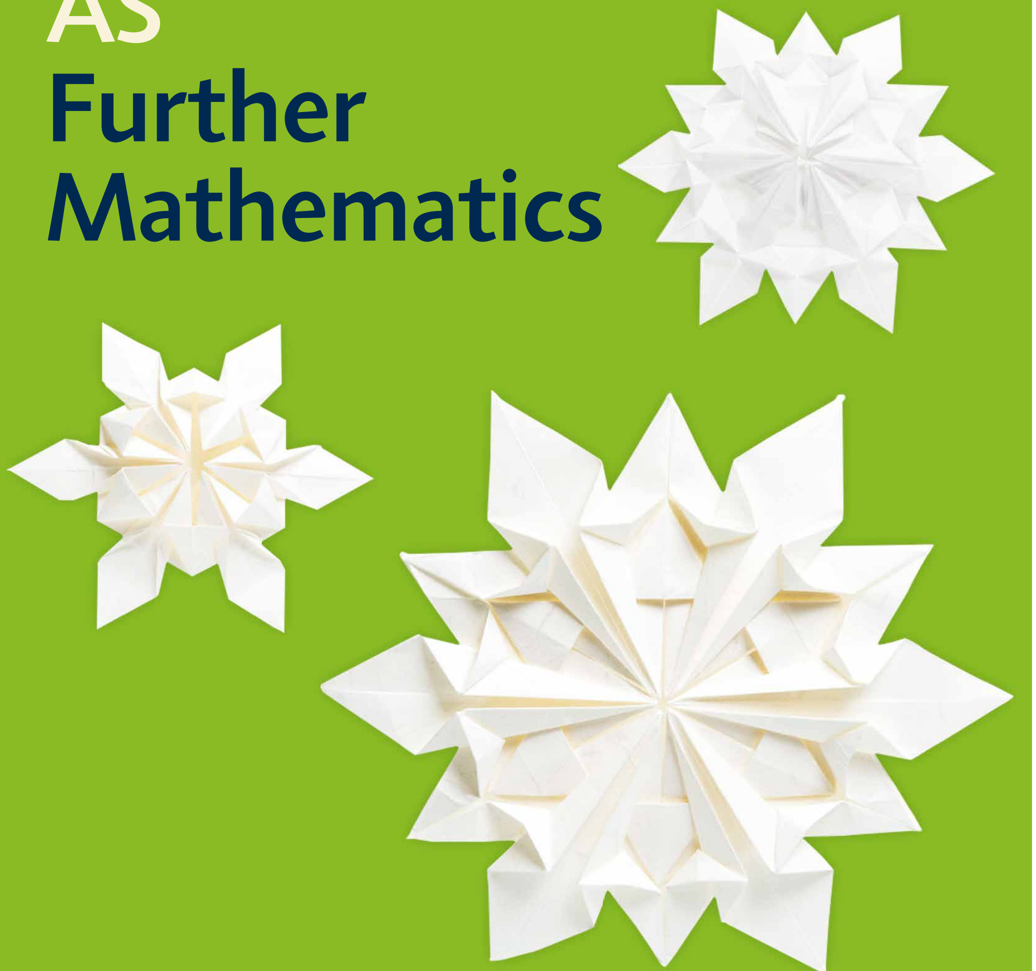
Pearson Edexcel

AS Further Mathematics



Specification

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Further Mathematics (8FM0)

First teaching from September 2017

First certification from 2018

Issue 4

Contents

Qualification at a glance

Content and assessment overview

This Pearson Edexcel Level 3 Advanced Subsidiary GCE in Further Mathematics builds on the skills, knowledge and understanding set out in the whole GCSE subject content for mathematics and the subject content for the Pearson Edexcel Level 3 Advanced Subsidiary and Advanced GCE Mathematics qualifications. Assessments will be designed to reward students for demonstrating the ability to provide responses that draw together different areas of their knowledge, skills and understanding from across the full course of study for the AS level Further Mathematics qualification and also from across the A level Mathematics qualification. Problem solving, proof and mathematical modelling will be assessed in Further Mathematics in the context of the wider knowledge which students taking AS Further Mathematics will have studied.

In this qualification, option F and option K (see *Appendix 9*) are routes that can be taught alongside the *Pearson Edexcel Level 3 Advanced Subsidiary in Mathematics* qualification.

