



The John Roan School Sixth Form

The best in everyone™

Part of United Learning

A-Level Physics

Exam board: OCR

Course code: H556

Student Handbook

Contents

Curriculum.....	p3
Specification.....	p6
Mark schemes.....	p27
Practical Skills Guidance	p28
Physics Equations not on the datasheet.....	p30
Assessment.....	p31
Model answers.....	p34
Homework.....	p35
How to get an A*.....	p37
Essential resources.....	p37
University courses and careers.....	p40

Inspired

Confident

Ambitious

At The John Roan Sixth Form,
students will be ***inspired*** by our
commitment to their destinations.

They will feel ***confident*** in their
abilities and prospects because of our
teaching and curriculum and they will
be ***ambitious*** because of the
opportunities we provide.

Welcome to Physics

Curriculum Aims (KS5)

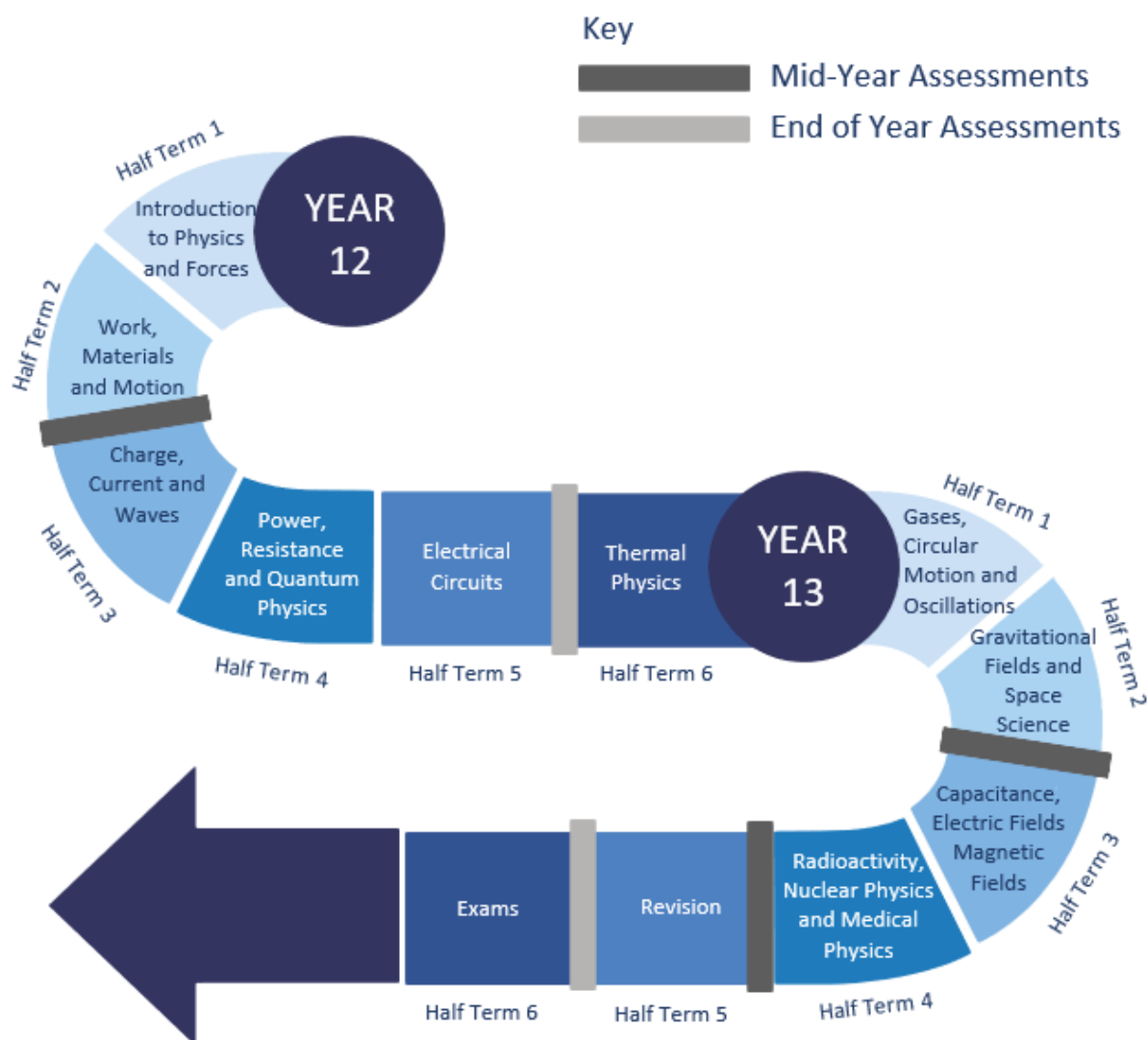
The purpose of the Physics curriculum is to ensure that students develop their knowledge understanding and skills with respect to the practical subject that is Physics. The teaching takes a content led approach to the course. This is a flexible approach where the specification is divided into topics, each covering different key concepts of physics. As learners progress through the course, they'll build on their knowledge of the laws of physics, applying their understanding to areas from sub-atomic particles to the entire universe.

Here we explore the John Roan curriculum principles in the context of the Physics curriculum:

- **Entitlement:** all pupils need to develop essential knowledge and understanding of different areas of the subject and how they relate to each other. Through their learning, they will develop and demonstrate a deep appreciation of the skills, knowledge and understanding of the scientific method. They will also develop competence and confidence in a variety of practical, mathematical and problem solving skills.
- **Coherence:** Our curriculum is carefully sequenced to maximise knowledge, skills and understanding. The course has 6 modules and there is a clear rationale for the order in which these are studied. The year 12 modules build on work from GCSE and then the year 13 modules further develop and enhance these foundations.
- **Mastery:** regular testing (low and high tariff questions) is embedded within the curriculum. This enables teachers to ensure that foundational knowledge, skills and concepts are secure. To support mastery pupils revisit prior learning on a lesson-by-lesson basis, while feedback is at the heart of the teaching process.
- **Adaptability:** the core curriculum is in line with the demands of the OCR specification and the focus is exam success for all. In addition, we are seeking to develop their interest in further study and careers associated with the subject. Teachers adapt lesson to meet the needs of their classes.
- **Representation:** All pupils will be able to see themselves within the Physics curriculum. Our curriculum aspires to take all students beyond their immediate experience and to build an understanding of how society make decisions about scientific issues and how the sciences contribute to the success of the economy and society as exemplified in 'How Science Works'.
- **Education with character:** Through the curriculum pupils are given regular opportunities to discuss and reflect upon a wide variety of scientific issues. There are opportunities to look into subjects that affect their daily lives, as well as go into areas beyond the specification. Targets for improvement or comments should be acted upon.

Physics

Key Stage 5



Roadmap of the Physics Curricula

The roadmap diagram sets out the route that pupils take through our curriculum. The approach is thematic and is underpinned by a sound rationale. In Year 12 students study modules 2, 3 and 4 building on GCSE work and extending further into A level work. At the end of year 12, we start on module 5 with topics that build on the earlier modules and continue into year 13 expanding the knowledge at the frontiers of physics.

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How we organise our work and learn in A-Level Physics

- Each lesson, you will be expected to work on file paper. Make sure you do the title and date for the work, and date each sheet you get. You will be expected to have with you a folder with the current topics you are working on in. The day-to-day folder will also have the physics datasheet, spare file paper and graph paper. You will also be expected to bring your PAG book and all practical work will be completed into the PAG book. You will also keep the most recent half-term's worth of assessments in here.
- You will need a level arch file and dividers. This should be used to store completed topics. There should be 1 topic per division, and all notes, worksheets, PHATs and the end of topic test and evaluation should be stored in here.
- In addition, you will be given a set of blank revision cards at the start of the year. You will work on these after each lesson to build up a set of revision notes for yourself, adding in information from lessons, PHATs and end of topic tests to support your learning.
- The PAG book will be a record of your achievements with regards to the practical endorsement. Each piece of practical work should be headed with a title and date, both underlined. The front of the book should act as a contents table, so write the name of the practical and the page number here too. Each page will also need to be numbered. All practical sheets should be stuck into the book. You should adhere to the guidance in the practical skills section of this booklet for guidance on results table and graphs.
- You will also have access to an online textbook as well as Uplearn. Use both of these to support your learning.
- In lessons, the lesson will start with a Do Now, which is recall knowledge. You should try to answer this without using your notes. After this, your teacher will connect your learning objectives for the lesson with the curriculum, teach and then get you to do a range of activities to check, practice and consolidate your learning.



