

Timing	Unit Title	Key Question	Knowledge	Assessing understanding
Year 12	<p>Students in the Further Mathematics class will receive twice as many mathematics lessons per week as those studying the standard Mathematics A-level. As a result, the core Mathematics A-level content will be covered in approximately half the time, with completion expected by the summer half-term. The order in which this material is taught broadly follows the Year 12 and Year 13 Mathematics curriculum sequence, subject to variation depending on how teaching groups are divided.</p> <p>For the Further Mathematics A-level, four units are taught:</p> <ul style="list-style-type: none"> ● Core Pure 1 (CP1) ● Core Pure 2 (CP2) ● Further Statistics 1 (FS1) ● Further Mechanics 1 (FM1) 			
Summer 2	CP1			
	Complex numbers	<p>Can you perform arithmetic with complex numbers in Cartesian form, including finding the modulus and argument?</p> <p>Can you find complex roots of quadratic and polynomial equations and understand the role of complex conjugates?</p> <p>Can you convert between Cartesian, modulus-argument, and exponential form of a complex number?</p>	<ul style="list-style-type: none"> ● Understand the definition of an imaginary number and perform arithmetic with complex numbers in Cartesian form $a + bi$. ● Find the modulus and argument of a complex number and convert between Cartesian and modulus-argument form. ● Find complex roots of quadratic and polynomial equations and use the conjugate root theorem for real polynomials. ● Solve equations with complex coefficients and understand the geometry of complex arithmetic. 	
	Argand Diagrams	Can you represent complex numbers and their operations geometrically on an	<ul style="list-style-type: none"> ● Represent complex numbers and their operations geometrically on an 	

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		<p>Argand diagram?</p> <p>Can you sketch and interpret loci in the Argand diagram defined by conditions on modulus and argument?</p>	<p>Argand diagram.</p> <ul style="list-style-type: none"> • Sketch and interpret loci in the Argand diagram defined by conditions on modulus, including circles and perpendicular bisectors. • Sketch and interpret loci defined by conditions on argument, including half-lines and sectors. • Find the Cartesian equation of a locus defined in terms of a complex number. 	
	Series	<p>Can you use the standard results for Σr, Σr^2, and Σr^3 to find the sum of more complex series?</p> <p>Can you apply the method of differences to find the sum of a series?</p>	<ul style="list-style-type: none"> • Use the standard results for Σr, Σr^2, and Σr^3 to find the sum of more complex finite series. • Apply the method of differences to find the sum of a telescoping series. 	
	Roots of polynomials	<p>Can you use the relationships between roots and coefficients (Vieta's formulae) for quadratic, cubic, and quartic equations?</p> <p>Can you find a new polynomial equation whose roots are a transformation of the roots of a given equation?</p>	<ul style="list-style-type: none"> • Use Vieta's formulae to relate the roots and coefficients of quadratic, cubic, and quartic equations. • Find expressions for symmetric functions of the roots of a polynomial without solving the equation. • Find a new polynomial equation whose roots are a linear or other transformation of the roots of a given equation. 	
	Volumes of revolution	<p>Can you find the volume of a solid of revolution formed by rotating a curve about the x-axis or y-axis using integration?</p>	<ul style="list-style-type: none"> • Find the volume of a solid of revolution formed by rotating a curve about the x-axis or y-axis using integration. • Find volumes of revolution for curves 	

