Comparison of content: Physics B to Physics

First published: 20 October 2014, Revised: 20 October 2014

The new A-level Physics specification has been designed to maintain the best of the current specification A while updating the content and adding some new topics. When the new specification is introduced there will be no equivalent specification B, so this document is intended to help those who currently teach specification B understand how much content is common between the two specifications and how much is in the new specification but not in the current 2455 specification. It is intended to provide an overview and full details should be viewed via thorough comparison of the two specifications.

The structure of the examination is also closer to the current specification A, with multiple choice questions, as well as five optional papers of which the student will take one. The five options include the current four - Astrophysics, Medical physics, Engineering physics (renamed from Applied physics) and Turning points in physics. A fifth has been added in the form of Electronics, which has been part of Physics in the past and is currently an AS/A-level in its own right.

Content

The following table compares the content of the current specification B to the new specification. Any content that is not covered, form an existing topic in the 2455 specification has been highlighted in **bold**. A later section lists any topic areas that are not covered in the current 2455 specification at all, as a topic or content within a topic.

3.1.1a What is music?

Specification B topic area	New specification (7408) reference	New specification topic area
Distinction between standing and progressive waves	3.3.1.1 Progressive waves	
Properties of waves		
Types of wave: longitudinal and transverse, examples of sound as longitudinal wave and electromagnetic wave as transverse wave	3.3.1.2 Longitudinal and transverse waves	Nature of longitudinal waves. Examples including sound electromagnetic waves and waves on a string.
Types of wave: polarised and unpolarised waves		Polarisation as evidence for the nature of transverse waves

Specification B topic area	New specification (7408) reference	New specification topic area
Distinction between standing (stationary) and progressive waves	3.3.1.3 Principle of superposition of waves and formation of stationary waves	Stationary waves
Conditions for production of a standing wave		The formation of stationary waves
Graphical treatment of superposition and standing waves		Graphical explanation of formation of stationary waves
Factors affecting frequency in strings and first harmonic frequency		Stationary waves formed on strings, First harmonic formula
		NEW: Stationary waves produced with microwaves
Appreciation that energy form point source is spread out over a surface area =4πr2 leading to the inverse square law	3.9.2.3 Classification by temperature, black body radiation	Inverse square law, assumption in its application
Quality of music heard/ conditions of ears/loud noise. Interpretation of loudness curves	3.10.2.2 Sensitivity and frequency response	Perception of relative intensity levels/logarithmic scale, equal loudness curves
	3.10.2.3 Defects of hearing	Hearing loss because of loud noise and age
Knowledge of the dB scale	3.10.2.2 Sensitivity and frequency response	Definition of intensity
		NEW: Intensity level, Measurement of sound intensity levels and the use of dB and dBA scales

3.1.1b Analogue or digital?

Specification B topic area	New specification (7408) reference	New specification topic area
Conversion of a sound to analogue voltage signal and then digital for storage/reasons for digitising.	3.13.2.1 Analogue and digital signals	Analogue-to-digital conversion
Converting analogue audio signals into digital data using two voltage levels		
Concept of sampling audio signals		
Advantages and disadvantages of digital sampling		
Process of recovery of original digital signal from noisy signal		
Effect of noise in communication systems		
Difference between analogue and digital signals		Difference between analogue and digital signals
Pulse code modulation		Pulse code modulation

3.1.1c Storage and playback

Specification B topic area	New specification (7408) reference	New specification topic area
Phase difference	3.3.1.1 Progressive waves	Formula for phase difference
		NEW: Phase difference measured in angles or in terms of fractions of a cycle
Interference		
Youngs slit experiment, need for coherent sources, paths difference	3.3.2.1 Interference	Use of two coherent sources ad use of single source to produce double slit pattern
	3.12.2.2 Significance of Young's double slits experiment	
Use of a laser and diffraction grating		**NEW: Derivation of dsin θ = n λ,** applications of diffraction gratings.

3.1.1d Transmitting data

Specification B topic area	New specification (7408) reference	New specification topic area
Diffraction as an effect that 'spreads' beam of radiation form satellite dish	3.3.2.2 Diffraction	
Refraction, refractive index of a substance, total internal reflection	3.3.2.3 Refraction at a plane surface	Refractive index of a substance, total internal reflection
Comparison of advantages and disadvantages of fibre optics, copper cable and satellites for different applications	3.13.6.2 Transmission-path media	Metal wire, optic fibre, electromagnetic (radio, microwave)
Radio communication (higher frequencies/line of sight, long distance communication via diffraction, reflection and refraction of sky waves)		Ground wave, refraction and reflection of sky waves, diffraction of long-wavelength radiation around the Earth's surface
Satellite communication		Satellite frequencies and typical transmission frequencies
Electromagnetic spectrum, advantages and disadvantages of fibre optics, copper cable and satellites for different applications		Advantages and disadvantages of various transmission media
Time-division multiplexing technique		
High-frequency carrier waves, reasons for carrier waves, modulation	3.13.6.3 Time-division multiplexing	Carrier wave and information signal, principles of modulation
	3.13.6.4 Amplitude(AM) and frequency modulation (FM) techniques	Graphical representations of both AM and FM modulated signals
		NEW: Bandwidth requirements of simple AM and FM
		NEW: Data capacity of a channel, comparison of bandwidth availability for various media

3.1.2a Smaller and smaller

Specification B topic area	New specification (7408) reference	New specification topic area
Evidence for nuclear model of the atom replacing the 'plum pudding model', constituents of the atom, proton, neutron and electron	3.2.1.1 Constituents of the atom	Simple model of the atom including the proton, neutron and electron
Proton number Z, nucleon number A, nuclide notation		Proton number Z and nucleon number A. Familiarity with the terms nuclide and isotope
Nuclear changes in alpha and beta	3.2.1.2 Stable and unstable nuclei	Alpha and beta decay, with equation
	3.8.1.2 α, β and γ radiation	Properties and identification
Qualitative study of the Rutherford alpha particle scattering experiment	3.8.1.1 Rutherford scattering	Qualitative study of Rutherford scattering
Evidence for particle properties of electrons	3.12.1.1 Cathode rays	Production of cathode rays in a discharge tube

3.1.2b Wave or particle?