Exam Specification

Content Overview	Assessment Overview	
Content is split into six teaching modules: - Module 1 – Development of practical skills in physics - Module 2 – Foundations of physics - Module 3 – Forces and motion - Module 4 – Electrons, waves and photons - Module 5 – Newtonian world and astrophysics - Module 6 – Particles and medical physics Component 01 assesses content from modules 1, 2, 3 and 5. Component 02 assesses content from modules 1, 2, 4 and 6. Component 03 assesses content from all modules (1 to 6).	Modelling physics (01) 100 marks 2 hours 15 minutes written paper	37% of total A level
	Exploring physics (02) 100 marks 2 hours 15 minutes written paper	37% of total A level
	Unified physics (03) 70 marks 1 hour 30 minutes written paper	26% of total A level
	Practical Endorsement in physics (04) (non exam assessment)	Reported separately (see Section 5g)



Exam Specification

Module 1 - Development of practical skills in physics			
1.1 Practical skills assessed in a written examination			
1.1.1 Planning			
(a) experimental design, including to solve problems set in a practical context, including selection of suitable apparatus, equipment, and techniques for the proposed experiment. Learners should be able to apply scientific knowledge based on the content of the specification to the practical context.			
(b) identification of variables that must be controlled, where appropriate			
(c) evaluation that an experimental method is appropriate to meet the expected outcomes			
1.1.2 Implementing			
(a) how to use a wide range of practical apparatus and techniques correctly			
(b) appropriate units for measurements			
(c) presenting observations and data in an appropriate format			
1.1.3 Analysis			
(a) processing, analysing and interpreting qualitative and quantitative experimental results Including reaching valid conclusions, where appropriate.			
(b) use of appropriate mathematical skills for analysis of quantitative data			
(c) appropriate use of significant figures			
(d) plotting and interpreting 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) how to evaluate results and draw conclusions Learners should be able to evaluate how the scientific community use results to validate new knowledge and ensure integrity.			
(b) the identification of anomalies in experimental measurements			
(c) the limitations in experimental procedures			
(d) precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus			
(e) refining of experimental design by suggestion of improvements to the procedures and apparatus			
1.2 Practical skills assessed in the practical endorsement			
1.2.1 Practical skills			
Practical work carried out throughout the course will enable learners to develop the following 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. Learners should understand how to minimise the risks involved.			
(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			



Exam Specification

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 The Practical Skills Handbook provides guidance on appropriate methods for citing information.			
Instruments and equipment			
(i) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding including in the specification			
1.2.2 Use of apparatus and techniques			
Through use of the apparatus and techniques listed below, and the minimum of 12 assessed practicals learners should be able to demonstrate all the practical skills listed within 1.2.1 and CPAC as exemplified through:			
(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 marking			
(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 fiducial marker, set square or plumb line			
(d) use of a stopwatch or light gates for timing			
(e) use of callipers and micrometers for small distances, using digital or Vernier scales			
(f) correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important			
(g) designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components			
(h) use of a signal generator and oscilloscope, including volts/division and time-base			
(i) generating and measuring 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 reference 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			



Exam Specification

Module 2 - Foundations in physics				
2.1	Physical quantities and units			
2.1.1	Physical quantities			
(a)	physical quantities have a numerical value and a unit			
(b)	making estimates of physical quantities listed in this specification			
2.1.2	S.I. units			
(a)	Système Internationale (S.I.) base quantities and their units - mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)			
(b)	derived units of S.I. base units Examples: momentum $\rightarrow \text{kg m s}^{-1}$ and Density $\rightarrow \text{kg m}^{-3}$			
(c)	units listed in the specification			
(d)	checking the homogeneity of physical equations using S.I. base units			
(e)	prefixes and their symbols to indicate decimal submultiples 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)	the conventions used for labelling graph axes and table columns e.g. speed / m s^{-1}			
2.2	Making measurements and analysing data			
2.2.1	Measurements and uncertainties			
(a)	systematic errors (including zero errors) and random errors in measurements			
(b)	precision and accuracy			
(c)	absolute and percentage uncertainties when data are combined by addition, subtraction, multiplication, division and raising to powers A rigorous statistical treatment is not expected.			
(d)	graphical treatment of errors and uncertainties; line of best fit; worst line; absolute and percentage uncertainties; percentage difference An elementary knowledge of error bars is expected at A level.			
2.3	Nature of quantities			
2.3.1	Scalars and vectors			
(a)	Scalar and vector quantities Learners will also be expected to give examples of each.			
(b)	vector addition and subtraction			
(c)	vector triangle to determine the resultant of any two coplanar vectors To be done by calculations or by scale drawing.			
(d)	resolving a vector into two perpendicular components; $F_x = F \cos \theta$; $F_y = F \sin \theta$			



Exam Specification

Module 3 - Forces and motion				
3.1 Motion				
3.1.1 Kinematics				
(a)	displacement, instantaneous speed, average speed, velocity and acceleration			
(b)	graphical representations of displacement, speed, velocity and acceleration Using data-loggers to analyse motion.			
(c)	displacement-time graphs, velocity is gradient			
(d)	velocity-time graphs, acceleration is gradient; displacement is area under graph Learners will also be expected to estimate the area under non-linear graphs.			
3.1.2 Linear motion				
(a)	(i) the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance $v = u + at$ $s = \frac{1}{2}(u + v)t$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ (ii) techniques and procedures used to investigate the motion and collisions of objects Apparatus may include trolleys, air-track gliders, ticker timers, light gates, data-loggers, and video techniques.			
(b)	(i) acceleration g of free fall (ii) techniques and procedures used to determine the acceleration of free fall using trapdoor and electromagnet arrangement or light gates and timer. Determining g in the laboratory.			
(c)	reaction time and thinking distance; braking distance and stopping distance for a vehicle			
3.1.3 Projectile motion				
(a)	independence of the vertical and horizontal motion of a projectile			
(b)	two-dimensional motion of a projectile with constant velocity in one direction and constant acceleration in a perpendicular direction			
3.2 Forces in action				
3.2.1 Dynamics				
(a)	net force = mass $\times$ acceleration; $F = ma$ Learners will also be expected to recall this equation.			
(b)	the newton as the unit of force			
(c)	weight of an object; $W = mg$ Learners will also be expected to recall this equation.			
(d)	the terms tension, normal contact force, upthrust and friction			
(e)	free-body diagrams			
(f)	one- and two-dimensional motion under constant force			
3.2.2 Motion with non-uniform acceleration				
(a)	drag as the frictional force experienced by an object travelling through a fluid			
(b)	factors affecting drag for an object travelling through air			
(c)	motion of objects falling in a uniform gravitational field in the presence of drag			
(d)	(i) terminal velocity (ii) techniques and procedures used to determine terminal velocity in fluids. E.g., ball-bearing in a viscous liquid or cones in air. Investigating factors affecting terminal velocity.			



Exam Specification

3.2.3 Equilibrium			
(a) moment of force			
(b) couple; torque of a couple			
(c) the principle of moments			
(d) centre of mass; centre of gravity; experimental determination of centre of gravity			
(e) equilibrium of an object under the action of forces and torques			
(f) condition for equilibrium of three coplanar forces; triangle of forces			
3.2.4 Density and pressure			
(a) density; $\rho = \frac{m}{V}$			
(b) pressure; $p = \frac{F}{A}$ for solids, liquids and gases			
(c) $p = h\rho g$; upthrust on an object in a fluid; Archimedes' principle			
3.3 Work, energy and power			
3.3.1 Work and conservation of energy			
(a) work done by a force; the unit joule			
(b) $W = Fx \cos \theta$ for work done by a force			
(c) the principle of conservation of energy			
(d) energy in different forms; transfer and conservation			
(e) transfer of energy is equal to work done			
3.3.2 Kinetic and potential energies			
(a) kinetic energy of an object; $E_k = \frac{1}{2}mv^2$ Learners will also be expected to recall this equation and derive it from first principles.			
(b) gravitational potential energy of an object in a uniform gravitational field; $E_p = mgh$ Learners will also be expected to recall this equation and derive it from first principles.			
(c) the exchange between gravitational potential energy and kinetic energy			
3.3.3 Power			
(a) power; the unit watt; $P = \frac{W}{t}$			
(b) $P = Fv$ Learners will also be expected to derive this equation from first principles.			
(c) efficiency of a mechanical system; efficiency = $\frac{\text{useful output energy}}{\text{total input energy}} \times 100\%$			
3.4 Materials			
3.4.1 Springs			
(a) tensile and compressive deformation; extension and compression			
(b) Hooke's law			
(c) force constant k of a spring or wire; $F = kx$			
(d) (i) force-extension (or compression) graphs for springs and wires (ii) techniques and procedures used to investigate force-extension characteristics for arrangements which may include springs, rubber bands, polythene strips.			



