FURTHER MATHS TERM BY TERM CURRICULUM

[Specification link - Edexcel Specification: AS Further Mathematics]

[Specification link - Edexcel Specification: A Level Further Mathematics]

January 2023

YEAR 12

TERM	Teacher 1 (Further Core Mathematics) delivered via 3 x 70minute lesson per week	Teacher 2 (Decision Mathematics & Further Mechanics) delivered via 1 x 70 minute lesson per week
1	FC1.1 Complex Numbers • Solve any quadratic equation with real coefficients. • Add, subtract and multiply complex numbers in the form x + iy with x and y real. • Understand and use the terms 'real part' and 'imaginary part'. • Use and interpret Argand diagrams. • Convert between the Cartesian form and the modulusargument form of a complex number. • Multiply and divide complex numbers in modulus-argument form. • Construct and interpret simple loci in the Argand diagram such as $\|z - a\| > r$ and $\arg(z - a) = \theta$.	D1.2 Algorithms on Graphs (Part 1) • Understand what an algorithm is. • Trace an algorithm in the form of a flow chart. • Trace an algorithm given as instructions written in text. • Know how to determine the output of an algorithm and how it links to the input. • Be able to determine the order of a given algorithm and standard network problems. • Know how to apply a bubble sort algorithm to a list of numbers or words. • Know how to apply the quick sort algorithm to a list of numbers or words, clearly identifying the pivots used for each pass. • Identify the number of comparisons and swaps used in a given pass. • Identify size, efficiency and order of an algorithm and use them to make predictions. • Know how to solve bin packing problems using full bin, first fit, and first fit decreasing algorithms, and understand their strengths and weaknesses. • Know the meaning of the vocabulary used in graph theory e.g. degree of a vertex, isomorphic graphs, walks, paths and cycles. • Be familiar with different types of graph e.g. complete, planar, isomorphic, simple, connected. • Understand graphs represented in matrix form. • Be familiar with k notation. • Know the definition of a tree. • Be able to determine if a graph is Eulerian, semi-Eulerian or neither, and find Eulerian cycles.

1	FC1.6 Matrices • Find the dimension of a matrix. • Add and subtract matrices of the same dimension. • Multiply a matrix by a scalar. • Multiply conformable matrices. • Calculate determinants of 2×2 and 3×3 matrices. • Understand and use singular and non-singular matrices. • Know the properties of inverse matrices. • Calculate the inverse of non-singular 2×2 and 3×3 matrices. • Use matrices and their inverses to solve linear simultaneous equations, including three linear simultaneous equations in three variables. • Interpret geometrically the solution and failure of solution of three simultaneous linear equations. • Use matrices to represent 2D rotations, reflections, enlargements and translations. • Understand and use zero and identity matrices. • Use matrix products to represent combinations of transformations. • Use matrices to represent linear transformations in three dimensions. • Use inverse matrices to reverse the effect of a linear transformation. • Use the determinant of a matrix to determine the area scale factor of a transformation. • Find invariant points and lines for a linear transformation.	D1.2 Algorithms on Graphs (Part 1) • Understand the meaning of a minimum spanning tree. • Apply Kruskal's algorithm to a network to find the minimum spanning tree. • Apply Prims algorithm to a network to find the minimum spanning tree. • Apply Prim's algorithm to a distance matrix to find the minimum spanning tree. • Apply Dijkstra's algorithm to find the shortest path between two vertices in a network. • Trace back through a network to be able to find the route corresponding to the shortest path. • Consider modifications to an original shortest path problem, for example by dealing with multiple start points or a different end point.
Assessment Point 1 A short assessment point is completed at the end of Term 1, following a short period of revision of the above topics (both the Further Core and Decision Mathematics modules).		

3	FC1.5 Transforming Polynomials • 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). FC1.7 Proof • Obtain a proof for the summation of a series, using induction. • Use proof by induction to prove that an expression is divisible by a certain integer. • Use mathematical induction to prove general statements involving matrix multiplication.	D1.9 Critical Path Analysis • Model a project by an activity network from a precedence table. • Complete a precedence table from a given network. • Understand the use of dummies. • Know how to carry out a forward pass and backward pass using early and late event times. • Interpret and use dummies. • Be able to identify critical activities and critical paths. • Know how to determine the total float of activities. • Construct and interpret Gantt (cascade) charts.
4	FC1.8 Vectors • Know how to find the vector equation of a line in both two and three dimensions. • Understand and use the Cartesian forms of an equation of a straight line in three dimensions. • Understand and use the vector and Cartesian forms of the equation of a plane. • Find the scalar product of two vectors. • Check whether vectors are perpendicular by using the scalar product. • Use the scalar product to express the equation of a plane. • Use the scalar product to calculate the angle between two lines. • Use the scalar product to calculate the angle between two planes. • Use the scalar product to calculate the angle between a line and a plane. • Find the points of intersection of lines and planes which meet. • Calculate the perpendicular distance between two lines. • Calculate the perpendicular distance from a point to a line or to a plane.	FM1.1 Momentum & Impulse (Part 1) • Understand the definitions, derivation, and units of momentum and impulse. • Understand what happens to the momentum of a sphere as a result of a collision. • Use the principle of conservation of momentum applied to direct collisions in 1-dimension. FM1.3 Work, Energy & Power • Understand the derivation, units and definitions of work and energy. • Define kinetic energy (KE). • Understand that work done on a body moving in a horizontal plane is the change in kinetic energy. • Understand the concept of gravitational potential energy (GPE). • Include GPE when applying the work-energy principle. • Know the conditions for conservation of mechanical energy. • Solve problems involving work and energy. • Understand that power in watts is the rate of doing work. • Calculate the power (P) of a vehicle with a tractive (driving) force F, moving with velocity v. • Use the formula $P = Fv$ in problem solving.

