CAMBRIDGE
International Examinations

Cambridge
O Level

SYLLABUS

Cambridge O Level

Mathematics (Syllabus D)

4024

For examination in June and November 2015

Mathematics (Syllabus D)
For Centres in Mauritius

4029

For examination in November 2015

Cambridge Secondary 2

Changes to syllabus for 2015

This syllabus has been updated, but there are no significant changes..

Contents

1. Introduction

1.1 Why choose Cambridge?

Recognition

Cambridge International Examinations is the world's largest provider of international education programmes and qualifications for learners aged 5 to 19. We are part of Cambridge Assessment, a department of the University of Cambridge, trusted for excellence in education. Our qualifications are recognised by the world's universities and employers.

Cambridge O Level is internationally recognised by schools, universities and employers as equivalent in demand to Cambridge IGCSE® (International General Certificate of Secondary Education). Learn more at **www.cie.org.uk/recognition**

Excellence in education

Our mission is to deliver world-class international education through the provision of high-quality curricula, assessment and services.

More than 9000 schools are part of our Cambridge learning community. We support teachers in over 160 countries who offer their learners an international education based on our curricula and leading to our qualifications. Every year, thousands of learners use Cambridge qualifications to gain places at universities around the world.

Our syllabuses are reviewed and updated regularly so that they reflect the latest thinking of international experts and practitioners and take account of the different national contexts in which they are taught.

Cambridge programmes and qualifications are designed to support learners in becoming:

- **confident** in working with information and ideas – their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **reflective** as learners, developing their ability to learn
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

Support for teachers

A wide range of materials and resources is available to support teachers and learners in Cambridge schools. Resources suit a variety of teaching methods in different international contexts. Through subject discussion forums and training, teachers can access the expert advice they need for teaching our qualifications. More details can be found in Section 2 of this syllabus and at **www.cie.org.uk/teachers**

Support for exams officers

Exams officers can trust in reliable, efficient administration of exams entries and excellent personal support from our customer services. Learn more at **www.cie.org.uk/examsofficers**

Not-for-profit, part of the University of Cambridge

We are a not-for-profit organisation where the needs of the teachers and learners are at the core of what we do. We continually invest in educational research and respond to feedback from our customers in order to improve our qualifications, products and services.

Our systems for managing the provision of international qualifications and education programmes for learners aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at **www.cie.org.uk/ISO9001**

1.2 Why choose Cambridge O Level?

Cambridge O Levels have been designed for an international audience and are sensitive to the needs of different countries. These qualifications are designed for students whose first language may not be English and this is acknowledged throughout the examination process. The Cambridge O Level syllabus also allows teaching to be placed in a localised context, making it relevant in varying regions.

Our aim is to balance knowledge, understanding and skills in our programmes and qualifications to enable candidates to become effective learners and to provide a solid foundation for their continuing educational journey.

Through our professional development courses and our support materials for Cambridge O Levels, we provide the tools to enable teachers to prepare students to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge O Levels are considered to be an excellent preparation for Cambridge International AS and A Levels, the Cambridge AICE (Advanced International Certificate of Education) Group Award, Cambridge Pre-U, and other education programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge O Levels at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge O Level syllabuses are designed on the assumption that candidates have about 130 guided learning hours per subject over the duration of the course, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

1.3 Why choose Cambridge O Level Mathematics?

Cambridge O Levels are established qualifications that keep pace with educational developments and trends. The Cambridge O Level curriculum places emphasis on broad and balanced study across a wide range of subject areas. The curriculum is structured so that students attain both practical skills and theoretical knowledge.

Cambridge O Level Mathematics is recognised by universities and employers throughout the world as proof of mathematical knowledge and understanding. Successful Cambridge O Level Mathematics candidates gain lifelong skills, including:

- the development of their mathematical knowledge;
- confidence by developing a feel for numbers, patterns and relationships;

- an ability to consider and solve problems and present and interpret results;
- communication and reason using mathematical concepts;
- a solid foundation for further study.

Students may also study for a Cambridge O Level in Additional Mathematics and Statistics. In addition to Cambridge O Levels, Cambridge also offers Cambridge IGCSE and Cambridge International AS and A Levels for further study in Mathematics as well as other maths-related subjects. See **www.cie.org.uk** for a full list of the qualifications you can take.

