

# SYLLABUS

**Cambridge O Level  
Mathematics (Syllabus D)**

**4024**

For examination in June and November 2018, 2019 and 2020

**Mathematics (Syllabus D)  
For Centres in Mauritius**

**4029**

For examination in November 2018, 2019 and 2020

## Changes to syllabus for 2018, 2019 and 2020

All the changes to syllabus **4024** also apply to syllabus **4029 for Mauritius only**. In addition, the default currency used in 4029 question papers will be US dollars rather than Mauritian rupees.

### Assessment objectives and weightings

The assessment objectives in section 5 have been reworded for clarity and grouped under two separate headings: AO1 Mathematical techniques; AO2 Applying mathematical techniques to solve problems.

Assessment objective weighting information has been added to clarify how skills will be assessed in the examination papers. The standard and focus of the assessment remain unchanged.

### Paper 1

Paper 1 question papers from 2018 will no longer be ordered strictly by increasing mark allocation.

### Paper 2

Paper 2 question papers from 2018 will no longer include optional questions; **all** questions on Paper 2 will be compulsory. The paper will no longer be divided into Sections A and B.

### Syllabus content

To exemplify the syllabus content on pages 11–21, notes and examples have been added in an additional column.

Some sections of the syllabus content have changed (as shown by black vertical lines on the left of pages 11–21).

New content has been **added** to the following sections: 1. Number; 13. Use of an electronic calculator; 16. Personal and small business finance; 20. Graphs of functions; 27. Coordinate geometry; 28. Geometrical terms; 35. Mensuration; 40. Probability; 41. Categorical, numerical and grouped data; 42. Statistical diagrams.

Some syllabus content has been **removed** from the following sections: 33. Loci – references removed to loci in three dimensions; 39. Transformations – references removed to shear and stretching.

Some sections of the syllabus content have been **re-ordered and re-grouped**, so the section numbering has changed. Some existing content has moved into sections with new headings as follows: 22. Sequences; 23. Variation; 27. Coordinate geometry; 30. Similarity and congruence; 41. Categorical, numerical and grouped data; 42. Statistical diagrams.

Some syllabus content has been **reworded** for clarity and consistency.

### Other changes

The syllabus title has been simplified to 'Cambridge O Level Mathematics (Syllabus D)'; the words '(Calculator Version)' have been removed. A new 'Syllabus content at a glance' section has been added. On page 8, the additional materials required in examinations and the regulations on use of calculators have been clarified.

This syllabus has been updated. Significant changes to the syllabus are indicated by black vertical lines either side of the text.

**You are strongly advised to read the whole syllabus before planning your teaching programme. In addition, you are strongly advised to refer to the published specimen assessment materials for first examination in 2018 on our website at [www.cie.org.uk](http://www.cie.org.uk)**

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## Contents

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|                                                               |    |
|---------------------------------------------------------------|----|
| 1. Introduction.....                                          | 2  |
| 1.1 Why choose Cambridge?                                     |    |
| 1.2 Why choose Cambridge O Level?                             |    |
| 1.3 Why choose Cambridge O Level Mathematics?                 |    |
| 1.4 How can I find out more?                                  |    |
| 2. Teacher support.....                                       | 5  |
| 2.1 Support materials                                         |    |
| 2.2 Endorsed resources                                        |    |
| 2.3 Training                                                  |    |
| 3. Syllabus content at a glance.....                          | 6  |
| 4. Assessment at a glance.....                                | 7  |
| 5. Syllabus aims and assessment objectives .....              | 9  |
| 5.1 Syllabus aims                                             |    |
| 5.2 Assessment objectives                                     |    |
| 5.3 Relationship between assessment objectives and components |    |
| 6. Syllabus content.....                                      | 11 |
| 7. Mathematical notation .....                                | 22 |
| 8. Other information.....                                     | 27 |

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# 1. Introduction

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## 1.1 Why choose Cambridge?

Cambridge International Examinations is part of the University of Cambridge. We prepare school students for life, helping them develop an informed curiosity and a lasting passion for learning. Our international qualifications are recognised by the world's best universities and employers, giving students a wide range of options in their education and career. As a not-for-profit organisation, we devote our resources to delivering high-quality educational programmes that can unlock learners' potential.