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Further Mathematics consists of two externally-examined papers.

Students must complete all assessments in May/June in any single year.

Paper 1: Core Pure Mathematics (*Paper code: 8FM0/01)
Written examination: 1 hour and 40 minutes ***50% of the qualification*** ***80 marks***
Content overview Proof, Complex numbers, Matrices, Further algebra and functions, Further calculus, Further vectors
Assessment overview • Students must answer all questions. • Calculators may be used in the assessment. Information on the use of calculators during the examinations for this qualification can be found in *Appendix 3: Use of Calculators.*

Paper 2: Further Mathematics Options (*Paper codes: 8FM0/2A-2K)
Written examination: 1 hour and 40 minutes ***50% of the qualification*** ***80 marks***
Content overview Students take **one** of the following ten options: **2A: Further Pure Mathematics 1 and Further Pure Mathematics 2** **2B: Further Pure Mathematics 1 and Further Statistics 1** **2C: Further Pure Mathematics 1 and Further Mechanics 1** **2D: Further Pure Mathematics 1 and Decision Mathematics 1** **2E: Further Statistics 1 and Further Mechanics 1** **2F: Further Statistics 1 and Decision Mathematics 1** **2G: Further Statistics 1 and Further Statistics 2** **2H: Further Mechanics 1 and Decision Mathematics 1** **2J: Further Mechanics 1 and Further Mechanics 2** **2K: Decision Mathematics 1 and Decision Mathematics 2**
Assessment overview • Students must answer all questions. • Calculators may be used in the assessment. Information on the use of calculators during the examinations for this qualification can be found in *Appendix 3: Use of calculators.*

*See *Appendix 8: Codes* for a description of this code and all other codes relevant to this qualification.

Paper 1: Core Pure Mathematics

Topics	What students need to learn:		
		Content	Guidance
1 **Proof**	1.1	Construct proofs using mathematical induction. Contexts include sums of series, divisibility and powers of matrices.	To include induction proofs for: (i) summation of series, e.g. show $\sum_{r=1}^{n} r^3 = \frac{1}{4}n^2(n+1)^2$ or show $\sum_{r=1}^{n} r(r+1) = \frac{n(n+1)(n+2)}{3}$ (ii) divisibility, e.g. show $3^{2n} + 11$ is divisible by 4 (iii) matrix products, e.g. show $\begin{pmatrix} 3 & -4 \\ 1 & -1 \end{pmatrix}^n = \begin{pmatrix} 2n+1 & -4n \\ n & 1-2n \end{pmatrix}$
2 **Complex numbers**	2.1	Solve any quadratic equation with real coefficients. Solve cubic or quartic equations with real coefficients.	Given sufficient information to deduce at least one root for cubics or at least one complex root or quadratic factor for quartics, for example: (i) $f(z) = 2z^3 + 5z^2 + 7z + 10$ Given that $z + 2$ is a factor of $f(z)$, use algebra to solve $f(z) = 0$ completely. (ii) $g(x) = x^4 - x^3 + 6x^2 + 14x - 20$ Given $g(1) = 0$ and $g(-2) = 0$, use algebra to solve $g(x) = 0$ completely.
	2.2	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'.	Students should know the meaning of the terms, 'modulus' and 'argument'.
	2.3	Understand and use the complex conjugate. Know that non-real roots of polynomial equations with real coefficients occur in conjugate pairs.	Knowledge that if z_1 is a root of $f(z) = 0$ then $z_1{}^*$ is also a root.