Specification B topic area	New specification (7408) reference	New specification topic area
Photon energy equation	3.2.1.3 Particles, antiparticles and photons	Photon energy equation
The photoelectric effect, work function, photoelectric equations	3.2.1.1 The photoelectric effect	Threshold frequency, photon explanation, work function, photoelectric equations
	3.2.2.4 Wave particle duality	Evidence for photoelectric effect
	3.12.2.4 The discovery of photoelectricity	The failure of classical wave theory to explain observations on photoelectricity
Electron diffraction as evidence for the wave nature of particles, de Broglie wavelength	3.2.2.4 Wave-particle duality	Electron diffraction suggests the wave nature of particles, de Broglie wavelength
	3.12.2.5 Wave particle duality	Low energy electron diffraction experiments, explanation of change of electron speed on the diffraction pattern

3.1.2c The particle picture

Specification B topic area	New specification (7408) reference	New specification topic area
Theoretical evidence for the existence of the neutrino	3.2.1.2 Stable and unstable nuclei	Equations for decay including the need for the neutrino
The creation of matter, pair production, annihilation	3.2.1.3 Particles, antiparticles and photons	For every type of particle, there is a corresponding antiparticle
		Knowledge of annihilation, pair production and the energies involved
		NEW: Comparison of particle and antiparticle masses, charge and rest energy in *MeV*
Classification of particles (Hadrons/Baryons/Mesons)	3.2.1.5 Classification of particles	The two classes of hadrons
Lepton/muon, their neutrinos and their antiparticles, the weak interaction		Leptons are subject to the weak interaction, leptons, muon, neutrino and their antiparticles
Strangeness as property that leads to particles with unusually long lifetimes		Strange particles
		New: Conservation of strangeness in string interactions
Quarks and antiquarks including discovery, Up, down and strange quarks only, properties (charge baryon number and strangeness)	3.2.1.6 Quarks and antiquarks	Properties of quarks
The decay of a free neutron should be known	3.2.1.7 Application of conservation laws	Decay of neutron should be known
Application of conservation laws for charge, baryon number and strangeness to interactions		Application of conservation laws for charge, baryon number, lepton number and strangeness to particle interactions
Qualitative treatment of the Big Bang theory	3.9.3.2 Hubble's law	Qualitative treatment of the Big Bang theory
Cosmic microwave background radiation as evidence for the Big Bang		Evidence from cosmological background radiation

3.1.2d Forces of nature

Specification B topic area	New specification (7408) reference	New specification topic area
Knowledge of the strong force, gluons as the exchange particles that lead to the strong force between quarks, protons and neutrons	3.2.1.2 Stale and unstable nuclei	The strong nuclear force, its role in keeping the nucleus stable **NEW: Range and repulsive nature**
Concept of exchange particles	3.2.1.4 Particle interactions	Concept of exchange particles to explain forces between elementary particles
Knowledge of the strong force, the electromagnetic force, the weak nuclear force and the gravitational force		The four fundamental interactions, gravity, electromagnetic, weak, strong (nuclear) **New: virtual particles as the exchange particle**
		New: the weak interaction limited to β-, β+ decay, electron capture and electron-proton collisions, W + andW- as the exchange particles
		New: Simple diagrams to represent the above reactions or interactions in terms of particles going in and out and exchange particles
	3.7.2.3 Comparison of electric and gravitational fields	Comparison of the magnitude of these forces between subatomic particles **NEW-Comparison of electric and gravitational fields**

3.1.2e Larger and larger

Specification B topic area	New specification (7408) reference	New specification topic area
Collisions of electrons and atoms, ionisation and excitation, the electron volt	3.2.2.2 Collisions of electrons with atoms	The electron volt, ionisation and excitation **NEW: understanding of ionisation and excitation in a fluorescent tube**

Specification B topic area	New specification (7408) reference	New specification topic area
Line spectra as evidence of transitions between discrete energy levels	3.2.2.3 Energy levels and photon emission	Line spectra as evidence of transitions between discrete energy levels in atoms
Luminosity of a star as total power radiated, classification by magnitude, relation between intensity and apparent magnitude	3.9.2.1 Classification by luminosity	Apparent magnitude m, relation between brightness and apparent magnitude **New: the Hipparcos scale, a difference of 1 on magnitude scale is equal to an intensity ratio of 2.56**
Qualitative understanding of the difference between apparent and absolute magnitude	3.9.2.2 Absolute magnitude	Parsec and light year, New-Definition of M, relation to m
Classification by temperature	3.9.2.3 Classification by temperature, black body radiation	
Black body radiation, Wien's Law, shape of black body curves		Wien's displacement law, general shape of black body curves **NEW: Stefan's law**
Description of the main classes of stars (O,B,A,F,G,K,M)	3.9.2.4 Principles of the use of stellar spectral classes	Description of the main classes
		NEW: Temp related to absorption spectra
Stellar evolution, Hertzsprung-Russell diagram (main sequence, dwarfs and giants)	3.9.2.5 The Hertzsprung-Russell diagram	General shape: main sequence, dwarfs and giants
Consideration of the life of a star similar to the sun		Stellar evolution: path of a star similar to our sun on the Hertzsprung-Russell diagram from formation to white dwarf
Doppler effect in sound and light limited to situations where the source is moving	3.9.3.1 Doppler effect	Formula for Z
Hubble's law, age of the universe	3.9.3.2 Hubble's law	Red shift, Simple interpretation as expansion of the universe; estimation of age of universe assuming H is constant
Quasars (most distant measurable objects), bright radio sources, show large red optical shifts, estimation of distance	3.9.3.3 Quasars	Quasars as the most distant visible measurable objects, discovery as bright radio sources, large optical red shifts, estimation including distance and power output

