OXFORD AQA
INTERNATIONAL QUALIFICATIONS

International AS and A-level

Further Mathematics

(9765) Specification





For teaching from 2027 onwards

For International AS exams
May/June 2028 onwards

For International A-level exams
May/June 2029 onwards

For teaching and examination outside the United Kingdom

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Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at **oxfordaqa.com/9765**
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose OxfordAQA International AS and A-levels?

Our International qualifications enable schools that follow a British curriculum to benefit from the best education expertise in the United Kingdom (UK).

Our International AS and A-levels offer the same rigour and high quality as AS and A-levels in the UK and are relevant and appealing to students worldwide. They reflect a deep understanding of the needs of teachers and schools around the globe and are brought to you by Oxford University Press and AQA, the UK's leading awarding body.

Providing valid and reliable assessments, these qualifications are based on over 100 years of experience, academic research and international best practice. They have been independently validated as being to the same standard as the qualifications accredited by the UK examinations regulator, Ofqual. They reflect the latest changes to the British system, enabling students to progress to higher education with up-to-date qualifications.

You can find out about OxfordAQA at **oxfordaqa.com**

1.2 Why choose our International AS and A-level Further Mathematics?

We have worked closely with teachers to design our specification to inspire, challenge and motivate every student, no matter what their level of ability, while supporting you in developing creative and engaging lessons.

Maths is for everyone. It is diverse, engaging and essential in equipping students with the right skills to reach their future destination, whatever that may be. At OxfordAQA, we design qualifications and support to enable students to engage with, explore, enjoy and succeed in maths. By putting students at the heart of everything we do, our aim is to support teachers to shape what success in maths looks like for every student.

Our question papers are designed with students in mind. We're committed to ensuring that students are settled early in our exams and have the best possible opportunity to demonstrate their knowledge and understanding of maths, to ensure they achieve the results they deserve.

The specification takes an approach to the study of mathematics that is consistent across the topic areas. Our experienced team has produced question papers and mark schemes that allow you to get back to inspirational mathematics teaching and allow students of all abilities to achieve their best on every question.

You can find out about all our International AS and A-level Mathematics qualifications at **oxfordaqa.com/maths**

1.3 Recognition

OxfordAQA meet the needs of international students. They are an international alternative and comparable in standard to the Ofqual regulated qualifications offered in the UK. Our qualifications have been independently benchmarked by UK ENIC, the UK national agency for providing expert opinion on qualifications worldwide. They have confirmed they can be considered 'comparable to the overall GCE A-level and GCSE standard offered in the UK'.

To read their report and see the latest list of universities who have stated they accept these international qualifications, visit oxfordaqa.com/recognition

1.4 The Oxford International Programme learner attributes

In order to equip students with the skills they need for success both now and in the future, we have worked with Oxford University Press to create the Oxford International Programme. This combines the Oxford International Curriculum with OxfordAQA qualifications, creating an integrated offer for international schools, from Early Years to A-level.

At its core we have introduced the Oxford International Programme learner attributes – the skills and competencies that enable our students to thrive academically, socially and personally.

The learner attributes, alongside our focus on demonstrating higher order critical thinking skills, ensure that students are equipped to get the grades that will take them places, and build the skills they need to be successful when they get there.



1.5 Support and resources to help you teach

We know that support and resources are vital for your teaching and that you have limited time to find or develop good quality materials. That's why we've worked with experienced teachers to provide you with resources that will help you confidently plan, teach and prepare for exams.

Teaching resources

You will have access to:

- sample schemes of work to help you plan your course with confidence
- teacher guidance notes to give you the essential information you need to deliver the specification
- training courses to help you deliver our qualifications
- student textbooks that have been checked and approved by us
- engaging worksheets and activities developed by teachers, for teachers.

Preparing for exams

You will have access to the support you need to prepare for our exams, including:

- specimen papers and mark schemes
- exemplar student answers with examiner commentaries
- a searchable bank of past AQA exam questions mapped to these qualifications.

Analyse your students' results with Data Insights

After the first examination series, you can use this tool to see which questions were the most challenging, how the results compare to previous years and where your students need to improve. Data Insights, our free online results analysis tool, will help you see where to focus your teaching.

Information about results, including maintaining standards over time, grade boundaries and our post-results services, will be available on our website in preparation for the first examination series.

Help and support

Visit our website for information, guidance, support and resources at oxfordaqa.com/9760

You can contact the subject team directly at **info@oxfordaqa.com** or call us on +44 (0)161 696 5995 (option 1 and then 1 again)

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm.

2 Specification at a glance

The titles of the qualifications are:

- OxfordAQA International Advanced Subsidiary Further Mathematics
- OxfordAQA International Advanced Level Further Mathematics.

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level. The International AS can be taken as a stand-alone qualification or can be used to count towards the International A-level. Students can take the International AS in the first year and then take the International A2 in the second year to complete the International A-level or they can take all the units together in the same examination series at the end of the course.

The International AS content will be 50% of the International A-level content and International AS assessments will contribute 50% of the total marks for the full International A-level qualification with the remaining 50% coming from the International A2 assessments.

Candidates may re-sit a unit any number of times within the shelf-life of the specification. The best result for each unit will count towards the final qualification. Exams will be available in October/November, January and May/June.

The guided learning hours (GLH) for an OxfordAQA International Advanced Subsidiary is 180.

The guided learning hours (GLH) for an OxfordAQA International Advanced Level is 360.

These figures are for guidance only and may vary according to local practice and the learner's prior experience of the subject.

2.1 Subject content

- Further Pure Mathematics 1 (page 11)
- Further Pure Mathematics 2 (page 16)
- Further Statistics 1 (page 20)
- Further Mechanics 1 (page 24)
- Further Pure Mathematics 3 (page 28)
- Further Pure Mathematics 4 (page 35)
- Further Statistics 2 (page 39)
- Further Mechanics 2 (page 42)

2.2 Assessments

Qualification title	International AS Further Mathematics	International A-level Further Mathematics
Total units	Three units - 2 compulsory and 1 option	Six units - 4 compulsory and 2 options
Compulsory units	Further Pure Mathematics 1 + Further Pure Mathematics 2	Further Pure Mathematics 1 + Further Pure Mathematics 2 + Further Pure Mathematics 3 + Further Pure Mathematics 4
Optional units	One of: Further Statistics 1 or Further Mechanics 1	Two of: Further Statistics 1* or Further Mechanics 1* or Further Statistics 2 or Further Mechanics 2

*For A-level certification, **at least one** of Further Statistics 1 or Further Mechanics 1 must be counted as the AS optional unit. Further Statistics 2 and Further Mechanics 2 cannot solely form the optional element of an A-level award.

The full list of entry combinations for the optional units in International A-level Further Mathematics is:

A-level optional unit combination	AS Optional unit	A2 Optional unit
1a	Further Statistics 1	Further Mechanics 1
1b	Further Mechanics 1	Further Statistics 1
2	Further Statistics 1	Further Statistics 2
3	Further Mechanics 1	Further Mechanics 2
4	Further Statistics 1	Further Mechanics 2
5	Further Mechanics 1	Further Statistics 2

Further Pure Mathematics 1
What's assessed Content from the Further Pure Mathematics 1 area of the specification
How it's assessed • Written exam: 1 hour 15 minutes • 60 marks • Calculator allowed • 33.3% of the International AS assessment • 16.7% of the International A-level assessment

Further Pure Mathematics 2
What's assessed Content from the Further Pure Mathematics 2 area of the specification
How it's assessed • Written exam: 1 hour 15 minutes • 60 marks • Calculator allowed • 33.3% of the International AS assessment • 16.7% of the International A-level assessment

Further Statistics 1

What's assessed

Content from the Further Statistics 1 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 33.3% of the International AS assessment (does not count towards AS if used as an A2 optional unit)
- 16.7% of the International A-level assessment

Further Mechanics 1

What's assessed

Content from the Further Mechanics 1 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 33.3% of the International AS assessment (does not count towards AS if used as an A2 optional unit)
- 16.7% of the International A-level assessment

Further Pure Mathematics 3

What's assessed

Content from the Further Pure Mathematics 3 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 16.7% of the International A-level assessment

Further Pure Mathematics 4

What's assessed

Content from the Further Pure Mathematics 4 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 16.7% of the International A-level assessment

Further Statistics 2

What's assessed

Content from the Further Statistics 2 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 16.7% of the International A-level assessment

Further Mechanics 2

What's assessed

Content from the Further Mechanics 2 area of the specification

How it's assessed

- Written exam: 1 hour 15 minutes
- 60 marks
- Calculator allowed
- 16.7% of the International A-level assessment

3 Subject content

3.1 Further Pure Mathematics 1

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics – Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2

FP1.1: Algebra and graphs

Content		Guidance
FP1.1.1	Rational functions	To include knowledge of rational functions of the form $\frac{ax+b}{cx+d}$, $\frac{ax+b}{cx^2+dx+e}$ and $\frac{x^2+ax+b}{x^2+cx+d}$, and sketching their graphs. To include knowledge of finding the equations of asymptotes which will always be parallel to the coordinate axes. To include knowledge of finding points of intersection with the coordinate axes or other straight lines. To include knowledge of solving associated inequalities. To include knowledge of using quadratic theory (not calculus) to find the possible values of the function and the coordinates of the maximum or minimum points on the graph. For example: $y=\frac{x^2+2}{x^2-4x}$, $y=k \Rightarrow x^2+2=kx^2-4kx$ which has real roots if $16k^2+8k-8\geq 0$ which leads to $k\leq -1$ or $k\geq \frac{1}{2}$ and stationary points at $(1,-1)$ and $\left(-2,\frac{1}{2}\right)$

Content		Guidance
FP1.1.2	Parabolas, ellipses and hyperbolas	To include knowledge of parabolas with equations of the form $y^2 = 4ax$, including sketching graphs. To include knowledge of ellipses with equations of the form $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, including sketching graphs. To include knowledge of hyperbolas with equations of the form $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, including sketching graphs and the asymptotes $\frac{x}{a} = \pm\frac{y}{b}$ To include knowledge of rectangular hyperbolas with equations of the form $xy = c^2$, including sketching graphs and the asymptotes $x = 0,\ y = 0$. To include knowledge of finding points of intersection with the coordinate axes or other straight lines, and to interpret the geometrical implication of equal roots, distinct real roots or no real roots. To include knowledge of the effects of single transformations on these equations and graphs, such as translations, stretches parallel to the x-axis or y-axis, and reflections in the line $y = x$.