Topics	What students need to learn:		
		Content	Guidance
2 **Complex numbers** *continued*	2.4	Use and interpret Argand diagrams.	Students should be able to represent the sum or difference of two complex numbers on an Argand diagram.
	2.5	Convert between the Cartesian form and the modulus-argument form of a complex number. Knowledge of radians is assumed.	
	2.6	Multiply and divide complex numbers in modulus argument form. Knowledge of radians and compound angle formulae is assumed.	Knowledge of the results, $\lvert z_1 z_2 \rvert = \lvert z_1 \rvert \lvert z_2 \rvert$, $\left\lvert \frac{z_1}{z_2} \right\rvert = \frac{\lvert z_1 \rvert}{\lvert z_2 \rvert}$ $\arg(z_1 z_2) = \arg z_1 + \arg z_2$ $\arg\left(\frac{z_1}{z_2}\right) = \arg z_1 - \arg z_2$
	2.7	Construct and interpret simple loci in the argand diagram such as $\lvert z - a \rvert > r$ and $\arg(z - a) = \theta$ Knowledge of radians is assumed.	To include loci such as $\lvert z - a \rvert = b$, $\lvert z - a \rvert = \lvert z - b \rvert$, $\arg(z - a) = \beta$, and regions such as $\lvert z - a \rvert \leqslant \lvert z - b \rvert$, $\lvert z - a \rvert \leqslant b$, $\alpha < \arg(z - a) < \beta$
3 **Matrices**	3.1	Add, subtract and multiply conformable matrices. Multiply a matrix by a scalar.	
	3.2	Understand and use zero and identity matrices.	
	3.3	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 $\mathbf{AB}$ is the transformation represented by $\mathbf{B}$ followed by the transformation represented by $\mathbf{A}$. 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 assumed.

Topics	What students need to learn:		
	Content		Guidance
3 **Matrices** *continued*	3.4	Find invariant points and lines for a linear transformation.	For a given transformation, students should be able to find the coordinates of invariant points and the equations of invariant lines.
	3.5	Calculate determinants of: 2×2 and 3×3 matrices and interpret as scale factors, including the effect on orientation.	Idea of the determinant as an area scale factor in transformations.
	3.6	Understand and use singular and non-singular matrices. Properties of inverse matrices. Calculate and use the inverse of non-singular 2×2 matrices and 3×3 matrices.	Understanding the process of finding the inverse of a matrix is required. Students should be able to use a calculator to calculate the inverse of a matrix.
	3.7	Solve three linear simultaneous equations in three variables by use of the inverse matrix.	
	3.8	Interpret geometrically the solution and failure of solution of three simultaneous linear equations.	Students should be aware of the different possible geometrical configurations of three planes, including cases where the planes: (i) meet in a point (ii) form a sheaf (iii) form a prism or are otherwise inconsistent
4 **Further algebra and functions**	4.1	Understand and use the relationship between roots and coefficients of polynomial equations up to quartic equations.	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) $\frac{1}{\alpha} + \frac{1}{\beta} + \frac{1}{\gamma}$ (iii) $(3 + \alpha)(3 + \beta)(3 + \gamma)$ (iv) $\alpha^3 + \beta^3 + \gamma^3$

Topics	What students need to learn:		
	Content		Guidance
4 **Further algebra and functions** *continued*	4.2	Form a polynomial equation whose roots are a linear transformation of the roots of a given polynomial equation (of at least cubic degree).	
	4.3	Understand and use formulae for the sums of integers, squares and cubes and use these to sum other series.	For example, students should be able to sum series such as $\sum_{r=1}^{n} r(r^2 + 2)$
5 **Further calculus**	5.1	Derive formulae for and calculate volumes of revolution.	Both $\pi \int y^2 \, dx$ and $\pi \int x^2 \, dy$ are required.
6 **Further vectors**	6.1	Understand and use the vector and Cartesian forms of an equation of a straight line in 3-D.	The forms, $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$ and $\frac{x - a_1}{b_1} = \frac{y - a_2}{b_2} = \frac{z - a_3}{b_3}$ Find the point of intersection of two straight lines given in vector form. Students should be familiar with the concept of skew lines and parallel lines.
	6.2	Understand and use the vector and Cartesian forms of the equation of a plane.	The forms, $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b} + \mu\mathbf{c}$ and $\mathbf{a}x + \mathbf{b}y + \mathbf{c}z = d$
	6.3	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.	$\mathbf{a.b} = \lvert\mathbf{a}\rvert \lvert\mathbf{b}\rvert \cos\theta$ The form $\mathbf{r.n} = k$ for a plane.
	6.4	Check whether vectors are perpendicular by using the scalar product.	Knowledge of the property that $\mathbf{a.b} = 0$ if the vectors $\mathbf{a}$ and $\mathbf{b}$ are perpendicular.
	6.5	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 perpendicular distance from (α, β, γ) to $n_1x + n_2y + n_3z + d = 0$ is $\frac{\lvert n_1\alpha + n_2\beta + n_3\gamma + d \rvert}{\sqrt{n_1^2 + n_2^2 + n_3^3}}$

Assessment information

- First assessment: May/June 2018.
- The assessment is 1 hour 40 minutes.
- The assessment is out of 80 marks.
- Students must answer all questions.
- Calculators may be used in the assessment. Information on the use of calculators during the examinations for this qualification can be found in *Appendix 3: Use of calculators.*
- The booklet 'Mathematical Formulae and Statistical Tables' will be provided for use in the assessment.