3.2.1a How is motion described?

Specification B topic area	New specification (7408) reference	New specification topic area
Vectors and scalars, examples to include speed, velocity, mass and force/weight	3.4.1.1 Scalars and vectors	Nature of scalars and vectors, examples to include speed, velocity, mass and force/ weight, acceleration, displacement/distance
Addition of two vectors by scale drawing and calculation (limited to two vectors)		Addition of vectors by calculation or scale drawing (limited to two vectors)
Resolution of vectors into two components at right angles to each other		Resolution of vectors into two components at right angles to each other

3.2.1b How do forces act?

Specification B topic area	New specification (7408) reference	New specification topic area
Conditions for equilibrium of two or three forces acting at a point	3.4.1.1 Scalars and vectors	Conditions for equilibrium for two or three coplanar forces acting at a point
Use of scale drawing or resolved forces to solve problems		Problems may be solves either by the use of resolved forces or the use of a closed triangle
Appreciation that a body is in equilibrium when at rest or when moving at constant velocity		Appreciation of the meaning of equilibrium on the context of an object at rest or moving with constant velocity

3.2.1c How does motion change?

Specification B topic area	New specification (7408) reference	New specification topic area
Understanding of rates of change with respect to time	3.4.1.3 Motion along a straight line	Displacement, speed, velocity and acceleration
Shapes of graphs for uniformly accelerated motion		Representation by graphical methods of uniform and non-uniform acceleration
Significance and calculation of gradient and area under s-t and v-t graphs for uniform and non-uniform motion		Significance of areas and gradients of displacement-time, velocity-time and acceleration-time graphs for uniform and non-uniform acceleration
Use of equations of motion for movement at constant velocity and acceleration		Equations for uniform acceleration

3.2.1d What makes motion change?

Specification B topic area	New specification (7408) reference	New specification topic area
Independent effect of motion in horizontal and vertical directions	3.4.1.4 Projectile motion	Independent effect of motion in horizontal and vertical directions in a uniform gravitational field
Explanation of the maximum speed of vehicles and the factors that affect it		The factors that affect the maximum speed of a vehicle
Terminal velocity		Terminal speed
Lift and drag forces		Qualitative treatment of lift and drag forces
Use of $F=ma$ in situations where the mass is constant	3.4.1.5 Newton's laws of motion	$F=ma$ for situations where the mass is constant
Momentum $=mv$	3.4.1.6 Momentum	Momentum = mass x velocity
Impulse = change in momentum $Ft=\Delta(mv)$		Impulse = change in momentum $F\Delta t=\Delta(mv)$

3.2.1e What energy changes occur?

Specification B topic area	New specification (7408) reference	New specification topic area
Use of safety features in cars such as crumple zones, and design of shoes	3.4.1.6 Momentum	How impact forces are related to contact times (kicking a football, crumple zones)
Explanation of the reduced force when momentum is dissipated over a longer time or energy over a longer distance		Force as the rate of change of momentum
Work, energy and power	3.4.1.7 Work, energy and power	
P=fv formula		*P=fv* formula
Qualitative and quantitative application of energy conservation in a uniform gravitational field	3.4.1.8 Conservation of energy	Qualitative and quantitative application of energy conservation to examples involving gravitational potential energy, kinetic energy and work done against resistive forces
Elastic potential energy	3.4.2.1 Bulk properties of solids	Hooke's law, elastic limit
Energy storied =area under force-extension graph		Energy stored = area under force-extension graph
Energy conservation between energy source, kinetic energy and gravitational potential energy, elastic potential energy, energy to deform and internal energy of surroundings		Quantitative and qualitative application of energy conservation to examples involving elastic strain energy, energy to deform
		Spring energy transformed to kinetic and gravitational potential energy
		NEW: Tensile strain and tensile stress, breaking stress
		NEW: Description of plastic behaviour, fracture and brittle behaviour linked to force-extension graph. Interpretation of simple stress-strain curves

3.2.2b Impact of energy conversion

Specification B topic area	New specification (7408) reference	New specification topic area
Density ρ=*m/v* (Calculations required)	3.4.2.1 Bulk properties of solids	Density ρ=*m/v*

