PHYSICS HANDBOOK

for

AS/A2 LEVEL

North Chadderton School

Interactive versions of this Handbook are online

at www.e-teach.org/physics www.webucate.org

www.webucation.org www.goscience.org

Contents

1. **Welcome to AS Physics**

We are delighted you have chosen to study physics at AS level.
We hope that you will benefit from this course and gain a greater understanding of why and how Physics is so important in the modern world.

(a) What is Physics?

Physics is the study of matter and energy and how they interact with each other. Physics goes from a grand scale, *aka* the Universe, to the very smallest parts of the building blocks of everything: atoms, and then even smaller than that….to look at the particles that build up the nucleus.

(b) Why study Physics?

Physics is interwoven into virtually every aspect of our lives. Every electrical device you use, including mobile phones, depends upon basic physics concepts and principles. Every mechanical device, including cars, also relies on applications of physics. Your body has also developed sense organs that take into account and adapt to the behaviour of sound, light, heat, electrical and mechanical systems. You are a biological *machine* adapted to be successful in a world where physical principles permeate everywhere.

Physics can give you a greater understanding of strange behaviours! These happen both on a very small scale and also on very large scales: particles that sometimes behave as if they were waves, particles that seem to tunnel through matter, some that cannot be seen, black holes, wormholes, quarks and strangeness numbers!

At the other extreme, you will look at the largest possible scale: the Universe, and find out there are some very strange behaviour indeed, which cannot be explained by laws that our famous Physicist Isaac Newton discovered. Yet, these laws were good enough to be used in sending the first men to the Moon!

Physics is not set in stone…fixed and for all time. It, like other science, is constantly evolving and new theories, discoveries, and ways of thinking gradually take the place of previous knowledge and understanding.

You can be part of this new age of discovery.

Isaac Newton was able to encapsulate the fun and excitement of studying Physics, and the excitement of new discoveries…

"I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me"

You will discover things that you never knew before, and learn about relatively new discoveries that have changed our ways of thinking.

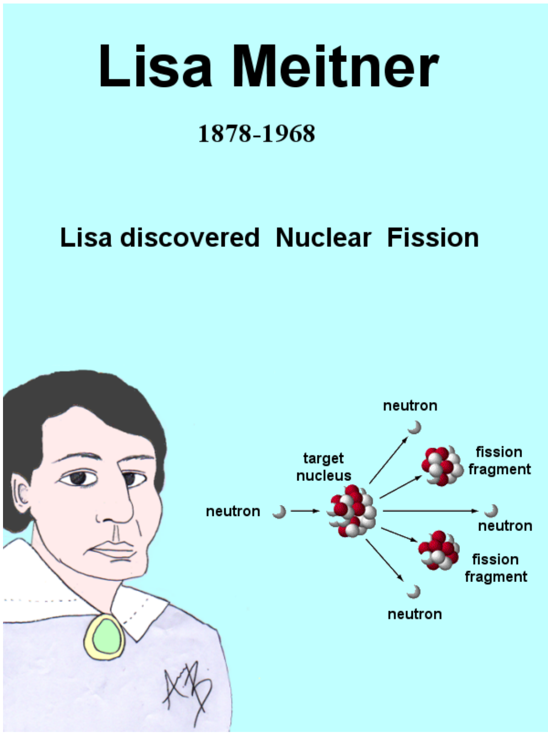
(c) Physics and the 21st Century?

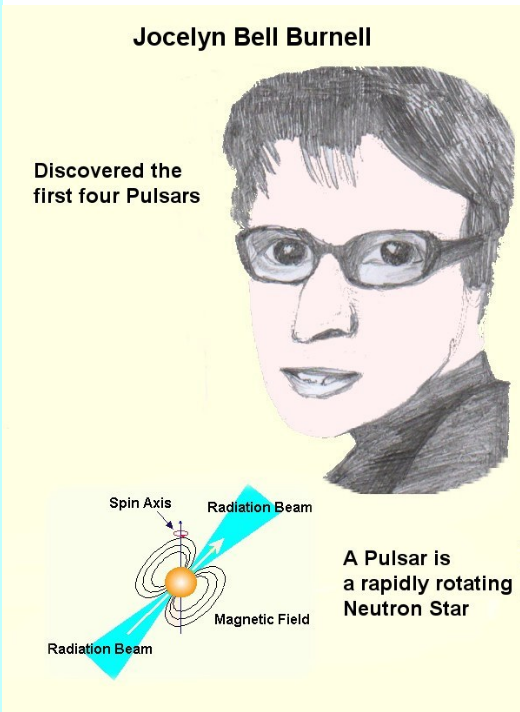
Underpinning your studies in physics is a set of concepts known as *"How Science Works"* . The more you study physics, the greater understanding and appreciation of how science is interwoven into virtually every aspect of our lives, at a local, national , and international level.

Everything using energy is based on knowledge, understanding and application of physics. Science, technology and society are all linked, and our use of science depends on decisions. For example, we often need to make decisions about the benefits of a certain technology against the risks. Some solutions to problems depend on a range of factors. Choices have to be made by comparing the advantages and disadvantages of different ways of generating electricity. A solution on generating electricity on a remote island in Scotland might be quite different than generation electricity on an island in Greece. Local resources need to be taken into account, to provide the best solution, together with cultural, economic and social issues.

Another example is the use of mobile phones and whether they provide a health issue to users. Some studies have shown there is a danger, and other evidence suggests that there is no causal link between their use and brain tumours. Many devices used today carry a degree of risk associated with them. The ALARA (as low as risk as reasonably achievable) is often applied when using devices such as mobile phones.

More details of "How Science Works" is given in *Appendix1*





2. **Studying A-level Physics at North Chadderton School**

(a) Aim of the Course

You might think that the aim of the course is to learn about physics.
To a large extent this is true. However, the course provides you with opportunities to develop skills that will enable you to succeed in *any* future studies, in careers, and being part of a global community:

1. Understanding the nature and limitations of scientific knowledge

This will include hypothesis and prediction, links between data and explanation, modelling, and the role of the scientific community in validating new knowledge;

2. Developing scientific enquiry skills

Experimental skills, data handling and assessing the quality of data;

3. Developing Skills in Communication

This involved the use of scientific language, mathematical skills and presentation of data

4. Applications and implications of science.

You will consider technological decision making in the context of benefit versus risk and ethics.

