A-Level Physics

OCR Physics A

Course Booklet

Name:………………………………………………………..

2025-27

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You may wish to keep a digital copy of this document that you can edit and share with your teachers via office 365, teams or google classroom.

My Studies

Target Grade for A-level Physics:	GCSE Grades				
	Chemistry:	Physics:	Biology:	Double Science:	
	Maths	English Lang:	English Lit:	English Lang:	
Others					

Day	P1 9 - 10	P2 10 - 11		P3 11.20 – 12.20	P4 12.20 – 1.20		P5 2.00 – 3.00
Mon			B			L	
Tue			R			U	
Wed			E			N	
Thur			A			C	
Fri			K			H	

Skills Audit

Please rate 1 – 5 1= poor 5=excellent

Skill	Sep	Autumn ½ term	Xmas Holiday	Spring ½ term	Easter Holiday	Summer ½ term	Year End	Evidence
Basic Maths								
Problem solving								
SPAG								
Extended writing								
Language precision								
Practical skills								
Data presentation								
Analysis & evaluation								
Note-taking								
Research								
Referencing								
Additional reading								
Revision								
Organisation								
Time management								
Deadlines								
Communication								
Teamwork								

A-Level Course:

All three externally assessed components (01–03) contain some synoptic assessment, some extended response questions and some stretch and challenge questions. Stretch and challenge questions are designed to allow the most able learners the opportunity to demonstrate the full extent of their knowledge and skills. Stretch and challenge questions will support the awarding of A* grade at A level, addressing the need for greater differentiation between the most able learners.

- **Unit H556/01 Modelling physics (2hrs 15mins)**
  This component is worth 100 marks and is split into two sections and assesses content from teaching modules 1, 2, 3 and 5. Learners answer all questions. **Section A** contains multiple choice questions. This section of the paper is worth 15 marks. **Section B** includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 85 marks.

- **Unit H556/02 Exploring physics (2hrs 15mins)**
  This component is worth 100 marks and is split into two sections and assesses content from teaching modules 1, 2, 4 and 6. Learners answer all questions. **Section A** contains multiple choice questions. This section of the paper is worth 15 marks. **Section B** includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 85 marks.

- **Unit H556/03 Unified physics (1hr 30mins)**
  This component assesses content from across all teaching modules 1 to 6. Learners answer all questions. This component is worth 70 marks. Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.

- **Practical Endorsement in Physics**: a series of practical tasks carried out as part of teaching and learning in order to ensure competence in practical work**.** You will be expected to keep a record of these practical activities in a lab book which will be checked by your teacher and the exam board.
  25% of the questions in your final exams will be related to the practical skills that you have learnt during the course.

Success Tips:

- Keep up with notes and reviewing during the year.
- Use the RAG sheets constantly, they are everything you need to know.
- Don't fall behind during the year. Complete your homework tasks and be proactive in finding help and additional information.
- Be organised, set up a timetable of revision so you know what you are revising and when (with plenty of time).
- Start early and find the best method. Some people like making flash cards, posters, quizzes or a mixture. Find what suits **you** and use it.
- Don't suffer alone. Meet up and revise certain topics in groups, make quizzes for each other. Or text attack each other (Really fun, you text a question to everyone in the class, first one to reply wins, create a big loop of questions).
- Use your teachers! Come in with questions you can't do or topics you need help with. Make them work, they can't guess what you are struggling with.
- It is supposed to be hard. Don't revise the stuff you find easy just because it makes you feel smart. Focus on the stuff you cannot do and make it easy with good quality, focused revision. Use your RAG sheets to make your revision specific.
- Do loads and loads of past papers and exam questions. Find the mark schemes and mark them, see what kind of language the mark scheme uses. After a while you will recognise what the examiners want to see from you. As this is a new course, the past papers will not be the same format as your exam but we will use specimen papers so you are not surprised when exam time comes.
- Read the examiners reports for exams. (after you have done the exam). These are invaluable, they give an insight into what the examiners are looking for and common mistakes made by students.
- **Don't give up**: It is never too late, and don't get disheartened. You can always ask for more help.

Department Expectations and Help

You are expected to match your contact hours per subject with self-study. This means you are expected to complete 5 hours of physics work as independent study per week. There are a variety of methods you could use to make sure this time is spent wisely but a good place to start might be.

- 1 hour reviewing notes from lessons and rewriting if necessary (also use this time to formulate questions to ask at the start of next lesson). If you don't get something, use the text books to help you annotate your notes.
- 1 hour completing the recommended reading ahead of next lesson and making notes where appropriate.
- 1-2 hour completing questions either from the revision guide, textbooks, or completing past paper questions (or ideally a mix of both). You should also self-assess these where possible.
- Past papers and mark schemes can be found here: https://www.ocr.org.uk/qualifications/past-paper-finder/ . In the drop-down boxes select Physics, AS/A level GCE, Physics A H156-H556 (from 2015)
- 1 hour reading around the subject and self-evaluating your learning. It is important to log and evidence this; for example print off an article you have read and annotate the article with your thoughts or make notes on an e-book and reference the book.

Online there is a wealth of resources for this course, SEARCH FOR IT! There is a suggested reading list further on in this guide.

You will have access to your text book and some resources via www.kerboodle.com, you will each be given a student login to access these resources.

My notes

As a Department, we expect you to keep good quality notes from your lessons and from the independent work that you complete outside of lessons. This means that on occasion your class teacher or another member of staff from the Science Department may wish to see your notes. With this in mind it is a very good idea to ensure that your notes are kept neatly, tidily, and reviewed after each of your lessons. This means that you need to be organised in your approach to your study.

You should keep your work in a lever arch file with dividers for each Unit of work, this will only need to be brought in to school for folder checks. You should have a smaller folder (also with dividers) in which to keep your current work. This is what you would bring to each lesson, and then at the end of a topic, the notes/work can be transferred across to your lever arch folder.

You will also be expected to keep a record of your practical work in a lab book, which will keep a working record of your lab work. This is likely to have holes punched in it for you so that you can keep it in your folder. All of you practical work must have a date on each page so it can act as a record of which skills you have been practicing, and what equipment you have been using.

Exam Specification

The personal Learning Checklists (PLC) for your subject are in this booklet and cover the key learning points of the course; you will be expected to monitor your own progress as you go through the course. You will also be asked to record your progress on an online spreadsheet which is shared with your teachers. This will help you to assess the quality of your own notes, learning and skills and the extent of the work that you have completed during your studies. It's very important that you set goals using the exam specification in order to ensure that your revision doesn't begin at the last minute. You should begin the process of revision after almost the first class, planning to have high quality notes in order to facilitate easy recall, understanding, and exam performance. You can use a highlighter to engage with the specification or simply underline or annotate the specification, highlighting all of the things that you have found a challenge to allow you to focus on the areas you have struggled with during your revision.

What style of lessons can I expect? How are the lesson success criteria generated?

Lessons will follow the same format as those that you have experienced in year 11, starting with a low stakes quiz and sharing of the intended learning outcomes, then cycles of teacher instruction, deliberate practice and review. The main difference will be that where there is a double lesson, we would not necessarily do a low stakes quiz at the start of the second lesson, although this may be appropriate at times.

At A-level we need to develop your practical skills as these form a large part of the questions in the final exams and there are skills that you must acquire in order to achieve the practical endorsement part of the qualification.

MONITORING AND COACHING

You will be expected to meet your subject teacher at least once per half term in order to monitor your progress and feedback to you on how you are doing; it's likely that this will be part of your normal sequence of lessons. However you may find that if this is difficult to schedule your teacher may, with notice, request that you do this out of lesson time. If this is the case please try to remember that your teacher is probably going out of their way in order to support you and please try to accommodate their request.

If you are absent from your lessons, you must make your teacher aware of the reason for your absence, by sending them an email explaining why. You will also then be required to catch up on any work you've missed before your next lesson. You are strongly discouraged from taking holidays during term as this will have a large impact on your learning. Any attendance concerns or missing of deadlines will lead to a cause for concern being raised and discussed with you and your parents, with strategies to try to improve.

If there is no immediate improvement, the cause for concern will be raised to a higher level, and more formal support will be put into place.

All notes about the support you've been offered and taken will be made on SIMS so that the information is available to all the staff supporting you, as well as your parents. Of course, this may well have an impact on the quality of the reference we can offer you at the end of your course.

A Level Physics – Reading Lists

To achieve the highest grades and increase your chances at university interviews it is essential that as part of your independent study regime you read around the subject. The list below are some suggested texts to get you started.

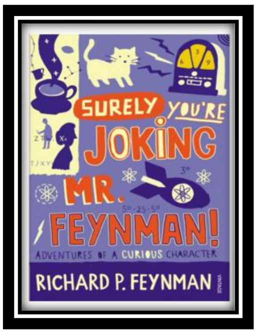
The titles are arranged in two groups; firstly study books that cover similar materials in a different format to your everyday textbooks and secondly additional reading that is beyond the course specification.