Prior learning

We recommend that candidates who are beginning this course should have previously studied an appropriate lower secondary Mathematics programme.

Progression

Cambridge O Level Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades C to A* in Cambridge O Level Mathematics are well prepared to follow courses leading to Cambridge International AS and A Level Mathematics, or the equivalent.

1.4 How can I find out more?

If you are already a Cambridge school

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at **info@cie.org.uk**

If you are not yet a Cambridge school

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**. Email us at **info@cie.org.uk** to find out how your organisation can register to become a Cambridge school.

2. Teacher support

2.1 Support materials

Cambridge syllabuses, past question papers and examiner reports to cover the last examination series are on the *Syllabus and Support Materials* DVD, which we send to all Cambridge schools.

You can also go to our public website at **www.cie.org.uk/olevel** to download current and future syllabuses together with specimen papers or past question papers and examiner reports from one series.

For teachers at registered Cambridge schools a range of additional support materials for specific syllabuses is available online. For Teacher Support go to **http://teachers.cie.org.uk** (username and password required).

2.2 Resource lists

We work with publishers providing a range of resources for our syllabuses including textbooks, websites, CDs etc. Any endorsed, recommended and suggested resources are listed on both our public website and on Teacher Support.

The resource lists can be filtered to show all resources or just those which are endorsed or recommended by Cambridge. Resources endorsed by Cambridge go through a detailed quality assurance process and are written to align closely with the Cambridge syllabus they support.

2.3 Training

We offer a range of support activities for teachers to ensure they have the relevant knowledge and skills to deliver our qualifications. See **www.cie.org.uk/events** for further information.

3. Assessment at a glance

All candidates take two papers.

Each paper may contain questions on any part of the syllabus and questions will not necessarily be restricted to a single topic.

Paper 1	2 hours

Paper 1 has approximately 25 short answer questions.

Candidates should show all working in the spaces provided on the question paper. Omission of essential working will result in loss of marks.

No calculators are allowed for this paper.

80 marks weighted at 50% of the total

Paper 2	2½ hours

Paper 2 has structured questions across two sections.

Section A (52 marks): approximately six questions. Candidates should answer all questions.

Section B (48 marks): five questions. Candidates should answer four.

Electronic calculators may be used.

Candidates should show all working in the spaces provided on the question paper. Omission of essential working will result in loss of marks.

100 marks weighted at 50% of the total

Availability

4024 is examined in the May/June examination series and the October/November examination series.

4029 is examined in the October/November examination series.

Detailed timetables are available from **www.cie.org.uk/examsofficers**

These syllabuses are available to private candidates.

Cambridge O Levels are available to Centres in Administrative Zones 3, 4 and 5. Centres in Administrative Zones 1, 2 or 6 wishing to enter candidates for Cambridge O Level examinations should contact Cambridge Customer Services.

Combining this with other syllabuses

Candidates can combine syllabus **4024** in an examination series with any other Cambridge syllabus, except:

- syllabuses with the same title at the same level
- 0580 Cambridge IGCSE Mathematics
- 0581 Cambridge IGCSE Mathematics (with Coursework)
- 4021 Cambridge O Level Mathematics A (Mauritius)
- 4026 Cambridge O Level Mathematics E (Brunei)
- 4029 Cambridge O Level Mathematics (Syllabus D) (Mauritius)

Candidates can combine syllabus **4029** in an examination series with any other Cambridge syllabus, except:

- syllabuses with the same title at the same level
- 0580 Cambridge IGCSE Mathematics
- 0581 Cambridge IGCSE Mathematics (with Coursework)
- 4021 Cambridge O Level Mathematics A (Mauritius)
- 4024 Cambridge O Level Mathematics (Syllabus D)

Please note that Cambridge O Level, Cambridge IGCSE and Cambridge International Level 1/Level 2 Certificate syllabuses are at the same level.

Calculating aids:

Paper 1 – the use of all calculating aids is prohibited.

Paper 2 – all candidates should have a **silent** electronic calculator. A scientific calculator with trigonometric functions is strongly recommended.

The General Regulations concerning the use of electronic calculators are contained in the *Cambridge Handbook*.

Unless stated otherwise within an individual question, three figure accuracy will be required. This means that four figure accuracy should be shown throughout the working, including cases where answers are used in subsequent parts of the question. Premature approximation will be penalised, where appropriate.