FP1.2: Coordinate geometry

Content		Guidance
FP1.2.1	Simple loci	To include knowledge of problems involving distances from points and distances from straight lines of the form $x = a$ and $y = b$. For example: Find the Cartesian equation of the locus of the points that are equidistant from the point (2, 3) and the line $x = 4$.

FP1.3: Complex numbers

Content		Guidance
FP1.3.1	Non-real roots of quadratic equations	To include knowledge of complex conjugates and that the non-real roots of quadratic equations with real coefficients occur in conjugate pairs. To include the notation z^* for the complex conjugate of z
FP1.3.2	Operations with complex numbers	To include knowledge of the sum, difference, product and quotient of complex numbers in the form $x + iy$, where x and y are real.
FP1.3.3	Real and imaginary parts	To include knowledge of comparing real and imaginary parts of an equation involving complex numbers, and their use in solving problems. To include knowledge of the notation Re for the real part and Im for the imaginary part. For example: $\mathrm{Re}(3+4\mathrm{i}) = 3$ and $\mathrm{Im}(3+4\mathrm{i}) = 4$
FP1.3.4	The Cartesian form of a complex number	To include knowledge of the Cartesian form, $x + \mathrm{i}y$, where x and y are real.
FP1.3.5	The polar co-ordinate form of a complex number	To include knowledge of the terms modulus, argument, conjugate, product and quotient, and the form $r(\cos\theta + \mathrm{i}\sin\theta)$ with the conventions $r \geq 0$ and $-\pi < \theta \leq \pi$
FP1.3.6	Argand Diagrams	To include knowledge of the representation of a complex number by a point on an Argand diagram.
FP1.3.7	Simple loci in the complex plane	To include knowledge of the loci: • circles in the form $\lvert z - z_1\rvert = r$ • perpendicular bisectors in the form $\lvert z - z_1\rvert = \lvert z - z_2\rvert$ • half-lines (rays) in the form $\arg(z - z_1) = \alpha$ where z_1 and z_2 are complex numbers.

FP1.4: Roots and coefficients of quadratic equations

Content		Guidance
FP1.4.1	Roots and coefficients of quadratic equations.	To include knowledge that if α and β are the roots of the quadratic equation $ax^2 + bx + c = 0$, then $\alpha + \beta = -\frac{b}{a}$ and $\alpha\beta = \frac{c}{a}$ To include knowledge of forming an equation with roots, for example: • α^3, β^3 • $\frac{1}{\alpha}, \frac{1}{\beta}$ • $\alpha + \frac{2}{\beta}, \beta + \frac{2}{\alpha}$

FP1.5: Series

Content		Guidance
FP1.5.1	Formulae for summing natural numbers	To include knowledge of the formulae for finding the sum of the natural numbers $\sum_{r=1}^{n} r = \frac{1}{2}n(n+1)$, the sum of the squares of the natural numbers $\sum_{r=1}^{n} r^2 = \frac{1}{6}n(2n+1)(n+1)$, and the sum of the cubes of the natural numbers $\sum_{r=1}^{n} r^3 = \frac{1}{4}n^2(n+1)^2$ To include the use of the above formulae to find polynomial expressions for summations. For example: • $\sum_{r=1}^{n} r^2(r+2)$ • $\sum_{r=1}^{n} (r^2 - r + 1)$ • $\sum_{r=3}^{2n} (r^3 + 2r)$

FP1.5.2	The method of differences	To include knowledge of the summation of a finite series by the method of differences. For example: • $\sum_{r=1}^{n} r \times r! = \sum_{r=1}^{n} \left((r+1)! - r!\right)$ • $\sum_{r=1}^{n} \left(\frac{2}{r(r+2)} \right)$ using the given result $\frac{1}{r} - \frac{1}{r+2} = \frac{2}{r(r+2)}$ • $\sum_{r=1}^{2n} \log\left(1 + \frac{2}{r}\right)$ using the result $\log(ar+b) - \log(r)$
FP1.5.3	Infinite series	To include knowledge of finding the sum of an infinite series when the limit of the partial sum exists.

3.2 Further Pure Mathematics 2

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Further Pure Mathematics 1

FP2.1: Trigonometry

Content		Guidance
FP2.1.1	General solutions of trigonometric equations	To include knowledge of the exact values for the sine, cosine and tangent of $\frac{\pi}{6}, \frac{\pi}{4}$ and $\frac{\pi}{3}$ For example: • $\sin(2x) = \frac{\sqrt{3}}{2}$ • $\cos\left(x + \frac{\pi}{6}\right) = -\frac{1}{\sqrt{2}}$ • $\tan^2\left(\frac{\pi}{3} - 2x\right) = 1$ • $\sin(2x) = 0.3$ • $\cos(3x - 1) = -0.2$

FP2.2: Calculus

Content		Guidance
FP2.2.1	Differentiation from first principles	To include knowledge of finding the gradient of the tangent to a curve at a point, by taking the limit as $h \to 0$ of the gradient of a chord joining two points whose x-coordinates differ by h, where the equation of the curve is given as $y = \mathrm{f}(x)$
FP2.2.2	Connected rates of change and small changes	To include knowledge of the chain rule for differentiation, such as $\frac{\mathrm{d}p}{\mathrm{d}t} = \frac{\mathrm{d}p}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$ where $p = kV^{\frac{4}{3}}$ To include knowledge of connected small changes, such as $\delta h \approx \frac{\mathrm{d}h}{\mathrm{d}x} \times \delta x$ where $h = 20x^{-2}$

Content		Guidance
FP2.2.3	Simple improper integrals	To include knowledge of the conditions under which an integral is improper. To include knowledge of evaluating simple improper integrals using a limiting process. For example: • $\int_0^4 \frac{1}{\sqrt{x}}\,\mathrm{d}x = \lim_{h\to 0^+} \int_h^4 \frac{1}{\sqrt{x}}\,\mathrm{d}x$ • $\int_4^\infty 2x^{-\frac{3}{2}}\mathrm{d}x = \lim_{a\to\infty} \int_4^a 2x^{-\frac{3}{2}}\mathrm{d}x$ • $\int_{-8}^{27} \frac{4}{\sqrt[3]{x}}\,\mathrm{d}x = \lim_{a\to 0^-} \int_{-8}^{a} \frac{4}{\sqrt[3]{x}}\,\mathrm{d}x + \lim_{b\to 0^+} \int_b^{27} \frac{4}{\sqrt[3]{x}}\,\mathrm{d}x$

FP2.3 Numerical methods

Content		Guidance
FP2.3.1	Numerical methods for roots of equations	To include knowledge of the following numerical methods, their graphical illustrations and their limitations: • change of sign method for locating roots of $\mathrm{f}(x) = 0$ in a given interval • interval bisection to find improved intervals and approximations for $\mathrm{f}(x) = 0$ • linear interpolation to find improved intervals and approximations for $\mathrm{f}(x) = 0$ • Newton–Raphson method to find improved intervals and approximations for $\mathrm{f}(x) = 0$
FP2.3.2	Numerical methods for first order differential equations of the form $\frac{\mathrm{d}y}{\mathrm{d}x} = \mathrm{f}(x, y)$	To include knowledge of Euler's step-by-step method, based on the linear approximation $y_{n+1} \approx y_n + h\mathrm{f}(x_n, y_n)$, $x_{n+1} = x_n + h$ where values x_0 and y_0 are given.

Content		Guidance
FP2.3.3	Reducing a relationship to a linear law	To include knowledge of reducing a given relationship to a linear law, including use of logarithms where appropriate. For example: • $\frac{1}{x}+\frac{1}{y}=k$ • $y^2=ax^3+b$ • $y=ax^n$ • $y=a\times b^t$ • $I=k\cos^2\theta+c$ To include knowledge of plotting points on a set of axes using numerical values, drawing a straight line of best fit and using it to estimate unknown constants.