3.2.2c Electrical energy

Specification B topic area	New specification (7408) reference	New specification topic area
Charge, current and potential difference. Electric current as rate of flow of charge. Potential difference defined	3.5.1.1 Basics of electricity	Electric current as the rate of charge, potential difference as work done per unit charge
Resistance defined		Resistance defined as *R=V/I*
Behaviour of ohmic and non-ohmic conductors including practical investigation of filament lamp	3.5.1.2 Current-voltage characteristics	For an ohmic conductor, a filament lamp and **NEW a semiconductor diode**
Electrical resistivity *R=ρL/A*	3.5.1.3 Resistivity	*ρ=RA/L*
Thermistor as a device for controlling temperature		Applications of thermistors to include temperature sensors and resistance-temperature graphs
Superconductivity and their benefit to society		Applications of superconductors
Resistances in series and parallel, power dissipation	3.5.1.4 Circuits	Resistors in series and in parallel, energy and power equations
Electrical variations produced by potential divider systems and on-off switches, use of potential divider to control voltage comparison with use of variable resistor	3.5.1.5 Potential divider	The potential divider used to supply constant or variable potential difference from a power supply. Examples should include the use of variable resistors
Electromotive force and internal resistance (and their measurement)	3.5.1.6 Electromotive force and internal resistance	

Specification B topic area	New specification (7408) reference	New specification topic area
Energy lost in transmission of electrical energy and how it is reduced in the national grid, appreciation of the role of ac transformers	3.7.4.6 The operation of a transformer	Causes of inefficiencies of a transformer, transmission of electrical power at high voltage including calculations of power loss in transmission lines
		NEW: The operation of a transformer, the transformer equation, transformer efficiency, production of eddy currents

3.2.2e Efficient use of energy

Specification B topic area	New specification (7408) reference	New specification topic area
Efficiency including the calculation of overall efficiency, efficiency of energy conversions in electrical generators, lamps and motors	3.4.1.7 Work, energy and power	Efficiency can be expressed as a percentage, Efficiency = useful output power/input power

3.4.1a Attracted to the earth

Specification B topic area	New specification (7408) reference	New specification topic area
Angular velocity, centripetal force	3.6.1.1 Periodic motion	Magnitude of angular speed, centripetal force
Newton's gravitational law	3.7.1.1 Newton's law	Gravity as a universal force acting between all matter
Study of forces and motion of bodies due to earth and atmosphere including satellite orbits	3.7.1.4 Orbits of planets and satellites	Orbital period and speed related to radius of circular orbit
		NEW: Derivation of $T^2 \propto r^3$

Specification B topic area	New specification (7408) reference	New specification topic area
Spherical bodies moving through a viscous medium on Earth-Stokes' law (at terminal velocity only)	3.12.1.4 Principle of Millikan's determination of the electronic charge, *e*	Stokes' Law for the viscous force on an oil droplet used to calculate the droplet radius
		NEW: Principle of Millikan's determination of Q. Condition for holding a charged oil droplet or charge Q, stationary between oppositely charged parallel plates. Motion of a falling oil droplet with and without an electric field. Terminal speed to determine the mass and the charge of the droplet. Significance of Millikan's results, quantisation of electric charge.

3.4.1b Leaving the earth

Specification B topic area	New specification (7408) reference	New specification topic area
Consideration of energy transfers involved during launch and return. Energy needed to escape from the Earth. Instantaneous kinetic energy that would result in needing to cause object to reach infinity leading to escape velocity	3.7.1.4 Orbits of plants and satellites	Total energy of an orbiting satellite, escape velocity, synchronous orbits **NEW: use of satellites in low orbits**
Gravitational potential energy	3.7.1.3 Gravitational potential	

3.4.1c It is rocket science

Specification B topic area	New specification (7408) reference	New specification topic area
Ideal gas equation, work done	3.6.2.2 Ideal gases	Ideal gas equation, work done
Avogadro constant		Avogadro constant *NA*
		NEW: Gas laws experimental relationships between *p, V, T* and mass
First law of thermodynamics	3.11.2.1 First law of thermodynamics	
Ideal gas equation	3.11.2.2 Non-flow processes	

3.4.2a Back and forth and up and down

Specification B topic area	New specification (7408) reference	New specification topic area
Simple harmonic motion, defining equation	3.6.1.2 Simple harmonic motion	Characteristics of simple harmonic motion, condition for SHM, defining equation
Graphical treatment with velocity as gradient of the displacement-time graph and acceleration as the gradient of a velocity-time graph		Graphical representations linking the variations of *x, v, a* and *t* with time. Appreciation that the *v-t* graph is derived from the gradient of the *x-t* graph and that the *a-t* graph is derived from the gradient of the *v-t* graph
		NEW: $v=\pm 2\pi\sqrt{A2-x2}$
Mass-spring system, simple pendulum	3.6.1.3 Simple harmonic systems	Mass-spring system, simple pendulum
Energy considerations		Variation of Ek, Ep and total energy with variation, and with time
Damping and resonance		Effects of damping on oscillations
Damping and resonance	3.6.1.4 Forced vibrations and resonance	Resonance and the effects of damping on the sharpness of resonance. Examples of these effects in mechanical systems

3.4.2b Round and round

Specification B topic area	New specification (7408) reference	New specification topic area
Requirement of centripetal force, $F=m\omega 2r$	3.6.1.1 Circular motion	Requirement of circular motion, $F=m\omega 2r$

3.4.2c Spinning faster and faster

Specification B topic area	New specification (7408) reference	New specification topic area
Moment of inertia defined, moment of inertia dependent on mass and mass distribution	3.11.1.1 Concept of moment of inertia	Qualitative knowledge of the factors that affect the moment of inertia of a rotating object
		NEW: equations for a point mass and an extended object
Angular kinetic energy = $\frac{1}{2} I\omega 2$	3.11.1.2 Rotational kinetic energy	EK = $\frac{1}{2} I\omega 2$