In Paper 2, candidates with suitable calculators are encouraged to use the value of π from their calculators. The value of π will be given as 3.142 to 3 decimal places for use by other candidates. This value will be given on the front page of the question paper only.

Units

SI units will be used in questions involving mass and measures: the use of the centimetre will continue.

Both the 12-hour clock and the 24-hour clock may be used for quoting times of the day. In the 24-hour clock, for example, 3.15 a.m. will be denoted by 03 15; 3.15 p.m. by 15 15, noon by 12 00 and midnight by 24 00.

Candidates will be expected to be familiar with the solidus notation for the expression of compound units, e.g. 5 cm/s for 5 centimetres per second, 13.6 g/cm3 for 13.6 grams per cubic centimetre.

Mathematical Instruments

Apart from the usual mathematical instruments, candidates may use flexicurves in this examination.

Mathematical Notation

Attention is drawn to the list of mathematical notation at the end of this booklet.

4. Syllabus aims and assessment objectives

The syllabus demands understanding of basic mathematical concepts and their applications, together with an ability to show this by clear expression and careful reasoning.

In the examination, importance will be attached to skills in algebraic manipulation and to numerical accuracy in calculations.

4.1 Syllabus aims

The course should enable students to:

- increase intellectual curiosity, develop mathematical language as a means of communication and investigation and explore mathematical ways of reasoning;
- acquire and apply skills and knowledge relating to number, measure and space in mathematical situations that they will meet in life;
- acquire a foundation appropriate to a further study of Mathematics and skills and knowledge pertinent to other disciplines;
- appreciate the pattern, structure and power of Mathematics and derive satisfaction, enjoyment and confidence from the understanding of concepts and the mastery of skills.

4.2 Assessment objectives

The examination tests the ability of candidates to:

1. recognise the appropriate mathematical procedures for a given situation;
2. perform calculations by suitable methods, with and without a calculating aid;
3. use the common systems of units;
4. estimate, approximate and use appropriate degrees of accuracy;
5. interpret, use and present information in written, graphical, diagrammatic and tabular forms;
6. use geometrical instruments;
7. recognise and apply spatial relationships in two and three dimensions;
8. recognise patterns and structures in a variety of situations and form and justify generalisations;
9. understand and use mathematical language and symbols and present mathematical arguments in a logical and clear fashion;
10. apply and interpret Mathematics in a variety of situations, including daily life;
11. formulate problems into mathematical terms, select, apply and communicate appropriate techniques of solution and interpret the solutions in terms of the problems.

5. Syllabus content

Theme or topic	Subject content
1. Number	*Candidates should be able to:* • use natural numbers, integers (positive, negative and zero), prime numbers, common factors and common multiples, rational and irrational numbers, real numbers; • continue given number sequences, recognise patterns within and across different sequences and generalise to simple algebraic statements (including expressions for the nth term) relating to such sequences.
2. Set language and notation	• use set language and set notation, and Venn diagrams, to describe sets and represent relationships between sets as follows: Definition of sets, e.g. $A = \{x : x \text{ is a natural number}\}$ $B = \{(x, y): y = mx + c\}$ $C = \{x : a \leqslant x \leqslant b\}$ $D = \{a, b, c\ldots\}$ Notation: Union of A and B — $A \cup B$ Intersection of A and B — $A \cap B$ Number of elements in set A — $n(A)$ "…is an element of…" — $\in$ "…is not an element of…" — $\notin$ Complement of set A — A' The empty set — $\varnothing$ Universal set — $\mathscr{E}$ A is a subset of B — $A \subseteq B$ A is a proper subset of B — $A \subset B$ A is not a subset of B — $A \nsubseteq B$ A is not a proper subset of B — $A \not\subset B$
3. Function notation	• use function notation, e.g. $f(x) = 3x - 5$, $f: x \mapsto 3x - 5$ to describe simple functions, and the notation $f^{-1}(x) = \frac{x+5}{3}$ and $f^{-1}: x \mapsto \frac{x+5}{3}$ to describe their inverses.
4. Squares, square roots, cubes and cube roots	• calculate squares, square roots, cubes and cube roots of numbers.
5. Directed numbers	• use directed numbers in practical situations (e.g. temperature change, tide levels).