Our programmes set the global standard for international education. They are created by subject experts, are rooted in academic rigour, and provide a strong platform for progression. Over 10 000 schools in 160 countries work with us to prepare nearly a million learners for their future with an international education from Cambridge.

### Cambridge learners

Cambridge programmes and qualifications develop not only subject knowledge but also skills. We encourage Cambridge learners to be:

- **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.

### Recognition

Cambridge O Level is internationally recognised by schools, universities and employers as equivalent in demand to Cambridge IGCSE® (International General Certificate of Secondary Education). There are over 700 000 entries a year in nearly 70 countries. Learn more at **[www.cie.org.uk/recognition](http://www.cie.org.uk/recognition)**

### 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](http://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](http://www.cie.org.uk/examsofficers)**

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](http://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 learners 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 students 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 learners 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/cambridgesecundary2](http://www.cie.org.uk/cambridgesecundary2)**

### Guided learning hours

Cambridge O Level syllabuses are designed on the assumption that learners 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 learners 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. Cambridge O Level Mathematics allows learners to gain lifelong benefits, including:

- confidence in their mathematical knowledge, and the ability to apply it in different contexts
- skills in communication and reasoning using mathematical concepts
- a solid foundation for further study
- the ability to be reflective when considering, presenting and interpreting mathematical results
- the ability to be engaged intellectually by developing a feel for numbers, patterns and relationships
- the ability to be innovative when applying their knowledge and understanding to solve problems in their future work.

Learners may also study for a Cambridge O Level in Additional Mathematics and for a Cambridge O Level in Statistics. In addition to Cambridge O Levels, Cambridge also offers Cambridge IGCSE and Cambridge International AS and A Levels for further study in mathematics. See **www.cie.org.uk** for a full list of the qualifications you can take.

### Prior learning

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

### Progression

Cambridge O Levels 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.

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## 2. Teacher support

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### 2.1 Support materials

We send Cambridge syllabuses, past question papers and examiner reports to cover the last examination series 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 from Teacher Support, our secure online support for Cambridge teachers. Go to **http://teachers.cie.org.uk** (username and password required).

### 2.2 Endorsed resources

We work with publishers providing a range of resources for our syllabuses including print and digital materials. Resources endorsed by Cambridge go through a detailed quality assurance process to ensure they provide a high level of support for teachers and learners.

We have resource lists which can be filtered to show all resources, or just those which are endorsed by Cambridge. The resource lists include further suggestions for resources to support teaching.

### 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. Syllabus content at a glance

All candidates will study the following themes or topics:

| Theme or topic                                  | Theme or topic                              |
|-------------------------------------------------|---------------------------------------------|
| 1. Number                                       | 22. Sequences                               |
| 2. Set language and notation                    | 23. Variation                               |
| 3. Squares, square roots, cubes and cube roots  | 24. Graphs in practical situations          |
| 4. Directed numbers                             | 25. Graphs of functions                     |
| 5. Vulgar and decimal fractions and percentages | 26. Function notation                       |
| 6. Ordering                                     | 27. Coordinate geometry                     |
| 7. Standard form                                | 28. Geometrical terms                       |
| 8. The four operations                          | 29. Geometrical constructions               |
| 9. Estimation                                   | 30. Similarity and congruence               |
| 10. Limits of accuracy                          | 31. Symmetry                                |
| 11. Ratio, proportion, rate                     | 32. Angles                                  |
| 12. Percentages                                 | 33. Loci                                    |
| 13. Use of an electronic calculator             | 34. Measures                                |
| 14. Time                                        | 35. Mensuration                             |
| 15. Money                                       | 36. Trigonometry                            |
| 16. Personal and small business finance         | 37. Vectors in two dimensions               |
| 17. Algebraic representation and formulae       | 38. Matrices                                |
| 18. Algebraic manipulation                      | 39. Transformations                         |
| 19. Indices                                     | 40. Probability                             |
| 20. Solutions of equations and inequalities     | 41. Categorical, numerical and grouped data |
| 21. Graphical representation of inequalities    | 42. Statistical diagrams                    |

## 4. Assessment at a glance

All candidates take two papers: Paper 1 and Paper 2.