Exam Specification

3.4.2 Mechanical properties of matter			
(a) force-extension (or compression) graph; work done is area under graph			
(b) elastic potential energy; $E = \frac{1}{2}Fx$; $E = \frac{1}{2}kx^2$			
(c) stress, strain and ultimate tensile strength			
(d) (i) Young modulus = $\frac{\text{tensile stress}}{\text{tensile strain}}$, $E = \frac{\sigma}{\epsilon}$ (ii) techniques and procedures used to determine the Young modulus for a metal.			
(e) stress-strain graphs for typical ductile, brittle and polymeric materials			
(f) elastic and plastic deformations of materials Investigating the properties of materials.			
3.5 Newton's laws of motion and momentum			
3.5.1 Newton's laws of motion			
(a) Newton's three laws of motion			
(b) linear momentum; $p = mv$; vector nature of momentum			
(c) net force = rate of change of momentum; $F = \frac{\Delta p}{\Delta t}$ Learners are expected to know that $F = ma$ is a special case of this equation.			
(d) impulse of a force; impulse = $F\Delta t$			
(e) impulse is equal to the area under a force-time graph Learners will also be expected to estimate the area under non-linear graphs. Using a spreadsheet to determine impulse from F - t graph.			
3.5.2 Collisions			
(a) the principle of conservation of momentum			
(b) collisions and interaction of bodies in one dimension and in two dimensions Two-dimensional problems will only be assessed at A level.			
(c) perfectly elastic collision and inelastic collision			



Exam Specification

Module 4 - Electrons, waves and photons				
4.1 Charge and current				
4.1.1 Charge				
(a)	electric current as rate of flow of charge; $I = \frac{\Delta Q}{\Delta t}$			
(b)	the coulomb as the unit of charge			
(c)	the elementary charge e equals $1.6 \times 10^{-19} \text{ C}$ Learners will be expected to know that an electron has charge $-e$ and a proton $+e$.			
(d)	net charge on a particle or an object is quantised and a multiple of e			
(e)	current as the movement of electrons in metals and movement of ions in electrolytes			
(f)	conventional current and electron flow			
(g)	Kirchhoff's first law: conservation of charge			
4.1.2 Mean drift velocity				
(a)	mean drift velocity of charge carriers			
(b)	$I = Anev$, where n is the number density of charge carriers			
(c)	distinction between conductors, semiconductors and insulators in term of n			
4.2 Energy, power and resistance				
4.2.1 Circuit symbols				
(a)	circuit symbols As set out in ASE publication <i>Signs, Symbols and Systematics (The ASE Companion to 16-19 Science, 2000)</i> .			
(b)	circuit diagrams using these symbols			
4.2.2 E.m.f and p.d				
(a)	potential difference (p.d.); the unit volt			
(b)	electromotive force (e.m.f.) of a source such as a cell or a power supply Epsilon is used as the symbol for e.m.f. to avoid confusion with E which is used for energy and electric field. The ASE guide 'Signs, symbols and systematics' details E as the correct symbol for e.m.f. and this will be credited in all examinations.			
(c)	distinction between e.m.f. and p.d. in terms of energy transfer			
(d)	energy transfer; $W = VQ$; $W = \epsilon Q$			
(e)	energy transfer $eV = \frac{1}{2}mv^2$ for electrons and other charged particles			
4.2.3 Resistance				
(a)	resistance; $R = \frac{V}{I}$; the unit ohm Learners will also be expected to recall this equation.			
(b)	Ohm's law			
(c)	(i) I - V ; characteristics of resistor, filament lamp, thermistor, diode and light-emitting diode (LED) (ii) techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components. Investigating components and analysing data using spreadsheet.			
(d)	light-dependent resistor (LDR); variation of resistance with light intensity			



Exam Specification

4.2.4 Resistivity				
(a)	(i) resistivity of a material; the equation $R = \frac{\rho L}{A}$; the unit ohm (ii) techniques and procedures used to determine the resistivity of a metal.			
(b)	the variation of resistivity of metals and semiconductors with temperature			
(c)	negative temperature coefficient (NTC) thermistor; variation of resistance with temperature			
4.3 Electrical circuits				
4.3.1 Series and parallel circuits				
(a)	Kirchhoff's second law; the conservation of energy			
(b)	Kirchhoff's first and second laws applied to electrical circuits			
(c)	total resistance of two or more resistors in series; $R = R_1 + R_2 + \dots$			
(d)	total resistance of two or more resistors in parallel; $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$			
(e)	analysis of circuits with components, including both series and parallel			
(f)	analysis of circuits with more than one source of e.m.f.			
4.3.2 Internal resistance				
(a)	source of e.m.f.; internal resistance			
(b)	terminal p.d.; 'lost volts'			
(c)	(i) the equations $\mathcal{E} = I(R + r)$ and $\mathcal{E} = V + Ir$ (ii) techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f. Investigating the internal resistance of a power supply.			
4.3.3 Potential dividers				
(a)	potential divider circuit with components			
(b)	potential divider circuits with variable components e.g. LDR and thermistor			
(c)	(i) potential divider equations e.g. $V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$ and $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (ii) techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR. Designing temperature and light sensing circuits.			
4.4 Waves				
4.4.1 Wave motion				
(a)	progressive waves; longitudinal and transverse waves			
(b)	(i) displacement, amplitude, wavelength, period, phase difference, frequency and speed of a wave (ii) techniques and procedures used to use an oscilloscope to determine frequency.			
(c)	the equation $f = \frac{1}{T}$			
(d)	the wave equation $v = f\lambda$			
(e)	Graphical representations of transverse and longitudinal waves			
(f)	(i) reflection, refraction, polarisation and diffraction of all waves (ii) techniques and procedures used to demonstrate wave effects using a ripple tank (iii) Techniques and procedures used to observe polarising effecting using microwaves and light.			
(g)	intensity of a progressive wave; $I = \frac{P}{A}$; intensity $\propto$ (amplitude) ²			



Exam Specification

4.4.2 Electromagnetic waves			
(a) electromagnetic spectrum; properties of electromagnetic waves			
(b) orders of magnitude of wavelengths of the principal radiations from radio waves to gamma rays			
(c) plain polarised waves, polarisation of electromagnetic waves Learners will be expected to know about polarising filters for light and metal grilles for microwaves in demonstrating polarisation.			
(d) (i) refraction of light; refractive index; $n = \frac{c}{v}$; $n \sin \theta = \text{constant}$ at a boundary where θ is the angle to the normal (ii) techniques and procedures used to investigate refraction and total internal reflection of light using ray boxes, including transparent rectangular and semi-circular block.			
(e) critical angle; $\sin c = \frac{1}{n}$; total internal reflection for light			
4.4.3 Superposition			
(a) (i) the principle of superposition of waves (ii) techniques and procedures used for superposition experiments using sound, light and microwaves.			
(b) graphical methods to illustrate the principle of superposition			
(c) interference, coherence, path difference and phase difference			
(d) constructive interference and destructive interference in terms of path difference and phase difference			
(e) two-source interference with sound and microwaves			
(f) Young double-slit experiment using visible light Learners should understand that this experiment gave a classical confirmation of the wave-nature of light. Internet research on the ideas of Newton and Huygens about the nature of light.			
4.4.4 Stationary waves			
(a) stationary (standing) waves using microwaves, stretched strings and air columns			
(b) graphical representations of a stationary wave			
(c) similarities and the differences between stationary and progressive waves			
(d) nodes and antinodes			
(e) (i) stationary wave patterns for a stretched string and air columns in closed and open tubes (ii) techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube.			
(f) the idea that the separation between adjacent nodes (or antinodes) is equal to $\lambda/2$, where λ is the wavelength of the progressive wave			
(g) fundamental mode of vibration (1 st harmonic) harmonics			
4.5 Quantum Physics			
4.5.1 Photons			
(a) the particulate nature (photon model) of electromagnetic radiation			
(b) photon as a quantum of energy of electromagnetic radiation			
(c) energy of photon; $E = hf$ and $E = \frac{hc}{\lambda}$			
(d) the electronvolt (eV) as a unit of energy			
(e) (i) using LEDs and the equation $eV = \frac{hc}{\lambda}$ estimate the value of Planck constant h (ii) Determine the Planck constant using different coloured LEDs. No knowledge of semiconductor theory is required.			