6. Vulgar and decimal fractions and percentages	• use the language and notation of simple vulgar and decimal fractions and percentages in appropriate contexts; • recognise equivalence and convert between these forms.
7. Ordering	• order quantities by magnitude and demonstrate familiarity with the symbols $=, \neq, >, <, \geqslant, \leqslant$.
8. Standard form	• use the standard form $A \times 10^n$ where n is a positive or negative integer, and $1 \leqslant A < 10$.
9. The four operations	• use the four operations for calculations with whole numbers, decimal fractions and vulgar (and mixed) fractions, including correct ordering of operations and use of brackets.
10. Estimation	• make estimates of numbers, quantities and lengths, give approximations to specified numbers of significant figures and decimal places and round off answers to reasonable accuracy in the context of a given problem.
11. Limits of accuracy	• give appropriate upper and lower bounds for data given to a specified accuracy (e.g. measured lengths); • obtain appropriate upper and lower bounds to solutions of simple problems (e.g. the calculation of the perimeter or the area of a rectangle) given data to a specified accuracy.
12. Ratio, proportion, rate	• demonstrate an understanding of the elementary ideas and notation of ratio, direct and inverse proportion and common measures of rate; • divide a quantity in a given ratio; • use scales in practical situations, calculate average speed; • express direct and inverse variation in algebraic terms and use this form of expression to find unknown quantities.
13. Percentages	• calculate a given percentage of a quantity; • express one quantity as a percentage of another, calculate percentage increase or decrease; • carry out calculations involving reverse percentages, e.g. finding the cost price given the selling price and the percentage profit.
14. Use of an electronic calculator	• use an electronic calculator efficiently; • apply appropriate checks of accuracy.
15. Measures	• use current units of mass, length, area, volume and capacity in practical situations and express quantities in terms of larger or smaller units.
16. Time	• calculate times in terms of the 12-hour and 24-hour clock; • read clocks, dials and timetables.
17. Money	• solve problems involving money and convert from one currency to another.
18. Personal and household finance	• use given data to solve problems on personal and household finance involving earnings, simple interest, discount, profit and loss; • extract data from tables and charts.

19. Graphs in practical situations	• demonstrate familiarity with cartesian coordinates in two dimensions; • interpret and use graphs in practical situations including travel graphs and conversion graphs; • draw graphs from given data; • apply the idea of rate of change to easy kinematics involving distance-time and speed-time graphs, acceleration and retardation; • calculate distance travelled as area under a linear speed-time graph.
20. Graphs of functions	• construct tables of values and draw graphs for functions of the form $y = ax^n$ where $n = -2, -1, 0, 1, 2, 3$, and simple sums of not more than three of these and for functions of the form $y = ka^x$ where a is a positive integer; • interpret graphs of linear, quadratic, reciprocal and exponential functions; • find the gradient of a straight line graph; • solve equations approximately by graphical methods; • estimate gradients of curves by drawing tangents.
21. Straight line graphs	• calculate the gradient of a straight line from the coordinates of two points on it; • interpret and obtain the equation of a straight line graph in the form $y = mx + c$; • calculate the length and the coordinates of the midpoint of a line segment from the coordinates of its end points.
22. Algebraic representation and formulae	• use letters to express generalised numbers and express basic arithmetic processes algebraically, substitute numbers for words and letters in formulae; • transform simple and more complicated formulae; • construct equations from given situations.
23. Algebraic manipulation	• manipulate directed numbers; • use brackets and extract common factors; • expand products of algebraic expressions; • factorise expressions of the form $ax + ay$ $ax + bx + kay + kby$ $a^2x^2 - b^2y^2$ $a^2 + 2ab + b^2$ $ax^2 + bx + c$ • manipulate simple algebraic fractions.
24. Indices	• use and interpret positive, negative, zero and fractional indices.