FP2.4: Matrices and transformations

Content		Guidance
FP2.4.1	Matrix algebra	To include knowledge of matrix algebra for up to 3×3 matrices. To include knowledge of the inverse of a 2×2 matrix. To include knowledge of the terms identity, singular, non-singular and transpose. To include knowledge of the notation $\mathbf{I}$ for the identity matrix, the notation $\mathbf{M}^{-1}$ for the inverse of the matrix $\mathbf{M}$, and the notation $\mathbf{M}^{\mathsf{T}}$ for the transpose of the matrix $\mathbf{M}$ To include knowledge of non-square matrices and the results: • $(\mathbf{AB})^{-1}=\mathbf{B}^{-1}\mathbf{A}^{-1}$ for non-singular square matrices • $(\mathbf{AB})^{\mathsf{T}}=\mathbf{B}^{\mathsf{T}}\mathbf{A}^{\mathsf{T}}$ for all matrices

Content		Guidance
FP2.4.2	2×2 matrices and transformations of points in two dimensions	To include knowledge of transformations, such as: • rotations, clockwise and anticlockwise, about the origin • reflections in a line through the origin • stretches parallel to the x-axis and y-axis • enlargements with centre the origin • shears, including parallel to the x-axis or parallel to the y-axis. For shears, if the line of invariant points is not the x-axis or the y-axis, it will be given that the matrix represents a shear. To include knowledge of combinations of the above transformations. For example: $\begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}, \begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & -\frac{1}{2} \end{bmatrix},$ $\begin{bmatrix} 2 & 0 \\ 0 & 3 \end{bmatrix}, \begin{bmatrix} 4 & 0 \\ 12 & 4 \end{bmatrix}$
FP2.4.3	The determinant of a 2×2 matrix	To include knowledge of determinants for 2×2 matrices and the notation of $\det(\mathbf{M})$ for the determinant of the matrix $\mathbf{M}$ To include knowledge of determinants, their relationship to area scale factor of a transformation and the interpretation of a negative determinant for the corresponding transformation. To include knowledge of the results: • $\det(\mathbf{AB}) = \det(\mathbf{A}) \times \det(\mathbf{B})$ • $\det(\mathbf{M}^{-1}) = \frac{1}{\det(\mathbf{M})}$
FP2.4.4	Invariant points and invariant lines in two dimensions	To include knowledge of invariant points for a two-dimensional transformation, invariant lines for a two-dimensional transformation, and the difference between lines of invariant points and invariant lines.

3.3 Further Statistics 1

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Statistics 1

FS1.1: Bayes' theorem

Content		Guidance
FS1.1.1	Tree diagrams	To include knowledge of constructing tree diagrams, assigning probabilities and their use in problem solving.
FS1.1.2	Bayes' Theorem	To include knowledge and application of Bayes' theorem to at most three events.

FS1.2: The discrete uniform distribution

Content		Guidance
FS1.2.1	The discrete uniform distribution	To include knowledge of the conditions for which the discrete uniform distribution is an appropriate model, and the notation $X \sim \mathrm{DU}(a,b)$ where a and b are the minimum and maximum integer values.
FS1.2.2	Calculation of probabilities	To include knowledge of finding probabilities using the discrete uniform distribution.
FS1.2.3	Mean, variance and standard deviation	To include knowledge of finding the mean, variance and standard deviation of a discrete uniform distribution, and their derivations.

FS1.3: The geometric distribution

Content		Guidance
FS1.3.1	The geometric distribution	To include knowledge of the conditions for which the geometric distribution is an appropriate model, the notation $X \sim \mathrm{Geo}(p)$ where p is the probability of success on a single trial, and the memoryless nature of the distribution.
FS1.3.2	Calculation of probabilities	To include knowledge of finding probabilities using the geometric distribution formula
FS1.3.3	Mean, variance and standard deviation	To include knowledge of finding the mean, variance and standard deviation of a geometric distribution, and their derivations.

FS1.4: The negative binomial distribution

Content		Guidance
FS1.4.1	The negative binomial distribution	To include knowledge of the conditions for which the negative binomial distribution is an appropriate model, and the notation $X \sim \text{NB}(r, p)$ where r is the required number of successes and p is the probability of a success on a single trial.
FS1.4.2	Calculation of probabilities	To include knowledge of finding probabilities using the negative binomial distribution formula and the binomial distribution probability tables in the Examinations booklet. To include knowledge of the notations ${}^{n}C_{r}$ and $\binom{n}{r}$
FS1.4.3	Mean, variance and standard deviation	To include knowledge of finding the mean, variance and standard deviation of a negative binomial distribution. Knowledge of the derivation of the mean and variance is not required.

FS1.5: Linear combinations of discrete random variables

Content		Guidance
FS1.5.1	Mean and variance of a linear combination of two discrete random variables.	To include knowledge of correlation and covariance, as well as the notation $\text{Cov}(X, Y)$ and the result
FS1.5.2	Mean and variance of a linear combination of independent discrete random variables.	To include knowledge that if X and Y are independent variables then $\text{Cov}(X, Y) = 0$ and $p_i = \text{P}(X = x_i)$

FS1.6: Probability generating functions

Content		Guidance
FS1.6.1	Probability generating functions	To include knowledge of the formulae $\text{G}_X(t) = \text{E}(t^X) = \sum_i t^{x_i} p_i$ where $p_i = \text{P}(X = x_i)$

Content		Guidance
FS1.6.2	Properties of probability generating functions	To include knowledge of the relationships: • $\mathrm{P}(X = x) = \text{coefficient of } t^x \text{ in } \mathrm{G}_X(t)$ • $\text{Mean} = \mathrm{G}'_X(1)$ • $\text{Variance} = \mathrm{G}''_X(1) + \mathrm{G}'_X(1) - \left(\mathrm{G}'_X(1)\right)^2$ To include knowledge and application of the property that the probability generating function of the sum of independent random variables is the product of their probability generating functions.
FS1.6.3	Derivations of probability generating functions	To include knowledge of deriving the probability generating function for discrete random variables with the following distributions: • discrete uniform distribution • binomial distribution • geometric distribution. To include knowledge of deriving the probability generating function for a discrete random variable whose probability distribution is given in the form of a table or a function.

FS1.7 Measures and hypothesis testing of correlation

Content		Guidance
FS1.7.1	Product moment correlation coefficient	To include knowledge of the calculation and interpretation of the product moment correlation coefficient. Where raw data is given, candidates will be expected to obtain product moment correlation coefficient values directly from calculators. Where summarised data is given, candidates may be required to use a formula from the Examinations booklet.
FS1.7.2	Spearman's rank correlation coefficient	To include knowledge of the calculation and interpretation of Spearman's rank correlation coefficient, and the use of the formula $r_s = 1 - \dfrac{6\sum d^2}{n\left(n^2 - 1\right)}$ for cases with no tied ranks.

FS1.7.3	Correlation	To include knowledge of which of the Product moment correlation coefficient and Spearman's rank correlation coefficient is most appropriate for a given set of data, for example based on whether the data features (approximate) linearity or monotonicity.
FS1.7.4	Tests for correlation between two variables in a population	To include knowledge of using the sample product moment correlation coefficient r to test $H_0: \rho = 0$ where ρ is the population product moment correlation coefficient. It will be assumed that the random sample will be taken from a normal distribution, but knowledge of this will not be examined. To include knowledge of when a test based on Spearman's rank correlation coefficient would be more appropriate. To include knowledge of using the sample Spearman's rank correlation coefficient r_s to test $H_0: \rho_s = 0$ where ρ_s is the population Spearman's rank correlation coefficient. To include knowledge of using tables of critical values from the Examinations booklet.

3.4 Further Mechanics 1

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Mechanics 1

FM1.1: Constant velocity in two dimensions

Content		Guidance
FM1.1.1	Kinematic quantities as scalars and vectors	To include knowledge of the quantities: distance, displacement, position, speed, average speed, velocity, average velocity, acceleration. To include which quantities are scalars, which are vectors, and how they are related. To include representing vectors in two dimensions using column vectors or the perpendicular units vectors **i** and **j**
FM1.1.2	Resultant velocity	To include knowledge of solving problems using vectors and vector triangles. To include knowledge and use of bearings in solving problems.
FM1.1.3	Relative velocity	To include knowledge of solving problems that involve bodies moving through air or on water where the air or water is also moving. To include knowledge of using relative velocity and initial conditions to find relative displacement, including the use of geometric approaches. To include knowledge of solving problems based upon interception or closest approach, using calculus or completing the square.

FM1.2: Dimensional analysis

Content		Guidance
FM1.2.1	Dimensional analysis	To include knowledge of finding the dimensions of quantities in terms of M (mass), L (length) and T (time), including familiar quantities and quantities defined within the question. To include knowledge of the term dimensionless. To include knowledge of dimensional analysis to predict the indices in proposed formulae, for example, for the period of a simple pendulum, and to use dimensional analysis to find units and check dimensional consistency.

FM1.3: Centres of mass

Content		Guidance
FM1.3.1	The concept of the centre of mass	To include knowledge that the centre of mass of a body is the point through which the entire weight of the body appears to act. To include the notation $(\bar{X}, \bar{Y})$ to represent the coordinates of the centre of mass.
FM1.3.2	Uniform laminas	To include knowledge of finding centres of mass by symmetry for uniform laminas, such as circles and rectangles; the result for a triangle or a semicircle will be given in a question if it is required. To include the term uniformly.
FM1.3.3	System of particles	To include knowledge of finding the centre of mass of a system of particles, including the relationships: • $\bar{X}\sum_i m_i = \sum_i m_i x_i$ • $\bar{Y}\sum_i m_i = \sum_i m_i y_i$
FM1.3.4	Composite bodies	To include knowledge of finding the centre of mass of a composite body formed by two or more laminas that may or may not overlap, or formed by particles attached to a lamina.
FM1.3.5	The position of a suspended body	To include knowledge of finding the position of a body using its centre of mass when freely suspended from a given point and in equilibrium.