Specification B topic area	New specification (7408) reference	New specification topic area
Angular acceleration defined as the rate of change of angular velocity	3.11.1.3 Rotational motion	Angular displacement, angular speed, angular velocity and angular acceleration
		NEW: Representation by graphical methods of uniform and non-uniform angular acceleration
Equations of motion for uniform angular acceleration treated by analogy with uniformly accelerated linear motion		Equations for uniform angular acceleration
Moment of inertia defined as ratio of torque to angular acceleration		Torque and angular acceleration $T = I\alpha$
Angular momentum, conservation of angular momentum, the effect of torque on angular momentum	3.11.1.5 Angular momentum	Angular momentum, Conservation of angular momentum, Angular impulse =change in angular momentum
$P=T\omega$ (in formulae booklet)	3.11.1.6 Work and power	$P=T\omega$

3.4.3a Gravity surveys

Specification B topic area	New specification (7408) reference	New specification topic area
Definition of gravitational field strength g = F/m, Newton's gravitational law F = -(GMm/r2). Magnitude of g in a radial field given by g = GM/r2	3.7.1.2 Gravitational field strength	Representation by gravitational field lines gas force per unit mass defined by g = F/m

3.4.3b Magnetic surveys

Specification B topic area	New specification (7408) reference	New specification topic area
Definition of magnetic flex density using $F = BIL$, factors affecting flux density	3.7.4.2 Magnetic flux density	Force on a current-carrying wire in a magnetic field $F = BIL$, when field is perpendicular to current
Concept of flux linkage	3.7.4.3 Magnetic flux and flux linkage	Magnetic and flux linkage defined
		NEW: Flux and flux linkage passing through a rectangular coil rotated in a magnetic field, flux linkage $N\phi = BAN\cos\theta$

Specification B topic area	New specification (7408) reference	New specification topic area
Faraday's and Lenz's laws	3.7.4.4 Electromagnetic induction	Faraday's and Lenz's laws
		NEW: Emf induced in a coil rotating uniformly in a magnetic field ε = BAN ω sin ωt

3.4.3d Medical diagnoses without surgery

Specification B topic area	New specification (7408) reference	New specification topic area
Principles of ultrasound, echoes wavelength of ultrasound	3.10.4.1 Ultrasound imaging	Principles of generation and detection of ultrasound pulses
Comparison of advantages and disadvantages of ultrasound and X-rays		Advantages and disadvantages of ultrasound imaging in comparison with alternatives
		NEW: A-scan and B-scan, use of equations
Principles of endoscope, refraction of light and total internal reflection. Fibre optics (coherent and non-coherent bundles)	3.10.4.2 Fibre optics and Endoscopy	Properties of fibre optics and applications in medical physics including total internal reflection and principles of a flexible endoscope. Use of coherent and non-coherent bundles.
Principles of MRI scanner (superconducting magnets, gradient coils, alignment of spinning protons)	3.10.4.3 MR scanner	Basic principles of MR scanner (protons initially aligned with spins parallel, gradient field coils used to scan cross-section)
Principles of X-rays, production (continuous and line spectrum),	3.10.5.1 The physics of diagnostic X-rays	The physics of diagnostic X-rays, principles of the production of X-rays
Advantages and disadvantages of MRI compared with X-rays and ultrasound	3.10.5.4 CT scanner	Comparisons of ultrasound and X-rays-advantages and disadvantages limited to image resolution, cost and safety issues

Specification B topic area	New specification (7408) reference	New specification topic area
Properties of electron beams, energy gained by electron =*eV,* with energy gun equation = *½ mv2*	3.12.1.1 Thermionic emission of electrons	Principle of thermionic emissions, work done on an electron accelerated through a p.d. *1/2mv2 = eV*
	3.12.2.5 Wave-particle duality	Low-energy diffraction experiments, qualitative explanation of effect of change of electron speed on the diffraction pattern

3.5.1a Power from engines

Specification B topic area	New specification (7408) reference	New specification topic area
Qualitative explanation of pressure and effect of volume and temperature changes on pressure *pV = NkT,* Avogadro constant and concept of absolute zero	3.6.2.2 Ideal gases	Ideal gas equation of *pV = NkT* , Avogadro constant, concept of absolute zero
		NEW: Molar mass and molecular mass
Brownian motion, kinetic theory model for a gas, qualitative explanation of pressure and effect changes of volume and temperature changes on pressure, kinetic energy of gas molecules and relation to Boltzmann constant	3.6.2.3 Molecular kinetic theory model	Brownian motion as evidence foe existence of electrons, explanation of relationships between *p*, *V* and *T* in terms of a simple molecular model.
		NEW: Assumptions leading to *pV = 1/3 Nm (C)2*including derivation

3.5.1b Heating, cooling and working

Specification B topic area	New specification (7408) reference	New specification topic area
Specific heat capacity *E = mcΔθ,* engine cooling using continuous flow of liquid	3.6.2.1 Thermal energy transfer	Calculations involving transfer of energy (including continuous flow), *Q = mcΔθ* where c is specific hear capacity
		NEW: For a change of state, *Q = ml* where *l* is specific latent heat