Each paper may contain questions on any part of the syllabus and questions may assess more than one 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. Essential working must be shown for full marks to be awarded.

**No calculators are allowed for this paper.**

80 marks

This paper will be weighted at 50% of the total qualification.

### Paper 2

2 hours 30 minutes

Paper 2 has approximately 11 structured questions.

Candidates should answer **all** questions.

**Electronic calculators may be used and candidates should have access to a calculator for this paper.**

Candidates should show all working in the spaces provided on the question paper. Essential working must be shown for full marks to be awarded.

100 marks

This paper will be weighted at 50% of the total qualification.

## Availability

4024 is examined in the June and November examination series.

4029 is examined in the November examination series.

This syllabus is available to private candidates.

Detailed timetables are available from [www.cie.org.uk/examsOfficers](http://www.cie.org.uk/examsOfficers)

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 at the same level with the same title ('Mathematics', including 'International Mathematics')

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

- syllabuses at the same level with the same title ('Mathematics', including 'International Mathematics')

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

## Additional materials for examinations:

For both Paper 1 and Paper 2, candidates should have these geometrical instruments:

- a pair of compasses
- a protractor
- a ruler.

Tracing paper may be used as an additional material for both of the written papers.

For Paper 2, candidates should have an electronic calculator – see below for details.

## Use of calculators:

**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. Algebraic or graphical calculators are not permitted.

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. To earn accuracy marks, premature approximation should be avoided.

In Paper 2, candidates are encouraged to use the value of  $\pi$  from their calculators. Otherwise, they should use the value of  $\pi$  given on the front page of the question paper as 3.142 to three decimal places.

## Units

SI units will be used in questions involving mass and measures, including use of centimetres.

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 expression of compound units in the following form: e.g. 5 cm/s for 5 centimetres per second; 13.6 g/cm<sup>3</sup> for 13.6 grams per cubic centimetre.

## Mathematical Notation

Please use the list of mathematical notation in section 7 of this syllabus.

## 5. Syllabus aims and assessment objectives

### 5.1 Syllabus aims

The aims are to enable candidates 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 their further study of mathematics and of 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.

### 5.2 Assessment objectives

The two assessment objectives in Cambridge O Level Mathematics are:

**AO1 Mathematical techniques**

**AO2 Applying mathematical techniques to solve problems**

#### AO1: Mathematical techniques

Candidates should be able to:

- recognise the appropriate mathematical procedures for a given situation
- perform calculations by suitable methods, with and without a calculator
- understand systems of measurement in everyday use and make use of them in the solution of problems
- estimate, approximate and work to degrees of accuracy appropriate to the context and convert between equivalent numerical forms
- organise, interpret and present information accurately in written, tabular, graphical and diagrammatic forms
- use mathematical and other instruments to measure and to draw to an acceptable degree of accuracy
- recognise and use spatial relationships in two and three dimensions, particularly when solving problems
- interpret, transform and make appropriate use of mathematical statements expressed in words or symbols
- recall, apply and interpret mathematical knowledge in the context of everyday situations.

## AO2: Applying mathematical techniques to solve problems

In questions which are set in context and/or which require a sequence of steps to solve, candidates should be able to:

- recognise patterns and structures in a variety of situations and form and justify generalisations
- make logical deductions from given mathematical data
- respond to a problem relating to a relatively unstructured situation by translating it into an appropriately structured form
- analyse a problem, select a suitable strategy and apply an appropriate technique to obtain its solution
- apply combinations of mathematical skills and techniques in problem solving
- set out mathematical work, including the solution of problems, in a logical and clear form using appropriate symbols and terminology.

## 5.3 Relationship between assessment objectives and components

The weightings allocated to each of the assessment objectives (AOs) are summarised below.