FM1.4: Collisions in one dimension

Content		Guidance
FM1.4.1	Momentum and the conservation of momentum	To include knowledge of calculating the magnitude of a body's momentum, and the vector nature of momentum and the use of the conservation of momentum in collisions between two bodies moving in one dimension, including the relationship $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
FM1.4.2	Impulse	To include knowledge of the impulse exerted on a body being as equal to the change of momentum for the body, and the formula $I = mv - mu$ To include knowledge of the impulse exerted on a body as being equal to the force acting on the body multiplied by the duration for which the force acted for, and the formulae: • $I = Ft$ for a constant force F • $I = \int F \, \mathrm{d}t$ for a variable force F
FM1.4.3	The coefficient of restitution and Newton's experimental law	To include knowledge of the relationships: • $v = eu$ • $v_1 - v_2 = -e(u_1 - u_2)$ • $0 \leq e \leq 1$

FM1.5: Collisions in two dimensions

Content		Guidance
FM1.5.1	The coefficient of restitution and Newton's experimental law	
FM1.5.2	Impacts with a fixed surface	To include knowledge of solving problems where the impact may be at any angle to the surface, and finding the magnitude of the impulse exerted on the body.

FM1.6: Elastic strings and strings

Content		Guidance
FM1.6.1	Hooke's law	To include knowledge of the modulus of elasticity and stiffness and the application of Hooke's law to strings and springs. To include knowledge of solving problems set in the horizontal direction, the vertical direction or on an inclined plane. To include knowledge of the formulae: • $T = \frac{\lambda}{l}e$ • $T = ke$ • $k = \frac{\lambda}{l}$
FM1.6.2	Elastic potential energy	To include knowledge of the formulae for elastic potential energy. To include knowledge of finding the elastic potential energy stored in strings and springs. To include knowledge of solving problems involving the transformation of energy from or to elastic potential energy, and the use of the conservation of energy.

3.5 Further Pure Mathematics 3

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Pure Mathematics 3
- Pure Mathematics 4
- Further Pure Mathematics 1
- Further Pure Mathematics 2

FP3.1: Series, limits and improper integrals

Content		Guidance
FP3.1.1	Maclaurin's theorem	To include knowledge of Maclaurin's theorem and its use to find the Maclaurin series of a function. To include knowledge of using standard results for Maclaurin series to find the Maclaurin series of a more complicated function. To include knowledge of the term ascending.
FP3.1.2	Series expansions	To include knowledge of the series expansions for e^x, $\ln(1+x)$, $\cos x$, $\sin x$ and $(1+x)^n$ for rational values of n, including the values of x for which the series expansions are valid. To include knowledge of using the series expansions above to find the series expansions of more complicated functions, including determining the values of x for which the series expansions are valid. For example: • $\ln\left(\frac{1+x}{1-x}\right)$ • $(1-2x)^{\frac{1}{2}}e^x$

Content		Guidance
FP3.1.3	Limits	To include knowledge of the results: • $\lim_{x\to\infty} x^k e^{-x} = 0$ for $k > 0$ • $\lim_{x\to 0} x^k \ln x = 0$ for $k > 0$ To include knowledge of using series expansions to show a limit exists, and to find the value of the limit. For example: • $\lim_{x\to 0} \frac{e^x - 1}{x}$ • $\lim_{x\to 0} \frac{\sin(3x)}{x}$ • $\lim_{x\to 0} \frac{x^2 e^x}{\cos(2x) - 1}$ • $\lim_{x\to 0} \frac{\sqrt{2+x} - \sqrt{2}}{x}$
FP3.1.4	Improper integrals	To include knowledge of evaluating improper integrals using a limiting process. For example: • $\int_0^e x \ln x \, dx$ • $\int_0^\infty x e^{-x} \, dx$

FP3.2: Calculus of inverse and reciprocal trigonometric functions

Content		Guidance
FP3.2.1	The calculus of inverse trigonometric functions	To include knowledge of differentiating $\sin^{-1}x$, $\cos^{-1}x$ and $\tan^{-1}x$ and their use with the rules for differentiation. To include knowledge of the results: • $\int \frac{1}{\sqrt{a^2-x^2}}\,\mathrm{d}x = \sin^{-1}\left(\frac{x}{a}\right)$ for $\lvert x\rvert < a$ • $\int \frac{1}{a^2+x^2}\,\mathrm{d}x = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$
FP3.2.2	The calculus of reciprocal trigonometric functions	To include knowledge of differentiating $\operatorname{cosec} x$, $\sec x$ and $\cot x$ and their use with the rules for differentiation. To include knowledge of the results: • $\int \operatorname{cosec} x\,\mathrm{d}x = -\ln\lvert\operatorname{cosec} x + \cot x\rvert = \ln\left\lvert\tan\left(\frac{x}{2}\right)\right\rvert$ • $\int \sec x\,\mathrm{d}x = \ln\lvert\sec x + \tan x\rvert = \ln\left\lvert\tan\left(\frac{x}{2}+\frac{\pi}{4}\right)\right\rvert$ • $\int \cot x\,\mathrm{d}x = \ln\lvert\sin x\rvert$ • $\int \operatorname{cosec}^2(kx)\,\mathrm{d}x = -\frac{1}{k}\cot(kx)$ • $\int \sec^2(kx)\,\mathrm{d}x = \frac{1}{k}\tan(kx)$

FP3.3: Hyperbolic functions

Content		Guidance
FP3.3.1	The hyperbolic functions sinh, cosh and tanh	To include knowledge of the domains and ranges of the hyperbolic functions, and the graphs of $y = \sinh x$, $y = \cosh x$ and $y = \tanh x$ To include knowledge of the exponential form of the hyperbolic functions and their use in solving equations of the form $a\sinh x + b\cosh x = c$ and proving simple identities. • $\sinh x = \frac{e^x - e^{-x}}{2}$ • $\cosh x = \frac{e^x + e^{-x}}{2}$ • $\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$
FP3.3.2	The inverse hyperbolic functions $\sinh^{-1}$, $\cosh^{-1}$ and $\tanh^{-1}$	To include knowledge of the domains and ranges of the inverse hyperbolic functions, and the graphs of $y = \sinh^{-1} x$, $y = \cosh^{-1} x$ and $y = \tanh^{-1} x$ To include knowledge of the logarithmic form of the inverse hyperbolic functions, including their proofs: • $\sinh^{-1} x = \ln\left(x + \sqrt{x^2 + 1}\right)$ • $\cosh^{-1} x = \ln\left(x + \sqrt{x^2 - 1}\right)$ for $x \geq 1$ • $\tanh^{-1} x = \frac{1}{2}\ln\left(\frac{1+x}{1-x}\right)$ for $\lvert x\rvert < 1$
FP3.3.3	The reciprocal hyperbolic functions cosech, sech and coth	To include knowledge of the domains and ranges of the reciprocal hyperbolic functions.
FP3.3.4	The relationships $\cosh^2 x - \sinh^2 x = 1$, $1 - \tanh^2 x = \operatorname{sech}^2 x$, $\coth^2 x - 1 = \operatorname{cosech}^2 x$, $\cosh(2x) = \cosh^2 x + \sinh^2 x$, and $\sinh(2x) = 2\sinh x \cosh x$	To include knowledge of proving these relationships, their use in proving identities and their use in solving equations.

Content		Guidance
FP3.3.5	The calculus of hyperbolic functions	To include knowledge of differentiating $\sinh x$, $\cosh x$ and $\tanh x$, including their proofs, and their use with the rules for differentiation. To include knowledge of integrating $\sinh x$, $\cosh x$ and $\tanh x$ and their use with the rules for integration.
FP3.3.6	The calculus of inverse hyperbolic functions	To include knowledge of differentiating $\sinh^{-1} x$, $\cosh^{-1} x$ and $\tanh^{-1} x$ and their use with the rules for differentiation. To include knowledge of the results: • $\int \frac{1}{\sqrt{x^2+a^2}}\,\mathrm{d}x = \sinh^{-1}\left(\frac{x}{a}\right) = \ln\left(x+\sqrt{x^2+a^2}\right)$ • $\int \frac{1}{\sqrt{x^2-a^2}}\,\mathrm{d}x = \cosh^{-1}\left(\frac{x}{a}\right) = \ln\left(x+\sqrt{x^2-a^2}\right)$ for $x > a$ • $\int \frac{1}{a^2-x^2}\,\mathrm{d}x = \frac{1}{a}\tanh^{-1}\left(\frac{x}{a}\right)+c = \frac{1}{2a}\ln\left\lvert\frac{a+x}{a-x}\right\rvert$ for $\lvert x\rvert < a$

FP3.4: Arc length and area of surface of revolution about the x-axis

Content		Guidance
FP3.4.1	Arc length	To include knowledge of finding the arc length of a curve defined by a Cartesian equation or defined by parametric equations, using the results: • $s = \int_{x_1}^{x_2} \sqrt{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2}\,\mathrm{d}x$ • $s = \int_{t_1}^{t_2} \sqrt{\left(\frac{\mathrm{d}x}{\mathrm{d}t}\right)^2+\left(\frac{\mathrm{d}y}{\mathrm{d}t}\right)^2}\,\mathrm{d}t$
FP3.4.2	Area of surface of revolution about the x-axis	To include knowledge of finding the area of a surface of revolution generated by rotating a curve through an angle of 2π radians about the x-axis, where the curve is defined by a Cartesian equation or defined by parametric equations, using the results: • $S = 2\pi\int_{x_1}^{x_2} y\sqrt{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2}\,\mathrm{d}x$ • $S = 2\pi\int_{t_1}^{t_2} y\sqrt{\left(\frac{\mathrm{d}x}{\mathrm{d}t}\right)^2+\left(\frac{\mathrm{d}y}{\mathrm{d}t}\right)^2}\,\mathrm{d}t$

FP3.5: Differential equations

Content		Guidance
FP3.5.1	First order linear differential equations	To include knowledge of using an integrating factor or using a complementary function and particular integral to solve first order linear differential equations of the form $\frac{\mathrm{d}y}{\mathrm{d}x} + \mathrm{P}(x)y = \mathrm{Q}(x)$ To include knowledge of finding general solutions and particular solutions using initial conditions.
FP3.5.2	Second order linear differential equations	To include knowledge of using auxiliary equations, complementary functions and particular integrals to solve second order linear differential equations of the form $a\frac{\mathrm{d}^2y}{\mathrm{d}x^2} + b\frac{\mathrm{d}y}{\mathrm{d}x} + cy = \mathrm{f}(x)$ where a, b and c are integers and $\mathrm{f}(x)$ is zero or of the form e^{kx}, $\cos(kx)$, $\sin(kx)$ or a polynomial of degree at most 4, or a linear combination of these forms. To include knowledge of using auxiliary equations whose roots may be real and distinct, real and repeated, or complex. To include knowledge of finding general solutions and particular solutions using boundary values and initial conditions.