Additional Study Books

- Physics for Dummies (I & II) by Steven Holzner, ISBN 9781118595763
- Easy Physics Step-by-Step by Jonathan Wolf, ISBN 9780071805926
- Excelling at A-level Physics Capacitors by Stathis Stefanidis ISBN 978-1973455387
- Excelling at A-level Physics Circular Motion by Stathis Stefanidis ISBN 978-1549866326
- Excelling at A-level Physics Gravitational fields by Stathis Stefanidis ISBN 978-1549608346
- Excelling at A-level Physics Capacitors by Stathis Stefanidis
- Excelling at A-level Physics Capacitors by Stathis Stefanidis

Further Reading

- Seventeen Equations that Changed the World by Ian Stewart, ISBN 9781847657695
- Physics in the Modern World by Jerry Marion, ISBN 9780323145312
- Physics Review – Physics journal published by Philip Allan Magazines
- **Surely You're Joking Mr Feynman: Adventures of a Curious Character**

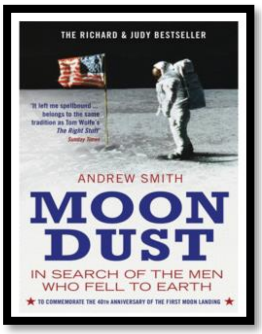


ISBN - 009917331X - Richard Feynman was a Nobel Prize winning Physicist. In my opinion he epitomises what a Physicist is. By reading this books you will get insight into his life's work including the creation of the first atomic bomb and his bongo playing adventures and his work in the field of particle physics.

(Also available on Audio book).

https://www.waterstones.com/books/search/term/surely+youre+joking+mr+feynman++adventures+of+a+curious+character

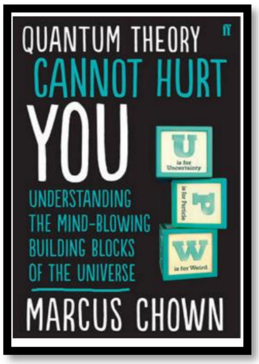
- **Moondust: In Search of the Men Who Fell to Earth**



ISBN – 1408802384 - One of the greatest scientific achievements of all time was putting mankind on the surface of the moon. Only 12 men made the trip to the surface, at the time of writing the book only 9 are still with us. The book does an excellent job of using the personal accounts of the 9 remaining astronauts and many others involved in the space program at looking at the whole space-race era, with hopefully a new era of space flight about to begin as we push on to put mankind on Mars in the next couple of decades.

https://www.waterstones.com/books/search/term/moondust++in+search+of+the+men+who+fell+to+earth

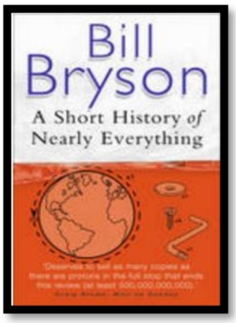
- **Quantum Theory Cannot Hurt You: Understanding the Mind-Blowing Building Blocks of the Universe**



ISBN - 057131502X - Any Physics book by Marcus Chown is an excellent insight into some of the more exotic areas of Physics that require no prior knowledge. In your first year of A-Level study you will meet the quantum world for the first time. This book will fill you with interesting facts and handy analogies to whip out to impress your peers!

https://www.waterstones.com/book/quantum-theory-cannot-hurt-you/marcus-chown/9780571315024

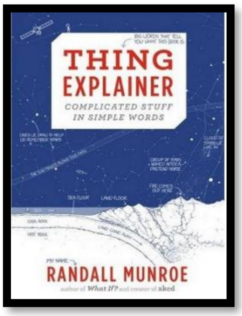
- **A Short History of Nearly Everything**



ISBN – 0552997048 - A modern classic. Popular science writing at its best. A Short History of Nearly Everything Bill Bryson's quest to find out everything that has happened from the Big Bang to the rise of civilization - how we got from there, being nothing at all, to here, being us. Hopefully by reading it you will gain an awe-inspiring feeling of how everything in the universe is connected by some fundamental laws.

https://www.waterstones.com/books/search/term/a+short+history+of+nearly+everything

- **Thing Explainer: Complicated Stuff in Simple Words**



ISBN – 1408802384 - This final recommendation is a bit of a wild-card – a book of illustrated cartoon diagrams that should appeal to the scientific side of everyone. Written by the creator of online comic XTCD (a great source of science humour) is a book of blueprints from everyday objects such as a biro to the Saturn V rocket and an atom bomb, each one meticulously explained BUT only with the most common 1000 words in the English Language. This would be an excellent coffee table book in the home of every scientist.

https://www.waterstones.com/book/thing-explainer/randall-munroe/9781473620919

Movie / Video Clip Recommendations

Hopefully you'll get the opportunity to soak up some of the Sun's rays over the summer – synthesising some important Vitamin-D – but if you do get a few rainy days where you're stuck indoors here are some ideas for films to watch or clips to find online.

Science Fictions Films

1. **Moon (2009)**
2. **Gravity (2013)**
3. **Interstellar (2014)**
4. **The Imitation Game (2015)**
5. **The Prestige (2006)**

Online Clips / Series

1. **Minute Physics –** Variety of Physics questions explained simply (in felt tip) in a couple of minutes. Addictive viewing that will have you watching clip after clip – a particular favourite of mine is "Why is the Sky Dark at Night?"

   https://www.youtube.com/user/minutephysics

2. **Wonders of the Universe / Wonders of the Solar System –** Both available of Netflix as of 17/4/16 – Brian Cox explains the Cosmos using some excellent analogies and wonderful imagery.

3. **Shock and Awe, The Story of Electricity –** A 3 part BBC documentary that is essential viewing if you want to see how our lives have been transformed by the ideas of a few great scientists a little over 100 years ago. The link below takes you to a stream of all three parts joined together but it is best watched in hourly instalments. Don't forget to boo when you see Edison. (alternatively watch any Horizon documentary – loads of choice on Netflix and the I-Player)

   https://www.youtube.com/watch?v=Gtp51eZkwoI

4. **NASA TV –** Online coverage of launches, missions, testing and the ISS. Plenty of clips and links to explore to find out more about applications of Physics in Space technology.

   http://www.nasa.gov/multimedia/nasatv/

5. **The Fantastic Mr. Feynman –** I cannot recommend this 1 hour documentary highly enough. See the life's work of the "great explainer", a fantastic mind that created mischief in all areas of modern Physics.

   https://www.youtube.com/watch?v=LyqleIxXTpw

Summer Tasks

Research activity

To get the best grades in A Level Physics you will have to get good at completing independent research and making your own notes on difficult topics. Below are links to 5 websites that cover some interesting Physics topics.

Using the Cornell notes system: http://coe.jmu.edu/learningtoolbox/cornellnotes.html make 1 page of notes **from each site** covering a topic of your choice.

a) http://home.cern/about

   CERN encompasses the Large Hadron Collider (LHC) and is the largest collaborative science experiment ever undertaken. Find out about it here and make a page of suitable notes on the accelerator.

b) http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

   The solar system is massive and its scale is hard to comprehend. Have a look at this award winning website and make a page of suitable notes.

c) https://phet.colorado.edu/en/simulations/category/html

   PhET create online Physics simulations when you can complete some simple experiments online. Open up the resistance of a wire html5 simulation. Conduct a simple experiment and make a one page summary of the experiment and your findings.

d) http://climate.nasa.gov/

   NASA's Jet Propulsion Laboratory has lots of information on Climate Change and Engineering Solutions to combat it. Have a look and make notes on an article of your choice.

e) http://www.livescience.com/46558-laws-of-motion.html

   Newton's Laws of Motion are fundamental laws for the motion of all the object we can see around us. Use this website and the suggested further reading links on the webpage to make your own 1 page of notes on the topics.

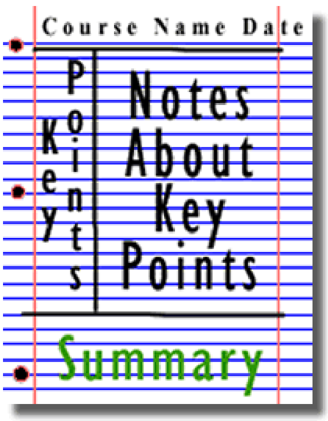


Figure 1: http://coe.jmu.edu/learningtoolbox/images/noteb4.gif

Pre-Knowledge Topics

Below are ten topics that are essential foundations for you study of A-Level Physics. Each topics has example questions and links where you can find our more information as you prepare for next year.

Symbols and Prefixes

At A level, unlike GCSE, you need to remember all symbols, units and prefixes. Below is a list of quantities you may have already come across and will be using during your A level course.

Prefix	Symbol	Power of ten
Nano	n	x 10^{-9}
Micro	µ	x 10^{-6}
Milli	m	x 10^{-3}
Centi	c	x 10^{-2}
Kilo	k	x 10^{3}
Mega	M	x 10^{6}
Giga	G	x 10^{9}

Quantity	Symbol	Unit
Velocity	v	ms^{-1}
Acceleration	a	ms^{-2}
Time	t	S
Force	F	N
Resistance	R	Ω
Potential difference	V	V
Current	I	A
Energy	E or W	J
Pressure	P	Pa
Momentum	p	$kgms^{-1}$
Power	P	W
Density	ρ	kgm^{-3}
Charge	Q	C

Solve the following:

1. How many metres in 2.4 km?
2. How many joules in 8.1 MJ?
3. Convert 326 GW into W.
4. Convert 54 600 mm into m.
5. How many grams in 240 kg?
6. Convert 0.18 nm into m.
7. Convert 632 nm into m. Express in standard form.
8. Convert 1002 mV into V. Express in standard form.
9. How many eV in 0.511 MeV? Express in standard form.
10. How many m in 11 km? Express in standard form.

Standard Form

At A level quantity will be written in standard form, and it is expected that your answers will be too.