The table shows the assessment objectives as an approximate percentage of each component and as an approximate percentage of the overall Cambridge O Level Mathematics qualification.

| Component                                       | AO1 (%) | AO2 (%) | Weighting of component in overall qualification (%) |
|-------------------------------------------------|---------|---------|-----------------------------------------------------|
| Paper 1                                         | 55–65   | 35–45   | 50                                                  |
| Paper 2                                         | 28–38   | 62–72   | 50                                                  |
| <b>Weighting of AO in overall qualification</b> | 40–50   | 50–60   |                                                     |

## 6. Syllabus content

| Theme or topic                                         | Subject content                                                                                                                                                                                                                                                                                                                                                                           | Notes/examples                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1. Number</b>                                       | <p>Candidates should be able to:</p> <ul style="list-style-type: none"> <li>identify and use natural numbers, integers (positive, negative and zero), prime numbers, square numbers, cube numbers, common factors and common multiples, rational and irrational numbers (e.g. <math>\pi</math>, <math>\sqrt{2}</math>), real numbers</li> </ul>                                           | Includes expressing numbers as a product of prime factors, finding the Lowest Common Multiple (LCM) and Highest Common Factor (HCF) of two or more numbers.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>2. Set language and notation</b>                    | <ul style="list-style-type: none"> <li>use language, notation and Venn diagrams to describe sets and represent relationships between sets</li> </ul> <p>Definition of sets:<br/>e.g.<br/> <math>A = \{x : x \text{ is a natural number}\}</math><br/> <math>B = \{(x, y) : y = mx + c\}</math><br/> <math>C = \{x : a \leq x \leq b\}</math><br/> <math>D = \{a, b, c, \dots\}</math></p> | <p>Includes using Venn diagrams to solve problems.</p> <p>Notation:</p> <p>Number of elements in set <math>A</math>      <math>n(A)</math></p> <p>"... is an element of ..."      <math>\in</math></p> <p>"... is not an element of ..."      <math>\notin</math></p> <p>Complement of set <math>A</math>      <math>A'</math></p> <p>The empty set      <math>\emptyset</math></p> <p>Universal set      <math>\mathcal{U}</math></p> <p><math>A</math> is a subset of <math>B</math>      <math>A \subseteq B</math></p> <p><math>A</math> is a proper subset of <math>B</math>      <math>A \subset B</math></p> <p><math>A</math> is not a subset of <math>B</math>      <math>A \not\subseteq B</math></p> <p><math>A</math> is not a proper subset of <math>B</math>      <math>A \not\subset B</math></p> <p>Union of <math>A</math> and <math>B</math>      <math>A \cup B</math></p> <p>Intersection of <math>A</math> and <math>B</math>      <math>A \cap B</math></p> |
| <b>3. Squares, square roots, cubes and cube roots</b>  | <ul style="list-style-type: none"> <li>calculate squares, square roots, cubes and cube roots of numbers</li> </ul>                                                                                                                                                                                                                                                                        | Includes recall of squares and their corresponding roots from 1 to 15 and cubes and their corresponding roots from 1 to 10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>4. Directed numbers</b>                             | <ul style="list-style-type: none"> <li>use directed numbers in practical situations</li> </ul>                                                                                                                                                                                                                                                                                            | e.g. temperature changes or flood levels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>5. Vulgar and decimal fractions and percentages</b> | <ul style="list-style-type: none"> <li>use the language and notation of simple vulgar and decimal fractions and percentages in appropriate contexts</li> <li>recognise equivalence and convert between these forms</li> </ul>                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>6. Ordering</b>                                     | <ul style="list-style-type: none"> <li>order quantities by magnitude and demonstrate familiarity with the symbols <math>=</math>, <math>\neq</math>, <math>&gt;</math>, <math>&lt;</math>, <math>\geq</math>, <math>\leq</math></li> </ul>                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| Theme or topic                             | Subject content                                                                                                                                                                                                                                                        | Notes/examples                                                                                                                                                                                                                                          |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>7. Standard form</b>                    | <ul style="list-style-type: none"> <li>use the standard form <math>A \times 10^n</math> where <math>n</math> is a positive or negative integer, and <math>1 \leq A &lt; 10</math></li> </ul>                                                                           | Convert numbers into and out of standard form.<br>Calculate with values in standard form.                                                                                                                                                               |
| <b>8. The four operations</b>              | <ul style="list-style-type: none"> <li>use the four operations for calculations with whole numbers, decimals and vulgar (and mixed) fractions, including correct ordering of operations and use of brackets</li> </ul>                                                 |                                                                                                                                                                                                                                                         |
| <b>9. Estimation</b>                       | <ul style="list-style-type: none"> <li>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</li> </ul> | e.g. by writing each number correct to one significant figure,<br>estimate the value of $\frac{41.3}{9.79 \times 0.765}$                                                                                                                                |
| <b>10. Limits of accuracy</b>              | <ul style="list-style-type: none"> <li>give appropriate upper and lower bounds for data given to a specified accuracy</li> <li>obtain appropriate upper and lower bounds to solutions of simple problems given data to a specified accuracy</li> </ul>                 | e.g. measured lengths<br><br>e.g. the calculation of the perimeter or the area of a rectangle                                                                                                                                                           |
| <b>11. Ratio, proportion, rate</b>         | <ul style="list-style-type: none"> <li>demonstrate an understanding of ratio and proportion</li> <li>increase and decrease a quantity by a given ratio</li> <li>use common measures of rate</li> <li>solve problems involving average speed</li> </ul>                 | Divide a quantity in a given ratio.<br>Direct and inverse proportion.<br>Use scales in practical situations.<br>Interpreting the ratio as old quantity : new quantity, e.g. decrease \$240 in the ratio 5 : 3.<br>e.g. hourly rate of pay or flow rates |
| <b>12. Percentages</b>                     | <ul style="list-style-type: none"> <li>calculate a given percentage of a quantity</li> <li>express one quantity as a percentage of another</li> <li>calculate percentage increase or decrease</li> <li>carry out calculations involving reverse percentages</li> </ul> | e.g. finding the cost price given the selling price and the percentage profit                                                                                                                                                                           |
| <b>13. Use of an electronic calculator</b> | <ul style="list-style-type: none"> <li>use a calculator efficiently</li> <li>apply appropriate checks of accuracy</li> <li>enter a range of measures including 'time'</li> <li>interpret the calculator display appropriately</li> </ul>                               | e.g. enter 2 hours 30 minutes as 2.5 hours<br>e.g. in money 4.8 means \$4.80; in time 3.25 means 3 hours 15 minutes                                                                                                                                     |