Exam Specification

4.5.2 The photoelectric effect				
(a)	(i) photoelectric effect, including a simple experiment to demonstrate this effect (ii) demonstration of the photoelectric effect using, e.g. gold-leaf electroscope and zinc plate. Learners should understand that the photoelectric effect provides evidence for particulate nature of electromagnetic radiation. Internet research on the development of quantum physics.			
(b)	a one-to-one interaction between a photon and a surface electron			
(c)	Einstein's photoelectric equation $hf = \phi + KE_{\max}$			
(d)	work function; threshold frequency			
(e)	the idea that the maximum kinetic energy of the photoelectrons is independent of the intensity of the incident radiation			
(f)	the idea that rate of emission of photoelectrons above the threshold frequency is directly proportional to the intensity of the incident radiation			
4.5.3 Wave-particle duality				
(a)	electron diffraction, including experimental evidence of this effect Learners should understand that electron diffraction provides evidence for wave-like behaviour of particles.			
(b)	diffraction of electrons travelling through a thin slice of polycrystalline graphite by the atoms of graphite and the spacing between the atoms			
(c)	the de Broglie equation $\lambda = \frac{h}{p}$			



Exam Specification

Module 5 -Newtonian World and Astrophysics				
5.1	Thermal Physics			
5.1.1	Temperature			
(a)	thermal equilibrium			
(b)	absolute scale of temperature (i.e. the thermodynamic scale) that does not depend on property of any particular substance			
(c)	temperature measurements both in degrees Celsius ($^{\circ}\text{C}$) and in kelvin (K)			
(d)	$T(\text{K}) \approx \theta(^{\circ}\text{C}) + 273$			
5.1.2	Solid, liquid and gas			
(a)	solids, liquids and gases in terms of the spacing, ordering and motion of atoms or molecules			
(b)	simple kinetic model for solids, liquids and gases			
(c)	Brownian motion in terms of the kinetic model of matter and a simple demonstration using smoke particles suspended in air			
(d)	internal energy as the sum of the random distribution of kinetic and potential energies associated with the molecules of a system			
(e)	absolute zero (0 K) as the lowest limit for temperature; the temperature at which a substance has minimum internal energy			
(f)	increase in the internal energy of a body as its temperature rises			
(g)	changes in the internal energy of a substance during change of phase; constant temperature during change of phase			
5.1.3	Thermal properties of materials			
(a)	specific heat capacity of a substance; the equation $E = mc\Delta\theta$ Estimating specific heat capacity, using method of mixture.			
(b)	(i) an electrical experiment to determine the specific heat capacity of a metal or a liquid (ii) techniques and procedures used for an electrical method to determine the specific heat capacity of a metal block and a liquid.			
(c)	specific latent heat of fusion and specific latent heat of vaporisation; $E = mL$			
(d)	(i) an electrical experiment to determine the specific latent heat of fusion and vaporisation (ii) techniques and procedures used for an electrical method to determine the specific latent heat of a solid and a liquid.			



Exam Specification

5.1.4 Ideal gases				
(a)	amount of substance in moles; Avogadro constant N_A equals $6.02 \times 10^{23} \text{ mol}^{-1}$			
(b)	model of kinetic theory of gases assumptions for the model: - large number of molecules in random, rapid motion - particles (atoms or molecules) occupy negligible volume compared to the volume of gas - all collisions are perfectly elastic and the time of the collisions is negligible compared to the time between collisions - negligible forces between particles except during collision			
(c)	pressure in terms of this model Explanation of pressure in terms of Newtonian theory.			
(d)	(i) the equation of state of an ideal gas $pV = nRT$, where n is the number of moles (ii) techniques and procedures used to investigate $PV = \text{constant}$ (Boyle's law) and $\frac{P}{T} = \text{constant}$			
(e)	the equation $pV = \frac{1}{3}Nmc^2$ where N is the number of particles (atoms or molecules) and $\overline{c^2}$ is the mean square speed Derivation of this equation is not required.			
(f)	root mean square (r.m.s.) speed; mean square speed Learners should know about the general characteristics of the Maxwell-Boltzmann distribution.			
(g)	the Boltzmann constant; $k = \frac{R}{N_A}$			
(h)	$pV = NkT$; $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ Learners will also be expected to know the derivation of the equation $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ from $pV = \frac{1}{3}Nmc^2$ and $pV = NkT$.			
(i)	internal energy of an ideal gas			
5.2 Circular motion				
5.2.1 Kinematics of circular motion				
(a)	the radian as a measure of angle			
(b)	period and frequency of an object in circular motion			
(c)	angular velocity ω ; $\omega = \frac{2\pi}{T}$ or $\omega = 2\pi f$			
5.2.2 Centripetal force				
(a)	a constant net force perpendicular to the velocity of an object causes it to travel in a circular path			
(b)	constant speed in a circle; $v = \omega r$			
(c)	centripetal acceleration; $a = \frac{v^2}{r}$; $a = \omega^2 r$			
(d)	(i) centripetal force; $F = \frac{mv^2}{r}$; $F = m\omega^2 r$ (ii) techniques and procedures used to investigate circular motion using a whirling bung			



Exam Specification

5.3	Oscillations			
5.3.1	Simple harmonic oscillations			
(a)	displacement, amplitude, period, frequency, angular frequency and phase difference			
(b)	angular frequency ω ; $\omega = \frac{2\pi}{T}$ or $\omega = 2\pi f$			
(c)	(i) simple harmonic motion; defining equation $a = -\omega^2 x$ (ii) techniques and procedures used to determine the period/frequency of simple harmonic oscillations e.g. mass on a spring, pendulum			
(d)	solutions to the equation $a = -\omega^2 x$ e.g. $x = A \cos \omega t$ or $x = A \sin \omega t$			
(e)	$v = \pm \omega \sqrt{A^2 - x^2}$ hence $v_{\max} = \omega A$			
(f)	the period of a simple harmonic oscillator is independent of its amplitude (isochronous oscillator)			
(g)	graphical methods to relate the changes in displacement, velocity and acceleration during simple harmonic motion			
5.3.2	Energy of a simple harmonic oscillator			
(a)	interchange between kinetic and potential energy during simple harmonic motion			
(b)	energy-displacement graphs for a simple harmonic oscillator			
5.3.3	Damping			
(a)	free and forced oscillations			
(b)	(i) the effects of damping on an oscillatory system (ii) observe forced and damped oscillations for a range of systems.			
(c)	resonance; natural frequency			
(d)	amplitude-driving frequency graphs for forced oscillators			
(e)	practical examples of forced oscillations and resonance			
5.4	Gravitational fields			
5.4.1	Point and spherical masses			
(a)	gravitational fields are due to objects having mass			
(b)	modelling the mass of a spherical object as a point mass at its centre			
(c)	gravitational field lines to map gravitational fields			
(d)	gravitational field strength; $g = \frac{F}{m}$			
(e)	the concept of gravitational fields as being one of a number of forms of field giving rise to a force Learners will be expected to link this with section 6.2.			
5.4.2	Newton's law of gravitation			
(a)	Newton's law of gravitation; $F = -\frac{GMm}{r^2}$ for the force between two point masses			
(b)	gravitational field strength $g = -\frac{GM}{r^2}$ for a point mass			
(c)	gravitational field strength is uniform close to the surface of the Earth and numerically equal to the acceleration of free fall			