FP3.6: Polar coordinates

Content		Guidance
FP3.6.1	Polar coordinates	To include knowledge of the relationship between polar coordinates (r,θ) and Cartesian coordinates (x,y) with the convention $r > 0$ To include knowledge of sketching curves given by equations of the form $r = \mathrm{f}(\theta)$ Knowledge of the formula $\tan\phi = r\frac{\mathrm{d}\theta}{\mathrm{d}r}$ is not required.
FP3.6.2	Area of a region	To include knowledge of finding the area of a region bounded by a curve defined by a polar equation using the result $\int_{\alpha}^{\beta} \frac{1}{2}r^2\,\mathrm{d}\theta$

3.6 Further Pure Mathematics 4

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Pure Mathematics 3
- Pure Mathematics 4
- Further Pure Mathematics 1
- Further Pure Mathematics 2
- Further Pure Mathematics 3

FP4.1: Vectors and three-dimensional coordinate geometry

Content		Guidance
FP4.1.1	The vector product	To include knowledge of the definition and properties of the vector product, finding the vector product and its use in the calculation of the area of a triangle or parallelogram.
FP4.1.2	The scalar triple product	To include knowledge of finding the scalar triple product and its use in the calculation of the volume of a parallelepiped and in identifying coplanar vectors.
FP4.1.3	Two-dimensional and three-dimensional coordinate geometry with vectors	To include knowledge of the use of vectors with points, lines and planes, including the intersection of a line with a plane, the angle between a line and a plane, and the angle between two planes. To include knowledge of the following forms: • $(\mathbf{r}-\mathbf{a})\times\mathbf{b}=\mathbf{0}$ for the equation of a line • $\frac{x-a_1}{b_1}=\frac{y-a_2}{b_2}=\frac{z-a_3}{b_3}$ for the equation of a line • $\mathbf{r}\cdot\mathbf{n}=d$ for the equation of a plane • $\mathbf{r}=\mathbf{a}+\lambda\mathbf{b}+\mu\mathbf{c}$ for the equation of a plane
FP4.1.4	Cartesian coordinate geometry of lines and planes	To include knowledge of finding the equation of the line of intersection of two non-parallel planes. To include knowledge of direction cosines, with the convention that $l,\ m,\ n$ are the direction cosines in the $x,\ y$ and z directions respectively, and the result $l^2+m^2+n^2=1$

FP4.2: Matrix algebra and linear equations

Content		Guidance
FP4.2.1	3×3 matrices and transformations of points in three dimensions	To include knowledge of the following transformations in three dimensions: • rotations about the coordinate axes only • reflections in the planes $x = 0, y = 0, z = 0, x = y, x = z$ and $y = z$ only • enlargements and combinations of these transformations. To include the terms rotate, reflect and enlarge.
FP4.2.2	The determinant and inverse of a 3x3 matrix	To include knowledge of determinants for 3×3 matrices, their relationship to volume scale factor and the results: • $\det(\mathbf{AB}) = \det(\mathbf{A}) \times \det(\mathbf{B})$ • $\det(\mathbf{M}^{-1}) = \frac{1}{\det(\mathbf{M})}$ To include knowledge of the inverse for 3 ×3 matrices
FP4.2.3	Invariant points and invariant lines in three dimensions.	To include knowledge of invariant points and invariant lines for three-dimensional transformations.
FP4.2.4	Eigenvalues and eigenvectors	To include knowledge of finding characteristic equations, eigenvalues and eigenvectors for 2×2 matrices and 3×3 matrices, for matrices where the eigenvalues will be real only but may be repeated.
FP4.2.5	Diagonalisation of matrices	To include knowledge of diagonalising 2×2 matrices and 3×3 matrices, $\mathbf{M} = \mathbf{UDU}^{-1}$ where $\mathbf{D}$ is a diagonal matrix containing the eigenvalues of $\mathbf{M}$ and $\mathbf{U}$ is a matrix whose columns are the eigenvectors of $\mathbf{M}$ corresponding to the entries of $\mathbf{D}$, and use of the result $\mathbf{M}^n = \mathbf{UD}^n\mathbf{U}^{-1}$
FP4.2.6	Linear Equations	To include knowledge of solving up to three linear equations in up to three unknowns using any method. To include knowledge of the geometrical interpretation of the solution of linear equations. To include knowledge of the terms unique, consistent and inconsistent.

FP4.3: Proof by induction and series

Content		Guidance
FP4.3.1	Proof by induction	To include knowledge of using proof by induction with sequences, series, matrices, calculus, complex numbers etc, such as: • prove that $7^n + 4^n + 1$ is divisible by 6 for all $n \in \mathbb{N}$ • prove that $\begin{bmatrix} 5 & 0 \\ 4 & 1 \end{bmatrix}^n = \begin{bmatrix} 5^n & 0 \\ 5^n - 1 & 1 \end{bmatrix}$ for all $n \in \mathbb{N}$ • prove that $\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(\mathrm{e}^x \cos x\right) = 2^{\frac{n}{2}} \mathrm{e}^x \cos\left(x + \frac{n\pi}{4}\right)$ for all $n \in \mathbb{N}$ • prove that $\sum_{k=0}^{n} \mathrm{i}^k = \frac{1 - \mathrm{i}^{n+1}}{1 - \mathrm{i}}$ for $n \geq 0$ • prove that $n! > 2^n$ for $n \geq 4$
FP4.3.2	Summation of series	To include knowledge of finding the summation of a finite series by using one or more of: • induction • partial fractions • method of differences For example: • Find $\sum_{r=1}^{n} \frac{1}{(2r-1)(2r+1)}$ To include knowledge of finding the summation of an infinite series when the limit of the summation of the finite series exists.

FP4.4: Roots and coefficients of polynomial equations

Content		Guidance
FP4.4.1	Roots and coefficients of polynomial equations	To include knowledge of the relationships between the roots and the coefficients of a polynomial equation, up to and including quartic equations. To include knowledge of the occurrence of non-real roots in conjugate pairs when the coefficients of the polynomial are real.

FP4.5: Complex numbers

Content		Guidance
FP4.5.1	De Moivre's theorem for integer n	To include knowledge of De Moivre's theorem, including its proof, $(\cos\theta + \mathrm{i}\sin\theta)^n = \cos(n\theta) + \mathrm{i}\sin(n\theta)$, $z + \frac{1}{z} = 2\cos\theta$ and $z - \frac{1}{z} = 2\mathrm{i}\sin\theta$, and their use, for example, in expressing $\sin^5\theta$ in terms of multiple angles, and $\tan 5\theta$ in terms of powers of $\tan\theta$ Including its use in proving trigonometric identities, proof by induction, calculus, solving equations etc.
FP4.5.2	De Moivre's theorem, the nth roots of unity and the exponential form of a complex number	To include knowledge of using, without justification, the identity $\mathrm{e}^{\mathrm{i}\theta} = \cos\theta + \mathrm{i}\sin\theta$, and its use with De Moivre's theorem for evaluating integrals, proving identities, proof by induction, solving equations, considering real or imaginary parts, etc.
FP4.5.3	Equations of the form $z^n = a + \mathrm{i}b$	To include knowledge of their solution, the geometrical interpretation and the use, for example, in expressing $\cos\left(\frac{5\pi}{12}\right)$ in surd form.

3.7 Further Statistics 2

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Pure Mathematics 3
- Pure Mathematics 4
- Statistics 1
- Statistics 2
- Further Statistics 1

FS2.1: Moment generating functions

Content		Guidance
FS2.1.1	Moment generating functions	To include knowledge of the formulae: • $\mathrm{M}_X(t) = \mathrm{E}\left(\mathrm{e}^{tX}\right) = \sum_i \mathrm{e}^{tx_i} p_i$ for discrete random variables • $\mathrm{M}_X(t) = \mathrm{E}\left(\mathrm{e}^{tX}\right) = \int \mathrm{e}^{tx} \mathrm{f}(x)\,\mathrm{d}x$ for continuous random variables.
FS2.1.2	Properties of moment generating functions	To include knowledge of the relationships: • $\text{Mean} = \mathrm{M}'_X(0)$ • $\text{Variance} = \mathrm{M}''_X(0) - \left(\mathrm{M}'_X(0)\right)^2$ • $\mathrm{M}_{a+bX}(t) = \mathrm{e}^{at}\mathrm{M}_X(bt)$ To include knowledge and application of the property that the moment generating function of the sum of independent random variables is the product of their moment generating functions.

Content		Guidance
FS2.1.3		To include knowledge of deriving the moment generating function for random variables with the following distributions: • Poisson distribution • exponential distribution • normal distribution To include knowledge of deriving the moment generating function for a discrete random variable whose probability distribution is given in the form of a table or a function. To include knowledge of deriving the moment generating function for a continuous random variable given by a probability density function.