| Theme or topic                                   | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Notes/examples                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>14. Time</b>                                  | <ul style="list-style-type: none"> <li>calculate times in terms of the 24-hour and 12-hour clock</li> <li>read clocks, dials and timetables</li> </ul>                                                                                                                                                                                                                                                                                                                                                                          | Includes problems involving time zones.                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>15. Money</b>                                 | <ul style="list-style-type: none"> <li>solve problems involving money and convert from one currency to another</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>16. Personal and small business finance</b>   | <ul style="list-style-type: none"> <li>use given data to solve problems on personal and small business finance involving earnings, simple interest and compound interest</li> <li>extract data from tables and charts</li> </ul>                                                                                                                                                                                                                                                                                                | <p>Includes discount, and profit and loss (as an amount or a percentage). Knowledge of compound interest formula given below is required:</p> <p>Value of investment = <math>P\left(1 + \frac{r}{100}\right)^n</math></p> <p>where <math>P</math> is the amount invested, <math>r</math> is the percentage rate of interest and <math>n</math> is the number of years of compound interest.</p>                                   |
| <b>17. Algebraic representation and formulae</b> | <ul style="list-style-type: none"> <li>use letters to express generalised numbers and express arithmetic processes algebraically</li> <li>substitute numbers for words and letters in formulae</li> <li>construct and transform formulae and equations</li> </ul>                                                                                                                                                                                                                                                               | <p>e.g. transform formulae where the subject appears twice or where a power of the subject appears</p> <p>e.g. construct equations from numerical and geometrical problems.</p>                                                                                                                                                                                                                                                   |
| <b>18. Algebraic manipulation</b>                | <ul style="list-style-type: none"> <li>manipulate directed numbers</li> <li>use brackets and extract common factors</li> <li>expand products of algebraic expressions</li> <li>factorise where possible expressions of the form: <math display="block">ax + bx + kay + kby</math> <math display="block">a^2x^2 - b^2y^2</math> <math display="block">a^2 + 2ab + b^2</math> <math display="block">ax^2 + bx + c</math> </li> <li>manipulate algebraic fractions</li> <li>factorise and simplify rational expressions</li> </ul> | <p>e.g. factorise <math>9x^2 + 15xy</math></p> <p>e.g. expand <math>3x(2x - 4y)</math>, <math>(x + 4)(x - 7)</math></p> <p>e.g. <math>\frac{x}{3} + \frac{x-4}{2}</math>, <math>\frac{2x}{3} - \frac{3(x-5)}{2}</math>, <math>\frac{3a}{4} \times \frac{9a}{10}</math></p> <p><math>\frac{3a}{4} \div \frac{9a}{10}</math>, <math>\frac{1}{x-2} + \frac{2}{x-3}</math></p> <p>e.g. <math>\frac{x^2 - 2x}{x^2 - 5x + 6}</math></p> |

