Subject Area: Mathematics

Curriculum Intent: We endeavour to develop understanding of mathematical processes in a way that promotes critical thinking, confidence, fosters enjoyment and cultivates life-ready, rational decision-makers. We instil precise mathematical language necessary to construct conjectures or inferences through a coherent line of reasoning and with a pervasive recognition that different areas of mathematics are connected. We utilise mathematical modelling to blur the distinction between abstract and practical modes of thought.

Dates	Content	Assessment	Rationale
1 and 2	Pure AS Unit 1: Algebra and Functions • Algebraic Expressions – basic manipulation with indices and surds; • Quadratic Functions – factorising, solving, graphs and discriminants; • Linear and quadratic simultaneous equations; • Linear and quadratic inequalities; • Cubic, quartic and reciprocal graphs; Transformations of graphs – f(*x*) notation. Statistics & Mechanics Unit 1: Statistical Sampling – terminology and techniques* • Measures of central tendency, other location and spread; • Coding. Statistics & Mechanics Unit 2a: Data Representation • Interpret diagrams for single-variable data; Pure AS Unit 2: Coordinate Geometry in the (x, y) plane • Straight Line Graphs; • Circles. Pure AS Unit 3: Further Algebra • Algebraic division, the factor theorem and proof; • The binomial expansion. Statistics & Mechanics Unit 6: Quantities and Units in Mechanics* • Introduction to mathematical modelling and standard S.I. units of length, time and mass; • Definitions of force, velocity, speed, acceleration and weight and displacement; • Vector and scalar quantities.	Concept Checks: Algebraic Expressions Completing the Square Quadratic Inequalities & Simultaneous Equations The Discriminant Graphs & Transformations Interpolation & Standard Deviation The Equation of a Straight Line The Equation of a Circle Proof Algebraic Division & the Factor Theorem The Binomial Expansion Unit Review: Indices & Surds Quadratic Functions Equations & Inequalities Graphs & Transformations Coordinate Geometry Progress Checks: PC0 PC1 PC2 Spaced Repetition: Paper 1 Paper 2 Paper 3 Weekly Fluency Check CEIAG: The ability to solve problems by thinking rationally and logically is desirable in any profession.	This course builds upon prerequisite skills akin to a mastery SoL. At GCSE, many students do not have the exposure to higher levels of algebraic manipulation or concepts (such as quadratic inequalities or transformations) for very long if at all. These skills underpin everything we do, necessitating an intensive period of revision and consolidation. This approach is not a requisition from the examination boards, but an internal decision based on an intensive scrutiny of internal GCSE results, patterns in attainment from past cohorts and a student voice survey. We extend students' understanding within this framework using algebraic and/or visual derivations alongside alternative ways of thinking about the ideas or applications that they may not have seen before. As stated previously, our SoL is somewhat predetermined according to fixed prerequisites. On the other hand, although the curriculum is relatively non-malleable, there is scope to interleave applied elements within the more rigid pure mathematics. It is important for students to perceive mathematics as a network of ideas that build upon and borrow from each other, rather than a collection of artificial categories and sub-categories. Explaining more about the applications at this early stage opens up cross-curricular links – particularly with Physics. Worked examples begin with deconstructions of key skills that may feature in an examination or problem-solving context. The skills accumulate throughout each lesson and may interleave other topic areas already covered. Consequently, spaced retrieval is the engine of this curriculum. Pure AS Unit 1 is a re-interpretation of the prerequisite algebraic content covered to varying levels of depth at GCSE – depending mainly on the secondary school. This unit takes a closer look at GCSE algebra, presenting a number of alternative representations of familiar topics – such as completing the square, and consolidates the underlying skills. Students are issued a 'GCSE to A-level Transition' booklet on GCSE Results Day to support this unit. Progress Check 0 takes place in Week 2 as a baseline assessment of algebra skills. We introduce the first statistics components immediately after the initial settling period of Term 1's algebraic mastery and assessment. Students ponder practical questions such as 'how can we measure how spread out the data is?' in order to derive the idea and the utility of certain measures of central tendency such as standard deviation. E. g. Where does this formula originate? Why do we use squaring when an absolute value would be more accurate? What are we measuring? What does this tell us? Where can we apply this…? Indeed, the utility and derivations of ideas is a thread running through the course and may occasionally venture beyond the range of the specification. E. g. Newton's law of gravitation, which we must not overlook if students are to understand forces – more specifically g.