Specification B topic area	New specification (7408) reference	New specification topic area
Internal energy *U,* first law of thermodynamics, raising energy by heating and working (Q defined by energy input to system due to difference in temperatures)	3.11.2.1 First law of thermodynamics	Application of first law of thermodynamics
		NEW: *Q = ΔU + W,* work is done by the system
The energy cycle should be exemplified by isothermal and adiabatic changes related to the first law of thermodynamics	3.11.2.2 Non-flow processes	Application of first law of thermodynamics to isothermal, adiabatic, constant pressure and constant volume changes
		NEW- Adiabatic: $pV\gamma$ = *constant*
Work done in engine cycles including the Carnot cycle	3.11.2.3 The *p*-*V* diagram	Representation of processes on *p* –*V* diagram, estimation of work done in terms of area below the graph, extension to cyclic processes
Basic understanding of each stage in a four-stroke engine, efficiency of engines	3.11.2.4 Engine cycles	Understanding of a four-stroke petrol cycle and a Diesel engine cycle with indicator diagrams), efficiency (overall, engine, thermal, mechanical)
		NEW: Input power, indicated power, Output or brake power, friction power, efficiency equations
Concept of entropy, efficiency including maximum efficiency	3.11.2.5 Second law and engines	Impossibility of an engine working only by First Law, Second Law of thermodynamics expressed as the need for engine to operate between a source and a sink, equations for efficiency and maximum theoretical efficiency
		Reasons for the lower efficiencies of practical engines. Maximising use of W and QH for example in combined heat and power schemes
		NEW: Reversed heat engines, basic principles and uses of heat pumps and refrigerators. Coefficients of performance equations

3.5.2d Accelerators and VDU

Specification B topic area	New specification (7408) reference	New specification topic area
Electric fields, uniform electric field equation	3.7.2.1 Coulomb's law	Representations of electric fields by electric field lines, equations for *E*
Accelerating particles, electron gun equation	3.7.2.2 Electric potential	**NEW: Understanding of definition of absolute electric potential including zero value at infinity, and of electric potential difference, equipotential surfaces, magnitude of *V* in a radial field, graphical representations of variations of *E* and *V* and *r*, *ΔV* from area under graph of *E* against *r***
Bending beams using magnetic fields, Balanced fields in velocity selector (*EQ= BQv),* Cyclotron frequency= *2πm/BQ*	3.7.4.2 Magnetic flux density	Moving charges in a magnetic field force on charged particles moving in a magnetic field, *F = BQv* when the field is perpendicular to velocity, application in devices such as the cyclotron
Scientists modify or produce new theories when events occur that are inexplicable using existing theories. Introduction to relativity	3.12.3.2 Einstein's theory of special relativity	The two postulates of Einstein's theory of special relativity
The effects of increasing mass on the operation of accelerators (eg the LHC) and time dilation on the decay of muons, time dilation equation	3.12.3.3 Time dilation	Proper time and time dilation as a consequence of special relativity, evidence for time dilation from muon decay, time dilation equation
	3.12.3.4 Length contraction	Length of object having a speed v (equation)
	3.12.3.5 Mass and energy	**NEW: equation for *E*, graphs of variation of mass and kinetic energy with speed**

3.5.3a Isotopes in medicine

Specification B topic area	New specification (7408) reference	New specification topic area
Proton number *Z* and nucleon number *A*, Familiarity with the terms nuclide and isotope	3.2.1.1 Constituents of the atom	Proton number *Z* and nucleon number *A,* nuclide notation, meaning of isotopes and the use of isotopic data
Nuclear stability and instability, changes in *Z* and *A* in α and β, nuclear changes in decay, nuclear equations	3.2.1.2 Stable and unstable nuclei	Unstable nuclei, alpha and beta decay, equations for alpha decay, β- decay including the need for the neutrino
α, β-, β+ and γ radiations	3.8.1.2 α, β and γ radiation	
Nature of ionising particles description		Their properties and experimental identification using simple absorption experiments
The choice of α, β and γ emitter to perform a particular function		Applications eg to relative hazards of exposure to humans
Inverse-square law for γ absorption		The inverse square law for γ radiation including its experimental verification and applications
		NEW: Background radiation; examples of its origins and experimental elimination from calculations
Quantitative use of $N = N0e^{-\lambda t}$ (no proof required)	3.8.1.3 Radioactive decay	Random nature of radioactive decay, $N = N0e^{-\lambda t}$
Recognition that $dN/dt = -\lambda N$represents radioactive changes		$\Delta N/\Delta t = -\lambda N$
Idea of half-life, calculations and use of half-life, relationship between half-life and decay constant		Half-life, determination from graphical decay data including decay curved and log graphs, application eg relevance to storage of radioactive waste, radioactive dating

Specification B topic area	New specification (7408) reference	New specification topic area
Nuclear changes in decay, decay equations	3.8.1.4 Nuclear instability	Changes of N and Z caused by radioactive decay and representation in simple decay equations
Diagnostic and therapeutic use of iodine-131, technetium-99m used as an example of a radioactive label		Existence of nuclear excited states; γ ray emission, application (eg use of technetium-99m as a γ source in medical diagnosis)
$I = I0e^{-\mu x}$ ½ value thickness, factors affecting μ	3.10.5.3 Absorption of X-rays	Exponential attenuation, linear coefficient μ, half value thickness $I = I0e^{-\mu}$
		NEW: Mass attenuation coefficient $\mu m = \mu/\rho$, differential tissue absorption of X-rays excluding details of the absorption process
Diagnostic and therapeutic use of iodine-131, technetium-99m	3.10.6.1 Imaging techniques	Use of gamma emitting radioisotope as a tracer, technetium-99m, iodine-131 and **NEW iridium-111** and their relevant properties
		NEW: The Molybdenum-Technetium generator, its basic use and importance, PET scans
Physical, biological and effective half-lives in medicine, calculations involving these quantities	3.10.6.1 Half-life	Physical, biological and effective half-lives1/TE= 1/TB + 1/TP