This means answers should be written as ….x 10^{y}. E.g. for an answer of 1200kg we would write 1.2 x 10^{3}kg. For more information visit: www.bbc.co.uk/education/guides/zc2hsbk/revision

1. Write 2530 in standard form.
2. Write 280 in standard form.

3. Write 0.77 in standard form.

4. Write 0.0091 in standard form.

5. Write 1 872 000 in standard form.

6. Write 12.2 in standard form.

7. Write 2.4×10^{2} as a normal number.

8. Write 3.505×10^{1} as a normal number.

9. Write 8.31×10^{6} as a normal number.

10. Write 6.002×10^{2} as a normal number.

11. Write 1.5×10^{-4} as a normal number.

12. Write 4.3×10^{3} as a normal number.

Rearranging formulae

This is something you will have done at GCSE and it is crucial you master it for success at A level. For a recap of GCSE watch the following links:

www.khanacademy.org/math/algebra/one-variable-linear-equations/old-school-equations/v/solving-for-a-variable

www.youtube.com/watch?v=_WWgc3ABSj4

Rearrange the following:

1. $E = m \times g \times h$ to find h
2. $Q = I \times t$ to find I
3. $E = ½ m v^2$ to find m
4. $E = ½ m v^2$ to find v
5. $v = u + at$ to find u
6. $v = u + at$ to find a
7. $v^2 = u^2 + 2as$ to find s
8. $v^2 = u^2 + 2as$ to find u

Significant figures

At A level you will be expected to use an appropriate number of significant figures in your answers. The number of significant figures you should use is the same as the number of significant figures in the data you are given. You can never be more precise than the data you are given so if that is given to 3 significant your answer should be too. E.g. Distance = 8.24m, time = 1.23s therefore speed = 6.75m/s

The website below summarises the rules and how to round correctly.

http://www.purplemath.com/modules/rounding2.htm

Give the following to 3 significant figures:

1. 3.4527
2. 40.691
3. 0.838991
4. 1.0247
5. 59.972

Calculate the following to a suitable number of significant figures:

6. 63.2/78.1
7. 39+78+120
8. (3.4+3.7+3.2)/3
9. 0.0256 x 0.129
10. 592.3/0.1772

Atomic Structure

You will study nuclear decay in more detail at A level covering the topics of radioactivity and particle physics. In order to explain what happens you need to have a good understanding of the model of the atom. You need to know what the atom is made up of, relative charges and masses and how sub atomic particles are arranged.

The following video explains how the current model was discovered www.youtube.com/watch?v=wzALbzTdnc8

Describe the model used for the structure of an atom including details of the individual particles that make up an atom and the relative charges and masses of these particles. You may wish to include a diagram and explain how this model was discovered by Rutherford.

Recording Data

Whilst carrying out a practical activity you need to write all your raw results into a table. Don't wait until the end, discard anomalies and then write it up in neat.

Tables should have column heading and units in this format quantity/unit e.g. length /mm

All results in a column should have the same precision and if you have repeated the experiment you should calculate a mean to the same precision as the data.

Below is a link to practical handbooks so you can familiarise yourself with expectations.

http://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-PHBK.PDF

Below is a table of results from an experiment where a ball was rolled down a ramp of different lengths. A ruler and stop clock were used.

1) Identify the errors the student has made.

	Time			
Length/cm	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**
10	1.45	1.48	1.46	1.463
22	2.78	2.72	2.74	2.747
30	4.05	4.01	4.03	4.03
41	5.46	5.47	5.46	5.463
51	7.02	6.96	6.98	6.98
65	8.24	9.68	8.24	8.72
70	9.01	9.02	9.0	9.01

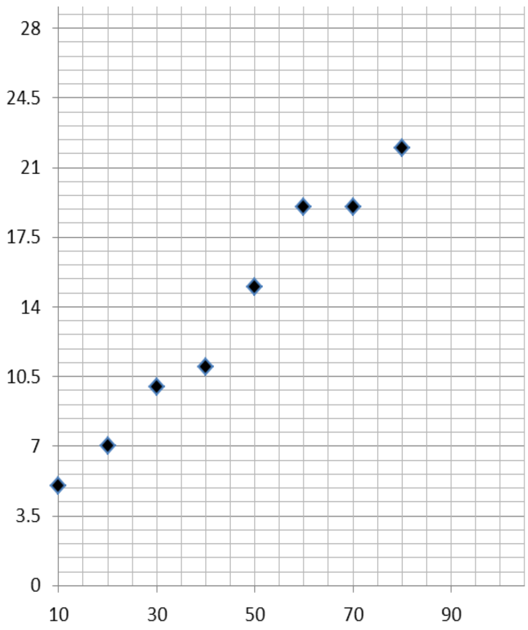
Graphs

After a practical activity the next step is to draw a graph that will be useful to you. Drawing a graph is a skill you should be familiar with already but you need to be extremely vigilant at A level. Before you draw your graph to need to identify a suitable scale to draw taking the following into consideration:

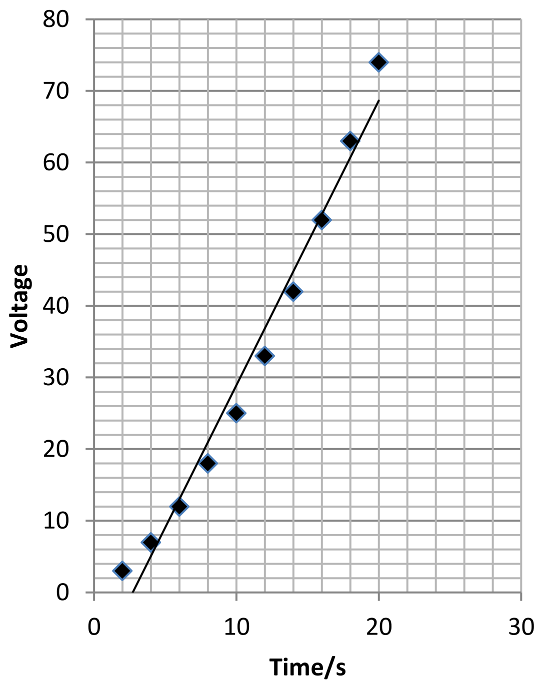
- the maximum and minimum values of each variable
- whether 0.0 should be included as a data point; graphs don't need to show the origin, a false origin can be used if your data doesn't start near zero.
- the plots should cover at least half of the grid supplied for the graph.
- the axes should use a sensible scale e.g. multiples of 1,2, 5 etc)

Identify how the following graphs could be improved

Graph 1



Graph 2



Forces and Motion

At GCSE you studied forces and motion and at A level you will explore this topic in more detail so it is essential you have a good understanding of the content covered at GCSE. You will be expected to describe, explain and carry calculations concerning the motion of objects. The websites below cover Newton's laws of motion and have links to these in action.

http://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws

http://www.sciencechannel.com/games-and-interactives/newtons-laws-of-motion-interactive/

Sketch a velocity-time graph showing the journey of a skydiver after leaving the plane to reaching the ground.

Mark on terminal velocity.

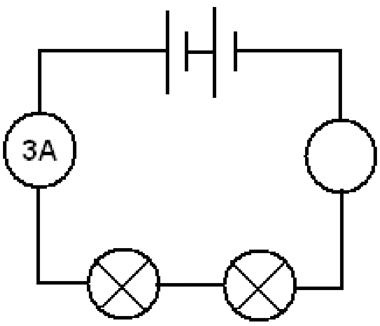
Electricity

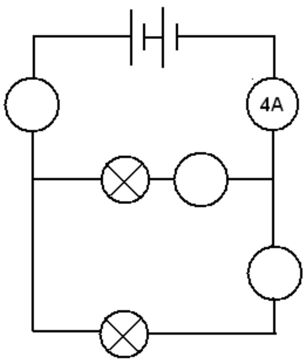
At A level you will learn more about how current and voltage behave in different circuits containing different components. You should be familiar with current and voltage rules in a series and parallel circuit as well as calculating the resistance of a device.

http://www.allaboutcircuits.com/textbook/direct-current/chpt-1/electric-circuits/

http://www.physicsclassroom.com/class/circuits

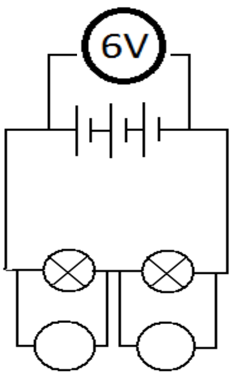
1a) Add the missing ammeter readings on the circuits below.

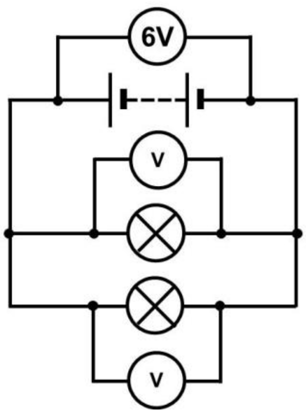




b) Explain why the second circuit has more current flowing than the first.

2) Add the missing potential differences to the following circuits





Wa

You of waves and used the wave equation to calculate speed, frec vill also have studied reflection and refraction.

Use this topic.

http /clips/zb7gkqt

https://www.khanacademy.org/science/physics/mechanical- waves-and-sound/mechanical-waves/v/introduction-to-waves

https://www.khanacademy.org/science/physics/mechanical-waves-and-sound/mechanical-waves/v/introduction-to-waves

1) Draw a diagram showing the refraction of a wave through a rectangular glass block. Explain why the ray of light takes this path.