25. Solutions of equations and inequalities	• solve simple linear equations in one unknown; • solve fractional equations with numerical and linear algebraic denominators; • solve simultaneous linear equations in two unknowns; • solve quadratic equations by factorisation and either by use of the formula or by completing the square; • solve simple linear inequalities.
26. Graphical representation of inequalities	• represent linear inequalities in one or two variables graphically. (Linear Programming problems are not included.)
27. Geometrical terms and relationships	• use and interpret the geometrical terms: point, line, plane, parallel, perpendicular, right angle, acute, obtuse and reflex angles, interior and exterior angles, regular and irregular polygons, pentagons, hexagons, octagons, decagons; • use and interpret vocabulary of triangles, circles, special quadrilaterals; • solve problems and give simple explanations involving similarity and congruence; • use and interpret vocabulary of simple solid figures: cube, cuboid, prism, cylinder, pyramid, cone, sphere; • use the relationships between areas of similar triangles, with corresponding results for similar figures, and extension to volumes of similar solids.
28. Geometrical constructions	• measure lines and angles; • construct simple geometrical figures from given data, angle bisectors and perpendicular bisectors using protractors or set squares as necessary; • read and make scale drawings. (Where it is necessary to construct a triangle given the three sides, ruler and compasses only must be used.)
29. Bearings	• interpret and use three-figure bearings measured clockwise from the north (i.e. 000°–360°).
30. Symmetry	• recognise line and rotational symmetry (including order of rotational symmetry) in two dimensions, and properties of triangles, quadrilaterals and circles directly related to their symmetries; • recognise symmetry properties of the prism (including cylinder) and the pyramid (including cone); • use the following symmetry properties of circles: (a) equal chords are equidistant from the centre; (b) the perpendicular bisector of a chord passes through the centre; (c) tangents from an external point are equal in length.

31. Angle	• calculate unknown angles and give simple explanations using the following geometrical properties: (a) angles on a straight line; (b) angles at a point; (c) vertically opposite angles; (d) angles formed by parallel lines; (e) angle properties of triangles and quadrilaterals; (f) angle properties of polygons including angle sum; (g) angle in a semi-circle; (h) angle between tangent and radius of a circle; (i) angle at the centre of a circle is twice the angle at the circumference; (j) angles in the same segment are equal; (k) angles in opposite segments are supplementary.
32. Locus	• use the following loci and the method of intersecting loci: (a) sets of points in two or three dimensions (i) which are at a given distance from a given point, (ii) which are at a given distance from a given straight line, (iii) which are equidistant from two given points; (b) sets of points in two dimensions which are equidistant from two given intersecting straight lines.
33. Mensuration	• solve problems involving (i) the perimeter and area of a rectangle and triangle, (ii) the circumference and area of a circle, (iii) the area of a parallelogram and a trapezium, (iv) the surface area and volume of a cuboid, cylinder, prism, sphere, pyramid and cone (formulae will be given for the sphere, pyramid and cone), (v) arc length and sector area as fractions of the circumference and area of a circle.
34. Trigonometry	• apply Pythagoras Theorem and the sine, cosine and tangent ratios for acute angles to the calculation of a side or of an angle of a right-angled triangle (angles will be quoted in, and answers required in, degrees and decimals of a degree to one decimal place); • solve trigonometrical problems in two dimensions including those involving angles of elevation and depression and bearings; • extend sine and cosine functions to angles between 90° and 180°; solve problems using the sine and cosine rules for any triangle and the formula $\frac{1}{2}ab\sin C$ for the area of a triangle; • solve simple trigonometrical problems in three dimensions. (Calculations of the angle between two planes or of the angle between a straight line and plane will not be required.)

35. Statistics	• collect, classify and tabulate statistical data; read, interpret and draw simple inferences from tables and statistical diagrams; • construct and use bar charts, pie charts, pictograms, simple frequency distributions and frequency polygons; • use frequency density to construct and read histograms with equal and unequal intervals; • calculate the mean, median and mode for individual data and distinguish between the purposes for which they are used; • construct and use cumulative frequency diagrams; estimate the median, percentiles, quartiles and interquartile range; • calculate the mean for grouped data; identify the modal class from a grouped frequency distribution.
36. Probability	• calculate the probability of a single event as either a fraction or a decimal (not a ratio); • calculate the probability of simple combined events using possibility diagrams and tree diagrams where appropriate. (In possibility diagrams outcomes will be represented by points on a grid and in tree diagrams outcomes will be written at the end of branches and probabilities by the side of the branches.)
37. Matrices	• display information in the form of a matrix of any order; • solve problems involving the calculation of the sum and product (where appropriate) of two matrices, and interpret the results; • calculate the product of a scalar quantity and a matrix; • use the algebra of 2×2 matrices including the zero and identity 2×2 matrices; • calculate the determinant and inverse of a non-singular matrix. ($\mathbf{A}^{-1}$ denotes the inverse of $\mathbf{A}$.)
38. Transformations	• use the following transformations of the plane: reflection (M), rotation (R), translation (T), enlargement (E), shear (H), stretching (S) and their combinations (If M(a) = b and R(b) = c the notation RM(a) = c will be used; invariants under these transformations may be assumed.); • identify and give precise descriptions of transformations connecting given figures; describe transformations using coordinates and matrices. (Singular matrices are excluded.)