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		Can you find volumes of revolution for curves defined parametrically?	<p>defined parametrically.</p> <ul style="list-style-type: none"> Find the volume of a solid formed by rotating a region between two curves. 	
	Matrices	<p>Can you perform matrix arithmetic including multiplication, finding determinants, and inverting 2×2 and 3×3 matrices?</p> <p>Can you use matrices to represent and perform linear transformations in 2D and 3D?</p> <p>Can you use matrices to solve systems of simultaneous equations and interpret geometrically when solutions do or do not exist?</p>	<ul style="list-style-type: none"> Perform matrix arithmetic including addition, multiplication, finding determinants, and inverting 2×2 and 3×3 matrices. Understand the conditions for a matrix to be singular and the geometric interpretation of a zero determinant. Use matrices to represent linear transformations in 2D and 3D, including rotations, reflections, and enlargements. Use matrices to solve systems of simultaneous equations using the inverse matrix method. 	
Year 13				
Autumn 1	CP1			
	Linear transformations	<p>Can you find and interpret the matrix representing a given linear transformation in 2D and 3D, including rotations, reflections, and enlargements?</p> <p>Can you find invariant points and invariant lines under a given linear transformation?</p> <p>Can you combine transformations by multiplying matrices and interpret the</p>	<ul style="list-style-type: none"> Find and interpret the matrix representing a given linear transformation in 2D and 3D, including rotations, reflections, and enlargements. Find invariant points and invariant lines under a given linear transformation. Combine transformations by multiplying matrices and interpret the 	

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		result geometrically?	<p>result geometrically.</p> <ul style="list-style-type: none"> Find the matrix representing the inverse of a linear transformation. 	
	Proof by induction	<p>Can you use the method of mathematical induction to prove statements involving sums of series?</p> <p>Can you use proof by induction to prove divisibility results and results involving matrices?</p> <p>Can you use proof by induction to prove results involving recurrence relations?</p>	<ul style="list-style-type: none"> Understand the structure of a proof by induction: base case, inductive hypothesis, inductive step, and conclusion. Use proof by induction to prove summation formulae for series. Use proof by induction to prove divisibility results. Use proof by induction to prove results involving matrices and recurrence relations. 	
	Vectors	<p>Can you find the equation of a straight line and a plane in three dimensions using vector and Cartesian forms?</p> <p>Can you use the scalar product to find angles between lines and planes and determine whether lines and planes are parallel or perpendicular?</p> <p>Can you find the intersection of lines and planes and calculate distances between points, lines, and planes?</p>	<ul style="list-style-type: none"> Find the vector and Cartesian equation of a straight line in three dimensions. Find the vector and Cartesian equation of a plane using the normal vector. Use the scalar product to find angles between lines and planes and determine whether they are parallel or perpendicular. Find the intersection of lines and planes and calculate distances between points, lines, and planes. 	
	CP2			
	Complex numbers	Can you convert between modulus-argument and exponential	<ul style="list-style-type: none"> Use de Moivre's theorem to find powers and roots of complex numbers 	

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		<p>(Euler) form and use de Moivre's theorem to find powers and roots of complex numbers?</p> <p>Can you use de Moivre's theorem to derive trigonometric identities?</p> <p>Can you find and plot nth roots of a complex number and understand their geometric arrangement on an Argand diagram?</p>	<p>in modulus-argument form.</p> <ul style="list-style-type: none"> ● Use de Moivre's theorem to derive trigonometric identities involving multiple angles. ● Find and plot nth roots of a complex number and understand their geometric arrangement on an Argand diagram. ● Use the exponential (Euler) form of a complex number and understand its relationship to modulus-argument form. 	
	<p>Methods in calculus</p>	<p>Can you use improper integrals and understand when they converge or diverge?</p> <p>Can you differentiate and integrate inverse trigonometric functions?</p> <p>Can you use the mean value theorem to find the mean value of a function over an interval?</p>	<ul style="list-style-type: none"> ● Evaluate improper integrals and determine whether they converge or diverge. ● Differentiate and integrate inverse trigonometric functions, including arcsin, arccos, and arctan. ● Use the mean value theorem to find the mean value of a function over a given interval. 	
	<p>Series</p>	<p>Can you find the Maclaurin series expansion of standard functions and use them to find approximations?</p> <p>Can you find the series expansion of more complex functions by combining and adapting standard Maclaurin series?</p>	<ul style="list-style-type: none"> ● Find the Maclaurin series expansion of standard functions including e^x, $\sin x$, $\cos x$, and $\ln(1+x)$. ● Use Maclaurin series to find approximations and identify the range of validity. ● Combine and adapt standard Maclaurin series to find expansions of more complex functions. 	