3 and 4	Statistics & Mechanics Unit 7: Kinematics continued • Motion in a straight line under constant acceleration; *suvat* formulae; Vertical motion under gravity. Pure AS Unit 5: Vectors • Definitions, magnitude/direction, addition and scalar multiplication; • Position vectors, distance between two points, geometric problems. Statistics & Mechanics Unit 3: Probability • Mutually exclusive events; • Independent events. Statistics & Mechanics Unit 4: Statistical Distributions • Use and identify discrete distributions; • Calculate probabilities using the binomial distribution (calculator use expected). Statistics & Mechanics Unit 8: Forces & Newton's Laws • Newton's first law, force diagrams, equilibrium, introduction to i, j system; • Newton's second law, (no resolving forces or use of $F = \mu R$); • Newton's third law: equilibrium, smooth pulley problems. Pure AS Unit 6: Differentiation • Definition, differentiating polynomials, second derivatives; • Gradients, tangents, normals, maxima and minima.	Concept Checks: Velocity-Time Graphs Vectors in 2D Sampling* Probability Discrete Random Variables Forces & Motion in 2D F = ma Unit Review: Polynomials The Binomial Expansion Data Collection & Interpretation Trigonometry Equations of Constant Acceleration Vectors Probability Progress Checks: PC3 PC4 Spaced Repetition: Paper 4 Paper 5 Paper 6 Weekly Fluency Check	We provide an overview of vectors in Term 3 that is much more rigorous than the introduction at GCSE. The timing is in preparation for 2D motion (S&M Unit 8) – an applied module extended further in Year 2 and within a mechanics setting. Vector equations of lines and dot products no longer feature in the 2017 specification. We have chosen to defer the Year 1 content for correlation and regression until Year 2. There are several reasons for this: • Edexcel have jettisoned most of the correlation and regression content in Year 1 – to the extent that PMCC and regression line calculations are now consigned to single functions on the ClassWiz calculator. Consequently, students need only know about the PMCC as a quantitative measure of correlation of bivariate data and that a regression line is a more mathematically rigorous 'line of best fit.' Indeed, this would consume a maximum of two lessons. • There is a slight gain in curriculum time in Year 1. • The short coverage of C and R in Year1 necessitates a review in Year 2 unless a regular feature in spaced retrieval testing/papers. This is essentially teaching the same content twice to the detriment of other topic areas. Most importantly, there is still an open discussion to as to whether we should introduce differentiation early, given that it is one of the most important topics in the course. This is a valid point since students may feel that they have enrolled on a GCSE Algebra course. The case against begins with the prerequisite units 1, 2 and 3 in pure mathematics. If run in sequence, these units could not be completed until mid-term 2, which would allow differentiation to be completed by the end of term 2. This option has weight; however, the students will not be exposed to any applied material until term 3 in the Spring. This would create a false dichotomy within the course, with all of the applied material bunched together in the remaining terms, and the majority of the paper already completed by December. Students may perceive the course as an amalgamation of two courses, rather than an intertwined network of concepts and techniques as stated in our Intent. CEIAG: Calculus underpins many STEM fields from astrophysics to zoology.
5 and 6	Pure AS Unit 7: Integration • Definition as opposite of differentiation, indefinite integrals of x^n; • Definite integrals and areas under curves. Statistics & Mechanics Unit 5: Statistical Hypothesis Testing • Language of hypothesis testing; • Significance levels; • Carry out hypothesis tests involving the binomial distribution. Pure AS Unit 8: Exponentials and Logarithms • Exponential functions and natural logarithms; • Laws of logarithms. Statistics & Mechanics Unit 9: Kinematics 2 • Variable force; • Calculus to determine rates of change for kinematics; • Use of integration for kinematics problems i.e. $r = \int v\,dt$, $v = \int a\,dt$.	Concept Checks: Differentiation from First Principles Differentiation Integration Hypothesis Testing with the Binomial Distribution Exponentials & Logarithms Variable Acceleration Unit Review: The Binomial Distribution Forces & Newton's Laws Differentiation Integration Hypothesis Testing Variable Acceleration Progress Checks: PC5 Spaced Repetition: Paper 7 Paper 8 Paper 9 Weekly Fluency Check CEIAG: Many scientific research papers require mathematical modelling and statistical analysis such as hypothesis testing.	Integration is generally defined as the 'opposite' of differentiation with 'integration from first principles' not a requirement of this course. This is contrary to 'differentiating from first principles' which is a new addition to the specification. Nevertheless, we present a simple example of this in the notes – introducing summing of infinitesimals and the Fundamental Theorem of Calculus – unifying differentiation and integration. We revisit it in later in Year 1 Mechanics when defining motion under gravity. It is required that students know that a definite integral is the limit of a sum – assessed on Edexcel 2019 Paper 2 – but has not featured at all in any textbook or preparatory examination material published by Edexcel. This is why the published exam material must underpin the structure and scaffolding of each lesson. PS/CV's: Teachers model and uphold the professional standards to promote similar behaviours in the student body. This imbibes wisdom and self-restraint as a guiding mechanism towards long-term good habits. PS/CV's: Here we begin to instil a methodology for a smooth transition to A-level mathematics. Students arrive with different backgrounds and different experiences at GCSE. Now they will begin to work more independently and see the value of following our professional standards.