These areas are commonly referred to as *How Science Works (Appendix 1)* . However, many of the skills are not just relevant to science, they can be applied to other subjects, and to most aspects of your life. Above all, want you to enjoy studying physics, and gain success to enable you to succeed in any further studies or career path you might choose.

(b) Course Entry Requirements

- Grade A* - C at GCSE science (core and additional)
- Grade C GCSE mathematics

Exceptions to these requirements may be only be considered in extenuating circumstances at the discretion of the department.

(c) Companion Subjects

There are no fixed requirements for studying other subjects alongside Physics. Maths AS would be useful, but not essential. Most students study at least another science, if they are intending to pursue a career or further educational course at University or College. Other students who are thinking of becoming an engineer or architect have combined physics with design technology and/or art.

However, if you are i*nterested* in Physics and *enjoy* studying science, then welcome aboard!

(d) Careers/Higher Educational Opportunities

Studying physics open up a range of opportunities in further education and in career paths. It is regarded as a stepping stone to further educational courses in science and engineering. Its mathematical content usually make it highly regarded by most university admissions officers. The range of opportunities is not limited to science. Many business and law courses, for example, will accept physics and an entry qualification.

Apart from careers in pure and applied science, including engineering, there are other interesting careers on offer in the modern world that you might not have even considered! Here are some listed at www.physics.org

Mechanical engineer	Ice Scientist	Laser Fusion Scientist	Solicitor	Science Communicator
Astrophysicist	TV Producer	Sound Engineer	Renewable Energy Manager	

For Career Paths you can peruse the many opportunities in the following fields at http://brightrecruits.com/ :

Astronomy and Space
Electronics and Semiconductors
Energy and Renewables
Computer Modelling
Defence and Aerospace
Environmental and Earth science
Manufacturing and industry
Nanotechnology
Nuclear and Fusion Technology
Optics and Photonics
Software Development

(e) Expectations and Challenges

Priorities for Action…and Success

Studying at A-level requires both commitment and time. You will have 5 hours of Physics per week and will be expected to put in *at least* as much time again outside lessons.

Your priorities will be :

1. Completing assignments 2. Meeting deadlines 3. Reviewing your work/notes

You will be expected to meet deadlines for all homework assignments. If you experience any difficulties in completion of your work. It is essential that you contact the teacher before the deadline.

From the very first day, in the first lesson, you will need to make sure you understand the work your have done. If you have any questions, then annotate your notes, and make sure you ask your teacher for assistance and further guidance.

Passive reading though notes is not a constructive way of revising and consolidating knowledge and understanding.

Highlight the main key points

These were given in the learning objectives for the lesson.

Practice calculations!

Remember, physics A-level requires you to be highly proficient at applying Maths to problem solving. Your teacher will provide you with homework and ample opportunities to develop your mathematical skills. You will need a scientific calculator for your work.

Ask for assistance

Your teacher will be able to assist you with any areas of work that you need assistance with, including maths.

When you have completed your work for the lesson it is essential that you go over this work on the same day to consolidate your knowledge and understanding , and to expand certain points if necessary. Contact your teacher(s) if you need any further help and guidance. Whatever strategies, don’t ever leave questions until the week before the exam!

Keeping Records of your Work

We ask you to be organised, and keep everything in a place where you can easily find your work and notes easily. Since we live in the 21st century, not everything is now done on paper. There will be times when you are required to do work on paper (still very common!), and times when an electronic activity is the only option/requirement.

So, in most cases, you will need a hybrid system of organising your work……..

(a) Paper-based storage system

This is a traditional way of storing notes/information. Very heavily dependent on your organisational skills, and still required in many aspects of your studies at A-level, such as practical work, and individual note-taking

Have two files for the subject :

You should have a ring binder to store all your current notes. This is convenient since the specification breaks down into well-defined sections. After the completion of each section, transfer the notes into the second ring binder. Label the dividers with the different sections of the physics specification.

(b) ***Electronic Storage system(s)***

You can use a laptop/desktop to store the notes/work you produce in class

1. Make a folder such as *Physics AS*,
2. Make subfolders for each Unit you study (*Unit 1, Unit2, etc.*)
3. Make any further subfolders in the Unit folder for different sections (*Particle, Quantum Physics, etc..)*

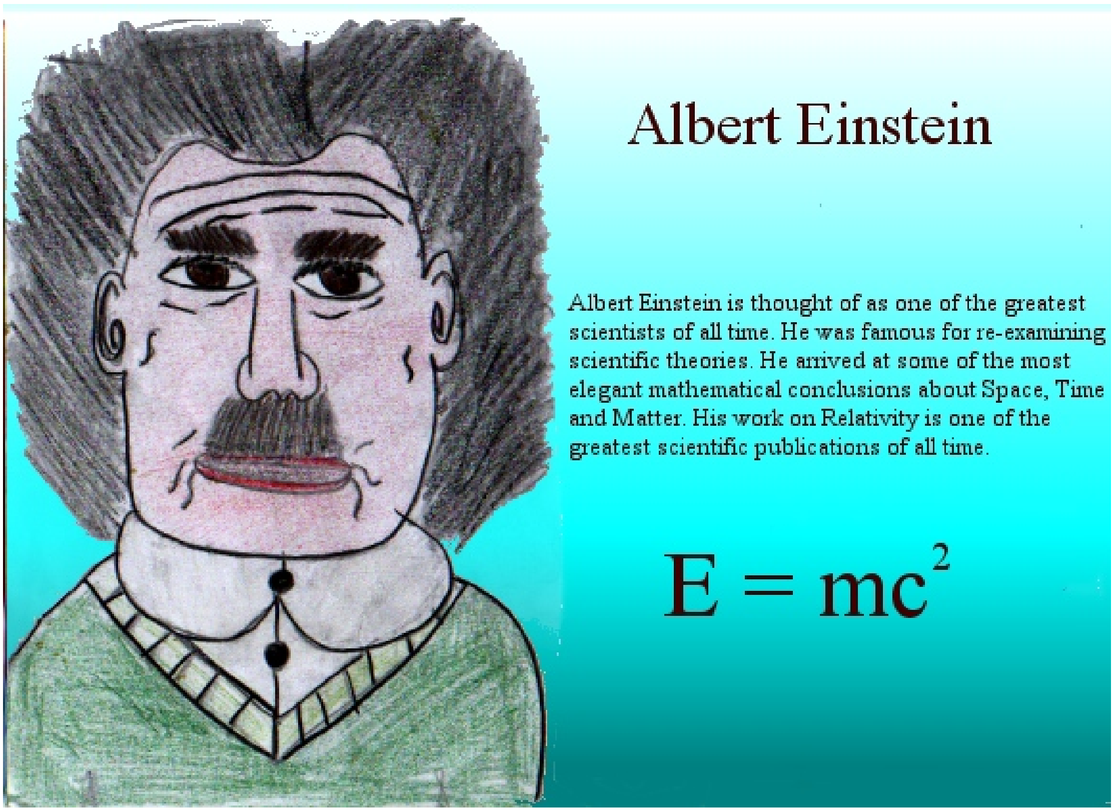
Using this method you do not have to do any transfer any notes, since they will be automatically in the right folder.