Exam Specification

5.4.3 Planetary motion			
(a) Kepler's three laws of planetary motion			
(b) the centripetal force on a planet is provided by the gravitational force between it and the Sun			
(c) the equation $T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$ Learners will also be expected to derive this equation from first principles.			
(d) the relationship for Kepler's third law $T^2 \propto r^3$ applied to systems other than our solar system			
(e) geostationary orbit; uses of geostationary satellites Predicting geostationary orbit using Newtonian laws.			
5.4.4 Gravitational potential and energy			
(a) gravitational potential at a point as the work done in bringing unit mass from infinity to the point; gravitational potential is zero at infinity			
(b) gravitational potential $V_g = -\frac{GM}{r}$ at a distance r from a point mass M ; changes in gravitational potential			
(c) force-distance graph for a point or spherical mass; work done is area under graph			
(d) gravitational potential energy $E = mV_g = -\frac{GMm}{r}$ at a distance r from a point mass M			
(e) escape velocity Predicting the escape velocity of atoms from the atmosphere of planets.			
5.5 Astrophysics and cosmology			
5.5.1 Stars			
(a) the terms planets, planetary satellites, comets, solar systems, galaxies and the universe			
(b) formation of a star from interstellar dust and gas in terms of gravitational collapse, fusion of hydrogen into helium, radiation and gas pressure Learners are not expected to know the details of fusion in terms of Einstein's mass-energy equation.			
(c) evolution of a low-mass star like our Sun into a red giant and white dwarf; planetary nebula			
(d) characteristics of a white dwarf; electron degeneracy pressure; Chandrasekhar limit			
(e) evolution of a massive star into a red super giant and then either a neutron star or black hole; supernova			
(f) characteristics of a neutron star and a black hole			
(g) Hertzsprung-Russell (HR) diagram as luminosity-temperature plot; main sequence; red giants; super red giants; white dwarf			



Exam Specification

5.5.2 Electromagnetic radiation from stars			
(a) energy levels of electrons in isolated gas atoms			
(b) the idea that energy levels have negative values			
(c) emission spectral lines from hot gases in terms of emission of photons and transition of electrons between discrete energy levels			
(d) the equations $hf = \Delta E$ and $\frac{hc}{\lambda} = \Delta E$ Learners will also require knowledge of section 4.5.			
(e) different atoms have different spectral lines which can be used to identify elements within stars			
(f) continuous spectrum, emission line spectrum and absorption line spectrum			
(g) transmission diffraction grating used to determine the wavelength of light The structure and use of an optical spectrometer are not required.			
(h) the condition for maxima $d \sin \theta = n \lambda$, where d is the grating spacing Proof of this equation is not required.			
(i) use of Wien's displacement law $\lambda_{\max} \propto \frac{1}{T}$ to estimate the peak surface temperature (of a star)			
(j) luminosity L of a star; Stefan's law $L = 4\pi r^2 \sigma T^4$ where σ is the Stefan constant Learners will also require knowledge of 4.4.1			
(k) use of Wien's displacement law and Stefan's law to estimate the radius of a star			
5.5.3 Cosmology			
(a) distances measured in astronomical unit (AU), light-year (ly) and parsec (pc)			
(b) stellar parallax; distances the parsec (pc)			
(c) the equation $p = \frac{1}{d}$, where p is the parallax in seconds of arc and d is the distance in parsec			
(d) the Cosmological principle; universe is homogeneous, isotropic and the laws of physics are universal			
(e) Doppler effect; Doppler shift of electromagnetic radiation			
(f) Doppler equation $\frac{\Delta \lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$ for a source of electromagnetic radiation moving relative to an observer			
(g) Hubble's law; $v = H_0 d$ for receding galaxies, where H_0 is the Hubble constant			
(h) model of an expanding universe supported by galactic red shift			
(i) Hubble constant H_0 in both $\text{km s}^{-1}\text{Mpc}^{-1}$ and s^{-1} units			
(j) the Big Bang theory			
(k) experimental evidence for the Big Bang theory from microwave background radiation at a temperature of 2.7 K The development and acceptance of Big Bang theory by the scientific community.			
(l) the idea that the Big Bang gave rise to the expansion of space-time			
(m) estimation for the age of the universe; $t \approx H_0^{-1}$			
(n) evolution of the universe after the Big Bang to the present			
(o) current ideas; universe is made up of dark energy, dark matter, and a small percentage of ordinary matter			



Exam Specification

Module 6 - Particles and Medical Physics

6.1 Capacitors				
6.1.1 Capacitors				
(a)	capacitance; $C = \frac{Q}{V}$; the unit farad			
(b)	charging and discharging of a capacitor or capacitor plates with reference to the flow of electrons			
(c)	total capacitance of two or more capacitors in series; $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$			
(d)	total capacitance of two or more capacitors in parallel; $C = C_1 + C_2 + \dots$			
(e)	(i) analysis of circuits containing capacitors, including resistors (ii) techniques and procedures used to investigate capacitors in both series and parallel combinations using ammeters and voltmeters.			
6.1.2 Energy				
(a)	p.d. - charge graph for a capacitor; energy stored is area under graph			
(b)	energy stored by capacitor; $W = \frac{1}{2} QV$, $W = \frac{1}{2} \frac{Q^2}{C}$ and $W = \frac{1}{2} V^2 C$			
(c)	uses of capacitors as storage of energy			
6.1.3 Charging and discharging capacitors				
(a)	(i) charging and discharging capacitor through a resistor (ii) techniques and procedures to investigate the charge and discharge of a capacitor using both meters and data-loggers. Investigating the charge and discharge of capacitors in the laboratory.			
(b)	time constant of a capacitor-resistor circuit; $\tau = CR$			
(c)	equations of the form $x = x_0 e^{-\frac{t}{CR}}$ for capacitor-resistor circuits $x = x_0(1 - e^{-\frac{t}{CR}})$ Learners will be expected to know how $\ln x$ - t graphs can be used to determine CR .			
(d)	graphical methods and spreadsheet modelling of the equation $\frac{\Delta Q}{\Delta t} = -\frac{Q}{CR}$ for a discharging capacitor Using spreadsheets to model the discharge of a capacitor.			
(e)	exponential decay graph; constant-ratio property of such a graph			
6.2 Electric Fields				
6.2.1 Point and spherical charges				
(a)	electric fields are due to charges			
(b)	modelling a uniformly charged sphere as a point charge at its centre			
(c)	electric field lines to map electric fields			
(d)	electric field strength; $E = \frac{F}{Q}$			
6.2.2 Coulomb's law				
(a)	Coulomb's law; $F = \frac{Qq}{4\pi\epsilon_0 r^2}$ for the force between two point charges Learners will also require knowledge of section 3.2.			
(b)	electric field strength $E = \frac{Q}{4\pi\epsilon_0 r^2}$ for a point charge			
(c)	similarities and differences between the gravitational field of a point mass and the electric field of a point charge Learners will also require knowledge of 5.4.			
(d)	the concept of electric fields as being one of a number of forms of field giving rise to a force Learners will be expected to link this with 5.4.			



Exam Specification

6.2.3	Uniform electric field			
(a)	uniform electric field strength; $E = \frac{V}{d}$			
(b)	electric field strength $C = \frac{q_0 A}{d}$; $C = \frac{z A}{d}$; $\epsilon = \epsilon_r \epsilon_0$ Learners are not expected to know why the relative permittivity $\epsilon_r \geq 1$.			
(c)	motion of charged particles in a uniform electric field Learners will also require knowledge of 3.1, 3.2 and 3.3.			
6.2.4	Electric potential and energy			
(a)	electric potential at a point as the work done in bringing unit positive charge from infinity to the point; electric potential is zero at infinity			
(b)	electric potential $V = \frac{Q}{4\pi\epsilon_0 r}$ at a distance r from a point charge; changes in electric potential			
(c)	capacitance $C = 4\pi\epsilon_0 R$ for an isolated sphere Derivation expected from equation for electric potential and $Q = VC$.			
(d)	force-distance graph for a point or spherical charge; work done is area under graph			
(e)	electric potential energy $= Vq = \frac{Qq}{4\pi\epsilon_0 r}$ at a distance r from a point charge Q			
6.3	Electromagnetism			
6.3.1	Magnetic fields			
(a)	magnetic fields are due to moving charges or permanent magnets			
(b)	magnetic field lines to map magnetic fields			
(c)	magnetic field patterns for a long straight current-carrying conductor, a flat coil and a long solenoid			
(d)	Fleming's left-hand rule			
(e)	(i) force on a current-carrying conductor; $F = BIL \sin \theta$ (ii) techniques and procedures used to determine the uniform magnetic flux density between the poles of a magnet using a current-carrying wire and digital balance.			
(f)	magnetic flux density; the unit tesla			
6.3.2	Motion of charged particles			
(a)	force on a charged particle travelling at right angles to a uniform magnetic field; $F = BQv$			
(b)	charged particles moving in a uniform magnetic field; circular orbits of charged particles in a uniform magnetic field Learners will also require knowledge of 3.2, 3.3 and 5.2.			
(c)	charged particles moving in a region occupied by both electric and magnetic fields; velocity selector			
6.3.3	Electromagnetism			
(a)	magnetic flux ϕ ; the unit weber $\phi = BA \cos \theta$			
(b)	magnetic flux linkage			
(c)	Faraday's law of electromagnetic induction and Lenz's law			
(d)	(i) e.m.f. = - rate of change of magnetic flux linkage; $\epsilon = - \frac{\Delta(N\phi)}{\Delta t}$ (ii) techniques and procedures used to investigate magnetic flux using search coils.			
(e)	simple a.c. generator			
(f)	(i) simple laminated iron-cored transformer; $\frac{n_s}{n_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s}$ for an ideal transformer (ii) techniques and procedures used to investigate transformers.			