FS2.2: Estimators

Content		Guidance
FS2.2.1	Estimators and estimates	To include knowledge of estimators and estimates To include knowledge of the sample statistic and its sampling distribution. To include knowledge of population parameters.
FS2.2.2	Properties of estimators	To include knowledge of unbiasedness, consistency and relative efficiency. To include knowledge of applications, such as means and variances of pooled estimators.

FS2.3: Estimation

Content		Guidance
FS2.3.1	Confidence intervals for the population mean of a distribution	To include knowledge of finding confidence intervals that are symmetrical about the sample mean and • for populations that are normally distributed with known population variance • for large samples using a normal approximation with known or unknown population variance • for small samples from a normal distribution with unknown population variance.
FS2.3.2	Inferences from confidence intervals	To include knowledge of using a confidence interval to comment on whether a hypothesised population mean is plausible

Content		Guidance
FS2.3.3	Estimation of sample size	To include knowledge of finding confidence intervals of a required width with a given level of confidence.

FS2.4: Hypothesis testing

Content		Guidance
FS2.4.1	Power of a test	To include knowledge of calculating $\mathrm{P}(\text{Type II error})$ or Power for a simple alternative hypothesis of a test where the significance level of the hypothesis test is given. Knowledge of deriving the power function is not required.
FS2.4.2	Tests for the difference between the population means of two independent distributions	To include knowledge of hypothesis testing for the difference between population means where: • the populations are normal and have known population variances • large samples are taken from populations with unknown distributions and known or unknown population variances, using normal approximations • small samples are taken from populations that are normally distributed with unknown population variances, only when it may be assumed that the population variances are equal so that a pooled estimate of variance may be calculated.
FS2.4.3	Tests for the difference between the population means of two non-independent distributions.	To include knowledge of using a t-statistic for small paired samples.
FS2.4.4	Tests for the population variance or the standard deviation of a normal distribution.	To include knowledge of using a χ^2 statistic.
FS2.4.5	Tests for the ratio of the population variances or the standard deviations of two independent normal distributions.	To include knowledge of using an F-statistic.
FS2.4.6	Contingency tables and goodness of fit tests	To include knowledge of $\sum_i \frac{(O_i - E_i)^2}{E_i}$ as an approximate χ^2 statistic with the convention that all E_i should be greater than 5 To include knowledge and use of Yates' correction for 2 × 2 contingency tables. To include knowledge of goodness of fit tests based on discrete distributions or on continuous distributions where integration may be required.

3.8 Further Mechanics 2

This topic assumes knowledge of:

- OxfordAQA International GCSE Mathematics - Extension Tier
- Pure Mathematics 1
- Pure Mathematics 2
- Pure Mathematics 3
- Pure Mathematics 4
- Mechanics 1
- Mechanics 2
- Further Mechanics 1

FM2.1: Vertical circular motion

Content		Guidance
FM2.1.1	Circular motion in a vertical plane	To include knowledge of the necessary conditions to complete circular motion in a vertical plane.

FM2.2: Projectile motion on inclined planes

Content		Guidance
FM2.2.1	Projectile motion on inclined planes	To include knowledge of problems where projectiles are launched from and land on an inclined plane, where students will be expected to solve these problems by resolving the acceleration in directions parallel and perpendicular to the plane. To include knowledge of finding the maximum range for a given inclined plane and speed of projection, to determine whether a projectile lands at a higher or lower point on the plane after a bounce, the greatest distance between the projectile and the plane, and the time of flight.

FM.2.3: Work done and energy

Content		Guidance
FM2.3.1	Work done by a variable force	To include knowledge of the formula $W = \int F \mathrm{d}x$ where F is a variable force. To include knowledge of solving problems involving energy transformations and the conservation of energy.

FM2.4: Collisions in two dimensions

Content		Guidance
FM2.4.1	Momentum and the conservation of momentum in two dimensions	To include knowledge of the vector nature of momentum and the use of the conservation of momentum in collisions between two bodies moving in two dimensions, including the relationship $m_1\mathbf{u}_1 + m_2\mathbf{u}_2 = m_1\mathbf{v}_1 + m_2\mathbf{v}_2$
FM2.4.2	Impulse as a vector	To include knowledge of the impulse exerted on a body being equal to the change of momentum for the body, and the formula $\mathbf{I} = m\mathbf{v} - m\mathbf{u}$
FM2.4.3	Coefficient of restitution and Newton's experimental law	
FM2.4.4	Oblique collisions	To include knowledge of collisions between two smooth bodies, such as spheres, where students will be expected to consider the components of velocities that are parallel and perpendicular to the line of centres.

FM2.5: Application of differential equations

Content		Guidance
FM2.5.1	Differential equations and Newton's second law	To include knowledge of solving problems with motion in a straight line and separable differential equations of the form: • $\frac{\mathrm{d}v}{\mathrm{d}t} = \mathrm{f}(t)$ • $\frac{\mathrm{d}v}{\mathrm{d}t} = \mathrm{f}(v)$ • $\frac{\mathrm{d}v}{\mathrm{d}t} = \mathrm{f}(x)$ To include knowledge of the relationship $\frac{\mathrm{d}v}{\mathrm{d}t} = v\frac{\mathrm{d}v}{\mathrm{d}x}$ To include knowledge of solving problems involving resistance forces, such as those of the form $a + bv$ and $a + bv^2$ where v is the speed.

FM2.6: Simple harmonic motion

Content		Guidance
FM2.6.1	The definition of simple harmonic motion	To include knowledge of the definition of simple harmonic motion: the acceleration of the body is directly proportional to its displacement from the equilibrium position, and the acceleration is always directed towards the equilibrium position. To include knowledge of solving problems that include elastic strings and springs, and motion in the horizontal direction or vertical direction. To include the formation of simple second order differential equations to show that a particular motion is simple harmonic motion.
FM2.6.2	Frequency, angular frequency, period, displacement and amplitude	To include knowledge of the terms frequency, angular frequency, period, displacement and amplitude
FM2.6.3	The relationship $v^2 = \omega^2\left(A^2 - x^2\right)$	
FM2.6.4	Solving second order differential equations of the form $\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\omega^2 x$	To include knowledge that the solutions can be stated in the forms: • $x = A\cos\left(\omega t + \varepsilon\right)$ • $x = C\cos\left(\omega t\right) + D\sin\left(\omega t\right)$
FM2.6.5	The simple pendulum	To include knowledge of forming and solving the differential equation, including use of a small angle approximation, and finding the period.

FM2.7: Centre of mass

Content		Guidance
FM2.7.1	Centre of mass of a uniform lamina by integration	To include knowledge of finding x and y coordinates of the centre of mass, $\left(\bar{X}, \bar{Y}\right)$, using the formulae: • $\bar{X} = \frac{\int_a^b xy\,\mathrm{d}x}{\int_a^b y\,\mathrm{d}x}$ • $\bar{Y} = \frac{\int_a^b \frac{1}{2}y^2\,\mathrm{d}x}{\int_a^b y\,\mathrm{d}x}$
FM2.7.2	Centre of mass of a uniform solid formed by rotating a region about the x-axis by integration	To include knowledge of finding the x coordinate of the centre of mass, $\bar{X}$, using the formula $\bar{X} = \frac{\int_a^b \pi xy^2\,\mathrm{d}x}{\int_a^b \pi y^2\,\mathrm{d}x}$

4 Scheme of assessment

Find mark schemes, and specimen papers for new courses, on our website at oxfordaqa.com/9765

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level.

The International AS can be taken as a stand-alone qualification or it can count towards the International A-level. To complete the International A-level, students can take the International AS in their first year and the International A2 in their second year or they can take all the units together in the same examination series at the end of the two year course.

The International AS content will be 50% of the International A-level content. International AS assessments contribute 50% of the total marks for the full International A-level qualification. The remaining 50% comes from the International A2 assessments.

The specification provides an opportunity for students to produce extended responses either in words or using open-ended calculations.

The specification content will be split across units and will include some synoptic assessment. This allows students to draw together different areas of knowledge from across the full course of study.

All materials are available in English only.

4.1 Availability of assessment units and certification

Exams and certification for this specification are available as follows:

Examination series	Availability of units		Availability of certification	
	FP1, FP2, FS1, FM1	FP3, FP4, FS2, FM2	International AS	International A-level
June 2028	✓		✓	
October/November 2028	✓		✓	
January 2029	✓		✓	
June 2029	✓	✓	✓	✓
October/November 2029	✓	✓	✓	✓
January 2030	✓	✓	✓	✓
June 2030	✓	✓	✓	✓

4.2 Aims

Courses based on this specification should encourage students to:

- develop their understanding of mathematics and mathematical processes in a way that promotes confidence and fosters enjoyment
- develop abilities to reason logically and to recognise incorrect reasoning, to generalise and to construct mathematical proofs
- extend their range of mathematical skills and techniques and use them in more difficult unstructured problems
- develop an understanding of coherence and progression in mathematics and how different areas of mathematics can be connected
- recognise how a situation may be represented mathematically and understand the relationship between 'real world' problems and standard and other mathematical models and how these can be refined and improved
- use mathematics as an effective means of communication
- read and comprehend mathematical arguments and articles concerning applications of mathematics
- acquire the skills needed to use technology such as calculators and computers effectively yet be aware of any limitations of using these
- develop an awareness of the relevance of mathematics to other fields of study, to the world of work and to society in general.

4.3 Assessment Objectives

The exams will measure how students have achieved the following assessment objectives:

- AO1: Recall and select knowledge of mathematical facts, concepts, models and techniques required to solve problems in a variety of contexts.
- AO2: Construct rigorous mathematical arguments and proofs through use of precise statements, mathematical manipulation, logical deduction, modelling assumptions and justifications to solve structured and unstructured problems, and to deduce, interpret and communicate results.