Essential: Backup your work on a weekly basis. This can be done by using a USB stick, or external hard drive. You will also be provided with a storage area online where you can upload your notes/work. In this way, you will always have a backup set of notes if your laptop develops a problem, or goes missing.

E-Learning: If you complete activities online on Moodle or Kerboodle, you work will be stored automatically. You also have the option to print out your work. In some activities you are required to download the assignment, complete it, and then upload it for marking. Feedback/marking on assignments will provided online

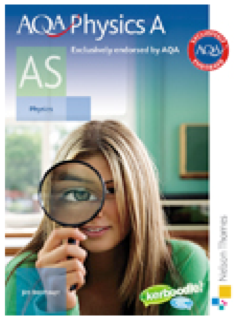
You will also be provided with the opportunity to upload your personal notes onto your own e-learning area on Moodle. This provides an additional means of storing your work.

You can download any aspect of your work on a 24/7 basis.



3. Resources for Learning

(a) AQA Physics Textbook



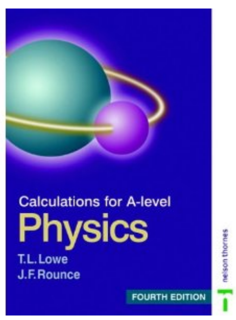
Author(s): J Breithaupt

Published by **Nelson Thornes** ISBN **978-0-7487-8282-6**

Key features:

- How Science Works; with links from the textbooks to make difficult concepts easier to understand.
- Practical experiments; to develop the investigatory skills needed for ISA exams
- Maths Skills; with worked examples written by examiners clearly demonstrating how to do the calculations.
- Clearly stated Learning Objectives to let you know exactly what they'll need to learn and understand in that topic.
- Essential examiner advice highlighting common errors as well as top tips on exam preparation help you to understand the examiner's expectations.

(b) Calculations for A-level Physics



You absolutely have to get to grips with Maths in this course! This book will help you to reach the highest grades. We provide you with this support book, which we will use to ensure that you have plenty of practice at developing and applying mathematical skills to solving problems in physics.

Appendix 5 gives the the mathematical requirements for this course.

(c) Support Materials/Revision Guides

You will be provided with a range of support materials for your course, and revision materials to help you to be fully prepared for the examinations.
Many of these resources will be available for downloading from our website at www.e-teach.org/physics and some will be provided on our own DVD/CDs

(d) E-learning Support/Activities

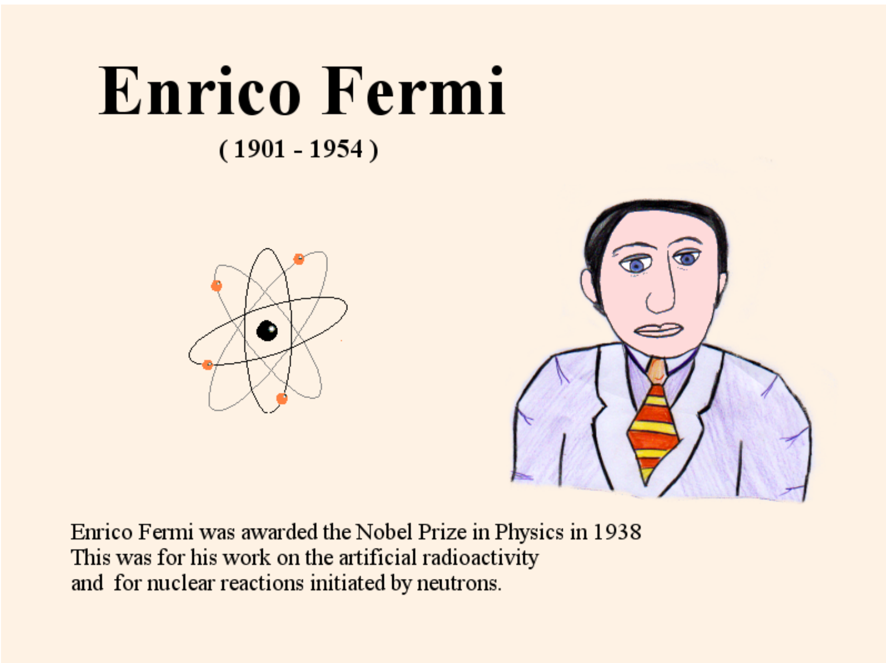
E-learning is not intended to replace teaching! It is designed to complement, enrich and enhance your learning.

You will need to have access to the internet. We will be using two Virtual Learning Environments (VLE's) during the course. Some of your activities will be done using online activities and assignments.

Some assignments will be done in lessons, using laptops, and other requires you to complete work outside of scheduled lessons. Some homework assignments will be set using the VLE's.

VLE's offer superb opportunities to develop your knowledge and understanding of the subject. Here are some of the features of Virtual Learning Environments:

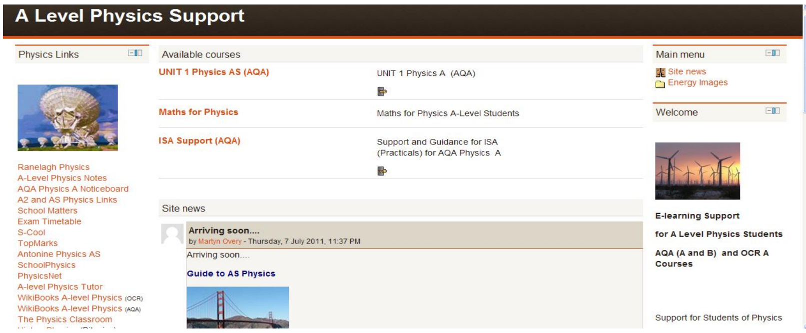
Animations	**Simulations**	**Exam Practice**
Web Quests	**Case Studies**	**Presentations**
Analysis Tools	**Teacher Notes**	**Interactive Learning**
Videos	**Revision Guides**	**Discussion Tools**



We offer two e-learning environments…………

(i) **Moodle** : **http://www.e-teach.org/physics**

Moodle is an Open Source Course Management System which is now used by over 60,000 educational establishments, around the world, from Universities to Primary Schools. North Chadderton School was one of the first schools to download and use Moodle for A-level Students.