3.5.3b Keeping the heart beating

Specification B topic area	New specification (7408) reference	New specification topic area
Definition of capacitance $Q = CV$	3.7.3.1 Capacitance	Definition of capacitance $C = Q/V$
Use of capacitors to store energy	3.7.3.3 Energy stored by a capacitor	$E = ½ Q V$ and interpretation of area under a graph of charge against pd

Specification B topic area	New specification (7408) reference	New specification topic area
Charge and discharge curves, quantitative work for discharge only, capacitors as a timing component	3.7.3.4 Capacitor charge and discharge	Graphical representation of charging and discharging of capacitors through resistors, Time constant RC, calculation of time constants including their determination from graphical data
		NEW: Quantitative treatment of capacitor charge

3.5.3c Where nuclear energy comes from

Specification B topic area	New specification (7408) reference	New specification topic area
A study of the instability in the nucleus and how changes can lead to the release of energy. The graph of neutron number N against proton number Z. Appreciation that when a nucleus decays the residual nucleus is closer to the line of stability and that mass is reduced in the process	3.8.1.4 Nuclear instability	Graph of N against Z for stable nuclei, possible decay modes of unstable nuclei including α β + and β- and electron capture
$\Delta E = \Delta mc2$ applied to nuclear processes	3.8.1.6 Mass and energy	Appreciation that E = mc2 applies to all energy changes, appreciation that $\Delta E = \Delta mc2$ applies to all energy changes. Simple calculations relating mass difference to energy change
Binding energy, binding energy per nucleon, mass defect, atomic mass units and conversions, use of the graph of binding energy per nucleon against nucleon number		Graph of binding energy per nucleon against nucleon number, fission and fusion processes, simple calculations from nuclear masses of energy released in fission and fusion reactions
$\Delta E = \Delta mc2$ applied to nuclear processes	3.12.3.5 Mass and energy	Equivalence of mass and energy $E = mc2$

3.5.3d Physics of fusion

Specification B topic area	New specification (7408) reference	New specification topic area
A consideration of the mechanisms involved in controlling and moderating a pressure water reactor as an example of a nuclear reactor	3.8.1.7 Physics of fission	Induced fission by thermal neutrons, possibility of chain reactions, critical mass. Functions of moderator, control rods and the coolant in a thermal nuclear reactor. Factors affecting the choice of materials for the moderator, control rods and the coolant (examples of materials used)
Moderation including simple mechanical model of moderation by elastic collision		Candidates should have studies a simple mechanical method of moderation by elastic collisions

3.5.3e Fusion-energy of the future?

Specification B topic area	New specification (7408) reference	New specification topic area
Calculation of closest distance of approach of two nuclei	3.8.1.5 Nuclear radius	Estimate of radius from closest approach of alpha particles
		NEW: determination of radius from electron diffraction, knowledge of typical values Dependence of radius on nucleon number derived from experimental data. Calculation of nuclear density.

3.5.3 Perceptions of risk

Specification B topic area	New specification (7408) reference	New specification topic area
Risk in nuclear engineering, minimising the risk	3.8.1.8 Safety aspects	Fuel used, remote handling of fuel, shielding, emergency shut-down. Production, remote handling and storage of radioactive waste materials.

New content for Physics (7408)

These are the new topics for our Physics specification (7408) with no equivalent in Physics specification B (2455).

New specification (7408) reference	General overview of content in topic
3.4.1.2 Moments	• Moment of a force about a point • Couple as a pair of equal and opposite coplanar forces • Principal of moments • Centre of mass
3.4.2.2 The Young modulus	• Young modulus = tensile stress/tensile strain = $FL/A\Delta L$ • Use of stress – strain graphs to find the Young modulus (one simple method of measurement is required)
3.7.3.2 Parallel plate capacitor	• Dielectric action in a capacitor • Relative permittivity and dielectric constant
3.7.4.5 Alternating currents	• Sinusoidal voltages and currents only • Root mean square, peak and peak-to-peak values for sinusoidal waveforms only • Application to calculation of mains electricity peak and peak-to-peak voltage values • Use of an oscilloscope as a dc and an ac voltmeter (to measure time intervals and frequencies and to display ac waveforms)
3.7.4.6 The operation of a transformer	• The transformer equation • Transformer efficiency • Production of eddy currents
3.9.1.1 Astronomical telescope consisting of two converging lenses	• Ray diagram to show the image formation in normal adjustment • Angular magnification in normal adjustment • Focal length of the lenses
3.9.1.2 Reflecting telescopes	• Cassegrain arrangement using a parabolic concave primary mirror and convex secondary mirror, ray diagram to show path of rays through the telescope as far as the eyepiece. • Relative merits of reflectors and refractors including a qualitative treatment of spherical and chromatic aberration.
3.9.1.3 Single dish radio telescopes, I-R, U-V and X-ray telescopes	• Similarities and differences compared to optical telescopes including structure, positioning and use, including comparisons of resolving and collecting powers.
3.9.1.4 Advantages of large diameter telescopes	• Minimum angular resolution of telescope (Rayleigh criterion) • Collecting power is proportional to diameter2 • Comparison of the eye and CCD as detectors