Exam Specification

6.4 Nuclear and particle physics				
6.4.1 The nuclear atom				
(a)	alpha-particle scattering experiment; evidence of a small charged nucleus			
(b)	simple nuclear model of the atom; protons; neutrons and electrons			
(c)	relative sizes of atom and nucleus			
(d)	proton number; nucleon number; isotopes; notation A_ZX for the representation of nuclei.			
(e)	strong nuclear force; short-range nature of the force; attractive to about 3 fm and repulsive below about 0.5 fm $1\text{ fm} = 10^{-15}\text{ m}$			
(f)	radius of nuclei; $R = r_0 A^{\frac{1}{3}}$ where r_0 is a constant and A is the nucleon number			
(g)	mean densities of atoms and nuclei			
6.4.2 Fundamental particles				
(a)	particles and antiparticles; electron-positron, proton-antiproton, neutron-antineutron and neutrino-antineutrino			
(b)	particle and its corresponding antiparticle have same mass; electron and positron have opposite charge; proton and antiproton have opposite charge			
(c)	classification of hadrons; proton and neutron as examples of hadrons; all hadrons are subject to both the strong nuclear force and the weak nuclear force			
(d)	classification of leptons; electron and neutrino as examples of leptons; all leptons are subject to the weak nuclear force but not the strong nuclear force			
(e)	simple quark model of hadrons in terms of up (u), down (d) and strange (s) quarks and their respective anti-quarks			
(f)	quark model of the proton (uud) and the neutron (udd)			
(g)	charges of the up (u), down (d), strange (s), anti-up ($\bar{u}$), anti-down ($\bar{d}$) and the anti-strange ($\bar{s}$) quarks as fractions of the elementary charge e			
(h)	beta-minus (β^-) decay; beta-plus (β^+) decay			
(i)	β^- decay in terms of a quark model; $d \rightarrow u + {}^0_{-1}e + \bar{\nu}$			
(j)	β^+ decay in terms of a quark model; $u \rightarrow d + {}^0_{+1}e + \nu$			
(k)	balancing of quark transformation equations in terms of charge			
(l)	decay of particles in terms of the quark model			



Exam Specification

6.4.3	Radioactivity			
(a)	radioactive decay; spontaneous and random nature of decay			
(b)	(i) α -particles, β -particles and γ -rays; nature, penetration and range of these radiations			
(b)	(ii) techniques and procedures used to investigate the absorption of α -particles, β -particles and γ -rays by appropriate materials			
(c)	nuclear decay equations for alpha, beta-minus and beta-plus decays; balancing nuclear transformation equations			
(d)	activity of a source; decay constant λ of an isotope; $A = \lambda N$ Learners will also require knowledge of 5.1.4(a).			
(e)	(i) half-life of an isotope; $\lambda \ t_{\frac{1}{2}} = \ln(2)$			
	(ii) techniques and procedures used to determine the half-life of an isotope such as protactinium.			
(f)	(i) 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			
	(ii) simulation of radioactive decay using dice.			
(g)	graphical methods and spreadsheet modelling of the equation $\frac{\Delta N}{\Delta t} = -\lambda N$ for radioactive decay Using spreadsheets to model the radioactive decay of nuclei.			
(h)	radioactive dating e.g. carbon-dating			
6.4.4	Nuclear fission and fusion			
(a)	Einstein's mass-energy equation; $\Delta E = \Delta mc^2$			
(b)	energy released (or absorbed) in simple nuclear reactions			
(c)	creation and annihilation of particle-antiparticle pairs			
(d)	mass defect; binding energy; binding energy per nucleon			
(e)	binding energy per nucleon against nucleon number curve; energy changes in reactions			
(f)	binding energy of nuclei using $\Delta E = \Delta mc^2$ and masses of nuclei			
(g)	induced nuclear fission; chain reaction			
(h)	basic structure of a fission reactor; components – fuel rods, control rods and moderator			
(i)	environmental impact of nuclear waste Decision making process when building new nuclear power stations.			
(j)	nuclear fusion; fusion reactions and temperature Learners will also require knowledge of 5.1.4.			
(k)	balancing nuclear transformation equations			



Exam Specification

6.5.1 Medical imaging			
6.5.1 Using X-rays			
(a) basic structure of an X-ray tube; components - heater (cathode), anode, target metal and high voltage supply			
(b) production of X-ray photons from an X-ray tube			
(c) X-ray attenuation mechanisms; simple scatter, photoelectric effect, Compton effect and pair production			
(d) attenuation of X-rays; $I = I_0 e^{-\mu x}$, where μ is the attenuation (absorption) coefficient			
(e) X-ray imaging with contrast media; barium and iodine			
(f) computerised axial tomography (CAT) scanning; components - rotating X-tube producing a thin fan-shaped X-ray beam, ring of detectors, computer software and display			
(g) advantages of a CAT scan over an X-ray image			
6.5.2 Diagnostic methods in medicine			
(a) medical tracers; technetium-99m and fluorine-18			
(b) gamma camera; components - collimator, scintillator, photomultiplier tubes, computer and display; formation of image			
(c) diagnosis using gamma camera			
(d) positron emission tomography (PET) scanner; annihilation of positron-electron pairs; formation of image			
(e) diagnosis using PET scanning Issues raised when equipping a hospital with an expensive scanner.			
6.5.3 Using ultrasound			
(a) ultrasound; longitudinal wave with frequency greater than 20 kHz			
(b) piezoelectric effect; ultrasound transducer as a device that emits and receives ultrasound			
(c) ultrasound A-scan and B-scan			
(d) acoustic impedance of a medium; $Z = \rho c$			
(e) reflection of ultrasound at a boundary; $\frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$			
(f) impedance (acoustic) matching; special gel used in ultrasound scanning			
(g) Doppler effect in ultrasound; speed of blood in the patient; $\frac{\Delta f}{f} = \frac{2v \cos \theta}{c}$ for determining the speed v of blood			



Mark Scheme

The markscheme given here is for an extended response question. They are by their nature, generic, with specific criteria adapted to the question. To achieve the higher of the 2 marks in each level, you need to have shown the examiner that you can do the part that is *italicised*.

This one is for practical design:

Level 3 (5–6 marks)

Clear description of a valid experiment which would lead to accurate results, sensible suggestions for table, graph and accuracy

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Reasonable description of experiment and sensible suggestion for table **or** graph **or** accuracy, or attempt at all three

There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.

Level 1 (1–2 marks)

Attempt at experiment and attempt at table **or** graph **or** accuracy

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.



Practical Skills guidance

Tables

The following guidelines should be followed when presenting results in tables.

- All raw data in a single table with ruled lines and border.
- Independent variable (IV) in the first column; dependent variable (DV) in columns to the right (for quantitative observations) OR descriptive comments in columns to the right (for qualitative observations).
- Processed data (e.g. means, rates, s.d.) in columns to the far right.
- No calculations in the table, only calculated values.
- Each column headed with informative description (for qualitative data) or physical quantity and correct units (for quantitative data); units separated from physical quantity using either brackets or a solidus (slash).
- No units in the body of the table, only in the column headings.
- Raw data recorded to a number of decimal places appropriate to the resolution of the measuring equipment.
- All raw data of the same type recorded to the same number of decimal places.
- Processed data recorded to up to one significant figure more than the raw data.

Graphs

The following guidelines should be followed when presenting data in graphs.

- There should be an informative title.
- Range bars may be used to show the highest and lowest readings for each set of data.
- Scales should be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions and that are easy to work with.
- Plotted points must be accurate to half a small square – so use a sharp pencil to plot them.
- A line of best fit should have a reasonable balance of points about the line. Using a clear ruler will help with this.
- For calculating gradients, the length of the hypotenuse of the triangle should be greater than half the length of the line which has been drawn.
- The values of Δx and Δy must be given to an accuracy of at least one small square and remember to give appropriate units for the gradient.
- The y-intercept must be read from the axis where $x=0$, otherwise calculate from $y=mx+c$.