This is designed specifically for your course at North Chadderton School.
You will have your own login and password, and your own online area, where you can download resources and assignments, watch presentations, complete revision/tests, and upload your work. Lesson notes and revision materials, exam papers will be available.

You can find more about Moodle at **http://moodle.org/about/**

and a demonstration website is at **http://demo.moodle.net/**

(ii) Kerboodle

This is an online learning facility provided by Nelson Thornes, to assist teachers in teaching and students in learning. You will be provided with a username and password to enter Kerboodle.

You can find out more about Kerboodle at

http://support.kerboodle.com/

(e) Enhancing your learning and understanding

Once upon a time, students were told to '*read around the subject'* by teachers.
This was not a very helpful term, and rather vague to say the least.. Yet, you really do need to keep track of developments in physics, and how physics appears in the modern world. Principal Examiners often set questions related to events in the news, and this can be related to local, national or international issues. So don't expect to find everything in an exam paper from the content in standard textbooks!

A list of very useful resources for keeping up to date with the latest developments is given in **Appendix 3**

4. What will I be doing in Year 12?

The AS specification has 3 Units of Study:

Unit 1: Particles, Quantum Physics and Electricity

This unit involves two contrasting topics in physics: particle physics and electricity. Through the study of these topics, you should gain awareness the on-going development of new ideas in physics and of the application of in-depth knowledge of well-established topics as electricity.

Particle physics

You will study the fundamental properties and nature of matter, radiation and quantum phenomena.

Electricity

In this module we will build on and develops previous work at GCSE studies.
It provides opportunities for practical work and looks into important applications of electricity in the modern world

Unit 1 – PHYA1 Particles, quantum phenomena and electricity
Written Examination – (70 marks/120 UMS), Time : 1¼ hours
Consisting of 6 or 7 structured questions
This will be worth 40% of the total AS marks and 20% of the total A Level marks
The assessment will normally be in JANUARY

Unit 2: Mechanics, Materials and Waves

This AS module is about the principles and applications of mechanics, materials and waves.

Mechanics

In this section you will be introduced to vectors and then develop your knowledge and understanding of forces and energy from GCSE Additional Science.

Materials

In this section you will study the properties and applications of materials in terms of their bulk properties and tensile strength.

Waves

This section extends GCSE studies on waves by developing your in-depth knowledge of the characteristics, properties and applications of waves, including refraction

Assessment :

Unit 2 – PHYA2 Mechanics, materials and waves

Written Examination – (70 marks/120 UMS),

Consisting of 6 or 7 structured questions

This will be worth 40% of the total AS marks, and 20% of the total A Level marks

The assessment will normally be in JUNE

Unit 3: Investigative and Practical Skills

Throughout the course you will carry out experimental and investigative activities in order to develop your practical skills. The experimental and investigative activities will be set in contest with the Units of Study.

You will be assessed on your practical skills using two methods:

- **Practical Skills Assessment (PSA)**
- **Investigative Skills Assignment (ISA).**

The PSA will be based around a school assessment throughout the AS course on your ability to follow and undertake certain standard practical activities.

The ISA will require you to undertake practical work, collect and process data and use it to answer questions in a written test (ISA test).

During the course you will gain experience in the use and application the following equipment:

Electric meters (analogue or digital), metre rule, set squares, protractors, vernier callipers, micrometer screw gauge (zero errors), an electronic balance, stopclock or stopwatch, thermometer (digital or liquid-in-glass), Newton meters.

Throughout AS Physics you will be given opportunities to:

• demonstrate and describe ethical, safe and skilful practical techniques
• process and select appropriate qualitative and quantitative methods
• make, record and communicate reliable and valid observations
• make measurements with appropriate precision and accuracy
• analyse, interpret, explain and evaluate the methodology, results and impact of your own and others experimental and investigative activities in a variety of ways

5. What will I be doing in Year 13 ?

The A2 specification has 3 units

Unit 4: Fields and Further Mechanics

This follows on from the work studied in AS Physics. The first section advances the study of momentum and introduces circular and oscillatory motion and covers gravitation. Electric and magnetic fields are then covered, together with basic electromagnetic induction. Electric fields lead into capacitors and how quickly they charge and discharge through a resistor.

This exam will be taken in the JANUARY of Year 13

Unit 5: Nuclear Physics, Thermal Physics + Optional Topic

This unit consists of two sections

Section A : Nuclear and Thermal Physics

This looks at the characteristics of the nucleus, the properties of unstable nuclei and how energy is obtained from the nucleus. Then we study the thermal properties of materials, and the properties and nature of gases.

Section B : Optional Topic

You will be given an opportunity to study one of the following topics, which will give a deeper understanding and awareness of a selected branch of physics

A Astronomy and Cosmology B Medical Physics

C Applied Physics D Turning Points in Physics

This exam will be taken in the JUNE of Year 13

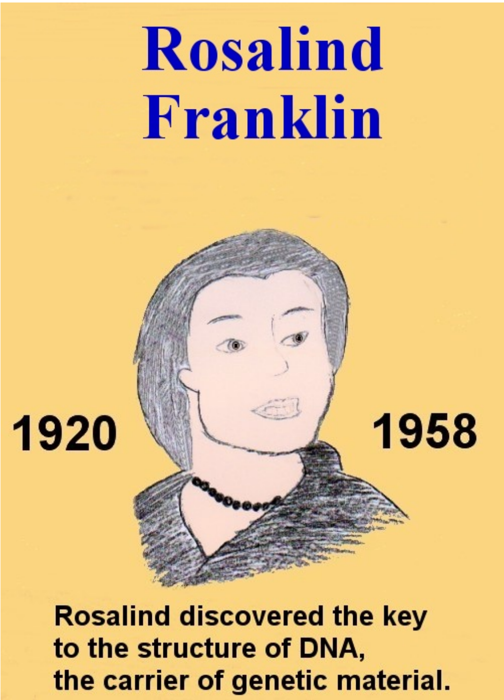
Unit 6: Practical and Investigative Skills

This is similar to Unit 3.