39. Vectors in two dimensions	• describe a translation by using a vector represented by $\begin{pmatrix} x \\ y \end{pmatrix}$, $\overrightarrow{AB}$ or **a**; • add vectors and multiply a vector by a scalar; • calculate the magnitude of a vector $\begin{pmatrix} x \\ y \end{pmatrix}$ as $\sqrt{x^2 + y^2}$. (Vectors will be printed as $\overrightarrow{AB}$ or **a** and their magnitudes denoted by modulus signs, e.g. l $\overrightarrow{AB}$ l or l**a**l. In all their answers to questions candidates are expected to indicate **a** in some definite way, e.g. by an arrow or by underlining, thus $\overrightarrow{AB}$ or a); • represent vectors by directed line segments; use the sum and difference of two vectors to express given vectors in terms of two coplanar vectors; use position vectors.

6. Mathematical notation

The list which follows summarises the notation used in the Cambridge's Mathematics examinations. Although primarily directed towards Advanced/HSC (Principal) level, the list also applies, where relevant, to examinations at Cambridge O Level/S.C.

1. Set Notation

$\in$	is an element of
$\notin$	is not an element of
$\{x_1, x_2, \ldots\}$	the set with elements $x_1, x_2, \ldots$
$\{x: \ldots\}$	the set of all x such that…
$\mathrm{n}(A)$	the number of elements in set A
$\varnothing$	the empty set
$\mathscr{E}$	universal set
A'	the complement of the set A
$\mathbb{N}$	the set of positive integers, {1, 2, 3, …}
$\mathbb{Z}$	the set of integers {0, ±1, ±2, ±3, …}
$\mathbb{Z}^+$	the set of positive integers {1, 2, 3, …}
$\mathbb{Z}_n$	the set of integers modulo n, {0, 1, 2, …, n – 1}
$\mathbb{Q}$	the set of rational numbers
$\mathbb{Q}^+$	the set of positive rational numbers, $\{x \in \mathbb{Q}: x > 0\}$
$\mathbb{Q}_0^+$	the set of positive rational numbers and zero, $\{x \in \mathbb{Q}: x \geqslant 0\}$
$\mathbb{R}$	the set of real numbers
$\mathbb{R}^+$	the set of positive real numbers $\{x \in \mathbb{R}: x > 0\}$
$\mathbb{R}_0^+$	the set of positive real numbers and zero $\{x \in \mathbb{R}: x \geqslant 0\}$
$\mathbb{R}^n$	the real n tuples
$\mathbb{C}$	the set of complex numbers
$\subseteq$	is a subset of
$\subset$	is a proper subset of
$\not\subseteq$	is not a subset of
$\not\subset$	is not a proper subset of
$\cup$	union
$\cap$	intersection
$[a, b]$	the closed interval $\{x \in \mathbb{R}: a \leqslant x \leqslant b\}$
$[a, b)$	the interval $\{x \in \mathbb{R}: a \leqslant x < b\}$
$(a, b]$	the interval $\{x \in \mathbb{R}: a < x \leqslant b\}$
(a, b)	the open interval $\{x \in \mathbb{R}: a < x < b\}$
yRx	y is related to x by the relation R
$y \sim x$	y is equivalent to x, in the context of some equivalence relation

2. Miscellaneous Symbols

$=$	is equal to
$\neq$	is not equal to
$\equiv$	is identical to or is congruent to
$\approx$	is approximately equal to
$\cong$	is isomorphic to
$\propto$	is proportional to
$<$; $\ll$	is less than, is much less than
$\leqslant$, $\not>$	is less than or equal to, is not greater than
$>$; $\gg$	is greater than, is much greater than
$\geqslant$, $\not<$	is greater than or equal to, is not less than
∞	infinity