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	FS1			
	Discrete random variables	<p>Can you find and use the probability distribution, expected value, and variance of a discrete random variable?</p> <p>Can you find the expected value and variance of a linear transformation of a discrete random variable?</p> <p>Can you use the discrete uniform distribution as a model and evaluate its suitability?</p>	<ul style="list-style-type: none"> Find and use the probability distribution, expected value, and variance of a discrete random variable. Find the expected value and variance of a linear transformation $aX + b$ of a discrete random variable. Use the discrete uniform distribution as a model and evaluate its suitability in context. 	
	Poisson distributions	<p>Can you calculate probabilities using the Poisson distribution and understand the conditions required for it to be a valid model?</p> <p>Can you use the Poisson distribution as an approximation to the binomial distribution and justify when this is appropriate?</p>	<ul style="list-style-type: none"> Understand the conditions required for a Poisson distribution to be a valid model. Calculate probabilities using the Poisson distribution $Po(\lambda)$, including cumulative probabilities. Use the Poisson distribution as an approximation to the binomial distribution and justify when this is appropriate. Know and use the result that the mean and variance of a Poisson distribution are both equal to λ. 	
	FM1			
	Momentum and impulse	Can you apply the principle of conservation of linear momentum to solve collision problems in one dimension?	<ul style="list-style-type: none"> Understand and use the principle of conservation of linear momentum for collisions in one dimension. Calculate impulse as the change in momentum and use the 	

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		<p>Can you calculate impulse and use the impulse-momentum theorem to solve problems involving variable forces?</p> <p>Can you use Newton's law of restitution to solve collision problems and interpret the value of the coefficient of restitution?</p>	<p>impulse-momentum theorem.</p> <ul style="list-style-type: none"> Solve problems involving collisions using Newton's law of restitution and understand the role of the coefficient of restitution. Solve problems involving oblique collisions with smooth surfaces. 	
	Work, energy, power	<p>Can you calculate the work done by a constant or variable force, including forces acting at an angle to the direction of motion?</p> <p>Can you apply the work-energy theorem and the principle of conservation of mechanical energy to solve problems?</p> <p>Can you calculate power and use it to solve problems involving vehicles moving at constant speed or accelerating against a resistance?</p>	<ul style="list-style-type: none"> Calculate work done by a constant and variable force, including forces at an angle to the direction of motion. Use the work-energy theorem to relate the net work done on a particle to its change in kinetic energy. Use the principle of conservation of mechanical energy to solve problems involving kinetic and potential energy. Calculate power as the rate of doing work and apply it to problems involving vehicles moving at constant speed or accelerating. 	
Autumn 2	CP2			
	Volumes of revolution	<p>Can you find the volume of a solid of revolution formed by rotating a curve about the x-axis or y-axis, including for parametrically defined curves?</p> <p>Can you find volumes of revolution for curves defined in polar form?</p>	<ul style="list-style-type: none"> Find the volume of a solid of revolution formed by rotating a curve about the x-axis or y-axis, including for parametrically defined curves. Find volumes of revolution for curves defined in polar form. Find the volume of a solid formed by rotating a region between two curves about either axis. 	

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	Polar coordinates	<p>Can you convert between polar and Cartesian coordinates and sketch curves given in polar form?</p> <p>Can you find the area enclosed by a polar curve using integration?</p> <p>Can you find tangents parallel and perpendicular to the initial line for polar curves?</p>	<ul style="list-style-type: none"> • Understand the polar coordinate system and convert between polar and Cartesian coordinates. • Sketch curves given in polar form, identifying key features such as symmetry, maximum radius, and intersections with the initial line. • Find the area enclosed by a polar curve or between two polar curves using integration. • Find tangents parallel and perpendicular to the initial line for polar curves. 	
	Hyperbolic functions	<p>Can you sketch and interpret the graphs of sinh, cosh, and tanh and understand their domains and ranges?</p> <p>Can you use hyperbolic identities, including the Osborn's rule relationship to trigonometric identities?</p> <p>Can you differentiate and integrate hyperbolic functions, including inverse hyperbolic functions, and express inverse hyperbolic functions in logarithmic form?</p>	<ul style="list-style-type: none"> • Understand the definitions of sinh, cosh, and tanh in terms of exponentials and sketch their graphs. • Use and derive hyperbolic identities, including $\cosh^2 x - \sinh^2 x = 1$, and apply Osborn's rule to relate them to trigonometric identities. • Differentiate and integrate hyperbolic functions. • Understand inverse hyperbolic functions and express them in logarithmic form. • Differentiate and integrate inverse hyperbolic functions. 	
	FS1			
	Hypothesis testing	Can you carry out hypothesis tests for the mean of a Poisson distribution and the parameter of a binomial distribution?	<ul style="list-style-type: none"> • Carry out hypothesis tests for the mean of a Poisson distribution and the parameter of a binomial distribution. 	