The only difference is that the investigations will be in context with the topics studies in Units 4 and 5.

You will be assessed on your practical skills using two methods:

- **Practical Skills Assessment (PSA)**
- **Investigative Skills Assignment (ISA).**



PHYSICS HANDBOOK

for

AS/A2 LEVEL

Explore the Universe with us…
in the 21st Century

APPENDICES

Appendix 1: How Science Works

How Science Works is an underpinning set of concepts and is the means whereby you come to understand how scientists investigate scientific phenomena in their attempts to explain the world about us.

How Science Works recognises the contribution scientists have made to their own disciplines and to the wider world. It recognises that scientists may be influenced by their own beliefs and that these can affect the way in which they approach their work.

Also, it acknowledges that scientists can and must contribute to debates about the uses to which their work is put and how their work influences decision-making in society.

It can also be used to promote and develop your skills in solving scientific problems by developing an understanding of:

• the concepts, principles and theories that form the subject content

• the procedures associated with the valid testing of ideas and, in particular, the collection, interpretation and validation of evidence

• the role of the scientific community in validating evidence and also in resolving conflicting evidence.

As you become proficient in these aspects of How Science Works, they can also engage with the place and contribution of science in the wider world. In particular, students will begin to recognise:

• the contribution that scientists, as scientists, can make to decision-making and the formulation of policy

• the need for regulation of scientific enquiry and how this can be achieved

• how scientists can contribute legitimately in debates about those claims which are made in the name of science.

More details of   How Science Works (HSW) are integrated into the study of Physics is given in the AQA Physics A Specification, which can be downloaded at:

http://store.aqa.org.uk/qual/gce/pdf/AQA-2450-W-SP.PDF



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Appendix 2 : **Please complete and give this to your Physics teacher(s)**

A-Level Physics : Student Details

Name……………………………………………

Physics Group ……………….

E-Mail address (for E-learning) : ___________________________

ICT Access/Skills (tick)

I have access to a computer at home. ☐

I have Broadband Internet access at home ☐

ICT Skills: I have experience in using

A word processor A database ☐ Spreadsheet ☐

PowerPoint or other presentation program ☐

I have used online learning before ☐

(such as SamLearning at KS3/KS4 or MyMaths)

GCSE Subjects and grades	Other Subjects studied in Year 12

Post –18 (options being considered)

Appendix 3 : Enhancing and enriching your learning

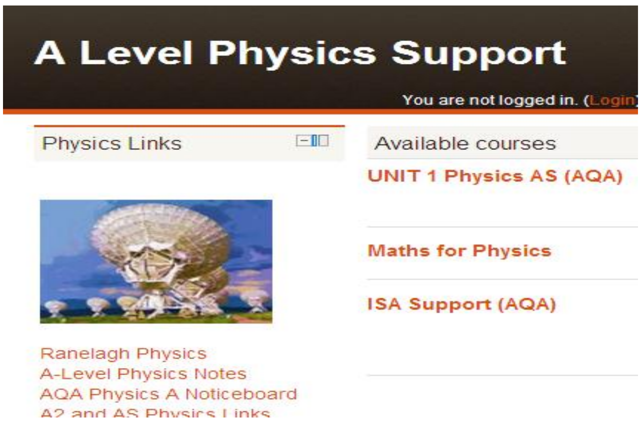
Physics Review

Don't waste valuable time going through ordinary newspapers looking for physics articles! This is a superb resource. Leading examiners and subject specialists update you on the key topics they need to understand to achieve your potential at AS and A2. Regular columns develop core A-level skills and help students apply their understanding to how science works. There will be copies made available for you to borrow (see Dr.Overy) OR you can subscribe at a reduced student

2. Internet Resources

Physics Newsfeeds

The latest **Newsfeeds** about Physics are sent directly to our A level Physics Support Website at: www.e-teach.org/physics



YouTube

There are some excellent **YouTube** videos for Physics

Someone has done all the hard work for you and listed them here:

http://physics.andreadecapoa.net/

You will also be given website addresses to relevant YouTube videos for all your Units of Study.

Physics A-Level Websites

These are general websites, but extremely useful for resources, for teaching and learning! Specific websites for each Unit will be provided during the course.

….Don't forget our e-learning website at **www.e-teach.org/physics**

This website provides you with valuable additional links and resources

Ranelagh Physics

Absolutely brilliant resources for AQA A-level Physics.
Extremely useful for both teachers and students

http://ranelaghalevelphysics.wikispaces.com

A-Level Physics Notes

Useful notes on a wide range of Physics Topics

www.thestudentroom.co.uk/wiki/Category:A_Level_Physics_Revision_Notes

AQA Physics A Noticeboard

Download past papers + mark schemes

http://web.aqa.org.uk/qual/gce/science/physics_a_noticeboard.php

A2 and AS Physics Links

A database of links to most topics at A-level

http://www.asa2physics.co.uk/pages/

School Matters

Teaching and learning resources from University of Liverpool

http://schools.matter.org.uk/a-level.html

Exam Timetable

Find out when your exams will be set ….a reminder!

http://www.modernisationonline.org.uk/comptimetable/

S-Cool

Great revision website. Interactive activities.

http://www.s-cool.co.uk/a-level/physics

TopMarks

Another database of physics resources

http://www.topmarks.co.uk/Search.aspx?Subject=23&AgeGroup=6

Antonine Physics AS

Useful note and online tests, as you go through the notes.
Good revision website

http://www.antonine-education.co.uk/Physics%20A%20level/welcome_to_as_physics.htm

SchoolPhysics

Excellent animations + Teaching and revision resources

http://www.schoolphysics.co.uk

PhysicsNet

Useful revision /consolidation resources.

http://physicsnet.co.uk/a-level-physics-as-a2/

A-level Physics Tutor

Useful website, although layout/presentation needs improvement.

http://www.a-levelphysicstutor.com

WikiBooks A-level Physics (OCR)

Wiki website dedicated to OCR A-level Physics course

WikiBooks A-level Physics (AQA)