3. Operations

$a + b$	a plus b
$a - b$	a minus b
$a \times b$, ab, $a.b$	a multiplied by b
$a \div b$, $\frac{a}{b}$, a/b	a divided by b
$a : b$	the ratio of a to b
$\sum_{i=1}^{n} a_i$	$a_1 + a_2 + \ldots + a_n$
$\sqrt{a}$	the positive square root of the real number a
$\lvert a \rvert$	the modulus of the real number a
$n!$	n factorial for $n \in \mathbb{N}$ ($0! = 1$)
$\binom{n}{r}$	the binomial coefficient $\frac{n!}{r!(n-r)!}$, for $n, r \in \mathbb{N}$, $0 \leqslant r \leqslant n$
	$\frac{n(n-1)\ldots(n-r+1)}{r!}$, for $n \in \mathbb{Q}$, $r \in \mathbb{N}$

4. Functions

f	function f
$\mathrm{f}(x)$	the value of the function f at x
$\mathrm{f} : A \to B$	f is a function under which each element of set A has an image in set B
$\mathrm{f} : x \mapsto y$	the function f maps the element x to the element y
f^{-1}	the inverse of the function f
$\mathrm{g} \circ \mathrm{f}$, gf	the composite function of f and g which is defined by $(\mathrm{g} \circ \mathrm{f})(x)$ or $\mathrm{gf}(x) = \mathrm{g}(\mathrm{f}(x))$
$\lim_{x \to a} \mathrm{f}(x)$	the limit of $\mathrm{f}(x)$ as x tends to a
$\Delta x; \delta x$	an increment of x
$\frac{\mathrm{d}y}{\mathrm{d}x}$	the derivative of y with respect to x
$\frac{\mathrm{d}^n y}{\mathrm{d}x^n}$	the nth derivative of y with respect to x
$\mathrm{f}'(x)$, $\mathrm{f}''(x)$, …, $\mathrm{f}^{(n)}(x)$	the first, second, …, nth derivatives of $\mathrm{f}(x)$ with respect to x
$\int y \mathrm{d}x$	indefinite integral of y with respect to x
$\int_a^b y \, \mathrm{d}x$	the definite integral of y with respect to x for values of x between a and b
$\frac{\partial y}{\partial x}$	the partial derivative of y with respect to x
$\dot{x}$, $\ddot{x}$, …	the first, second, … derivatives of x with respect to time

5. Exponential and Logarithmic Functions

e	base of natural logarithms
e^x, $\exp x$	exponential function of x
$\log_a x$	logarithm to the base a of x
$\ln x$	natural logarithm of x
$\lg x$	logarithm of x to base 10

6. Circular and Hyperbolic Functions and Relations

sin, cos, tan, cosec, sec, cot	the circular functions
$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, cosec^{-1}, $\sec^{-1}$, $\cot^{-1}$	the inverse circular relations
sinh, cosh, tanh, cosech, sech, coth	the hyperbolic functions
$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, cosech^{-1}, sech^{-1}, $\coth^{-1}$	the inverse hyperbolic relations

7. Complex Numbers

i	square root of -1
z	a complex number, $z = x + \mathrm{i}y$ $= r(\cos\theta + \mathrm{i}\sin\theta), r \in \mathbb{R}_0^+$ $= re^{i\theta}, r \in \mathbb{R}_0^+$
$\mathrm{Re}\, z$	the real part of z, $\mathrm{Re}(x + \mathrm{i}y) = x$
$\mathrm{Im}\, z$	the imaginary part of z, $\mathrm{Im}(x + \mathrm{i}y) = y$
$\lvert z \rvert$	the modulus of z, $\lvert x + \mathrm{i}y \rvert = \sqrt{(x^2 + y^2)}$, $\lvert r(\cos\theta + \mathrm{i}\sin\theta) \rvert = r$
$\arg z$	the argument of z, $\arg(r(\cos\theta + \mathrm{i}\sin\theta)) = \theta, -\pi < \theta \leqslant \pi$
z^*	the complex conjugate of z, $(x + \mathrm{i}y)^* = x - \mathrm{i}y$