Practical Skills guidance

Referencing

Whenever a piece of information that has been retrieved from a source is provided in a text, a reference should be provided.

The Harvard system looks like this:

The first laser was operated in 1960 by Theodor Malman (Hecht, 1987)
There is then a list of full references at the end of the document in alphabetical order. For multi-author works, then the first author followed by 'et al' is used.

Books

General Format:

Authors (year), *Title*, edition (if relevant), publisher's location, publisher.

e.g. Bone (2015), *A level Physics for OCR A*, Oxford, Oxford University Press

If a book does not have named authors, then the reference begins with the title.

Journal Articles

General Format:

Author (year), 'Article Title', *Journal Title*, vol. no, issue no, pp. xx-xx

e.g. Aad, G et al (2012), 'Observation of a new particle in search for the Standard Model Higgs boson with the ATLAS detector at the LHC' *Physics letters B*, vol 716, no 1, pp 1-29

Websites

General Format:

Authors (year), Title [online] last accessed date: URL

e.g. Dianna Cowern (2015), Crazy pool vortex [online] Last accessed 22 April 2015: <https://www.youtube.com/watch?v=pnbJEg9r1o8>

If it is not possible to identify the author, then the organisation is given. If no website or organisation can be found, then consideration should be given as to whether the website is a trustworthy source!



Physics Equations not on the datasheet:

Module 3:

3.2.1 a - net force = mass x acceleration; $F = m a$

3.2.1 c - weight of an object; $W = m g$

3.3.2 a - kinetic energy of an object; $E_k = \frac{1}{2} m v^2$

3.3.2 b - gravitational potential energy of an object in a uniform gravitational field; $E_p = m g h$

Module 4:

4.2.3 a - resistance; $R = V / \underline{I}$; the unit ohm

Equations you need to be able to derive:

From Module 3:

3.3.2 a - $E_k = \frac{1}{2} m v^2$

3.3.2 b - $E_p = m g h$

3.3.3 b - $P = F v$

From Module 5.1.4 Ideal Gases:

(h) $pV = NkT$; $\frac{1}{2} m \overline{c^2} = \frac{3}{2} kT$

Learners will also be expected to know the derivation of the equation $\frac{1}{2} m \overline{c^2} = \frac{3}{2} kT$ from $pV = \frac{1}{3} N m \overline{c^2}$ and $pV = NkT$.

From Module 5.4.3 Planetary Motion

(c) the equation $T^2 = \left(\frac{4\pi^2}{GM} \right) r^3$

Learners will also be expected to derive this equation from first principles.

From Module 6.2.4 Electric Potential and Energy

(c) capacitance $C = 4\pi\epsilon_0 R$ for an isolated sphere

Derivation expected from equation for electric potential and $Q = VC$.



Assessment

Methods of formal assessment in Physics are as follows:

1. End of Unit Assessments
2. Mock Examinations

1. End of Unit Assessments

You will complete an end of unit assessment at the end of each unit of work as laid out in the table below. You will be given a minimum of 1 weeks' notice to prepare for each assessment and may be allocated revision tasks as homework or may have to complete this in your own time.

Module 2/3	Module 4
Foundations of Physics	Charge and Current
Motion	Energy, Power and Resistance
Forces in Action	Electrical Circuits
Work, Energy and Power	Waves 1
Materials	Waves 2
Laws of Motion and Momentum	Quantum Physics
Module 5	Module 6
Thermal Physics	Capacitance
Ideal Gas	Electric Fields
Circular Motion	Magnetic Fields
Oscillations	Particle Physics
Gravitational Fields	Radioactivity
Stars	Nuclear Physics
Cosmology	Medical Imaging



Assessment

Methods of formal assessment in Physics are as follows:

1. End of Unit Assessments
2. Mock Examinations

2. Mock Examinations

Throughout Year 12 and 13 you will be entitled to rigorous mock examinations to simulate the real thing. By the time you sit your real exam in the Summer of year 13 you will have extensive experience completing each exam paper under simulated conditions. You will be sitting the following examinations for Physics:

Mock Examination	Papers
Mock Exam – Winter Term of Year 12	• Paper based on Modules 2 and 3
UCAS Exams – Summer of Year 12	• Paper 1: Breadth of Physics • Paper 2: Depth of Physics • Based on Modules 1, 2, 3 and 4.
Mock Exam – Winter Term of Year 13	• Paper 1: Modelling Physics • Based on Modules 1, 2, 3 and 5. • Paper 2: Electrons, Waves & Photons. • Based on Module 1, 2 and 4 exam.
Final Mock Exam – Spring Term of Year 13	• Paper 1: Modelling Physics • Based on Modules 1, 2, 3 and 5. • Paper 2: Exploring Physics • Based on Modules 1, 2, 4 and 6. • Paper 3: Unified Physics • Based on All 6 modules.

The dates for these exams will be given to you at the beginning of the academic year. You will be given plenty of notice and time to revise, as well as a personalised exam table for each set of exams.

Access Arrangements

If at any time you feel you would benefit from additional access arrangements in an exam, such as the use of a laptop, please speak with your subject teacher as soon as possible.



Assessment

Command Works

All the exam questions that you encounter have command words that tell you what they want you to do with the question. Here is a list of them all:

Calculate	This is used when a numerical answer is required using equations/ideas from the specification. Working should be shown. The final answer must be consistent with the number of significant figures given in the question.
Compare	Both similarities and differences between ideas or concepts is required.
Complete	Add words, numbers, labels or plots to complete a sentence, table, diagram graph, equation, etc.
Deduce/ predict	An answer is required that is not recall, but one based on making logical connections between other pieces of information.
Define	A formal statement or a word equation is required. Any symbols used must be defined.
Describe	This requires candidates to state in words and/or in diagrams the main points of the topic. The amount of description will depend on the marks allocated.
Determine	This often implies that the quantity can be calculated from the available information (e.g. graph, table, text, etc).
Discuss	An answer that requires a critical account of the points involved in the topic.
Drawdiagram	A simple freehand drawing is required (e.g. apparatus, circuits, etc). Labelling of apparatus is expected. Circuits diagrams must be drawn using conventional symbols.
Estimate	This may require a calculation in which sensible assumptions are made and realistic values for quantities.
Evaluate	Make qualitative, or quantitative, judgements and or reasoning conclusions.
Explain	This requires reasoning and perhaps also reference to theory. Use of correct physics vocabulary and principles may be expected. The depth of the expected answer will depend on the marks awarded for the question.
List	A number of points with no explanation are required.
Name	Provide appropriate word(s) or term(s).
Outline	Provide a description setting out the main characteristics / points.
Plan	Consider, set out and communicate what is to be done.
Plot	Translate data from a table, or text, onto a labelled grid or graph.
Show	The actual, or an approximate value, for a physical quantity is given in the question. Candidates are expected to derive a given result. It is good practice to show all steps of the working and also to provide explanations where necessary.
Sketch .. a graph	The shape of the graph needs to be correct. Candidates may also be expected to show additional information on the graph (values on the axes, y-intercept, gradient, whether or not the curve/line passes through the origin, etc.)
State	Candidates are expected to write a brief answer without any supporting or justifying statements.
Suggest	There is often no single correct answer. Candidates will be given credit for sensible reasoning based on correct physics.
Use / using	The answer must be based on information given in the question.
What	MCQ: A request for information, clarified by the context or question in which it is set.
Which	MCQ: Identify an object, work or explanation.
Why	MCQ: For what reason?



Model Answers

All AS and A level exam papers have model answers as videos that can be found using sharepoint.

Please use these, along with your class noted to enhance your revision cards.



Homework & Independent Work

Objectives of a Sixth Form Homework Policy

Objectives of a John Roan Sixth Form Homework policy are as follows:

- To enable our students to achieve the best grades that they are capable of at Post-16 through:
 - The consolidation and revision of learned material
 - The application of learned material
 - Preparation for lessons to enable access to challenging subject content
- To reinforce high expectations of our students as independent learners
- To equip our students with the study skills required for University and other destinations

Expectation of subject homework

At The John Roan Sixth Form we aim to teach students to become independent learners who use their private study time effectively. Students will be given guidance and support with creating revision schedules, effective note taking, essay writing and academic literacy, but will also be expected to practise and demonstrate these in their home learning.

As a benchmark, students should expect to receive an amount of homework per subject that is equivalent to twice the number of contact hours that they receive in school: six hours per subject which amounts to 18 hours per week.