Wiki website dedicated to AQA A-level Physics

The Physics Classroom

Lots of multimedia resources + notes/revision materials

http://www.physicsclassroom.com/

Higher Physics

http://www.bbc.co.uk/scotland/learning/bitesize/higher/physics/

SamLearning

Interactive revision materials.
Our students obtain login information from our school

http://www.samlearning.com/

Animated Physics

http://www.animatedscience.co.uk/?cat=21

Java Applets (Animations)

Brilliant interactive resources for a wide range of topics

http://www.walter-fendt.de/ph14e/

Appendix 4 : **Glossary of terms used in examination questions**

You need to pay very careful attention to the wording questions. Principal examiners choose their words very carefully, so you must be aware of what they are looking for in an answer. In physics it is essential that you know definitions exactly. Waffle counts for nothing. You are strongly advised to keep a definitions booklet, as you go through the course, with all the definitions, laws, principles, and the correct units for physical quantities.

"State"

In Physics this usually applies to Units or a Law or Principle. Make sure you know the correct definition….A-level standard, not media news standards. For example, Newton's Third Law of Motion is NOT 'Action and reaction are equal and opposite', but "If an object A is applied to an object B then object B applies an equal and opposite force to object A "

"List"

This needs a number of features or points only. No explanation is required

"Define / What is meant by…?"

"Define" means you must explain clearly what is meant by a particular word or term.
If you have been taught a specific definition then you should use this phrase.
"What is meant by …?" does not require such a formal definition (but it is not incorrect to give one).

"Outline"

This means that you should give a brief summary of the main points. Look at how many marks are available and how much space is given for clues to the detail you need to give!
Do not repeat the same point five times expecting to get five marks!

"Describe"

This usually involves a few sentences, normally recalling a procedure or method. If it asks you to describe a graph, you should describe the shape of the graph, picking out key points (e.g. "it begins to level out at …" or "it gets steeper at …"). Note that an explanation is not required, unless it states *'describe and explain'*

If you are asked to describe an experiment, then you should state clearly how you would carry it out.

"Describe how you …"

This does mean you, the AS Physics student. The examiner will be looking for evidence of scientific procedures, knowledge and understanding that you have acquired during the course. It expects you to say what you could do in a school laboratory situation or how you would apply your knowledge to a familiar or unfamiliar situation.

"Evaluate"

Not to be confused with 'list'. You need to give explanations. Evaluation of the evidence for and against a particular point of view means that you must give an explanation of the points that you make. Often used with data analysis questions, where you would need to consider the evidence then make careful judgements based on the evidence provided.

“Explain”

This is a **why** question You need to give a reason or an interpretation – **not** a description! It involves you using your science knowledge to explain a process or application of a concept to a familiar or unfamiliar situation. Explaining a graph is not describing the shape of the graph, it is telling the examiner why, in terms of physics, the graph is the shape that it is.

“Suggest”

You will not have been taught a specific answer to a question that starts “suggest”. What you are expected to do here is to draw upon the information given in the question and upon your general knowledge and understanding of physics concepts to come up with an answer. There may be more than one correct response to a “suggest” question.

“Give the evidence for…” / “Use examples from…”

Follow any instructions very carefully. Usually you will be expected to refer closely to information given in the question. You will not get full marks unless you do so.

“Plot / sketch”

These terms are used when you are drawing graphs.
Plot means that you must be accurate, using graph paper where appropriate.
Sketch means you need to show the general shape of the expected curve.
Always label the axes correctly. In some cases, you would be expected to give appropriate scales.

“Calculate”

This means get out your calculator, enter the appropriate numbers and come up with an answer. In Physics you must ensure that the data is in appropriate SI units before substitution. In all cases, show your working. This gives the examiner an opportunity to give you intermediate marks, if you do not have the correct answer and units.

Appendix 5 : Mathematical Requirements

In order to develop your skills, knowledge and understanding in science, you will need to have been taught and to have acquired competence in the appropriate areas of mathematics relevant to the subject as set out below:

Arithmetic and computation	• recognise and use expressions in decimal and standard form • use ratios, fractions and percentages • use calculators to find and use x^n, $1/x$, $\sqrt{x}$, $\log_{10}x$, e^x, $\log_e x$ • use calculators to handle sin x, cos x, tan x when x is expressed in degrees or radians.
Handling data	• use an appropriate number of significant figures • find arithmetic means • make order of magnitude calculations.
Algebra	• understand and use the symbols: =, <, <<, >>, >, ∝, ~. • change the subject of an equation by manipulation of the terms, including positive, negative, integer and fractional indices • substitute numerical values into algebraic equations using appropriate units for physical quantities • solve simple algebraic equations.

Graphs	• translate information between graphical, numerical and algebraic forms • plot two variables from experimental or other data • understand that $y = mx + c$ represents a linear relationship • determine the slope and intercept of a linear graph • draw and use the slope of a tangent to a curve as a measure of rate of change • understand the possible physical significance of the area between a curve and the x -axis and be able to calculate it or measure it by counting squares as appropriate • use logarithmic plots to test exponential and power law variations • sketch simple functions including $y = k/x$, $y = kx^2$, $y = k/x^2$, $y = \sin x$, $y = \cos x$, $y = e^{-kx}$
Geometry and trigonometry	• calculate areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders and spheres • use Pythagoras' theorem, and the angle sum of a triangle • use sines, cosines and tangents in physical problems • understand the relationship between degrees and radians and translate from one to the other.