8. Matrices

$\mathbf{M}$	a matrix $\mathbf{M}$
$\mathbf{M}^{-1}$	the inverse of the square matrix $\mathbf{M}$
$\mathbf{M}^{\mathrm{T}}$	the transpose of the matrix $\mathbf{M}$
$\det \mathbf{M}$	the determinant of the square matrix $\mathbf{M}$

9. Vectors

$\mathbf{a}$	the vector $\mathbf{a}$
$\overrightarrow{AB}$	the vector represented in magnitude and direction by the directed line segment AB
$\hat{\mathbf{a}}$	a unit vector in the direction of the vector $\mathbf{a}$
$\mathbf{i}, \mathbf{j}, \mathbf{k}$	unit vectors in the directions of the cartesian coordinate axes
$\lvert \mathbf{a} \rvert$	the magnitude of $\mathbf{a}$
$\lvert \overrightarrow{AB} \rvert$	the magnitude of $\overrightarrow{AB}$
$\mathbf{a} \cdot \mathbf{b}$	the scalar product of $\mathbf{a}$ and $\mathbf{b}$
$\mathbf{a} \times \mathbf{b}$	the vector product of $\mathbf{a}$ and $\mathbf{b}$

10. Probability and Statistics

A, B, C etc.	events
$A \cup B$	union of events A and B
$A \cap B$	intersection of the events A and B
$\mathrm{P}(A)$	probability of the event A
A'	complement of the event A, the event 'not A'
$\mathrm{P}(A\|B)$	probability of the event A given the event B
X, Y, R, etc.	random variables
x, y, r, etc.	values of the random variables X, Y, R, etc.
$x_1, x_2, \ldots$	observations
$f_1, f_2, \ldots$	frequencies with which the observations $x_1, x_2, \ldots$ occur
$p(x)$	the value of the probability function $\mathrm{P}(X = x)$ of the discrete random variable X
$p_1, p_2, \ldots$	probabilities of the values $x_1, x_2, \ldots$ of the discrete random variable X
$\mathrm{f}(x), \mathrm{g}(x), \ldots$	the value of the probability density function of the continuous random variable X
$\mathrm{F}(x), \mathrm{G}(x), \ldots$	the value of the (cumulative) distribution function $\mathrm{P}(X \leqslant x)$ of the random variable X
$\mathrm{E}(X)$	expectation of the random variable X
$\mathrm{E}[\mathrm{g}(X)]$	expectation of $\mathrm{g}(X)$
$\mathrm{Var}(X)$	variance of the random variable X
$\mathrm{G}(t)$	the value of the probability generating function for a random variable which takes integer values
$\mathrm{B}(n, p)$	binomial distribution, parameters n and p
$\mathrm{N}(\mu, \sigma^2)$	normal distribution, mean μ and variance σ^2
μ	population mean
σ^2	population variance
σ	population standard deviation
$\bar{x}$	sample mean
s^2	unbiased estimate of population variance from a sample, $s^2 = \frac{1}{n-1}\sum(x - \bar{x})^2$
ϕ	probability density function of the standardised normal variable with distribution N (0, 1)
Φ	corresponding cumulative distribution function
ρ	linear product-moment correlation coefficient for a population
r	linear product-moment correlation coefficient for a sample
$\mathrm{Cov}(X, Y)$	covariance of X and Y

7. Other information

Equality and inclusion

Cambridge International Examinations has taken great care in the preparation of this syllabus and assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), Cambridge has designed this qualification with the aim of avoiding direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. Arrangements can be put in place for these candidates to enable them to access the assessments and receive recognition of their attainment. Access arrangements will not be agreed if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is found in the *Cambridge Handbook* which can be downloaded from the website **www.cie.org.uk**

Language

This syllabus and the associated assessment materials are available in English only.

Grading and reporting

Cambridge O Level results are shown by one of the grades A*, A, B, C, D or E, indicating the standard achieved, A* being the highest and E the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade E. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending); X (no results) and Y (to be issued) may also appear on the statement of results but not on the certificate.

Entry codes

To maintain the security of our examinations we produce question papers for different areas of the world, known as 'administrative zones'. Where the component entry code has two digits, the first digit is the component number given in the syllabus. The second digit is the location code, specific to an administrative zone. Information about entry codes, examination timetables and administrative instructions can be found in the *Cambridge Guide to Making Entries*.

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