New specification (7408) reference	General overview of content in topic
3.9.2.6 Supernovae, neutron stars and black holes	• Defining properties-rapid increase in absolute magnitude of supernovae, composition and density of neutron stars, escape velocity>c for black holes • Gamma ray burst due to the collapse of supergiant stars to form neutron stars/black holes • Comparison of energy output with total energy output of the sun • Use of type 1a supernovae as standard candles to determine distance • Controversy concerning accelerating universe and dark energy • Supermassive black holes at the centre of galaxies • Calculation of the radius of the event horion for a black hole, Schwarzchild radius (Rs)
3.9.3.4 Detection of Exoplants	• Difficulties detecting exoplanets directly • Detection techniques: limited to variation in Doppler shift (radial velocity method) • Transit method, typical light curve
3.13.1.1 MOSFET	• MOSFET (structure, behaviour and characteristics) • Drain source and gate VDS VGS IDSS Vth • Use as a switch, use as a device with a very high input resistance
3.13.1.2 Zener diode	• Characteristic curve showing zener breakdown voltage and typical minimum operating current • Anode and a cathode • Use with a resistor as a constant voltage source • Use to provide a reference voltage
3.13.1.3 Photodiode	• Characteristic curves and spectral response curves • Use in photo-conductive mode as a detector in optical systems • Use with a scintillator to detect atomic particles
3.13.1.4 Hall effect sensor	• Use of a magnetic field sensor to monitor attitude • Use in tachometer
3.13.3.1 LC resonance filters	• Resonant frequency with formula • Analogy between LC circuit and mass-spring system • Induction as a mass analogy • Capacitance as spring analogy • Energy (voltage) response curve • Q factor equation

New specification (7408) reference	General overview of content in topic
3.13.3.2 The ideal operational amplifier	• Operation and characteristics of an ideal op-amp • Power supply and signal connections • Infinite open-loop gain • Infinite input resistance • Open-loop transfer function for a real operational amplifier • *Vout* = A*OL* (*V*+-*V*-)
3.13.4.1 Inverting amplifier configuration	• Derivation of *Vout/Vin*= - *(Rf/Rl)*, and calculations • Meaning of virtual earth, virtual earth analysis
3.13.4.2 Non-inverting amplifier configuration	• V*out*/V*in* = 1+ *Rf*/*Rl*
3.13.4.3 Summing amplifier configuration	• V*out*= -*Rf*(*V1/R1*+*V2/R2*…) • Difference amplifier configuration *Vout* = (*V*+-*V*-) + *Rf/Rl*
3.13.4.4 Real operational amplifiers	• Limitations of real operational amplifiers • Frequency response curve *gain x bandwidth* = *constant* for a given device
3.13.5.1 Combinational logic	• Identification and use of AND, NAND, OR, NOR, NOT and EOR gates in combination in logic circuits • Construction and deduction of a logic circuit
3.13.5.2 Sequential logic	• Counting circuits-binary counter, BCD counter, Johnson counter • Inputs to the circuits-clock, reset, up/down • Outputs from the circuits • Modulo-n counter from basic counter with the logic driving a reset pin
3.13.5.3 Astables	• The astable as an oscillator to provide a clock pulse • Clock (pulse), rate (frequency), pulse width, period, duty cycle, mark-to-space ratio • Variation of running frequency using an external RC network
3.13.6.1 Principles of communication	• Communication systems, block diagram of real time communication system
3.10.1.1 Physics of the eye	• Physics of vision • The eye as an optical refracting system, including ray diagrams of image formation • Sensitivity of the eye (Spectral response as a photodetector) • Spatial resolution-explanation in terms of the behaviour of rods and cones • Properties of converging and diverging lenses, principal focus, focal length and power with equations

New specification (7408) reference	General overview of content in topic
3.10.1.2 Defects of vision and their correction using lenses	• Myopia, hypermetropia and astigmatism • Correction of defects of vision using lenses • Ray diagrams of calculations of powers (in dioptres) of correcting lenses for myopia and hypermetropia • The format of prescriptions for astigmatism
3.10.2.1 Ear as a sound detection system	• Simple structure of the ear, transmission processes
3.10.3.1 Simple ECG machines and the normal ECG waveform	• Principles of operation for obtaining the ECG waveform, explanation of the characteristic shape of a normal ECG waveform
3.10.5.2 Image detection and enhancement	• Flat panel (FTP) detector including X-ray scintillator, photodiode pixels, electronics scanning • Advantages of FTP detector compared with photographic detection
3.10.6.3 Gamma camera	• Basic structure and workings of a photomultiplier tube and gamma camera
3.10.6.4 Use of high-energy x-rays	• External treatment using high-energy x-rays
3.10.6.5 Use of radioactive implants	• Internal treatment using beta emitting implants
3.10.6.6 Imaging comparisons	• Make comparisons between imaging techniques. Questions limited to convenience, image resolution and safety issues
3.12.1.3 Specific charge of the electron	• Determination of the specific charge of an election, e/m by any one method • Significance of Thomson's determination of e/m • Comparison with the specific charge of the hydrogen ion
3.12.2.1 Newton's corpuscular theory of light	• Comparison of Huygens wave theory in general terms • The reason why Newton's theory was preferred
3.12.2.3 Electromagnetic waves	• Nature of electromagnetic waves • Maxwell's formula for the speed of electromagnetic waves in vacuum • Candidates should appreciate that εo related to the electric field strength due to a charged object in free space. μo related to the magnetic flux density due to a current-carrying wwe in free space. • Hertz's discovery of radio waves
3.12.2.6 Electron microscopes	• Estimate of anode voltage needed to produce wavelengths of the order of the size of the atom • Principle of operation of the transmission electron microscope • Principle of operation of the scanning tunnelling microscope

New specification (7408) reference	General overview of content in topic
3.12.3.1 The Michelson-Morley experiment	• Principle of the Michelson-Morley interferometer • Outline of the experiment as a means of detecting absolute motion • Significance of the failure to detect absolute light • The invariance of the speed of light