Appendix 6: Data and Formulae

DATA

FUNDAMENTAL CONSTANTS AND VALUES

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}
molar gas constant	R	8.31	$J\ K^{-1}\ mol^{-1}$
the Boltzmann constant	k	1.38×10^{-23}	$J\ K^{-1}$
the Stefan constant	σ	5.67×10^{-8}	$W\ m^{-2}\ K^{-4}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	e/m_e	1.76×10^{11}	$C\ kg^{-1}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	e/m_p	9.58×10^7	$C\ kg^{-1}$
neutron rest mass (equivalent to 1.00867 u)	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 (1u is equivalent to 931.3 MeV)	u	1.661×10^{-27}	kg

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

ASTRONOMICAL DATA

Body	*Mass/kg*	*Mean radius/m*
Sun	1.99×10^{30}	6.96×10^8
Earth	5.98×10^{24}	6.37×10^6

Appendix 6: AS Formulae

AS FORMULAE

PARTICLE PHYSICS

Rest energy values

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 $E = hf = hc/\lambda$

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

energy levels $hf = E_1 - E_2$

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

ELECTRICITY

current and pd $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

emf $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

resistors in series $R = R_1 + R_2 + R_3 + \ldots$

resistors in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

resistivity $\rho = \frac{RA}{L}$

power $P = VI = I^2R = \frac{V^2}{R}$

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

MECHANICS

moments moment = Fd

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

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

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

force $F = ma$

work, energy and power $W = Fs \cos\theta$

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

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

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

MATERIALS

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

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

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

WAVES

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

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 $n_1 > n_2$

Appendix 6: A2 Formulae

A2 FORMULAE

MOMENTUM

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

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

CIRCULAR MOTION

angular velocity $\omega = \frac{v}{r}$

$\omega = 2\pi f$

centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

centripetal force $F = \frac{mv^2}{r} = m\omega^2 r$

OSCILLATIONS

acceleration $a = -(2\pi f)^2 x$

displacement $x = A \cos(2\pi f t)$

speed $v = \pm 2\pi f \sqrt{A^2 - x^2}$

maximum speed $v_{max} = 2\pi f A$

maximum acceleration $a_{max} = (2\pi f)^2 A$

for a mass-spring system $T = 2\pi \sqrt{\frac{m}{k}}$

for a simple pendulum $T = 2\pi \sqrt{\frac{l}{g}}$

GRAVITATIONAL FIELDS

force between two masses $F = \frac{G m_1 m_2}{r^2}$

gravitational field strength $g = \frac{F}{m}$

magnitude of gravitational field strength in a radial field $g = \frac{GM}{r^2}$

gravitational potential $\Delta W = m\Delta V$

$V = -\frac{GM}{r}$ $\quad g = -\frac{\Delta V}{\Delta r}$

ELECTRIC FIELDS AND CAPACITORS

force between two point charges $F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$

force on a charge $F = EQ$

field strength for a uniform field $E = \frac{V}{d}$

field strength for a radial field $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

electric potential $\Delta W = Q\Delta V$

$V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r}$

capacitance $C = \frac{Q}{V}$

decay of charge $Q = Q_0 e^{-t/RC}$

time constant RC

capacitor energy stored $E = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{Q^2}{C}$

MAGNETIC FIELDS

force on a current $F = BIl$

force on a moving charge $F = BQv$

magnetic flux $\Phi = BA$

magnetic flux linkage $N\Phi = BAN$

magnitude of induced emf $\varepsilon = N \frac{\Delta\Phi}{\Delta t}$

emf induced in a rotating coil $N\Phi = BAN \cos\theta$

$\varepsilon = BAN\omega \sin \omega t$

transformer equations $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$\text{efficiency} = \frac{I_s V_s}{I_p V_p}$

RADIOACTIVITY AND NUCLEAR PHYSICS

the inverse square law for γ radiation $I = \frac{k}{x^2}$

radioactive decay $\frac{\Delta N}{\Delta t} = -\lambda N$ $\quad N = N_0 e^{-\lambda t}$

activity $A = \lambda N$

half-life $T_{½} = \frac{\ln 2}{\lambda}$

nuclear radius $R = r_0 A^{1/3}$

energy-mass equation $E = mc^2$

GASES AND THERMAL PHYSICS

gas law $pV = nRT$

$pV = NkT$

kinetic theory model $pV = \frac{1}{3} N m (c_{rms})^2$

kinetic energy of gas molecule $\frac{1}{2} m (c_{rms})^2 = \frac{3}{2} kT = \frac{3RT}{2 N_A}$

energy to change temperature $Q = mc\Delta T$

energy to change state $Q = ml$

Appendix 6: A2 OPTIONS: Data and Formulae

OPTIONS FORMULAE

ASTROPHYSICS

1 astronomical unit = 1.50×10^{11} m

1 light year = 9.46×10^{15} m

1 parsec = 206265 AU = 3.08×10^{16} m = 3.26 lyr

Hubble constant, H = 65 km s^{-1} Mpc^{-1}

lens equation $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

in normal adjustment $M = \frac{f_0}{f_e}$

resolving power $\theta \approx \frac{\lambda}{D}$

magnitude equation $m - M = 5 \log \frac{d}{10}$

Wien's law $\lambda_{max} T = 0.0029$ m K

Hubble's law $v = H d$

Stefan's law $P = \sigma A T^4$

Doppler shift for v << c $z = \frac{\Delta f}{f} = -\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

Schwarzschild radius $R_s = \frac{2GM}{c^2}$

MEDICAL PHYSICS

lens equations $P = \frac{1}{f}$

$m = \frac{v}{u}$

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

intensity level intensity level = $10 \log \frac{I}{I_0}$

absorption $I = I_0 e^{-\mu x}$

$\mu_m = \frac{\mu}{\rho}$

APPLIED PHYSICS

moment of inertia $I = \Sigma mr^2$

angular kinetic energy $E_k = \frac{1}{2} I\omega^2$

equations of angular motion $\omega_2 = \omega_1 + \alpha t$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$\theta = \frac{1}{2}(\omega_1 + \omega_2)t$

torque $T = I\alpha$

angular momentum angular momentum = $I\omega$

work done $W = T\theta$

power $P = T\omega$

thermodynamics $Q = \Delta U + W$

$W = p\Delta V$

adiabatic change pV^γ = constant

isothermal change pV = constant

heat engines

efficiency = $\frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$

maximum efficiency = $\frac{T_H - T_C}{T_H}$

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power = (area of p-V loop) × (no. of cycles per second) × number of cylinders

output of brake power $P = T\omega$

friction power = indicated power – brake power

heat pumps and refrigerators

refrigerator: $COP_{ref} = \frac{Q_{out}}{W} = \frac{Q_{out}}{Q_{in} - Q_{out}}$

heat pump: $COP_{hp} = \frac{Q_{in}}{W} = \frac{Q_{in}}{Q_{in} - Q_{out}}$

TURNING POINTS IN PHYSICS

electrons in fields $F = \frac{eV}{d}$

$F = Bev$

$r = \frac{mv}{Be}$

$\frac{1}{2} mv^2 = eV$

$\frac{QV}{d} = mg$

$F = 6\pi\eta r v$

wave particle duality $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

special relativity $E = mc^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$

$l = l_0 \left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$ $t = t_0 \left(1 - \frac{v^2}{c^2}\right)^{-\frac{1}{2}}$

Appendix 7: Glossary of terms related to measurements

The AQA team of physics GCE examiners has produced the following list of definitions for use with AQA GCE Physics specifications and examinations.