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		<p>Can you find and interpret critical regions and calculate the actual significance level of a test?</p> <p>Can you carry out a one-tailed and two-tailed hypothesis test and interpret the result in context?</p>	<ul style="list-style-type: none"> Find and interpret critical regions and calculate the actual significance level of a test. Carry out one-tailed and two-tailed hypothesis tests and interpret results in context. 	
	<p>Chi-squared tests</p>	<p>Can you calculate expected frequencies and carry out a chi-squared test for independence in a contingency table?</p> <p>Can you apply the chi-squared goodness of fit test to assess whether a given distribution is a suitable model for observed data?</p> <p>Can you calculate and interpret degrees of freedom, and understand when to merge cells in a contingency table?</p>	<ul style="list-style-type: none"> Calculate expected frequencies and carry out a chi-squared test for independence in a contingency table. Apply the chi-squared goodness of fit test to assess whether a given distribution is a suitable model for observed data. Calculate and interpret degrees of freedom and understand when and how to merge cells with low expected frequencies. 	
FM1				
	<p>Elastic collision in one dimension</p>	<p>Can you use Newton's law of restitution alongside conservation of momentum to solve direct collision problems?</p> <p>Can you solve problems involving successive collisions between particles and with walls?</p> <p>Can you find the range of values of e for which specific outcomes occur following a collision?</p>	<ul style="list-style-type: none"> Use Newton's law of restitution and conservation of momentum to solve problems involving direct collisions between particles. Understand the significance of the coefficient of restitution e, where $0 \leq e \leq 1$, and classify collisions as perfectly elastic, inelastic, or perfectly inelastic. Solve problems involving successive collisions between particles and with 	

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			<p>walls.</p> <ul style="list-style-type: none"> Find the range of values of e for which specific outcomes occur, such as a particle reversing direction or overtaking another. 	
Spring 1	CP2			
	Methods in differential equations	<p>Can you find the complementary function and particular integral to solve first and second order linear differential equations with constant coefficients?</p> <p>Can you solve differential equations where the particular integral takes the form of a polynomial, exponential, or trigonometric function?</p> <p>Can you solve systems of coupled first order differential equations?</p>	<ul style="list-style-type: none"> Find the complementary function of a first and second order linear differential equation with constant coefficients. Find the particular integral for equations where the right-hand side is a polynomial, exponential, or trigonometric function. Combine the complementary function and particular integral to find the general solution and apply initial conditions to find the particular solution. Solve systems of coupled first order differential equations. 	
	Modelling with differential equations	<p>Can you set up and solve differential equations arising from real-world contexts, including population models and harmonic motion?</p> <p>Can you interpret the solution of a differential equation in context and evaluate the suitability of the model?</p> <p>Can you recognise and solve equations</p>	<ul style="list-style-type: none"> Set up differential equations from real-world contexts and interpret their solutions. Recognise and solve equations that lead to simple harmonic motion and understand the physical meaning of the solution. Recognise and solve equations that lead to damped oscillations and classify the type of damping. 	