Quality of Written Communication (QWC)

Students must:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Questions in the papers for this specification do not include specific marks for QWC. However, poor written communication may lead to lower marks due to lack of clarity in answers.

4.3.1 Assessment Objective weightings for International AS Further Mathematics

Assessment Objectives (AOs)	Unit weightings (approx %)			Overall weighting of AOs (approx %)
	F Pure 1	F Pure 2	Unit FS1 or FM1	
AO1	13.3 - 16.7	13.3 - 16.7	13.3 - 16.7	40 - 50
AO2	16.7 - 20	16.7 - 20	16.7 - 20	50 - 60
Overall weighting of units (%)	33.3	33.3	33.3	100

4.3.2 Assessment Objective weightings for International A-level Further Mathematics

Assessment Objectives (AOs)	Unit weightings (approx %)						Overall weighting of AOs (approx %)
	F Pure 1	F Pure 2	Unit FS1 or FM1	F Pure 3	F Pure 4	Unit FS1 or FM1 or FS2 or FM2	
AO1	6.7 - 8.4	6.7 - 8.4	6.7 - 8.4	6.7 - 8.4	6.7 - 8.4	6.7 - 8.4	40 - 50
AO2	8.4 - 10	8.4 - 10	8.4 - 10	8.4 - 10	8.4 - 10	8.4 - 10	50 - 60
Overall weighting of units (%)	16.7	16.7	16.7	16.7	16.7	16.7	100

4.4 Assessment weightings

The raw marks awarded on each unit will be transferred to a uniform mark scale (UMS) to meet the weighting of the units and to ensure comparability between units sat in different exam series. Students' final grades will be calculated by adding together the uniform marks for all units. The maximum raw and uniform marks are shown in the table below.

Unit	Maximum raw mark	Percentage weighting A-level (AS)	Maximum uniform mark
FurtherPure 1	60	16.7 (33.3)	80
Further Pure 2	60	16.7 (33.3)	80
Further Statistics 1	60	16.7 (33.3)	80
Further Mechanics 1	60	16.7 (33.3)	80
Further Pure 3	60	16.7	80
Further Pure 4	60	16.7	80
Further Statistics 2	60	16.7	80
Further Mechanics 2	60	16.7	80

Qualification	Maximum raw mark	Percentage weighting A-level (AS)	Maximum uniform mark
International AS	-	50 (100)	240
International A-level	-	100	480

5 General administration

We are committed to delivering assessments of the highest quality and have developed practices and procedures to support this aim. To ensure all students have a fair experience, we have worked with other awarding bodies in England to develop best practice for maintaining the integrity of exams. This is published through the Joint Council for Qualifications (JCQ). We will maintain the same high standard through their use for OxfordAQA Exams.

More information on all aspects of administration is available at **oxfordaqa.com/exams-administration**

For any immediate enquiries please contact info@oxfordaqa.com

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

5.1 Entries and codes

You should use the following subject award entry codes:

Qualification title	OxfordAQA Exams entry code
OxfordAQA International Advanced Subsidiary Further Mathematics	9766
OxfordAQA International Advanced Level Further Mathematics	9767

Please check the current version of the Entry Codes book and the latest information about making entries on **oxfordaqa.com/exams-administration**

You should use the following unit entry codes:

Unit Further Pure 1	FM1P1
Unit Further Pure 2	FM2P2
Unit Further Statistics 1	FM3S1
Unit Further Mechanics 1	FM4M1
Unit Further Pure 3	FM5P3
Unit Further Pure 4	FM6P4
Unit Further Statistics 2	FM7S2
Unit Further Mechanics 2	FM8M2

A unit entry will not trigger certification. You will also need to make an entry for the overall subject award in the series that certification is required.

Exams will be available in October/November, January and May/June.

5.2 Overlaps with other qualifications

There is overlapping content in the International AS and A-level specifications. This helps you teach the International AS and A-level together.

5.3 Awarding grades and reporting results

The International AS qualification will be graded on a five-point scale: A, B, C, D and E.

The International A-level qualification will be graded on a six-point scale: A*, A, B, C, D and E.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark needed for each grade in each unit when we issue students' results. We will report a student's unit results to schools in terms of uniform marks and unit grades and we will report qualification results in terms of uniform marks and grades.

The relationship between uniform marks and grades is shown in the table below.

	Uniform mark range per unit and per qualification							
Grade	F Pure 1	F Pure 2	Option FS1 or FM1	International AS Further Mathematics	F Pure 3	F Pure 4	Option FS1 or FM1 or FS2 or FM2	International A-level Further Mathematics
Maximum uniform mark	80	80	80	240	80	80	80	480
A*								*See note below
A	64 - 80	64 - 80	64 - 80	192 - 240	64 - 80	64 - 80	64 - 80	384 - 480
B	56 - 63	56 - 63	56 - 63	168 – 191	56 - 63	56 - 63	56 - 63	336 - 383
C	48 - 55	48 - 55	48 - 55	144 - 167	48 - 55	48 - 55	48 - 55	288 - 335
D	40 - 47	40 - 47	40 - 47	120 - 143	40 - 47	40 - 47	40 - 47	240 - 287
E	32 - 39	32 - 39	32 - 39	96 - 119	32 - 39	32 - 39	32 - 39	192 - 239

* For the award of grade A*, a student must achieve grade A in the full International A-level qualification and a minimum of 144 uniform marks in the aggregate of units Further Pure 3 and Further Pure 4.

5.4 Re-sits

Unit results remain available to count towards certification, whether or not they have already been used, provided the specification remains valid. Students can re-sit units as many times as they like, as long as they're within the shelf-life of the specification. The best result from each unit will count towards the final qualification grade. Students who wish to repeat a qualification may do so by re-sitting one or more units.

To be awarded a new subject grade, the appropriate subject award entry, as well as the unit entry/entries, must be submitted.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools.

5.6 Access to assessment: equality and inclusion

Our general qualifications are designed to prepare students for a wide range of occupations and further study whilst assessing a wide range of competences.

The subject criteria have been assessed to ensure they test specific competences. The skills or knowledge required do not disadvantage particular groups of students.

Exam access arrangements are available for students with disabilities and special educational needs.

We comply with the *UK Equality Act 2010* to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student. Information about access arrangements is issued to schools when they become OxfordAQA centres.

5.7 Working with OxfordAQA for the first time

You will need to apply to become an OxfordAQA centre to offer our specifications to your students. Find out how at oxfordaqa.com/centreapprovals

5.8 Private candidates

Centres may accept private candidates for examined units/components only with the prior agreement of OxfordAQA. If you are an approved OxfordAQA centre and wish to accept private candidates, please contact OxfordAQA at: info@oxfordaqa.com

Private candidates may also enter for examined only units/components via the British Council; please contact your local British Council office for details.

6 Appendix: Mathematical notation

The tables below set out the notation used by the International AS and A-level Mathematics and Further Mathematics specifications. Students will be expected to understand this notation without need for further explanation.

Mathematics students will not be expected to understand notation that relates only to Further Mathematics content. Further Mathematics students will be expected to understand all notations in the tables.

Students studying for AS Mathematics or AS Further Mathematics will be expected to understand notation that relates to AS content; they will not be expected to understand notation that relates only to A-level content.

6.1 Set Notation

Reference	Notation	Guidance
1.1	$\in$	is an element of
1.2	$\notin$	is not an element of
1.3	$\forall$	for all
1.4	$\{x_1, x_2, ...\}$	the set with elements $x_1, x_2, ...$
1.5	$\{x : ...\}$	the set of all x such that ...
1.6	$\mathbb{N}$	the set of natural numbers {1, 2, 3, ...}
1.7	$\mathbb{Z}$	the set of integers {..., -2, -1, 0, 1, 2, ...}
1.8	$\mathbb{R}$	the set of real numbers
1.9	$\mathbb{Q}$	the set of rational numbers
1.10	$\mathbb{C}$	the set of complex numbers (Further Mathematics only)
1.11	$\cup$	union
1.12	$\cap$	intersection
1.13	(x, y)	the ordered pair x, y
1.14	$[a, b]$	the closed interval $\{x \in \mathbb{R} : a \leq x \leq b\}$
1.15	$[a, b)$	the interval $\{x \in \mathbb{R} : a \leq x < b\}$
1.16	$(a, b]$	the interval $\{x \in \mathbb{R} : a < x \leq b\}$
1.17	(a, b)	the open interval $\{x \in \mathbb{R} : a < x < b\}$

6.2 Relational and logical notation

Reference	Notation	Guidance
2.1	$=$	is equal to
2.2	$\neq$	is not equal to
2.3	$\equiv$	is identical to
2.4	$\approx$	is approximately equal to
2.5	$\propto$	is proportional to
2.6	$<$	is less than
2.7	$\leq$	is less than or equal to
2.8	$>$	is greater than
2.9	$\geq$	is greater than or equal to
2.10	$\Rightarrow$	implies
2.11	$\Leftarrow$	is implied by
2.12	$\Leftrightarrow$	implies and is implied by

6.3 Miscellaneous notation

Reference	Notation	Guidance
3.1	∞	infinity
3.2	$\therefore$	therefore
3.3	$\because$	because
3.4	S_n	sum of the first n terms of a sequence
3.5	S_∞	sum to infinity of a series

6.4 Operations

Reference	Notation	Guidance
4.1	$a + b$	a plus b
4.2	$a - b$	a minus b
4.3	$a \times b$, ab	a multiplied by b
4.4	$a \div b$, $\frac{a}{b}$	a divided by b
4.5	a^b	a to the power of b
4.6	$\sum_{i=1}^{n} u_i$	$u_1 + u_2 + \ldots + u_n$