2) Describe the difference between a longitudinal and transverse waves and give an example of each

3) Draw a wave and label the wavelength and amplitude

Unit 1: Practical Skills in Physics

Topic 1: Practical Skills Assessed in a Written Examination

Key Words	Definition
Independent Variable	
Dependent Variable	
Control Variable	
Quantitative	
Qualitative	
Precision	
Accuracy	
Margin of Error	
Percentage Error	
Uncertainty	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
1.1.1 Planning					
a) Design experiments to solve problems set in a practical context. Including selection of suitable apparatus, equipment and techniques for the proposed experiment.					
(b) Identify variables that must be controlled, where appropriate.					
(c) Evaluate whether an experimental method is appropriate to meet the expected outcomes.					
1.1.2 Implementing					
(a) Demonstrate how to use a wide range of practical apparatus and techniques correctly.					
(b) Select appropriate units for measurements.					
(c) Present observations and data in an appropriate format.					
1.1.3 Analysis					
(a) Process, analyse and interpret qualitative and quantitative experimental results to reach valid conclusions, where appropriate.					
(b) Use appropriate mathematical skills for analysis of quantitative data.					
(c) Select appropriate number of significant figures.					
(d) Plot and interpret suitable graphs from experimental results, including (i) selection and labelling of axes with appropriate scales, quantities and units (ii) measurement of gradients and intercepts.					
1.1.4 Evaluation					
(a) Demonstrate the ability to evaluate results and draw conclusions, including evaluation of how the scientific community use results to validate new knowledge and ensure integrity.					
(b) Identify anomalies in experimental measurements.					
(c) Identify the limitations in experimental procedures.					
(d) Discuss precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus.					
(e) Refine experimental design by suggestion of improvements to the procedures and apparatus.					

Unit 1: Practical Skills in Physics

Topic 2: Practical Skills Assessed in the Practical Endorsement

Criteria	RAG				
	Be Lesson	After Lesson	EOM	Mock Rev	Revision
1.2.1 Practical Skills					
Independent thinking:					
(a) Apply investigative approaches and methods to practical work including how to solve problems in a practical context.					
Use and application of scientific methods and practices:					
(b) Safely and correctly use a range of practical equipment and materials. Including identification of potential hazards and how to minimise them.					
(c) Follow written instructions.					
(d) Make and record observations/measurements.					
(e) Keep appropriate records of experimental activities.					
(f) Present information and data in a scientific way.					
(g) Use appropriate software and tools to process data, carry out research and report findings.					
Research and referencing:					
(h) Use online and offline research skills including websites, textbooks and other printed scientific sources of information.					
(i) Correctly cite sources of information.					
Instruments and equipment:					
(j) Use a wide range of experimental and practical instruments, equipment and techniques.					

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
1.2.2 Use of Apparatus and Techniques					
(a) use of appropriate analogue apparatus to record a range of measurements (to include length/ distance, temperature, pressure, force, angles and volume) and to interpolate between scale markings.					
(b) Use of appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance and mass.)					
(c) Use of methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiduciary marker, set square or plumb line.					
(d) Use of a stopwatch or light gates for timing.					
(e) Use of calipers and micrometers for small distances, using digital or vernier scales.					
(f) Correctly construct circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important.					
(g) Design, construct and check circuits using DC power supplies, cells, and a range of circuit components.					
(h) Use a signal generator and oscilloscope, including volts/division and time-base.					
(i) Generate and measure waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/radio wave source.					
(j) Use of a laser or light source to investigate characteristics of light, including interference and diffraction.					
(k) Use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.					
(l) Use of ionising radiation, including detectors.					

Unit 2: Foundations of Physics

Key Words	Definition
Scalar quantity	
Vector quantity	
Random Error	
Systematic Error	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
2.1.1 Physical quantities					
(a) Explain that some physical quantities consist of a numerical magnitude and a unit.					
(b) Make suitable estimates of physical quantities included within this specification.					
2.1.2 Units					
(a) Use Système Internationale (S.I.) base quantities and their units – mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)					
(b) Use derived units of S.I. base units Examples: momentum (kg m s^{-1}) and density (kg m^{-3})					
(c) Use correctly the named units listed in this specification as appropriate.					
(d) Check the homogeneity of physical equations using S.I. base units					
(e) Use correctly the following prefixes and their symbols to indicate decimal sub-multiples or multiples of units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T).					
(f) Use the conventions for correctly labelling graph axes and table columns.					
2.2.1 Measurements and Uncertainties					
(a) Identify and explain systematic errors (including zero errors) and random errors in measurements.					
(b) Discuss precision and accuracy of measurements.					
(c) Calculate absolute and percentage uncertainties when data are combined by addition,					

subtraction, multiplication, division and raising to powers.					
(d) Carry out: graphical treatment of errors and uncertainties; line of best fit; worst line; absolute and percentage uncertainties; percentage difference; error bars.					
2.3.1 Scalars and vectors					
(a) Define *scalar* and *vector* quantities and give examples.					
(b) Add and subtract vectors.					
(c) Draw and use a vector triangle to determine the resultant of two coplanar vectors such as displacement, velocity and force.					
(d) Resolve a vector such as displacement, velocity and force into two perpendicular components; $F_x = F \cos \theta$; $F_y = F \sin \theta$.					

Unit 3: Forces and Motion

Topic 1: Motion

Speed	
Velocity	
Instantaneous Speed	
Distance	
Displacement	
Acceleration	
Force	
Average Speed	
Acceleration of Free-fall	
Reaction Time	
Thinking Distance	
Braking Distance	
Stopping Distance	

Criteria	RAG				
	Before Lesson	**After Lesson**	**EOM**	**Mock Rev**	**Revision**
3.1.1 Kinematics					
(a) Define *displacement, instantaneous speed, average speed, velocity* and *acceleration*.					
(b) Apply graphical methods to represent displacement, speed, velocity and acceleration.					
(c) Determine velocity from the gradient of a displacement against time graph.					
(d) Analyse Velocity time graphs to determine acceleration from the gradient and displacement from the area under the graph.					
3.1.2 Linear motion					
(a i) Select, use and apply the equations of motion for constant acceleration in a straight line, including the motion of bodies falling in the Earth's uniform gravitational field without air resistance.					
(a ii) Describe techniques and procedures used to investigate the motion and collisions of objects.					
(b i) Describe and explain acceleration g of free fall.					
(b ii) Describe techniques and procedures used to determine the acceleration of free fall using trapdoor and electromagnet arrangement or light gates and timer.					
(c) Define the terms: reaction time, thinking distance, breaking distance and stopping distance of a vehicle, and analyse problems using these terms.					
3.1.3 Projectile motion					
(a) Describe and explain the independence of the vertical and horizontal motion of a projectile.					
(b) Analyse the two-dimensional motion of a projectile with constant velocity in one direction and constant acceleration in a perpendicular direction.					

Unit 3: Forces and Motion

Topic 2 – Forces in Action

Key Words	Definition
Newton	
Weight	
Tension	
normal contact force	
Upthrust	
Friction	
Terminal Velocity	
Centre of Mass	
Centre of Gravity	
Volume	
Couple	
Torque	
Force	
Drag	
Mass	
Principle of moments	
Pressure	
Moment	
Fluid	
Density	

Area	

Criteria	RAG				
	Before Lesson	**After Lesson**	**EOM**	**Mock Rev**	**Revision**
3.2.1 Dynamics					
(a) **Recall** and solve problems using the relationship: net force = mass x acceleration ($F = ma$) appreciating that acceleration and the net force are always in the same direction.					
(b) Define the *Newton*.					
(c) **Recall** and use the relationship weight = mass x acceleration of free fall ($W = mg$).					
(d) Define the terms: *tension, normal contact force, upthrust* and *friction*.					
(e) Be able to draw and understand free body diagrams.					
(f) Describe and explain one and two dimensional motion under a constant force.					
3.2.2 Motion with Non-Uniform Acceleration					
(a) Explain that an object travelling in a fluid experiences a resistive or a frictional force known as drag.					
(b) State the factors that affect the magnitude of the drag force for an object travelling through air.					
(c) Describe the motion of objects falling in a uniform gravitational field in the presence of drag.					
(d) State that the weight of an object is the gravitational force acting on the object.					
(d i) Define and explain the term *terminal velocity*.					
(d ii) Describe techniques and procedures used to determine terminal velocity in fluids.					
3.2.3 Equilibrium					
(a) Define and apply the *moment of a force.*					
(b) Explain that a *couple* is a pair of forces that tends to produce rotation only. Define and apply the *torque of a couple*.					
(c) Apply the principle of moments to solve problems					
(d) Define the terms: centre of mass and centre of gravity. Describe a simple experiment to determine the centre of gravity of an object.					
(e) Explain that both the net force and net moment on an extended object in equilibrium is zero.					
(f) Draw and use a triangle of forces to represent the equilibrium of three coplanar forces acting at a point in an object.					
3.2.4 Density and Pressure					
(a) Select and use the equation for density, $\rho = m/V$.					
(b) Select and use the equation for pressure for solids liquids and gases, $p = F/A$, where F is the force normal to the area A.					