Accepted value

The accepted value of a measurement is the value of the most *accurate measurement* available. It is sometimes referred to as the .true. value.

Accuracy

Accuracy is a measure of confidence in an *accurate measurement*, often expressed as an upper and lower limit of the measurement based on the *uncertainty* in the measurement (e.g. $g = 9.8 \pm 0.3$ m s^{-2}).

Accurate measurements

A measurement which can be described as accurate is one that has been obtained using accurately calibrated instruments correctly and where no systematic errors arise.

Dependent variable

Dependent variables are those variable physical quantities whose values change as a result of a change of value of another variable quantity. The dependent variable is usually plotted on the vertical or y-axis of a graph.

Error

The difference between a measurement and its accepted value.
Often a misnomer suggesting that a mistake was made in taking a reading.

Independent variable

Independent variables are those variable physical quantities whose values are controlled or selected by the experimenter. Changing the value of an independent variable usually results in a change of value of a dependent variable. The independent variable is usually plotted on the horizontal or x-axis of a graph.

Linearity

This is a design feature of many instruments and it means that the readings are directly proportional to the magnitude of the variable being measured. *The scale of a moving coil meter is linear if it has evenly spaced graduations on its scale each representing equal increases in current.*

Mean value The mean value of a set of readings is calculated by adding the readings together and dividing by the number of readings.

Appendix 8: SI Base Units

Quantity	Name	Symbol
Length	metre	*m*
Mass	kilogram	*kg*
Time	second	*s*
Electric Current	ampere	*A*
Thermodynamic Temperature	kelvin	*K*
Amount of Substance	mole	*mol*
Luminous Intensity	candela	*cd*

Appendix 9 : Derived Units

Quantity	Name	Symbol	In terms of other derived units	In terms of base units
Area	square metre	m^2		$m \times m$
Volume	cubic metre	m^3		$m \times m \times m$
Speed/Velocity	metre per second	$m\,s^{-1}$		$\frac{m}{s}$
Acceleration	metre per second squared	$m\,s^{-2}$		$\frac{\frac{m}{s}}{s}$
Density	kilogram per cubic metre	$kg\,m^{-3}$	$\frac{kg}{m^3}$	$\frac{kg}{m \times m \times m}$
Specific Volume	cubic metre per kilogram	$m^3\,kg^{-1}$	$\frac{m^3}{kg}$	$\frac{m \times m \times m}{kg}$
Current Density	ampere per square metre	$A\,m^{-2}$	$\frac{A}{m^2}$	$\frac{A}{m \times m}$
Magnetic Field Strength	ampere per metre	$A\,m^{-1}$		$\frac{A}{m}$
Concentration	mole per cubic metre	$mol\,m^{-3}$	$\frac{mol}{m^3}$	$\frac{mol}{m \times m \times m}$

Frequency	hertz	Hz		$\frac{1}{s}$
Force	newton	N		$m\,kg\,s^{-2}$
Pressure/Stress	pascal	Pa	$\frac{N}{m^2}$	$m^{-1}\,kg\,s^{-2}$
Energy/Work/Quantity of Heat	joule	J	N m	$m^2\,kg\,s^{-2}$
Power/Radiant Flux	watt	W	$\frac{J}{s}$	$m^2\,kg\,s^{-3}$
Electric Charge/Quantity of Electricity	coulomb	C		s A
Electric Potential/Potential Difference/Electromotive Force	volt	V	$\frac{W}{A}$	$m^2\,kg\,s^{-3}\,A^{-1}$
Capacitance	Farad	F	$\frac{C}{V}$	$m^{-2}\,kg^{-1}\,s^4\,A^2$
Electric Resistance	Ohm	Ω	$\frac{V}{A}$	$m^2\,kg\,s^{-3}\,A^{-2}$
Electric Conductance	siemens	S	$\frac{A}{V}$	$m^{-2}\,kg^{-1}\,s^3\,A^2$
Magnetic Flux	weber	Wb	V s	$m^2\,kg\,s^{-2}\,A^{-1}$
Magnetic Flux Density	Tesla	T	$\frac{Wb}{m^2}$	$kg\,s^{-2}\,A^{-1}$
Inductance	henry	H	$\frac{Wb}{A}$	$m^2\,kg\,s^{-2}\,A^{-2}$
Celsius Temperature	degree Celsius	°C		K - 273.15
Luminous Flux	lumen	lm		cd sr
Illuminance	lux	lx	$\frac{lm}{m^2}$	$m^{-2}\,cd\,sr$
Activity of a Radionuclide	bequerel	Bq		s^{-1}

Appendix 10 : Prefixes and the Greek Alphabet

Prefix	Symbol	Factor	Common Term
peta	P	10^{15}	quadrillions
tera	T	10^{12}	trillions
giga	G	10^{9}	billions
mega	M	10^{6}	millions
kilo	k	10^{3}	thousands
hecto	h	10^{2}	hundreds
deca	da	10^{1}	tens
deci	d	10^{-1}	tenths
centi	c	10^{-2}	hundredths
milli	m	10^{-3}	thousandths
micro	μ	10^{-6}	millionths
nano	n	10^{-9}	billionths
pico	p	10^{-12}	trillionths
femto	f	10^{-15}	quadrillionths

Greek	*Name*	*Letter*	*Greek*	*Name*	*Letter*
α	alpha	a	ν	nu	n
β	beta	b	ξ	xi	x
γ	gamma	g	ο	omicron	Short o (ŏ)
δ (Δ)	delta	d (D)	π	pi	p
ε	epsilon	Short e (ĕ)	ρ	rho	r
ζ	zeta	z	σ (Σ)	sigma	s (S)
η	eta	Long e (ē)	τ	tau	t
θ	theta	th	υ	upsilon	u
ι	iota	i	φ (Φ)	phi	ph [or f (F)]
κ	kappa	k	χ	chi	ch
λ (Λ)	lambda	l (L)	ψ (Ψ)	psi	ps
μ	mu	m	ω (Ω)	omega	Long o [ō (Ō)]