Dates	Content	Assessment		Rationale
1 and 2	Pure A-Level Unit 1: Proof • Examples including proof by deduction, proof by exhaustion and disproof by counter example. Pure A-Level Unit 2: Algebraic and Partial Fractions – Simplifying algebraic fractions; Partial fractions. Pure A-Level Unit 5: The Binomial Theorem • Expanding $(a + bx)^n$ for rational n knowledge of range of validity; Expansion of functions by first using partial fractions. Pure A-Level Unit 3: Functions and Modelling • Modulus function; Composite and inverse functions; Transformations; • Modelling with functions (trigonometric, exponential, reciprocal etc.) Pure A-Level Unit 4: Sequences and Series • Arithmetic and geometric progressions (proofs of 'sum formulae'); Sigma notation; • Recurrence and iterations. Statistics & Mechanics A-Level Unit 4: Moments • Forces' turning effect Pure A-Level Unit 6: Trigonometry • Radians (exact values), arcs and sectors; Small angles; Secant, cosecant and cotangent (definitions, identities and graphs); Inverse trigonometric functions; • Compound and double (and half) angle formulae; Geometric proof of compound angle formula; R cos (x ± α) or R sin (x ± α); Proving trigonometric identities; Pure A-Level Unit 7: Parametric Equations • Definition and converting between parametric and Cartesian forms; • Curve sketching and modelling; Solving problems in context (e.g. mechanics). Statistics & Mechanics A-Level Unit 2: Probability • Using set notation for probability. Conditional probability; Questioning assumptions. Pure A-Level Unit 8: Differentiation • Differentiating sin x and cos x from first principles; Differentiating exponentials and logs.	Concept Checks: Proof by Contradiction Spaced Retrieval: Year 1-to-Year 2 Bridging Task Concept Checks: Partial Fractions The Binomial Expansion Functions Transformations of Graphs Arithmetic/Geometric Sequences & Series Recurrence Relations Moments Radians Small Angle Approximations Reciprocal Trigonometric Functions Pythagorean Trigonometric Identities Compound & Double Angle Identities Harmonic Trigonometric Functions Parametric Equations Conditional Probability CEIAG: Trigonometry, logarithms, exponential functions and parametric equations are pervasive in mathematical modelling of real-life situations such as harmonic motion, growth and decay.	Unit Review: Algebra Functions Sequences & Series Trigonometry Trigonometric Functions Trigonometric Identities Progress Checks: PC1 PC2 (Trial Examination)	Unfortunately, some of the most powerful tools at a mathematician's disposal, such as 'proof by contradiction', are shoehorned into the 2017 Year 2 scheme – moreover, proof is stripped of its status and tacked onto algebraic fractions without any small-step progression built into the objectives. Consequently, we have fleshed-out the proof component from two sides of the Pearson textbook into an exploration into logic, implications, truth tables, algebraic representations of infinite sets, and the formation of contrapositive arguments. The binomial theorem for negative or rational values of *n* extends naturally from the partial fraction content. The processes are highly technical but can be mastered with plenty of practice. Re-introducing the binomial theorem early bootstraps the Year 1 work with natural number values for *n* alongside Hypothesis Testing – another technical (Year 1) topic. Function notation becomes more prevalent in Year 2 as does the importance of domain and range in the act of curve sketching – all of which are embedded across a multitude of topic areas. The limiting behaviour of key 'parent' functions and rational functions plays a more important role in establishing equations of asymptotes. By thinking of asymptotes as limits, we can assert the importance of a limit outside of the trappings of differentiation from first principles. The bonus of covering some of the more rigorous topics early is the potential to practice their content for a longer period in preparation for the external examinations. The obvious downside to this approach is that there is more time to forget the content. Nevertheless, the core retrieval and revision within students' independent study – contrived from regular data capture – will guarantee a greater exposure to more of the right kind of question on a regular basis that suits each individual need. Consequently, the content will be less likely to slip. The framework for this is set up as follows: 1. Suppose students are taught a hypothetical **Objective A** from the specification – annotated worked examples are recorded within the printed notes provided. Brief fluency-heavy written exercises attached to this objective are completed to short deadlines. 2. Students complete a *Concept Check* worksheet for Objective A one to two weeks later. The main focus is exam-style of the shorter variety – i.e. 5 – 6 marks. 