Unit 3: Forces and Motion

Topic 3 – Work, Energy and Power

Key Words	Definition
Watt	
Sankey diagram	
Efficiency	
Gravitational potential energy	
Kinetic energy	
Energy	
Conservation of energy	
Work done	
Sound energy	
Joule	
Chemical energy	
Internal energy	
Nuclear energy	
Electromagnetic wave energy	
Power	

Criteria	RAG

	Before Lesson	After Lesson	EOM	Mock Rev	Revision
3.3.1 Work and conservation of energy					
(a) Define *work done* by a force and the *joule.*					
(b) Calculate the work done by a force using $W = Fx$ and $W = Fx \cos \theta$.					
(c) State the principle of conservation of energy.					
(d) Describe examples of energy in different forms, its conversion and conservation, and apply the principle of energy conservation to simple examples.					
(e) Apply the idea that work done is equal to the transfer of energy to solve problems.					
3.3.2 Kinetic and potential energies					
(a) **Recall** and apply the equation for kinetic energy, $E_k = ½ mv^2$. Derive this equation from first principles.					
(b) **Recall** and apply the equation for the change in gravitational potential energy near the Earth's surface, $E_p = mgh$. Derive this equation from first principles.					
(c) Analyse problems where there is an exchange between gravitational potential energy and kinetic energy.					
3.3.3 Power					
(a) Define *power* as the rate of work done, P=W/t, and the *Watt*.					
(b) Use the equation P=Fv Derive this equation using first principles.					
(c) Calculate power when solving problems.					
(d) Select and apply the relationship for efficiency, efficiency = useful output energy / total input energy x 100%.					

Unit 3: Forces and Motion

Topic 4 – Materials

Key Words	Definition
Ductile	
Stress	
Strain	
Brittle	
Ultimate tensile stress	
Polymeric	
Elastic potential energy	
Plastic	
Young's Modulus	
Elastic deformation	
Hooke's Law	
Elastic limit	
Tensile forces	
Compressive forces	
Elastic	
Extension	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
3.4.1 Springs					
(a) Describe how deformation is caused by a force in one dimension and can be tensile or compressive, and can cause extension or compression.					
(b) Recall and use Hooke's Law.					
(c) Select and apply the equation $F = kx$, where k is the force constant of the spring or the wire.					
(d i) Draw and interpret Force-Extension (or compression) graphs for spring and wires. Describe the behaviour of springs and wires in terms of force, extension, elastic limit, Hooke's Law and the force constant (i.e. force per unit extension or compression).					
(d ii) Describe and carry out techniques and procedures used to investigate force–extension characteristics for arrangements which may include springs, rubber bands, polythene strips.					
3.4.2 Mechanical Properties of Matter					
(a) Determine the area under a force against extension (or compression) graph to find the work done by the force.					
(b) Select and use the equations for elastic potential energy $E = \frac{1}{2} Fx$ and $E = \frac{1}{2} kx^2$.					
(c) Define and use the terms *stress*, *strain*, and *ultimate tensile strength* (*breaking stress*).					
(d i) Define *Young's Modulus* as tensile stress/tensile strain, $E = \delta/\varepsilon$					
(d ii) Describe experiments to determine the Young modulus of a metal.					
(e) Describe the shapes of the stress against strain graphs for typical ductile, brittle and polymeric materials.					
(f) Define the terms *elastic deformation* and *plastic deformation* of a material.					

Unit 3: Forces and Motion

Topic 5 – Newton's Laws of Motion and Momentum

Key Words	Definition
Newton's First Law	
Newton's Second Law	
Newton's Third Law	
Linear Momentum	
Impulse of a Force	
Principle of Conservation of Momentum	
Elastic Collision	
Inelastic Collision	

Criteria	RAG				
	Before Lesson	**After Lesson**	**EOM**	**Mock Rev**	**Revision**
3.5.1 Newton's Laws of Motion					
(a) Recall and use Newton's three laws of motion					
(b) Define the term *linear momentum*; p = mv; Understand the vector nature of momentum.					
(c) Select and use the equation: net force = rate of change of momentum; $F = \Delta p / \Delta t$ (F = ma is a special case of this equation.)					
(d) Defie the term *impulse of a force*; impulse = $F\Delta t$					
(e) Calculate the impulse of a force as the area under a force–time graph.					
3.5.2 Collisions					
(a) Describe and explain the principle of conservation of momentum.					
(b) Describe and explain collisions and interaction of bodies in one dimension and in two dimensions.					
(c) Define the terms *perfectly elastic collision* and *inelastic collision*.					

Unit 4: Electrons, Waves & Photons

Topic 1 – Charge and Current

Electric Current - Key Words	Definition
Charge	
Coulomb	
Current	
Conductor	
Semi-conductor	
Insulator	
Conservation of charge	
Drift velocity	
Ampere	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
4.1.1 Charge					
(a) Explain that electric current is the rate of flow of charge; $I = \Delta Q/\Delta t$					
(b) Define the *coulomb*.					
(c) Recall and use the elementary charge $e = 1.6 \times 10^{-19}$. (an electron as a charge of $-e$ and a proton $+e$)					
(d) Recall that the net charge on a particle or an object is quantised as a multiple of *e*.					
(e) Explain that electric current in a metal is due to the movement of electrons, whereas in an electrolyte the current is due to the movement of ions.					
(f) Explain what is meant by conventional current and electron flow.					
(g) Describe Kirchhoff's first law and appreciate that this is a consequence of conservation of charge.					
4.1.2 Mean Drift Velocity					
(a) State what is meant by the term *mean drift velocity* of charge carriers.					
(b) Select and use the equation $I = Anev$.					
(c) Describe the difference between conductors, semiconductors and insulators in terms of the number density *n*.					

Unit 4: Electrons, Waves & Photons

Topic 2 – Energy, Power and Resistance

Key Words	Definition
Terminal	
LDR	
Voltmeter	
Coulomb	
Component	
Ampere	
Current	
Parallel	
Electromotive force	
Thermistor	
Fixed resistor	
Cell	
Charge	
Potential difference	
Series	
Diode	

Fuse	
Battery	
Volt	
Watt	
LED	
Ammeter	
Energy	
Power	
Ohm	
Resistance	
Resistor	
I-V characteristic	
Semiconductor	
Ohm's Law	
Resistivity	
Joule	
Kilo-watt hour	
Sankey diagram	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
4.2.1 Circuit Symbols					
(a) Recall and use appropriate circuit symbols as detailed.					
(b) Interpret and draw circuit diagrams using these symbols.					
4.2.2 E.m.f. and p.d.					
(a) Define *potential difference* (p.d.), *the volt*.					
(b) Define electromotive force (e.m.f) of a source such as a cell or a power supply.					
(c) Describe the difference between e.m.f. and p.d. in terms of energy transfer.					
(d) Select and use the equation $W = VQ$, *and* $W=\varepsilon Q$.					
(e) Energy transfer $eV = 1/2\ mv^2$ for electrons and other charged particles.					
4.2.3 Resistance					
(a) Define *resistance* and the *Ohm*. **Recall** and use the equation for resistance $R = V/I$.					
(b) State and use Ohm's law.					
(c i) Describe the I–V characteristics of a resistor at constant temperature, filament lamp, thermistor, diode and light-emitting diode (LED).					
(c ii) Describe an experiment to obtain the I–V characteristics for a range of Ohmic and non-ohmic components.					
(d) Describe the variation of resistance with light intensity. Describe the uses and benefits of using light-emitting diodes (LEDs).					
4.2.4 Resistivity					
(a i) Define *resistivity* of a material. Select and use the equation $R = \rho L/A$.					
(a ii) Describe and carry out techniques and procedures to determine the resistivity of a material.					
(b) Describe how the resistivity of metals and semiconductors are affected by temperature.					
(c) Describe how the resistance of a pure metal wire and of a negative temperature coefficient (NTC) thermistor is affected by temperature.					
4.2.5 Power					
(a) Select and use the power equations $P = IV$, $P = I^2R$ and $P = V^2/R$.					
(b) Select and use the equation W = VIt					
(c) Define the *kilowatt-hour* (kWh) as a unit of energy. Calculate energy in kWh and the cost of this energy when solving problems.					

Unit 4: Electrons, Waves & Photons

Topic 3 – Electrical Circuits

Key Words	Definition
Series circuit	
Parallel circuit	
Internal resistance	
Kirchoff's first law	
Kirchoff's second law	
Potential divider	
Thermistor	
LDR	

Criteria	RAG				
	Before Lesson	**After Lesson**	**EOM**	**Mock Rev**	**Revision**
4.3.1 Series and Parallel Circuits					
(a) State Kirchoff's second law and appreciate that this is a consequence of conservation of energy.					
(b) Apply Kirchoff's first and second laws to circuits.					
(c) Select and use the equation for the total resistance of two or more resistors in series; $R = R_1 + R_2 + ….$					
(d) Select and use the equation for the total resistance of two or more resistors in parallel; $1/R = 1/R_1 + 1/R_2 + …$					
(e) Solve circuit problems involving series and parallel circuits with various components.					
(f) Solve circuit problems involving series and parallel circuits with one or more sources of e.m.f.					
4.3.2 Internal Resistance					
(a) Explain that all sources of e.m.f. have an internal resistance.					
(b) Explain the meaning of the term *terminal p.d.* and '*lost volts'*					
(c i) Select and use the equations $\varepsilon = I(R + r)$ and $\varepsilon = V + Ir$.					
(c ii) Desribe and carry out techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f.					
4.3.3 Potential Dividers					
(a) Draw and set up a simple potential divider circuit.					
(b) Explain how a potential divider circuit can be used to produce a variable p.d.					
(c i) Select and use the potential divider equations $V_{out} = (R_2/(R_1 + R_2)) \times V_{in}$ and $V_1/V_2 = R_1/R_2$.					
(c ii) Describe and carry out the techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR.					

