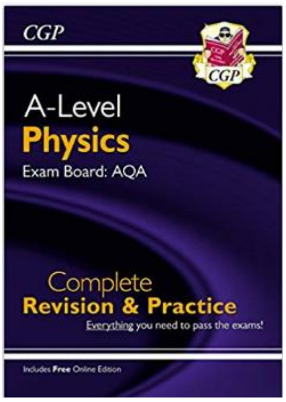
Textbooks & workbooks

AQA approved textbooks are published by Collins, Hodder and Oxford University Press. I recommend the following textbook for AS and year 1 of A-level:



AQA Physics A Level Year 1 Student Book by Jim Breithaupt.

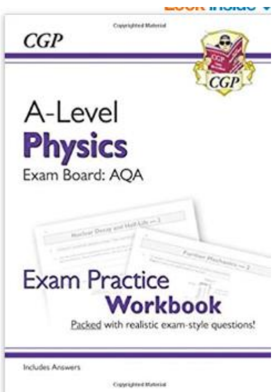
Is available **for free electronically** via Kerboodle.



A-Level Physics Complete Revision & Practice by CGP

Amazon price: £19.99

School price £10.00



A-Level Physics Exam Practice Workbook by CGP

Amazon price: £10.99

School price: £6.00

Revision guides

These are great if you want a quick overview of the course when you're revising for your exams. Remember to use other tools as well, as these aren't detailed enough on their own.

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 me.

Magazines

Physics World (available from my library), Focus, New Scientist or Philip Allan updates can help you put the physics you're learning in context.

The Student Room

Join the A-level Physics forums and share thoughts and ideas with other students if you're stuck with your homework. **Just be very careful not to share any details about your assessments, there are very serious consequences if you're caught cheating.** Visit https://www.thestudentroom.co.uk/

Equation sheet

You will need to learn to love your equation sheet – every physicist's best friend.

Equations… learn, love and live them.

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	m s^{-1}
permeability of free space	μ_0	$4\pi \times 10^{-7}$	H m^{-1}
permittivity of free space	ε_0	8.85×10^{-12}	F m^{-1}
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	N m^{2} kg^{-2}
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
electron rest mass	m_e	9.11×10^{-31}	kg
proton rest mass	m_p	$1.67(3) \times 10^{-27}$	kg
neutron rest mass	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	N kg^{-1}
acceleration due to gravity	g	9.81	m s^{-2}
atomic mass unit	u	1.661×10^{-27}	kg
mass of the Sun		1.99×10^{30}	kg
mean radius of the Sun		6.96×10^{8}	m
mass of the Earth		5.98×10^{24}	kg
mean radius of the Earth		6.37×10^{6}	m

Particle Physics

Class	Name	Symbol	Rest energy/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^{\pm}$	0.510999
	muon	$\mu^{\pm}$	105.659
mesons	π meson	$\pi^{\pm}$	139.576
		π^0	134.972
	K meson	$K^{\pm}$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

		Lepton number
Particles:	$e^-, \nu_e; \mu^-, \nu_\mu$	$+1$
Antiparticles:	$e^+, \overline{\nu_e}, \mu^+, \overline{\nu_\mu}$	-1

Photons and energy levels

photon energy $E = hf = \frac{hc}{\lambda}$

photoelectricity $hf = \phi + E_{k\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$

first harmonic $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 and n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

force $F = \frac{\Delta(mv)}{\Delta t}$

impulse $F\,\Delta t = \Delta(mv)$

work, energy and power $W = F s \cos\theta$

$E_k = \frac{1}{2} m v^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}, P = Fv$

$efficiency = \frac{useful\ output\ power}{input\ power}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k\,\Delta L$

Young modulus $= \frac{tensile\ stress}{tensile\ strain}$ *tensile stress* $= \frac{F}{A}$ *tensile strain* $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

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Electricity

current and pd	$I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$
resistivity	$\rho = \frac{RA}{L}$
resistors in series	$R_T = R_1 + R_2 + R_3 + ...$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$
power	$P = VI = I^2R = \frac{V^2}{R}$
emf	$\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

Circular motion

magnitude of angular speed	$\omega = \frac{v}{r}$
	$\omega = 2\pi f$
centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
centripetal force	$F = \frac{mv^2}{r} = m\omega^2 r$

Simple harmonic motion

acceleration	$a = -\omega^2 x$
displacement	$x = A\cos(\omega t)$
speed	$v = \pm\omega\sqrt{(A^2 - x^2)}$
maximum speed	$v_{max} = \omega A$
maximum acceleration	$a_{max} = \omega^2 A$
for a mass-spring system	$T = 2\pi\sqrt{\frac{m}{k}}$
for a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$

Thermal physics

energy to change temperature	$Q = mc\Delta\theta$
energy to change state	$Q = ml$
gas law	$pV = nRT$ $pV = NkT$
kinetic theory model	$pV = \frac{1}{3}Nm(c_{rms})^2$
kinetic energy of gas molecule	$\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

Gravitational fields

force between two masses	$F = \frac{Gm_1m_2}{r^2}$
gravitational field strength	$g = \frac{F}{m}$
magnitude of gravitational field strength in a radial field	$g = \frac{GM}{r^2}$
work done	$\Delta W = m\Delta V$
gravitational potential	$V = -\frac{GM}{r}$
	$g = -\frac{\Delta V}{\Delta r}$

Electric fields and capacitors

force between two point charges	$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$
force on a charge	$F = EQ$
field strength for a uniform field	$E = \frac{V}{d}$
work done	$\Delta W = Q\Delta V$
field strength for a radial field	$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$
electric potential	$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
field strength	$E = \frac{\Delta V}{\Delta r}$
capacitance	$C = \frac{Q}{V}$
	$C = \frac{A\varepsilon_0\varepsilon_r}{d}$
capacitor energy stored	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
capacitor charging	$Q = Q_0(1 - e^{-\frac{t}{RC}})$
decay of charge	$Q = Q_0 e^{-\frac{t}{RC}}$
time constant	RC

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Magnetic fields

force on a current	$F = BIl$
force on a moving charge	$F = BQv$
magnetic flux	$\Phi = BA$
magnetic flux linkage	$N\Phi = BAN\cos\theta$
magnitude of induced emf	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$
	$N\Phi = BAN\cos\theta$
emf induced in a rotating coil	$\varepsilon = BAN\omega\sin\omega t$
alternating current	$I_{rms} = \dfrac{I_0}{\sqrt{2}}$ $\quad V_{rms} = \dfrac{V_0}{\sqrt{2}}$
transformer equations	$\dfrac{N_s}{N_p} = \dfrac{V_s}{V_p}$
	efficiency $= \dfrac{I_s V_s}{I_p V_p}$

Nuclear physics

inverse square law for γ radiation	$I = \dfrac{k}{x^2}$
radioactive decay	$\dfrac{\Delta N}{\Delta t} = -\lambda N$, $N = N_0 e^{-\lambda t}$
activity	$A = \lambda N$
half-life	$T_{½} = \dfrac{\ln 2}{\lambda}$
nuclear radius	$R = R_0 A^{1/3}$
energy-mass equation	$E = mc^2$