3. Objective A sits within a larger group of objectives that form a specific topic – delivered as a series of lessons. Objective A now makes its way into a *Unit Review* worksheet with a stronger emphasis on modelling and problem-solving purely within one specific topic area. Unit Reviews are set one to two weeks after the initial Concept Check. By staggering the independent study in this manner, students maintain focus - even one month after the content was taught. 4. The content now transfers to the *Spaced Retrieval Practice Papers*, which punctuate the independent study programme. The format is persistent, challenging exam-style questions. Objective A will remain a feature of the Spaced retrieval Practice Papers until the end of the course through an assortment of new and legacy exam questions. It will also feature in the weekly SR tests if data suggests it is an area of weakness across a specific group. Students also build their own independent study plan based upon their own performances in the Progress Checks. The plan operates as follows: 1. Students compare their score cohort's average score on a particular question in the progress check. This gives them a residual percentage – i.e. how far is their score from the average? 2. If their residual percentage is more than 10% below the cohort average in a specific question, the students must: a. Write detailed annotated notes of worked examples from an online video attached to the topic area under scrutiny. b. Re-attempt the Concept Check affiliated with the topic. c. Review the work in an Achieve session with the class teacher. The greater component in Term 2 is Unit 6: Trigonometry, which spans approximately one month of lessons. The identities are essential in the later calculus units and some of the complex manipulation proves useful again in parametric equations. More importantly, the identities themselves are prerequisite to writing parametric equations in Cartesian form. Term 2 concludes with an interesting unit of conditional probability followed by differentiation from first principles of sine and cosine – both fascinating exercises in utilising identities and limits. I would like to add that the ground work for all this new material that stretches back into Year 1 is revisited regularly in the Spaced Retrieval programme – both outside of the classroom and intermixed with the daily lesson content. Hence, the switching from one strand to another is smooth rather than a jolt.
3 and 4	Pure A-Level Unit 8: Differentiation • Differentiating products, quotients, implicit and parametric functions; • Second derivatives (rates of change of gradient, inflections); • Rates of change problems (including growth and kinematics) – see Differential equations. Pure A-Level Unit 9: Numerical methods - see Integration (Part 2) for the *trapezium rule* • Location of roots; Solving by iterative methods (knowledge of 'staircase and cobweb' diagrams); Newton-Raphson method; Problem solving. Statistics & Mechanics A-Level Unit 3: The Normal distribution • Understand and use the Normal distribution; Use the Normal distribution as an approximation to the binomial distribution; Selecting the appropriate distribution; • Statistical hypothesis testing for the mean of the Normal distribution. Statistics & Mechanics A-Level Unit 1: Regression and Correlation • Change of variable; Correlation coefficients; Statistical hypothesis testing for zero corr. Statistics & Mechanics A-Level Unit 6: Applications of Kinematics – Projectiles. Pure A-Level Unit 10 & 11: Integration • Integrating x^n (including when $n = -1$), exponentials, trigonometric and parametrically defined functions; Using the reverse of differentiation, and using trigonometric identities to manipulate integrals; Integration by substitution; Integration by parts; Use of partial fractions; Areas under graphs (incl. curves expressed parametrically) or between 2 curves, incl. understanding area as limit of a sum.	Concept Checks: The Chain Rule; Product Rule; Quotient Rule Diff. Trig. Functions Implicit Differentiation Parametric Diff. Iteration; The Newton-Raphson Method The Normal Distribution The Normal Approx. to the Binomial Dist. Hypothesis Testing with the Normal Distribution Hypothesis Testing for Zero Correlation Non-Linear Regression Projectiles Integrating Trigonometric Functions Integration by Sub. The Normal Distribution Hypothesis Testing Projectiles Integration by Parts; Reverse Chain Rule	Unit Review: Parametric Equations Conditional Probability Differentiation Further Differentiation Numerical Methods Progress Checks: PC4 (Trial Examination)	We separate the core calculus content in Term 3 and 4 by a longer stretch of applied material – some of the most important and challenging in the course. Given *differentiation rules* (such as the chain rule, product rule and quotient rule) demand regular rather than sporadic practise, this can take place in the background while the ideas of the normal distribution and kinematics are addressed. After allowing