Assessment Point 2 A broader, practice-paper style assessment point is completed during Term 4, after most of the content for AS has been taught. This will cover a wider range of content from the Further Core 1, Decision Mathematics 1 and Further Mechanics 1 modules, and is designed to reflect the demands of the formal AS paper towards the end of the academic year.		
5	**FC1.4 Volumes of Revolution** • Derive formulae for and calculate volumes of revolution about both the x and y-axes. • Solve modelling problems which involve volumes of revolution.	**FM1.5 Elastic Collisions in One Dimension** • Express the 'compressibility', 'bounciness' or 'elasticity' of an object by a value called the coefficient of restitution (e). • Know that $0 \leq e \leq 1$ [and that e = 0 means inelastic and e =1 means perfectly elastic]. • Know and be able to use Newton's (experimental) law of restitution for direct impacts of elastic spheres. • Calculate the change in kinetic energy due to an impact. • Solve problems of the following types involving elastic impacts: a) successive collisions between pairs of spheres (horizontal motion). b) bouncing ball (off a horizontal elastic plane). c) successive collisions including two spheres and sphere against a wall. d) determination of the number of collisions or deriving the possible range of e.
Revision for AS exams AS exams		
	Paper 1: Further Core Mathematics 1 50%, 1 hour 40 mins, 80 marks	Only Year 12 content assessed
	Paper 2: Decision Mathematics 1 & Further Mechanics 1 50%, 1 hour 40 mins, 80 marks	Only Year 12 content assessed Section A (25% of AS Level) Section B (25% of AS Level)

YEAR 13

Module 1 is taught by Teachers 1 and 2 across the Year, with particular focus through practical assessed activities.

TERM	Teacher 1 (Further Core Mathematics) delivered via 3 x 70minute lesson per week	Teacher 2 (Decision Mathematics & Further Mechanics) delivered via 1 x 70 minute lesson per week
1	FC2.1 Complex Numbers • Multiply and divide complex numbers in modulus-argument and exponential form. • Know and use cosine and sine in terms of the exponential form. • Understand, remember and be able to use de Moivre's theorem: $z^n = r^n e^{in\theta} = r^n(\sin n\theta + i\cos n\theta)$. • Derive multiple angle formulae/expressions e.g. $\cos 3\theta$ in terms of powers of $\cos\theta$, and $\sin^3\theta$ in terms of multiple angles of $\sin\theta$. • Apply de Moivre's theorem to sum a geometric series. • Know how to solve completely equations of the form $z^n - a - ib = 0$, giving special attention to cases where $a = 1$, $b = 0$. FC2.5 Hyperbolic Functions • Know the definitions of $\sinh x$, $\cosh x$ and $\tanh x$ including their domains and ranges. • Sketch graphs of the hyperbolic functions. • Differentiate and integrate the hyperbolic functions and know the standard results. • Understand and be able to use the inverse hyperbolic functions including domains and ranges. • Derive, use and know the logarithmic forms of the inverse hyperbolic functions.	D1.3 The Planarity Algorithm • Apply the planarity algorithm for planar graphs. • Determine if a graph contains a Hamiltonian cycle. D1.5 Route Inspection • Determine whether a graph is traversable. • Apply an algorithm to solve the route inspection problem; • Find a route by inspection. • Understand the importance of the order of vertices of the graph in finding a route.
Assessment Point 1 A practice-paper style assessment point is completed at the start of Term 2. This includes contents from the Further Core 1 and Decision Mathematics 1 modules, as well as the Further Core 2 content covered during Term 1.		