Unit 3: Electrons, Waves & Photons

Topic 4 – Waves

Waves - Key Words	Definition
Transverse wave	
Longitudinal wave	
Displacement	
Amplitude	
Wavelength	
Frequency	
Period	
Phase difference	
Radian	
Progressive wave	
Electromagnetic wave	
Intensity	
Reflection	

Refraction	
Diffraction	
Plane polarised wave	
Malus’s law	
Strain analysis	
Superposition	
Coherence	
Interference	
Diffraction grating	
Stationary wave	
Node	
Antinode	
Fundamental frequency	
Harmonic	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
4.4.1 Wave motion					
(a) Describe and distinguish between progressive longitudinal and transverse waves.					
(b i) Define and use the terms *displacement, amplitude, wavelength, period, phase difference, frequency* and *speed of a wave.*					
(b ii) Describe and carry out techniques and procedure to use an oscilloscope to determine frequency.					
(c) Select and use the equation $f = 1/T$					
(d) Select and use the wave equation $v = f\lambda$					
(e) Draw and interpret graphical representations of transverse and longitudinal waves.					
(f i) explain what is meant by reflection, refraction, polarisation and diffraction of all waves.					
(f ii) Describe and carry out techniques and procedures used to demonstrate wave effects using a ripple tank.					
(f iii) Describe and carry out techniques and procedures used to observe polarising effects using microwaves and light.					
(g) Define *intensity of a progressive wave* and use the equation $I = P/A$; intensity $\propto$ (amplitude)^2					
2.4.2 Electromagnetic Waves					
(a) Describe the properties of electromagnetic waves. Describe the electromagnetic spectrum.					
(b) State the orders of magnitude of the wavelengths of the different regions of the electromagnetic spectrum from radio waves to gamma waves.					
(c) Explain what is meant by plane polarised waves and understand the polarisation of electromagnetic waves.					
(d i) Describe and explain the refraction of light. Select and use the equation for refractive index; $n=c/v$. Recall that $n \sin \theta$ = constant at a boundary where θ is the angle to the normal.					
(d ii) Describe and carry out techniques and procedures used to investigate refraction and TIR of light using ray boxes, including transparent rectangular and semi-circular blocks.					
(e) Describe and explain TIR for light including the critical angle; $\sin C = 1/n$					
4.4.3 Superposition					
(a i) State and use the principle of superposition of waves					

(a ii) Describe and carry out techniques and procedures used for superposition experiments using sound, light and microwaves.					
(b) Apply graphical methods to illustrate the principle of superposition.					
(c) Explain the terms *interference, coherence, path difference* and *phase difference.*					
(d) State what is meant by *constructive interference* and *destructive interference*, and explain them in terms of path and phase difference.					
(e) Describe experiments that demonstrate two-source interference using sound, light and microwaves.					
(f) Describe the Young double-slit experiment using visible light and explain how it is a classical confirmation of the wave-nature of light.					
(g i) Select and use the equation $\lambda = ax/D$ for electromagnetic waves.					
(g ii) Describe techniques and procedures used to determine the wavelength of light using (1) a double slit, and (2) a diffraction grating.					
4.4.4 Stationary Waves					
(a) Describe experiments to demonstrate stationary waves using microwaves, stretched strings and air columns.					
(b) Explain the formation of stationary (standing) waves using graphical methods.					
(c) Describe the similarities and differences between progressive and stationary waves.					
(d) Define the terms *nodes* and *antinodes*.					
(e i) determine the stationary wave patterns for stretched string and air columns in closed and open pipes.					
(e ii) Describe and carry out techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube.					
(f) use the equation: separation between adjacent nodes (or antinodes) = $\lambda/2$					
(g) define and use the terms *fundamental mode of vibration* and *harmonics*.					

Unit 4 Electrons, Waves & Photons: Topic 5 – Quantum Physics

Key Words	Definition
Photon	
Planck's Constant	
Electronvolt	
LED	
Photoelectric effect	
Stopping potential	
Threshold frequency	
Wave-particle duality	
De Broglie wavelength	
Spectra	
Emission spectra	
Absorption spectra	

Work function	

Criteria	RAG				
	Before Lesson	**After Lesson**	**EOM**	**Mock Rev**	**Revision**
4.5.1 Photons					
(a) Describe the particulate nature (photon model) of electromagnetic radiation.					
(b) State that a photon is a quantum of energy of electromagnetic radiation.					
(c) select and use the equations for the energy of a photon: $E = hf$ and $E = hc/\lambda$					
(d) Define and use the electronvolt (eV) as a unit of energy.					
(e i) Describe an experiment using LEDs to estimate the Planck constant *h* using the equation of $eV = hc/\lambda$ (no knowledge of semiconductor theory is expected)					
(e ii) Determine the Planck constant using different coloured LEDs.					
4.5.2 The photoelectric effect					
(a i) Describe and explain the phenomenon of the photoelectric effect.					
(a ii) Demonstrate the photoelectric effect using a gold leaf electroscope and a zinc plate.					
(b) Describe the photoelectric effect in terms of a one-to-one interaction between a photon and a surface electron.					
(c) Select, explain and use Einstein's photoelectric equation $hf = \phi + KE_{max}$					
(d) Define and use the terms *work function* and *threshold frequency*.					
(e) Explain why the maximum kinetic energy of the electrons is independent of the intensity of the incident radiation.					
(f) Explain why the photoelectric current in a photocell circuit is proportional to intensity of the incident radiation.					
4.5.3 Wave-particle duality					
(a) Explain electron diffraction as evidence for the wave nature of particles like electrons.					
(b) Explain that electrons travelling through polycrystalline graphite will be diffracted by the atoms and the spacing between the atoms.					
(c) Select and apply the de Broglie equation $\lambda = h/p = h/mv$					

Module 5: Newtonian world and Astrophysics

5.1 Thermal Physics

Key Words	Definition
Temperature	
Equilibrium	
Celcius	
Kelvin	
Brownian Motion	
Internal Energy	
Specific Heat Capacity	
Specific Latent Heat	
Avogadro Constant	
Ideal Gas	
Boyle's Law	
Root Mean Square Speed	

Mean Square Speed	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
5.1 Thermal Physics					
(a) Describe thermal equilibrium					
(b) Describe absolute scale of temperature (i.e. the thermodynamic scale) that does not depend on property of any particular substance					
(c) Apply temperature measurements both in degrees Celsius ***(°C)*** and in kelvin ***(K)***					
(d) Use the equation: $T(K) \approx \theta(°C) + 273$					
(e) Describe solids, liquids and gases in terms of the spacing, ordering and motion of atoms or molecules					
(f) Describe simple kinetic model for solids, liquids and gases					
(g) Explain Brownian motion in terms of the kinetic model of matter and a simple demonstration using smoke particles suspended in air					
(h) Describe internal energy as the sum of the random distribution of kinetic and potential energies associated with the molecules of a system					
(i) Describe absolute zero **(0K)** as the lowest limit for temperature; the temperature at which a substance has minimum internal energy					
(j) Explain that an increase in the internal energy of a body occurs as its temperature rises					
(k) Describe the changes in the internal energy of a substance during change of phase; constant temperature during change of phase					
(l) Use the equation: $E = mc\Delta\theta$ for specific heat capacity of a substance					
(m) Describe and complete an electrical experiment to determine the specific heat capacity of a metal or a liquid					
(n) Describe techniques and procedures used for an electrical method to determine the specific heat capacity of a metal block and a liquid					
(o) Use the equation: $E = mL$ specific latent heat of fusion and specific latent heat of vaporisation					
(p) Describe and complete an electrical experiment to determine the specific latent heat of fusion and vaporisation					

Module 5: Newtonian world and Astrophysics

5.2 Circular Motion

Key Words	Definition
Radian	
Period	
Displacement	
Amplitude	
Phase Difference	
Frequency	
Angular frequency	
Angular velocity	
Centripetal Force	
Centripetal Acceleration	
Simple Harmonic Motion	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P5.2.2: Circular motion					
(a) Use the radian as a measure of angle					
(b) Determine the period and frequency of an object in circular motion					
(c) Use the equation: $\omega = 2\pi/T$ or $\omega = 2\pi f$ for angular velocity ω					
(d) Describe how a constant net force perpendicular to the velocity of an object causes it to travel in a circular path					
(e) Use the equation: $v = \omega r$ for constant speed in a circle					
(f) Use the equations: $a = v^2/r$; $a = \omega^2 r$ for centripetal acceleration					
(g) Use the equations: $F = mv^2/r$; $F = m\omega^2 r$ for centripetal force					
(h) Use techniques and procedures to investigate circular motion using a whirling bung					
P5.2.2: Circular motion					
(a) Recall and define the terms displacement, amplitude, period, frequency, angular frequency and phase difference					
(b) Use the equation: $\omega = 2\pi/T$ or $\omega = 2\pi f$ for angular frequency ω					
(c) Define simple harmonic motion and use the equation: $a = -\omega^2 x$					
(d) Use techniques and procedures to determine the period/frequency of simple harmonic oscillations					
(e) Determine solutions to the equation $a = \omega^2 x$ e.g. $x = A \cos \omega t$ or $x = A \sin \omega t$					
(f) Use the equations: $v = \pm \omega\sqrt{A^2 - x^2}$ hence $v_{max} = \omega A$					
(g) Recall that the period of a simple harmonic oscillator is independent of its amplitude (isochronous oscillator)					
(h) Use graphical methods to relate the changes in displacement, velocity and acceleration during simple harmonic motion					
(i) Describe the interchange between kinetic and potential energy during simple harmonic motion					
(j) Draw energy-displacement graphs for a simple harmonic oscillator					
(k) Recall what free and forced oscillations are describe the effects of damping on an oscillatory system					