time to absorb and master processes of differentiation, we introduce and cement integration until the final examinations. One salient advantage of a mathematics education is the luxury of practicing core skills constantly. If we take Year 2 trigonometric equations as an example, the first few steps in solving an equation of this type rely on new knowledge and techniques, while the later steps require older, more secure techniques such as solving quadratic equations. Terms 3 and 4 are heavy with content as evident in the scale of the independent study on the student calendar. The students by now have adjusted to the heightened expectations in Year 2 and are running their own routines within our prescribed study framework. It has recently become evident that the students are noticeably less reliant on teacher intervention while the quality of work is improving. It is also worth noting that Spaced Retrieval Practice Papers and Progress Checks are evolving into full-blown A-level Mathematics papers, given their synoptic design. While exam-content has always been at the centre, the scope of questions remains limited until enough of the course is complete. However, the contextual style and mathematical modelling are pervasive throughout the scheme and students by now are accustomed to the requirements. The mechanics content has historically been a challenge for our students if they have not also opted to study a science – particularly physics. We are now working closely with the Physics department and sharing practice as a means of greater unification of teaching strategies and work examples. We are also looking at a more practical approach to tackling projectile motion and other motion under gravity that will be both engaging and purposeful. Indeed, testing these ideas with empirical evidence is essential when attempting to model the real world. The route map of post-16 Mathematics (and Further Mathematics) (https://undergroundmathematics.org/) suggests navigable routes through an intensive mathematics education, some of which mirror our current Scheme of Learning. It is clear that flexibility is built-in to our scheme, but there are restrictions across many routes. For example, (in Year 1) algebraic geometry of circles requires secure understanding of completing the square – a process intrinsic to quadratic expressions; the groundwork of which stems from algebraic manipulation covered at GCSE and Term 1 of Year 1. In this way, we can think of mathematics as a hierarchy of skills; built layer by layer. (We address this argument in our Course Guide, issued to the students on the first day of the course). The apex is the study of differential equations – covered more extensively in further Mathematics – but introduced as a means of modelling real-world rates of change problems in the A-level Mathematics classroom. The map corroborates this stratification, even placing Differential Equations at the pinnacle of Further Mathematics. The reasoning is straight forward; differential equations are the culmination of the greatest range of skills presented at the post-16 level and are essential in modelling the real-world. A-level is preparation for dealing with equations of this type in a multitude of fields.
5 and 6	Statistics & Mechanics A-Level Unit 5 & 7: Forces at any Angle & Applications of Forces • Equilibrium and statics of a particle (including ladder problems); Dynamics of a particle. Pure A-Level Unit 12: Vectors in 3D • Use of vectors in three dimensions; Knowledge of col. vectors and i, j and k unit vectors. Statistics & Mechanics A-Level Unit 8: Further Kinematics • Constant acceleration (equations of motion in 2D; the i, j system); • Variable acceleration (use of calculus and finding vectors $\dot{r}$ and $\ddot{r}$ at a given time).	Concept Checks: Trapez. Rule; Parametric Integration; Diff. Equations; Forces & Friction; Statics & Dynamics on an Inclined Plane; Connected Particles on an Inclined Plane; Vectors in 3D	Kinematics in 2D Variable Acceleration Unit Review: Integration; Diff. Equations; Friction; Forces & Motion; Vectors in 3D; Kinematics	The course ends with some interesting applications of vector calculus in a mechanics setting. Many of the applied modules are staggered in such a way as to support the work done in further mathematics given that we have parallel delivery. The logistics of mixed Mathematics and Further Mathematics students also places restrictions on when to begin certain topics. Pearson's Parallel Delivery Scheme of Work has proved useful but teacher discretion and designing the curricula in tandem are the critical factors in the successful flow of both courses. PS/CV's: At this point, students will have a strong footing in the techniques and thinking strategies necessary to unpick problems on a local, national or global scale across many fields. This could be looking into combating local socio-economic issues or the global food-energy-water nexus.