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Curriculum Plan - Further Maths

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Year 12	**Golden Treads:** Mathematical augment, language and Proof Mathematical problem solving Mathematical Modelling		**Enrichment:** Senior Maths Challenge		**Review and evaluation:** June 2025
	Topics and Substantive Knowledge	**Assessment**	**Misconceptions**	**Key Vocabulary**	**Knowledge tracking**
Term 1 **Teacher 1**	**Decision 1:** Ch 6 – Linear programming Formulation of problems as linear programs. Graphical solution of two variable problems using objective line and vertex methods including cases where integer solutions are required. Ch 2 – Graphs and networks Use of the order of the nodes to determine whether a graph is Eulerian, semi-Eulerian or neither. Students will be expected to be familiar with the following types of graphs: complete (including K notation), planar and isomorphic. Ch 8 – Critical path analysis Modelling of a project by an activity network, from a precedence table. Completion of the precedence table for a given activity network. Algorithm for finding the critical path. Earliest and latest event times. Earliest and latest start and finish times for activities. Identification of critical activities and critical path(s). Calculation of the total float of an activity. Construction of Gantt (cascade) charts. Activity on arc will be used. The use of dummies is included. In a precedence network, precedence tables will only show immediate predecessors. Calculating the lower bound for the number of workers required to complete the project in the shortest possible time is required. Each activity will require only one worker.	**1 Review sheet formally marked per half term**	Often inaccurate use of inequalities. Objective function rarely answered correctly. Meaning of Eulerian is often poorly dealt with. Reasons for using dummies often weak. Backward pass errors quite common.	Graph Subgraph Weighted graph Network Degree or valency Path Hand-shaking lemma Cycle Digraph	**Before:** **Decision Ch 6 (from GCSE)** Linear graphs Describing regions with inequalities Shading regions from inequalities **Decision Ch 2 (from GCSE)** Characteristics of triangles **Decision Ch 8 (from Ch 2)** Shortest routes through graphs **After:** Simplex in Year 13
Teacher 2	**Core Pure 1:** Ch 1 – Complex numbers Solve any quadratic equation with real coefficients. Solve cubic or quartic equations with real Coefficients. Add, subtract, multiply and divide complex numbers in the form x + iy with x and y real. Understand and use the terms ‘real part’ and ‘imaginary Part’. Understand and use the complex conjugate. Know that non-real roots of polynomial equations with real coefficients occur in conjugate pairs. Given sufficient information to deduce at least one root for cubics or at least one complex root or quadratic factor for quartics. Knowledge that if z1 is a root of f(z) = 0	**1 Review sheet formally marked per half term**	Occasional over reliance on calculator methods for quadratic formula. Regular errors when taking the wrong sign. Errors when dealing with i2. Not applying the change of sign rule.	Manipulating complex numbers Complex conjugates and roots of equations The Argand diagram Modulus Argument	Before: From AS: Quadratic functions Algebraic division Equation of a circle Vectors in two dimensions From A Level: Trigonometry – Radians

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	then z1* is also a root. Ch 2 – Argand Diagrams Use and interpret Argand Diagrams. Convert between the Cartesian form and the modulus-argument form of a complex number. Multiply and divide complex numbers in modulus argument form. Students should be able to represent the sum or difference of two complex numbers on an Argand diagram. Construct and interpret simple loci in the argand diagram such as $z - a > r$ and $\arg(z - a) = \theta$ Ch 6 – Matrices Add, subtract and multiply conformable matrices. Multiply a matrix by a scalar. Understand and use zero and identity matrices. Use matrices to represent linear transformations in 2-D. Successive transformations. Single transformations in 3-D. For 2-D, identification and use of the matrix representation of single and combined transformations from: reflection in coordinate axes and lines $y = \pm x$, rotation through any angle about (0, 0), stretches parallel to the x-axis and y-axis, and enlargement about centre (0, 0), with scale factor k, ($k \neq 0$), where $k \in \mathbb{R}$. Knowledge that the transformation represented by AB is the transformation represented by B followed by the transformation represented by A. 3-D transformations confined to reflection in one of $x = 0$, $y = 0$, $z = 0$ or rotation about one of the coordinate axes. Knowledge of 3-D vectors is covered.		Need to show working to demonstrate no real roots. Roots of unity often show misunderstanding.	Order Identity Inverse Reflection Rotation Enlargement Translation Stretch	Compound angle formulae After: Complex in Year 13 Before: From AS: Vectors in 2D From A Level: Vectors in 3D After: None
Term 2 Teacher 1	**Decision 1:** Ch 1 – Algorithms The general ideas of algorithms and the implementation of an algorithm given by a flow chart or text. Bin packing, bubble sort and quick sort. The meaning of the order of an algorithm is expected. Students will be expected to determine the order of a given algorithm and the order of standard network problems. When using the quick sort algorithm, the pivot should be chosen as the middle item of the list. Ch 3 – Algorithms on graphs The minimum spanning tree (minimum connector) problem. Prim's and Kruskal's Algorithm. Dijkstra's algorithm for finding the shortest path. Matrix representation for Prim's algorithm is expected. Drawing a network from a given matrix and writing down the matrix associated with a network may be required.	**1 Review sheet formally marked per half term**	Incorrect pivot often chosen. Quadratic and cubic order of an algorithm causes issues. Using Dijkstra's from an incorrect starting point. Not showing full working values for Dijkstra's.	Algorithm Bin packing Bubble sort Quick sort	**Before:** **Decision Ch 1 (from GCSE)** Function machines Direction proportion **Decision Ch 3 (from Ch 2)** Weighted networks Order of vertices Distance matrices Minimum spanning trees **After:** **Decision Ch 5** Ch 3 Route inspection in Year 13, including Floyd's algorithm