Module 5: Newtonian world and Astrophysics

5.3 Damping

Key Words	Definition
Damped Oscillations	
Resonance	
Natural Frequency	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P5.3: Damping					
(a) Describe observe forced and damped oscillations for a range of systems					
(b) Define the terms: resonance and natural frequency					
(c) Draw and interpret amplitude-driving frequency graphs for forced oscillators					
(d) Describe practical examples of forced oscillations and resonance					

Module 5: Newtonian world and Astrophysics

5.4 Gravitational Fields

Key Words	Definition
Gravitational field	
Field lines	
Field strength	
Newton's Law of gravitation	
Kepler's Law	
Geostationary	
Gravitational Potential	
Work done	
Escape Velocity	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P5.3: Gravitational Fields					
(a) Recall that gravitational fields are due to objects having mass					
(b) Use modelling the mass of a spherical object as a point mass at its centre					
(c) Use gravitational field lines to map gravitational fields					
(d) Use the equation: $g = F/m$ for gravitational field strength					
(e) Explain the concept of gravitational fields as being one of a number of forms of field giving rise to a force					
(f) Use the equation: Newton's law of gravitation; $F = -GMm/r^2$ for the force between two point masses					
(g) Use the equation: gravitational field strength $g = -GM/r^2$ for a point mass					
(h) Recall that gravitational field strength is uniform close to the surface of the Earth and numerically equal to the acceleration of free fall					
(i) Recall Kepler's three laws of planetary motion					
(j) Recall that the centripetal force on a planet is provided by the gravitational force between it and the Sun					
(k) Use the equation: $T^2 = (4\pi^2/GM)r^3$ and be able to derive it from first principles					
(l) Describe the relationship for Kepler's third law (m) $T^2 \propto r^3$ and apply it to systems other than our solar system					
(n) Recall what a geostationary orbit is and describe the uses of geostationary satellites					
(o) Predict geostationary orbits using Newtonian laws					
(p) Describe gravitational potential at a point as the work done in bringing unit mass from infinity to the point					
(q) Recall that gravitational potential is zero at infinity					
(r) Apply the equation for gravitational potential (s) $V_g = -GM/r$ at a distance r from a point mass M					
(t) Describe changes in gravitational potential for given circumstances					
(u) Draw force–distance graph for a point or spherical mass and recall that work done is the area under graph					

(v) Apply the equation for gravitational potential energy ***$E = mV_g = -GMm/r$*** at a distance ***r*** from a point mass ***M***					
(w) Define escape velocity					
(x) Predict the escape velocity of atoms from the atmosphere of planets					

Module 5: Newtonian world and Astrophysics

5.5 Astrophysics and Cosmology

Key Words	Definition
Planet	
Planetary Satellite	
Comet	
Solar system	
Galaxy	
Universe	
Red giant	
White dwarf	
Planetary nebula	
Chandrasekhar limit	
Neutron star	
Black hole	
Supernova	
Continuous spectrum	

Emission line spectrum	
Absorption line spectra	
Diffraction grating	
Wien’s displacement Law	
Luminosity	
Astronomical unit	
Light year	
Parsec	
Stellar parallax	
Homogeneous	
Isotropic	
Doppler shift	
Hubble’s Law	
Dark energy	
Dark matter	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P5.5: Astrophysics and Cosmology					
(a) Define the terms planets, planetary satellites, comets, solar systems, galaxies and the universe					
(b) Describe formation of a star from interstellar dust and gas in terms of gravitational collapse, fusion of hydrogen into helium, radiation and gas pressure					
(c) Describe evolution of a low-mass star like our Sun into a red giant and white dwarf and describe planetary nebula					
(d) Describe characteristics of a white dwarf, define electron degeneracy pressure and discuss Chandrasekhar limit					
(e) Describe the evolution of a massive star into a red super giant and then either a neutron star or black hole and describe supernova					
(f) Describe characteristics of a neutron star and a black hole					
(g) Describe and explain the Hertzsprung–Russell (HR) diagram as luminosity-temperature plot for main sequence; red giants; super red giants; white dwarfs					
(h) For stars describe energy levels of electrons in isolated gas atoms					
(i) Describe energy levels of electrons in isolated gas atoms					
(j) Recall the idea that energy levels have negative values					
(k) Describe emission spectral lines from hot gases in terms of emission of photons and transition of electrons between discrete energy levels					
(l) Use the equations $hf = \Delta E$ and $hc/\lambda = \Delta E$					
(m) Recall that different atoms have different spectral lines which can be used to identify elements within stars					
(n) Recall what continuous spectrum, emission line spectrum and absorption line spectrum are					
(o) Describe how transmission diffraction grating is used to determine the wavelength of light					
(p) Describe the condition for maxima $d \sin\theta = n\lambda$, where d is the grating spacing					
(q) Use of Wien's displacement law $\lambda_{max} \propto 1/T$ to estimate the peak surface temperature (of a star)					
(r) Use the equation: for luminosity L of a star in Stefan's law $L = 4\pi^2 \sigma T^4$ where σ is the Stefan constant					

(s) Use Wien's displacement law and Stefan's law to estimate the radius of a star					
(t) Recall that distances in cosmology are measured in astronomical unit (AU), light-year (ly) and parsec (pc)					
(u) Define stellar parallax; distances the parsec (pc)					
(v) Use the equation $\boldsymbol{p = 1/d}$, where $\boldsymbol{p}$ is the parallax in seconds of arc and $\boldsymbol{d}$ is the distance in parsec					
(w) Recall the Cosmological principle; universe is homogeneous, isotropic and the laws of physics are universal					
(x) Describe the Doppler effect and the Doppler shift of electromagnetic radiation					
(y) Use the Doppler equation: $\boldsymbol{\Delta \lambda/\lambda \approx \Delta f/f \approx v/c}$ for a source of electromagnetic radiation moving relative to an observer					
(z) Use the equation for: Hubble's law; $\boldsymbol{v \approx H_0 d}$ for receding galaxies, where $\boldsymbol{H_0}$ is the Hubble constant					
(aa) Describe the model of an expanding universe supported by galactic red shift					
(bb) Recall and use the Hubble constant $\boldsymbol{H_0}$ in both $\mathbf{km\ s^{-1}\ Mpc^{-1}}$ and $\mathbf{s^{-1}}$ units					
(cc) Recall and describe the principles of the Big Bang theory					
(dd) Recall experimental evidence for the Big Bang theory from microwave background radiation at a temperature of 2.7 K					
(ee) Discuss the development and acceptance of Big Bang theory by the scientific community					
(ff) Recall the idea that the Big Bang gave rise to the expansion of space-time					
(gg) Describe the estimation for the age of the universe; $\boldsymbol{t \approx H_0^{-1}}$					
(hh) Describe the evolution of the universe after the Big Bang to the present					
(ii) Describe the current ideas of universe is made up of dark energy, dark matter, and a small percentage of ordinary matter.					

Module 6: Particles and medical physics

6.1 Capacitors

Key Words	Definition
Capacitance	
Farad	
Time constant	
Exponential decay	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P6.1: Capacitors					
(a) Use the equation for: capacitance; $C = Q/V$ and recall the unit farad					
(b) Describe charging and discharging of a capacitor or capacitor plates with reference to the flow of electrons					
(c) Describe the total capacitance of two or more capacitors in series as $1/C = 1/C1 + 1/C2$					
(d) Describe the total capacitance of two or more capacitors in parallel as $C = C1 + C2 + \ldots$					
(e) Complete analysis of circuits containing capacitors, including resistors					
(f) Use techniques and procedures to investigate capacitors in both series and parallel combinations using ammeters and voltmeters.					
(g) Draw p.d. – charge graphs for a capacitor and recall energy stored is area under graph					
(h) Recall that energy is stored by capacitor $W = ½\ QV$, $W = ½Q^2/C$ and $W = ½V^2C$					
(i) Investigate charging and discharging capacitor through a resistor					
(j) Use techniques and procedures to investigate the charge and the discharge of a capacitor using both meters and data-loggers					
(k) Recall the time constant of a capacitor–resistor circuit; $\pi = CR$					
(l) Use the equations of the form $x = x^0e^{-1/CR}$ and $x = x^0\ (1 - e^{-1/CR})$ for capacitor–resistor circuits					
(m) Use graphical methods and spreadsheet modelling of the equation $\Delta Q/\Delta t = - Q/CR$ for a discharging capacitor					
(n) Recall how lnx–t graphs can be used to determine CR					
(o) Draw exponential decay graphs and determine constant-ratio property of such a graph.					