2	FC2.4 Polar Coordinates • Understand and be able to use polar coordinates and be able to convert between polar and Cartesian coordinates. • Know how to sketch standard polar curves. • Find tangents parallel and perpendicular to the initial line. • Find (compound) areas under polar graphs using the $\frac{1}{2}\int$ formula “ r”dθ. FC2.2 Series • Use the method of differences to sum simple finite series. • Find and use higher derivatives of functions. • Know how to express functions as an infinite series in ascending powers using Maclaurin’s expansion. • Find the series expansion of composite functions.	D1.6 The Travelling Salesperson Problem • Understand the travelling salesman problem and that there is no simple algorithm to solve it for complex networks. • Use the nearest neighbour algorithm to find upper bounds for the problem. • Find lower bounds for a problem. • Understand that not all upper and lower bounds give a solution to the problem. • Know how to identify the best upper and lower bounds. • Solve the travelling salesman problem and interpret this solution in the context of the problem. D1.8 The Simplex Algorithm • Understand and use slack, surplus and artificial variables. • Use slack variables to write inequality constraints as equations. • Know how to rewrite LP problems so that each equation contains all the variables x, y, s, and t. • Put the information in an initial tableau. • Find the pivot and use it to form a new tableau. • Identify if a tableau satisfies the optimality condition. • Know how to use slack and surplus variables. • Understand and be able to use artificial variables. • Use the two-stage simplex algorithm. • Use the Big-M method. • Relate the solution to the original problem.

3	**FC2.3 Further Calculus** • Know how to deal with infinity as a limit of a definite integral. • Integrate functions across limits which include values when the function is undefined i.e. deal with discontinuous integrands. • Understand and be able to evaluate the mean value of a function. • Integrate functions which can be split into partial fractions up to denominators with quadratic factors. • Differentiate inverse trigonometric functions such as $\arctan x$. • Know how to integrate functions of the form $(a^2 - x^2)^{-\frac{1}{2}}$ and $(a^2 + x^2)^{-1}$ and be able to choose trigonometric substitutions to integrate associated functions. • Derive formulae for and calculate volumes of revolution about both the x and y-axes. • Find volumes of revolution for functions given in parametric form. **FC2.6 Differential Equations** • Identify the form of first order differential equations that can be solved by an integrating factor and carry out the solution. • Find general and particular solutions of differential equations of this form. • Solve second order differential equations of the form y" + ay' + by = f(x) where f(x) is a polynomial, exponential or trigonometric function. • Find general and particular solutions of second order differential equations of this form. • Use differential equations in modelling in kinematics and in other contexts. • Solve the equation for simple harmonic motion $\ddot{x} = -\omega^2 x$ and relate the solution to the motion. • Model damped oscillations using second order differential equations and interpret their solutions.	**D1.10 Resource Histograms** • Draw and interpret resource histograms. • Level resource histograms. • Construct a scheduling diagram. • Interpret and modify schedules to meet requirements. **FM1.2 Momentum & Impulse (Part 2)** • Extend the definition of linear momentum and impulse to 2-D using vectors. • Use the impulse-momentum principle in vector form, i.e. I = mv – mu. **FM1.4 Elastic Strings & Springs** • Investigate the ability of strings to stretch and springs to stretch and compress. • Define the modulus of elasticity (λ), natural length (a) and extension (x). • Use the above definitions to work out the tension in a stretched string or a stretched/ compressed spring i.e. use Hooke's Law, $T = \frac{\lambda x}{a}$. • Derive the elastic potential energy (EPE) from Hooke's Law by applying the work done in stretching a string/spring, i.e. $EPE = \frac{\lambda x^2}{2a}$. • Calculate the tension in a string or spring when a system is held in equilibrium. • Include EPE when using the work-energy principle. • Know the conditions for conservation of mechanical energy. • Solve string/spring problems involving work and energy (i.e. KE, GPE and EPE).
	Assessment Point 2 (Mock) Students sit a mock paper at the end of Term 3 which covers most of the AS Level and A Level content.	

4	Revision for final exams	FM1.6 Elastic Collisions in Two Dimensions • Understand that during an impact the impulse acts perpendicularly to the surface through the centre of the sphere. • Apply Newton's (experimental) law of restitution in the direction of the impulse. • Appreciate that perpendicular to the impulse, the velocity component does not change. • Understand and be able to calculate an angle of deflection. • Calculate the kinetic energy 'lost' in an impact. • Work in speeds and angles or in velocity vectors (i, j). • Understand that, during a collision between two smooth spheres, total momentum is conserved and the impulse acts in the direction of the line of centres. • Apply Newton's (experimental) law of restitution in the direction of the line of centres. • Appreciate that perpendicular to the line of centres, velocity components do not change. • Understand and be able to calculate an angle of deflection. • Calculate the kinetic energy 'lost' in a collision. • Work in speeds and angles or in velocity vectors (i, j).
5	Revision for final exams	
6	Paper 1: Further Core Mathematics 25%, 1 hour 30 mins, 75 marks	Any pure content can be assessed on either paper
	Paper 2: Further Core Mathematics 25%, 1 hour 30 mins , 75 marks	
	Paper 3: Decision Mathematics 1 25%, 1 hour 30 mins, 75 marks	
	Paper 4: Further Mechanics 1 25%, 1 hour 30 mins, 75 marks	