Deadlines

Failure to meet deadlines for homework will result in a one hour detention after school the following day, while repeated failures to meet homework deadline will escalate to an academic support plan or school based exclusion. Students who are placed into detention will still be expected to complete missed homework. Students are encouraged to communicate with teachers about other deadlines in place so that they can be supportive of work set in other subjects.

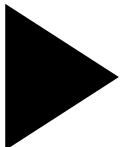
Homework setting

All homework will be set for students using Show My Homework which is available as an app which can be accessed via a mobile phone, or as a website that can be accessed via a computer. In some instances, homework will be set on software including Microsoft Teams. However, instructions for any homework set on these platforms will be repeated on Show My Homework to ensure consistency.



Homework & Independent Work

Examples of homework set at KS5 in A-Level Physics will typically include:

Revision	Application	Flipped-Learning
		
Revision homework tasks will enable you to consolidate your learning and eliminate gaps in subject knowledge, helping you to prepare for your exams.	Application homework tasks test for understanding of recently-acquired subject knowledge and develop your technique for exams.	Flipped learning homework tasks ensure that you are able to access challenging subject material and allow you to progress quickly through your course.
✓ Standing Homework of producing revision notes from the lesson. ✓ You can use your revision cards to do this. ✓ Creating mind maps and flashcards ✓ Creating / revising from check lists ✓ Creating glossaries of terms ✓ Creating flow charts ✓ Creating a topic quiz ✓ Revising for a topic quiz ✓ Completing past papers	✓ Standing homework of completing end of topic questions ✓ Completing PAG write up ✓ Completion of a practical follow up sheet. ✓ Completing a calculation sheet. ✓ Completing past papers questions ✓ Preparing a presentation for a lesson ✓ Completing coursework or another assignment for a deadline ✓ Independent or guided research on a lesson topic ✓ Completing a topic quiz	✓ Standing homework of pre-reading the next lesson's topic. ✓ Preparation of notes in advance of a next lesson ✓ Answering comprehension questions ahead of a new topic ✓ Preparing a presentation for a lesson ✓ Independent research in preparation for an experiment ✓ Independent or guided research ahead of a lesson

Inspired

Confident

Ambitious



How to get an A* at Physics A-Level

- To get an A* grade in Physics you will need to demonstrate in your exams that you have a detailed and comprehensive knowledge and understanding of scientific ideas, processes, techniques and procedures from the range covered in the specification, applying them to familiar and new contexts.
- You will need to select information carefully to ensure that it is relevant to the question, giving explanations that are lucid and well-structured and you will communicate this clearly and concisely using appropriate scientific terminology.
- You will be able to manipulate algebraic equations fluently and accurately, using significant figures, powers of ten and SI units, and carry out complex calculations yielding results that are error free and expressed with appropriate precision.
- You will demonstrate a firm grasp of the scientific reasons for using the whole range of practical procedures mentioned in the specification.
- You will use your knowledge and understanding to demonstrate wide-ranging insights into the development and refinement of most areas of practical designs and procedures.
- You will be able to suggest and make observations and measurements with appropriate precision and use a range of qualitative and quantitative data to form a judgement or reach a conclusion.
- You will be able to select and link information and ideas from different parts of the specification in order to give explanations that are usually complete and accurate.
- You will analyse with fluency and accuracy, information and evidence that is provided in a wide variety of unfamiliar contexts selecting a full range of appropriate techniques involving theoretical and practical areas of the specification.
- You will get about 80% of the marks!



Essential Resources & Wider Reading



Podcasts

Sean Carroll's Mindscape

Talk Nerdy

Ologies

The Titan Physicists Quirks and Quarks

This Week In Science

The Infinite Monkey Cage

Science with Dr Karl

Great moments in science

Science friction



Websites

<https://gorillaphysics.com/> - Revision materials

<https://isaacphysics.org/> - Stretch and support materials

<https://www.alevelphysicsonline.com/> - Revision Materials

<https://www.iop.org/#gref> - The Institute of Physics

www.sixtysymbols.com - Videos about the Symbols of Physics and Astronomy

www.physicsworld.com - Physics World

<http://home.web.cern.ch/topics/large-hadron-collider> - Information about the LHC at CERN



Videos

Sunshine (2007)

Hidden Figures (2016)

The Theory of Everything (2014)

Infinity (1996)

Copenhagen (2002)

Interstellar (2014)

Particle Fever (2013)

The Imitation Game (2014)

The Martian (2015)



Essential Resources & Wider Reading



Books

"Moondust: In Search of the Men Who Fell to Earth" by Andrew Smith
"Surely You're Joking Mr Feynman: Adventures of a Curious Character", "QED- The Strange Theory of Light and Matter" and others by Richard Feynman
"Quantum Theory Cannot Hurt You: Understanding the Mind-Blowing Building Blocks of the Universe" by Marcus Chown
"A Brief History of Time" by Stephen Hawking
"How to Build a Universe" by Brian Cox and Robin Ince
"The Elegant Universe" by Brian Greene
"Three Roads to Quantum Gravity" by Lee Smolin
"Blackholes and Timewarps: Einstein's Outrageous Legacy" by Kip Thorne
"In Search of Schrodinger's Cat" and "Schrodinger's Kittens" by John Gribbin
"Quantum Theory Cannot Hurt You" by Marcus Chown
"How to Teach Quantum Physics to Your Dog" by Chad Orzel
"Why does $E=mc^2$?" by Brian Cox and Jeff Forshaw
"A Short History of Nearly Everything" by Bill Bryson
"Hidden Unity in Nature's Laws" by John C. Taylor
"Fizz: Nothing is as it seems" by Zvi Schreiber
"Great Physicists" by William H Cropper
"What if?" by Randall Munroe



Books

"The perfect theory: A century of geniuses and the battle over general relativity" by Pedro G. Ferreira
"Reality is Not What it Seems" and "Seven Brief Lessons in Physics" by Carlo Rovelli
"The Particle at the End of the Universe" by Sean Carroll
"Longitude" by Dava Sobel
"Quantum" by Manjit Kumar
"Relativity: The Special and General Theory" by Albert Einstein
"Quantum Theory: A Very Short Introduction" by John Polkinghorne
"The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory" by Brian Greene
"12 Books that Changed the World" by Melvyn Bragg
"Why the Toast Always Lands Butter Side Down: The Science of Murphy's Law" by Richard Robinson
"Stargazing 2011" by Heather Couper
"Why Don't Penguins' Feet Freeze? And 114 Other Questions" by New Scientist
"Newton" by Peter Ackroyd
"The Grand Design" by Stephen Hawking and Leonard Mlodinow
"The Flying Circus of Physics" by Jearl Walker
"The Skeptics' Guide to the Universe" by Steven Novella
"Bad Science" by Ben Goldacre
"The Complete Robot" by Isaac Asimov
"Forces of Nature" by Brian Cox and Andrew Cohen
"A Universe from Nothing" by Lawrence M Krauss



University Courses & Career Paths



Transferrable skills

Critical thinking
Analysis
Problem Solving
Public speaking
Presentation skills

Teamworking
Numeracy
Communication
Time Management &
Organisation

IT skills
Research & Data
Analysis
Reasoning



University Courses

Physics, Astrophysics, Quantum Physics, Particle Physics
Thermodynamics, Nanotechnology

Natural Sciences, Materials Science, Chemistry, Geology.
Mathematics, Statistics, Economic, Finance, Accountancy.

General Engineering, Mechanical Engineering, Chemical Engineering,
Biomedical Engineering, Electrical Engineering, Engineering, Civil
Engineering, Aerospace Engineering, Energy Engineering, Materials
Engineering, Mechanical Engineering, Robotics Engineering, Agricultural
Engineering, Architectural Engineering, Automotive Engineering,
Manufacturing Engineering, Motorsport Engineering

Biotechnology, Life Sciences, Biomedical Engineering, Ophthalmic,
Medicine, Dentistry, Medical Physics, Diagnostic Radiography, Pharmacy,
Architecture, Computer Science, Software Engineering



Career Paths

Jobs commonly associated with Physics A-level include research scientist, academic researcher, lecturer/ teacher, rocket scientist, astronomer, geophysicist, radiation protection practitioner, sound engineer and automotive technicians. However, while some employers look for the knowledge you get from your chosen subject, a lot will look at the skills you take from it. Physicists work in fields such as data analysis, software engineering and telecommunications. Industries employing physicists include aerospace, energy, health and medicine, instrumentation, manufacturing, meteorology and climate change, oil and gas, banking, finance and law.

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