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Teacher 2	**Core Pure 1:** Ch 4 – Roots Understand and use the relationship between roots and coefficients of polynomial equations up to quartic equations. Form a polynomial equation whose roots are a linear transformation of the roots of a given polynomial equation (of at least cubic degree). Understand and use formulae for the sums of integers, squares and cubes and use these to sum other series. For example, given a cubic polynomial equation with roots α, β and γ students should be able to evaluate expressions such as (i) $\alpha^2 + \beta^2 + \gamma^2$ (ii) $1/\alpha + 1/\beta + 1/\gamma$ (iii) $(3 + \alpha)(3 + \beta)(3 + \gamma)$ (iv) $\alpha^3 + \beta^3 + \gamma^3$ Ch 7 – Linear transformations Find invariant points and lines for a linear transformation. Calculate determinants of: 2 × 2 and 3 × 3 matrices and interpret as scale factors, including the effect on orientation. Understand and use singular and non-singular matrices. Properties of inverse matrices. Understanding the process of finding the inverse of a matrix is required. Calculate and use the inverse of non-singular 2 × 2 matrices and 3 × 3 matrices. Solve three linear simultaneous equations in three variables by use of the inverse matrix. Interpret geometrically the solution and failure of the solution of three simultaneous linear equations.	Core Pure topics covered to date	Transformations are often overthought. Substitution method generally works best. Using incorrect signs for coefficients. Often there is confusion between finding an invariant point and an invariant line. Students often struggle to complete lengthy inverse matrix problems.	Roots Sum Product Sum of pairs Standard formulae	**Before:** Sigma notation Factor theorem Vectors in 2D Vectors in 3D **After:** Further Series in Year 13
Term 3 Teacher 1	**Decision:** Ch 4 – Route inspection Algorithm for finding the shortest route around a network, travelling along every edge at least once and ending at the start vertex. Also known as the 'Chinese postman' problem. Students will be expected to use inspection to consider all possible pairings of odd nodes. The network will contain at most four odd nodes. **Core Pure 1:** Ch 9 – Vectors Understand and use the vector and Cartesian forms of an equation of a straight line in 3-D.	Decision paper in class	Confusing the route inspection algorithm with Prim's/Kruskal's. Forgetting to end at the starting vertex. Using the same vector multiple times (or a multiple of the same		**Before:** **Decision Ch 4 (from Decision Ch 2)** Properties of graphs **Core Pure Ch 9 (from GCSE and Pure Ch 11)** Vectors in 2D Trigonometry **After:**

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	Understand and use the vector and Cartesian forms of the equation of a plane. Calculate the scalar product and use it to express the equation of a plane, and to calculate the angle between two lines, the angle between two planes and the angle between a line and a plane. Check whether vectors are perpendicular by using the scalar product. Find the intersection of a line and a plane. Calculate the perpendicular distance between two lines, from a point to a line and from a point to a plane. The forms, $r = a + \lambda b + \mu c$ and $ax + by + cz = d$. Knowledge of the property that $a.b = 0$ if the vectors a and b are perpendicular.		vector) to incorrectly find equations or angles. Confusing all the different methods. Interchanging position vectors and directions		**Decision Ch 4 (to Decision Ch 5)** Ch 3 Route inspection in Year 13, including Floyd's algorithm
Teacher 2	**Core Pure 1:** Ch 8 – Proof by induction Construct proofs using mathematical induction. Contexts include sums of series, divisibility and powers of matrices. (Covers Pure basics of sequences and series) **Further Mechanics 1:** Intro to mechanics. Ch 1 – Momentum and impulse. Momentum and impulse. The impulse-momentum principle. The principle of conservation of momentum applied to two spheres colliding directly. Questions involving oblique impact will not be set. The spheres may be modelled as particles. (Covers AS Mechanics basics of F=ma and suvat equations)		Errors often made when writing out proofs. Starting at the endpoint for the inductive step. Sign errors when dealing with impulse.	Inductive	**Before:** **Core Pure Ch 8 (from AS Pure Ch 7 and GCSE):** Factor theorem Algebraic proof **F. Mech Ch 1 (from AS Pure, GCSE and Core Pure Ch 1):** Vectors in 2D Vectors in 3D Speed/distance/time
Term 4 Teacher 1	**Core Pure 1:** Ch 3 – Series Understand and use formulae for the sums of integers, squares and cubes and use these to sum other series. (Covers Pure basics of sequences and series) Ch 5 – Volumes of revolution Derive formulae for and calculate volumes of revolution.		Expanding $(2r-1)^2$ incorrectly. Incorrect choice of limit values. Calculator errors very common, when evaluating a volume from the definite integrals. Rotation around incorrect axis. Using incorrect limits for integration.		**Before:** **Core Pure Ch 3 (from GCSE and Pure Y1 Ch 1)** Factorising polynomials Nth terms of sequences **Core Pure Ch 5 (from Pure Y1 Ch 13)** Definite integrals