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		that lead to simple harmonic motion and damped oscillations?	<ul style="list-style-type: none"> Evaluate the suitability of a differential equation model and suggest refinements in context. 	
	FS1			
	Geometric and negative binomial distributions	<p>Can you calculate probabilities using the geometric distribution and understand the conditions required for it to be a valid model?</p> <p>Can you find the mean and variance of the geometric and negative binomial distributions and apply them to problems in context?</p> <p>Can you recognise when a negative binomial distribution is an appropriate model and calculate probabilities from it?</p>	<ul style="list-style-type: none"> Understand the conditions required for a geometric distribution to be a valid model and calculate probabilities from it. Know and use the mean and variance of the geometric distribution. Understand the negative binomial distribution as an extension of the geometric distribution and calculate probabilities from it. Know and use the mean and variance of the negative binomial distribution and apply both distributions to problems in context. 	
	FM1			
	Elastic strings and springs	<p>Can you apply Hooke's law and calculate the elastic potential energy stored in a stretched or compressed string or spring?</p> <p>Can you apply conservation of energy to solve problems involving elastic strings and springs on horizontal and vertical surfaces?</p>	<ul style="list-style-type: none"> Understand and use Hooke's law for elastic strings and springs, including natural length and modulus of elasticity. Calculate the elastic potential energy stored in a stretched or compressed elastic string or spring. Apply conservation of energy to solve problems involving elastic strings and springs. Solve problems involving a particle 	

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			moving on a horizontal or vertical surface with an attached elastic string or spring.	
Spring 2	FS1			
	Central limit theorem	<p>Can you state and apply the central limit theorem to approximate the distribution of the sample mean for a large sample?</p> <p>Can you use the normal approximation to the distribution of the sample mean to calculate probabilities and construct hypothesis tests?</p> <p>Can you identify when the central limit theorem is appropriate to apply and justify its use in context?</p>	<ul style="list-style-type: none"> Understand the statement of the central limit theorem and the conditions required for it to apply. Use the central limit theorem to approximate the distribution of the sample mean as normal for large samples. Apply the normal approximation to the sample mean to calculate probabilities. Use the central limit theorem in the context of hypothesis testing and interpret results in context. 	
	Probability generating functions	<p>Can you find and use the probability generating function of a discrete random variable, including standard distributions such as binomial, Poisson, and geometric?</p> <p>Can you use probability generating functions to find the mean and variance of a distribution by differentiation?</p> <p>Can you find the probability generating function of a sum of independent random variables and use it to identify the resulting distribution?</p>	<ul style="list-style-type: none"> Find the probability generating function (PGF) of a discrete random variable and use it to find probabilities. Know and use the PGFs of standard distributions including binomial, Poisson, and geometric. Use differentiation of a PGF to find the mean and variance of a distribution. Find the PGF of a sum of independent random variables and use it to identify the resulting distribution. 	
	FM1			

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	Elastic collisions in two dimensions	<p>Can you resolve velocity components and apply Newton's law of restitution to solve oblique collision problems between spheres?</p> <p>Can you solve problems involving the oblique impact of a sphere with a smooth plane surface?</p> <p>Can you find the directions of motion after an oblique collision and calculate the loss in kinetic energy?</p>	<ul style="list-style-type: none"> ● Resolve velocity components along and perpendicular to the line of centres for oblique collisions between spheres. ● Apply Newton's law of restitution along the line of centres and conservation of momentum to solve oblique impact problems. ● Solve problems involving the oblique impact of a sphere with a smooth plane surface. ● Find the direction of motion of particles after an oblique collision and calculate the loss in kinetic energy. 	
Summer 1	FS1	<p>Can you understand and calculate the size and power of a hypothesis test, and distinguish between Type I and Type II errors?</p> <p>Can you construct a power function and use it to assess the quality of a hypothesis test?</p> <p>Can you compare the power of two tests and understand the relationship between the size of a test and its power?</p>	<ul style="list-style-type: none"> ● Understand and distinguish between Type I and Type II errors in the context of hypothesis testing. ● Calculate the probability of making a Type I error (the size of a test) and a Type II error. ● Construct a power function and use it to assess the quality of a hypothesis test. ● Compare the power of two tests and understand the relationship between the size of a test and its power. 	
	Quality of tests			