Sample assessment materials

A sample paper and mark scheme for this paper can be found in the *Pearson Edexcel Level 3 Advanced Subsidiary GCE in Further Mathematics Sample Assessment Materials (SAMs)* document.

Further Statistics 1

Topics	What students need to learn:		
		Content	Guidance
1 **Discrete probability distributions**	1.1	Calculation of the mean and variance of discrete probability distributions.	Use of $\mathrm{E}(X) = \mu = \sum x\mathrm{P}(X = x)$ and $\mathrm{Var}(X) = \sigma^2 = \sum x^2\mathrm{P}(X = x) - \mu^2$
		Extension of expected value function to include $\mathrm{E}(\mathrm{g}(X))$.	The formulae used to define $\mathrm{g}(x)$ will be consistent with the level required in AS Mathematics and AS Further Mathematics. Questions may require candidates to use these calculations to assess the suitability of models.
2 **Poisson & binomial distributions**	2.1	The Poisson distribution.	Students will be expected to use this distribution to model a real-world situation and to comment critically on the appropriateness. Students will be expected to use their calculators to calculate probabilities including cumulative probabilities. Students will be expected to use the additive property of the Poisson distribution. E.g. if X = the number of events per minute and $X \sim \mathrm{Po}(\lambda)$, then the number of events per 5 minutes ~ $\mathrm{Po}(5\lambda)$.
		The additive property of Poisson distributions.	If X and Y are independent random variables with $X \sim \mathrm{Po}(\lambda)$ and $Y \sim \mathrm{Po}(\mu)$, then $X + Y \sim \mathrm{Po}(\lambda + \mu)$ No proofs are required.
	2.2	The mean and variance of the binomial distribution and the Poisson distribution.	Knowledge and use of : If $X \sim \mathrm{B}(n, p)$, then $\mathrm{E}(X) = np$ and $\mathrm{Var}(X) = np(1-p)$ If $Y \sim \mathrm{Po}(\lambda)$, then $\mathrm{E}(Y) = \lambda$ and $\mathrm{Var}(Y) = \lambda$ Derivations are not required.
	2.3	The use of the Poisson distribution as an approximation to the binomial distribution.	When n is large and p is small the distribution $\mathrm{B}(n, p)$ can be approximated by $\mathrm{Po}(np)$. Derivations are not required.
	2.4	Extend ideas of hypothesis tests to test for the mean of a Poisson distribution	Hypotheses should be stated in terms of a population parameter μ or λ

Topics	What students need to learn:		
	Content		Guidance
3 **Chi squared tests**	3.1	Goodness of fit tests and Contingency Tables.	Applications to include the discrete uniform, binomial and Poisson distributions.
		The null and alternative hypotheses.	Lengthy calculations will not be required.
		The use of $\sum_{i=1}^{n}\frac{(O_i - E_i)^2}{E_i}$ as an approximate χ^2 statistic.	Students will be expected to determine the degrees of freedom when one or more parameters are estimated from the data. Cells should be combined when $E_i < 5$.
		Degrees of freedom.	Students will be expected to obtain p-values from their calculator or use tables to find critical values.

Further Mechanics 1

Topics	What students need to learn:		
	Content		Guidance
1 **Momentum and impulse**	1.1	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.
2 **Work, energy and power**	2.1	Kinetic and potential energy, work and power. The work-energy principle. The principle of conservation of mechanical energy.	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 $F = \mu R$ when a particle is moving, is assumed.
3 **Elastic collisions in one dimension**	3.1	Direct impact of elastic spheres. Newton's law of restitution. Loss of kinetic energy due to impact.	Students will be expected to know and use the inequalities $0 \leqslant e \leqslant 1$ (where e is the coefficient of restitution). The spheres may be modelled as particles.
	3.2	Successive direct impacts of spheres and/or a sphere with a smooth plane surface.	The spheres may be modelled as particles.