Module 6: Particles and medical physics

6.2 Electric Fields

Key Words	Definition
Electric Field	
Uniform electric field	
Electric potential	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P6.2: Electric Fields					
(a) Recall that electric fields are due to charges					
(b) Model a uniformly charged sphere as a point charge at its centre					
(c) Draw electric field lines to map electric fields					
(d) Use the equation E= F/Q for electric field strength					
(e) Use the equation: Coulomb's law; $F = Qq/4\pi\varepsilon_0 r^2$ for the force between two point charges					
(f) Use the equation: $E = Q/ 4\pi\varepsilon_0 r^2$ electric field strength for a point charge					
(g) Discuss the similarities and differences between the gravitational field of a point mass and the electric field of a point charge					
(h) Describe the concept of electric fields as being one of a number of forms of field giving rise to a force					
(i) Use the equation: $E = V/d$ for uniform electric field strength					
(j) Use the equation: $C = \varepsilon_0 A/d$; $C\ \varepsilon A/d$; $\varepsilon=\varepsilon r \varepsilon_0$ for parallel plate capacitor; permittivity					
(k) Describe motion of charged particles in a uniform electric field					
(l) Recall how electric potential is zero at infinity and electric potential at a point as the work done in bringing unit positive charge from infinity to the point					
(m) Use the equation: electric potential $V = Q/4\pi\varepsilon_0 r^2$ at a distance *r* from a point charge					
(n) Describe changes in electric potential					
(o) Use the equation capacitance $C = 4\pi\varepsilon_0 R$ for an isolated sphere and derive it from $Q = VC$					
(p) Draw force–distance graphs for a point or spherical charge and recall that work done is area under graph					
(q) Use the equation: electric potential energy $Qq/4\pi\varepsilon r = Qq/4\pi\varepsilon_0 r$ of a distance r from a point charge Q					
(r) Recall that electric fields are due to charges					

Module 6: Particles and medical physics

6.3 Electromagnetism

Key Words	Definition
Magnetic Field	
Solenoid	
Fleming's Left Hand rule	
Magnetic Flux density	
Tesla	
Velocity selector	
Flux	
Flux Linkage	
Weber	
Faraday's Law	
Lenz's Law	
Search coils	
Transformer	

Criteria	RAG

	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P6.3: Electromagnetism					
(a) Recall that magnetic fields are due to moving charges or permanent magnets					
(b) Draw magnetic field lines to map magnetic fields					
(c) Draw magnetic field patterns for a long straight current carrying conductor, a flat coil and a long solenoid					
(d) Recall and apply Fleming's left-hand rule					
(e) Use the equation: force on a current-carrying conductor; $F = BIL\sin\theta$					
(f) Use techniques and procedures to determine the uniform magnetic flux density between the poles of a magnet using a current-carrying wire & digital balance					
(g) Describe magnetic flux density and use the unit tesla.					
(h) Recall force on a charged particle travelling at right angles to a uniform magnetic field; $F = BQv$					
(i) Recall that charged particles moving in a uniform magnetic field; circular orbits of charged particles in a uniform magnetic field					
(j) Describe how charged particles move in a region occupied by both electric and magnetic fields and recall what velocity selector is					
(k) Explain and use the terms: magnetic flux density, flux φ and flux linkage $\varphi = Ba\cos\theta$ and use the unit weber					
(l) Explain how to use Faraday's law to determine the magnitude of an induced e.m.f.					
(m) Use the equation that combines Faraday's and Lenz's laws $E = -\Delta(N\phi)/\Delta t$					
(n) Use techniques and procedures used to investigate magnetic flux using search coils					
(o) Describe and explain a simple a.c. generator and a simple laminated iron-cored transformer					
(p) Use the equation: $ns/np = vs/vp = Ip/Is$ for an ideal transformer					
(q) Use techniques and procedures to investigate transformers					
(r) Recall that magnetic fields are due to moving charges or permanent magnets					

Module 6: Particles and medical physics

P6.4: Nuclear and particle physics

Key Words	Definition
Strong nuclear force	
Particles and antiparticles	
Positron	
Neutrino	
Hadron	
Lepton	
Quark	
β+ decay	
B- decay	
spontaneous	
Random	
Decay constant	

Half life	
Annihilation	
Pair production	
Mass defect	
Binding energy	
Induced nuclear fission	
Chain reaction	
Fuel rods	
Control rods	
Moderator	
Fusion	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P6.4: Nuclear and particle physics					
Describe and explain alpha-particle scattering experiment as evidence of a small charged nucleus					
Recall the simple nuclear model of the atom and describe the relative sizes of atom and nucleus					
Recall the meaning of the terms proton number; nucleon number; isotopes and recall the notation $^{A}_{Z}X$ for the representation of nuclei					
Describe the strong nuclear force and short-range nature of the force and recall that it is attractive to about 3 fm and repulsive below about 0.5 fm					
Use the equation: for radius of nuclei; $R = r_0A^{1/3}$ = where r_0 is a constant and A is the nucleon number					
Calculate mean densities of atoms and nuclei					
Define the terms particles and antiparticles; electron–positron, proton-antiproton, neutron-antineutron and neutrino-antineutrino					
Recall that a particle and its corresponding antiparticle have same mass; electron and positron have opposite charge; proton and antiproton have opposite charge					
Describe the classification of hadrons; proton and neutron as examples of hadrons					
Recall that all hadrons are subject to the strong nuclear force					
Describe the classification of leptons; electron and neutrino as examples of leptons					
Recall that all leptons are subject to the weak nuclear force					
Describe simple quark model of hadrons in terms of up (u), down (d) and strange (s) quarks and their respective anti-quarks					
Describe the quark model of the proton (uud) and the neutron (udd)					
Recall the charges of the up (u), down (d), strange (s), anti-up ($\overline{u}$), anti-down ($\overline{d}$) and the anti-strange($\overline{s}$) quarks as fractions of the elementary charge e					
Describe beta-minus **(β-)** decay and beta-plus **(β+)** decay					
Describe β– decay in terms of a quark model;					
Describe β+ decay in terms of a quark model;					
Balance quark transformation equations in terms of charge					
Describe the decay of particles in terms of the quark model					
Describe radioactive decay in terms of the spontaneous and random nature of decay					

Explain the relationships between the nature, penetration, ionising ability and range in different materials of nuclear radiations (alpha, beta and gamma)					
Use techniques and procedures to investigate the absorption of α-particles, β-particles and γ-rays by appropriate materials					
Use nuclear decay equations for alpha, beta-minus and beta-plus decays					
Describe the activity of a source; decay constant λ of an isotope and use $A = \lambda N$					
Calculate the half-life of an isotope; $\lambda t_{1/2} = \ln(2)$					
Use techniques and procedures to determine the half-life of an isotope such as protactinium					
Use the equations: $A = A_0 e^{-\lambda t}$ and $N = N_0 e^{-\lambda t}$, where A is the activity and N is the number of undecayed nuclei					
Simulate radioactive decay using dice					
Use graphical methods and spreadsheet modelling of the equation $\Delta N/\Delta t = -\lambda N$ for radioactive decay					
Describe applications of radioactive dating, e.g. carbon-dating					
Recall and use Einstein's mass–energy equation; $\Delta E = \Delta mc^2$					
Describe how energy is released (or absorbed) in simple nuclear reactions					
Describe the creation and annihilation of particle–antiparticle pairs					
Define the terms mass defect; binding energy; binding energy per nucleon					
Describe the binding energy per nucleon against nucleon number curve for energy changes in reactions					
Explain the binding energy of nuclei using Einstein's mass–energy equation and masses of nuclei					
Describe induced nuclear fission and chain reactions					
Recall the basic structure and function of a fission reactor including components – fuel rods, control rods and moderator					
Describe the environmental impact of nuclear waste					
Discuss the decision making process when building new nuclear power stations					
Describe nuclear fusion including fusion reactions and temperature					
Balance nuclear transformation equations					

Module 6: Particles and medical physics

P6.5: Medical imaging

Key Words	Definition
X-ray	
Attenuation	
Simple scatter	
Photoelectric effect	
Compton effect	
Pair production	
Contrast media	
CAT	
Tracer	
Gamma camera	
Scintillator	
Collimator	

Photomultiplier tube	
PET	
Ultrasound	
Piezoelectric effect	
Transducer	
A-scan	
B-scan	
Acoustic impedance	

Criteria	RAG				
	Before Lesson	After Lesson	EOM	Mock Rev	Revision
P6.5: Medical imaging					
Describe basic structure of an X-ray tube including components – heater (cathode), anode, target metal and high voltage supply					
Describe the production of X-ray photons from an X-ray tube					
Describe and explain X-ray attenuation mechanisms; simple scatter, photoelectric effect, Compton effect and pair production					
Describe X-ray imaging with contrast media using barium and iodine					
Describe computerised axial tomography (CAT) scanning including components – rotating X-tube, ring of detectors, computer software and display					
Discuss advantages of a CAT scan over an X-ray image					
Describe the use of medical tracers including technetium–99m and fluorine–18					
Discuss and explain gamma camera; components – collimator, scintillator, photomultiplier tubes, computer and display and describe the formation of image					
Explain diagnosis using gamma camera					
Describe the positron emission tomography (PET) scanner including annihilation of positron–electron pairs and the formation of image					
Discuss diagnosis using PET scanning					
Discuss Issues raised when equipping a hospital with an expensive scanner					
Describe ultrasound as a longitudinal wave with frequency greater than 20 kHz					
Describe the Piezoelectric effect and the ultrasound transducer as a device that emits and receives ultrasound					
Discuss the differences between ultrasound A-scan and B-scan					
Describe the acoustic impedance of a medium and reflection of ultrasound at a boundary;					
Discuss impedance (acoustic) matching and use of special gel in ultrasound scanning					
Explain the Doppler effect in ultrasound for the speed of blood in the patient $\Delta f/f = 2v\cos\theta/c$ for r determining the speed v of blood					