4.7	$\prod_{i=1}^{n} u_i$	$u_1 \times u_2 \times \ldots \times u_n$
4.8	$\sqrt{a}$	the principal square root of a
4.9	$\sqrt[n]{a}$	the principal nth root of a
4.10	$\lvert a \rvert$	the modulus of a
4.11	$n!$	the factorial of n
4.12	$\binom{n}{r}$, ${}^{n}\mathrm{C}_{r}$	the binomial coefficient

6.5 Functions, limits and calculus

Reference	Notation	Guidance
5.1	$\mathrm{f}(x)$	the function f evaluated at x
5.2	f^{-1}	the inverse of the function f
5.3	gf	the composite function of f and g, $\mathrm{gf}(x) = \mathrm{g}(\mathrm{f}(x))$
5.4	$\lim_{x \to a} \mathrm{f}(x)$	the limit of $\mathrm{f}(x)$ as x tends to a
5.5	Δx, δx	an increment of x
5.6	$\frac{\mathrm{d}y}{\mathrm{d}x}$	the first derivative of y with respect to x
5.7	$\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\rvert_{x=a}$	the first derivative of y with respect to x evaluated at $x = a$
5.8	$\frac{\mathrm{d}^2 y}{\mathrm{d}x^2}$	the second derivative of y with respect to x
5.9	$\frac{\mathrm{d}^n y}{\mathrm{d}x^n}$	the nth derivative of y with respect to x
5.10	$\left.\frac{\mathrm{d}^n y}{\mathrm{d}x^n}\right\rvert_{x=a}$	the nth derivative of y with respect to x evaluated at $x = a$
5.11	$\mathrm{f}'(x)$	the first derivative of $\mathrm{f}(x)$ with respect to x
5.12	$\mathrm{f}''(x)$	the second derivative of $\mathrm{f}(x)$ with respect to x
5.13	$\mathrm{f}^{(n)}(x)$	the nth derivative of $\mathrm{f}(x)$ with respect to x
5.14	$\dot{x}$	the first derivative of x with respect to t
5.15	$\ddot{x}$	the second derivative of x with respect to t

5.16	$\int y\,\mathrm{d}x$	the indefinite integral of y with respect to x
5.17	$\int_a^b y\,\mathrm{d}x$	the definite integral of y with respect to x between the limits of $x = a$ and $x = b$

6.6 Exponentials and logarithms

Reference	Notation	Guidance
6.1	e	the base of natural logarithms
6.2	$\mathrm{e}^x, \exp(x)$	the exponential function of x
6.3	$\ln x$	the natural logarithm of x
6.4	$\log_a x$	the logarithm to the base a of x

6.7 Trigonometric functions

Reference	Notation	Guidance
7.1	sin, cos, tan	the functions: sine, cosine and tangent
7.2	$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$	the inverse functions: inverse sine, inverse cosine and inverse tangent
7.3	cosec, sec, cot	the reciprocal functions: cosecant, secant and cotangent
7.4	cosec^{-1}, $\sec^{-1}$, $\cot^{-1}$	the inverse reciprocal functions: inverse cosecant, inverse secant and inverse cotangent (Further Mathematics only)
7.5	°	degrees
7.6	rad	radians

6.8 Hyperbolic functions (Further Mathematics only)

Reference	Notation	Guidance
8.1	sinh, cosh, tanh	the functions: hyperbolic sine, hyperbolic cosine and hyperbolic tangent
8.2	$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$	the inverse functions: inverse hyperbolic sine, inverse hyperbolic cosine and inverse hyperbolic tangent
8.3	cosech, sech, coth	the reciprocal functions: hyperbolic cosecant, hyperbolic secant and hyperbolic cotangent
8.4	cosech^{-1}, sech^{-1}, $\coth^{-1}$	the inverse reciprocal functions: inverse hyperbolic cosecant, inverse hyperbolic secant and inverse hyperbolic cotangent

6.9 Complex numbers (Further Mathematics only)

Reference	Notation	Guidance
9.1	i	the imaginary unit, $\sqrt{-1}$
9.2	z	a complex number
9.3	z^*	the complex conjugate of z
9.4	$x + \mathrm{i}y$	a complex number (in Cartesian form) with real part x and imaginary part y
9.5	$r(\cos\theta + \mathrm{i}\sin\theta)$	a complex number (in modulus-argument form) with modulus r and argument θ
9.6	$r\mathrm{e}^{\mathrm{i}\theta}$	a complex number (in exponential form) with modulus r and argument θ
9.7	$\lvert z\rvert$	the modulus of z
9.8	$\arg(z)$	the principal argument of z, $\arg(z) = \theta$ where $-\pi < \theta \leq \pi$
9.9	$\mathrm{Re}(z)$	the real part of z
9.10	$\mathrm{Im}(z)$	the imaginary part of z

6.10 Matrices (Further Mathematics only)

Reference	Notation	Guidance
10.1	$\mathbf{0}$	the zero matrix
10.2	$\mathbf{I}$	the identity matrix
10.3	$\mathbf{M}$	a matrix $\mathbf{M}$
10.4	$\mathbf{M}^{-1}$	the inverse of the matrix $\mathbf{M}$
10.5	$\mathbf{M}^{\mathrm{T}}$	the transpose of the matrix $\mathbf{M}$
10.6	$\det(\mathbf{M})$	the determinant of the matrix $\mathbf{M}$

6.11 Vectors (Further Mathematics only)

Reference	Notation	Guidance
11.1	$\mathbf{a}$	a vector $\mathbf{a}$
11.2	$\overrightarrow{AB}$	a vector representing the line segment AB
11.3	$\mathbf{i}, \mathbf{j}, \mathbf{k}$	the perpendicular unit vectors in the directions of the Cartesian coordinate axes
11.4	$\lvert\mathbf{a}\rvert$	the magnitude of vector $\mathbf{a}$
11.5	$\begin{bmatrix} a \\ b \end{bmatrix}$	a 2-dimensional column vector
11.6	$\begin{bmatrix} a \\ b \\ c \end{bmatrix}$	a 3-dimensional column vector
11.7	$\mathbf{a} \cdot \mathbf{b}$	the scalar product of $\mathbf{a}$ and $\mathbf{b}$
11.8	$\mathbf{a} \times \mathbf{b}$	the vector product of $\mathbf{a}$ and $\mathbf{b}$ (Further Mathematics only)

6.12 Probability and statistics

Reference	Notation	Guidance
12.1	A etc	the event A
12.2	$A \cup B$	the union of event A and event B
12.3	$A \cap B$	the intersection of event A and event B
12.4	$\mathrm{P}(A)$	the probability of event A occurring
12.5	A'	the complement of event A
12.6	$\mathrm{P}(\mathrm{A} \mid B)$	the probability of event A occurring given event B has occurred
12.7	X, Y etc	random variables
12.8	x, y etc	values of the random variables X, Y etc
12.9	x_1, x_2, ...	values of observations

12.10	$\mathrm{P}(X = x)$	the probability function of the discrete random variable X
12.11	$\mathrm{E}(X)$	the expectation of the random variable X
12.12	$\mathrm{Var}(X)$	the variance of the random variable X
12.13	$\mathrm{Cov}(X, Y)$	the covariance of X and Y (Further Mathematics only)
12.14	$\sim$	has the distribution
12.15	$\mathrm{B}(n, p)$	binomial distribution with parameters n and p, where n is the number of trials and p is the probability of a success in a trial
12.16	$\mathrm{N}(\mu, \sigma^2)$	normal distribution with mean μ and variance σ^2
12.17	$Z \sim \mathrm{N}(0, 1)$	the standard normal distribution
12.18	$\mathrm{Po}(\lambda)$	Poisson distribution with parameter λ, where λ is the mean and variance
12.19	$\mathrm{Exp}(\lambda)$	exponential distribution with parameter λ, where $\frac{1}{\lambda}$ is the mean and standard deviation
12.20	$\mathrm{U}(a, b)$	continuous uniform distribution between a and b
12.21	$\mathrm{DU}(a, b)$	discrete uniform distribution on the integers a to b (Further Mathematics only)
12.22	$\mathrm{Geo}(p)$	geometric distribution with parameter p, the probability of success on a single trial. (Further Mathematics only)
12.23	$\mathrm{NB}(r, p)$	negative binomial distribution where r is the required number of successes and p is the probability of a success on a single trial. (Further Mathematics only)
12.24	μ	population mean
12.25	σ^2	population variance
12.26	σ	population standard deviation
12.27	$\bar{x}$	sample mean, unbiased estimate for the population mean
12.28	s^2	sample variance, unbiased estimate for the population variance
12.29	s, S	sample standard deviation
12.30	H_0	null hypothesis
12.31	H_1	alternative hypothesis

12.32	r	product moment correlation coefficient for a sample (Further Mathematics only)
12.33	ρ	product moment correlation coefficient for a population (Further Mathematics only)
12.34	r_s	Spearman's rank correlation coefficient for a sample (Further Mathematics only)
12.35	ρ_s	Spearman's rank correlation coefficient for a population (Further Mathematics only)

6.13 Mechanics

Reference	Notation	Guidance
13.1	t	time
13.2	$\mathbf{r}$	position
13.3	s, $\mathbf{s}$	displacement
13.4	u, $\mathbf{u}$	initial velocity
13.5	v, $\mathbf{v}$	velocity or final velocity
13.6	a, $\mathbf{a}$	acceleration
13.7	g	acceleration due to gravity
13.8	μ	coefficient of friction
13.9	e	coefficient of restitution (Further Mathematics only)

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