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Teacher 2	**Further Mechanics 1:** Ch 1 – Momentum and impulse. Ch 2 – Work, energy and power. Kinetic and potential energy, work and power. The work energy principle. The principle of conservation of mechanical energy. (Covers AS Mech force diagrams and suvat equations as well as Mech Y2 friction) Problems involving motion under a variable resistance and/or up and down an inclined plane may be set. Knowledge of resolving forces is assumed. Knowledge of friction, including F= μR when a particle is moving, is assumed.		Often incorrect units are used. Regular misconceptions with resolving. Regular sign errors with COM.	Newton's 2nd law Momentum Impulse Friction Coefficient of friction	**Before:** **F. Mech Ch 1 (from AS Pure, GCSE and Core Pure Ch 1):** Vectors in 2D Vectors in 3D Speed/distance/time **After:** **F. Mech Ch 2 (to AS Mech and Y2 Mech)** Force diagrams Suvat equations Inclined planes Friction
Term 5 Teacher 1	Revision and catch up Exam practice	**Year 12 Internal assessments: full AS Core Pure paper, full AS Decision paper, AS F. Mech topics covered to date**			
Teacher 2	**Further Mechanics 1:** Ch 4 – Elastic collisions. Direct impact of elastic spheres. Newton's law of restitution. Loss of kinetic energy due to impact. Successive direct impacts of spheres and/or a sphere with a smooth plane surface. Students will be expected to know and use the inequalities $0 \leq e \leq 1$ (where e is the coefficient of restitution). Revision and catch up.	**Topic tests completed for homework**	Often candidates struggle with the algebra required for the elastic collisions. Initial direction is often misapplied.	Restitution Elastic	**Before:** **F. Mech Ch 4 (from F. Mech Ch 1, Ch 2 and AS Mech Ch 9)** Collision of particles Kinematics **After:** **(to F. Mech Ch 5)** Elastic collisions in two dimensions

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Term 6 Teacher 1	**Core Pure 2:** Ch 1 – Complex numbers Understand de Moivre's theorem and use it to find multiple angle formulae and sums of series. Know and use the definition $e^{i\theta} = \cos\theta + i\sin\theta$ and the form $z = re^{i\theta}$ Find the n distinct nth roots of $re^{i\theta}$ for $r \neq 0$ and know that they form the vertices of a regular n-gon in the Argand Diagram. Use complex roots of unity to solve geometric problems. Find $\cos p\theta$, $\sin q\theta$ and $\tan r\theta$ in terms of powers of $\sin\theta$, $\cos\theta$ and $\tan\theta$ and powers of $\sin\theta$, $\cos\theta$ and $\tan\theta$ in terms of multiple angles. Ch 2 – Series Understand and use formulae for the sums of integers, squares and cubes and use these to sum other series. Understand and use the method of differences for summation of series including use of partial fractions. To include the derivation of the series expansions of compound functions. Find the Maclaurin series of a function including the general Term. Recognise and use the Maclaurin series for e^x, $\ln(1+x)$, $\sin x$, $\cos x$ and $(1+x)^n$, and be aware of the range of values of x for which they are valid (proof not required).	**Topic tests completed for homework**	Errors often made with negative angles. Wrong side of bisector often chosen. Reflections and perpendicular lines poorly dealt with in general. Non-standard limits cause difficulty.	Summing Series using standard formulae Method of differences - Telescoping	**Before:** **Core Pure 2 Ch 1 (from AS Pure Ch 1, Ch 7):** Quadratic functions Algebraic division Equation of a circle Vectors in two dimensions Trigonometry Factor theorem manipulation 2.10 Partial fractions 4.3 Sigma notation 7.2, 7.5 Implicit differentiation 7.4 Product rule
Teacher 2	**Further Mechanics 1:** Revision and catch up Exam practice				