| Theme or topic                                      | Subject content                                                                                                                                                                                                                                                                                                                                                                                               | Notes/examples                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>19. Indices</b>                                  | <ul style="list-style-type: none"> <li>understand and use the rules of indices</li> <li>use and interpret positive, negative, fractional and zero indices</li> </ul>                                                                                                                                                                                                                                          | e.g. work out $2^{-3} \times 2^4$<br>e.g. simplify $3x^{-4} \times \frac{2}{3}x^{\frac{1}{2}}$ , $\frac{2}{5}x^{\frac{1}{2}} \div 2x^{-2}$<br>and $\left(\frac{2x^5}{3}\right)^3$<br>e.g. $5^{\frac{1}{2}} = \sqrt{5}$<br>e.g. evaluate $2^5$ , $4^0$ , $5^{-2}$ , $100^{\frac{1}{2}}$ , $8^{-\frac{2}{3}}$<br>e.g. solve $32^x = 2$ |
| <b>20. Solutions of equations and inequalities</b>  | <ul style="list-style-type: none"> <li>solve simple linear equations in one unknown</li> <li>solve fractional equations with numerical and linear algebraic denominators</li> <li>solve simultaneous linear equations in two unknowns</li> <li>solve quadratic equations by factorisation, completing the square or by use of the formula</li> <li>solve simple linear inequalities</li> </ul>                | Includes writing a quadratic expression in completed square form.                                                                                                                                                                                                                                                                    |
| <b>21. Graphical representation of inequalities</b> | <ul style="list-style-type: none"> <li>represent linear inequalities graphically</li> </ul>                                                                                                                                                                                                                                                                                                                   | Linear programming problems are not included.                                                                                                                                                                                                                                                                                        |
| <b>22. Sequences</b>                                | <ul style="list-style-type: none"> <li>continue a given number sequence</li> <li>recognise patterns in sequences and relationships between different sequences</li> <li>generalise sequences as simple algebraic statements</li> </ul>                                                                                                                                                                        | Includes linear sequences, quadratic and cubic sequences, exponential sequences and simple combinations of these.<br><br>Including expressions for the $n$ th term.                                                                                                                                                                  |
| <b>23. Variation</b>                                | <ul style="list-style-type: none"> <li>express direct and inverse variation in algebraic terms and use this form of expression to find unknown quantities</li> </ul>                                                                                                                                                                                                                                          | Includes linear, square, square root and cubic variation (direct and inverse).<br>e.g. $y$ is inversely proportional to the square of $x$ . Given that $y = 2$ when $x = 6$ , find the value of $y$ when $x = 2$                                                                                                                     |
| <b>24. Graphs in practical situations</b>           | <ul style="list-style-type: none"> <li>interpret and use graphs in practical situations including travel graphs and conversion graphs</li> <li>draw graphs from given data</li> <li>apply the idea of rate of change to easy kinematics involving distance–time and speed–time graphs, acceleration and deceleration</li> <li>calculate distance travelled as area under a linear speed–time graph</li> </ul> |                                                                                                                                                                                                                                                                                                                                      |

| Theme or topic                 | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Notes/examples                                                                                                                                                                                                                                                                                                                                   |
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| <b>25. Graphs of functions</b> | <ul style="list-style-type: none"> <li>construct tables of values and draw graphs for functions of the form <math>ax^n</math> where <math>a</math> is a rational constant, and <math>n = -2, -1, 0, 1, 2, 3</math>, and simple sums of not more than three of these and for functions of the form <math>ka^x</math> where <math>a</math> is a positive integer</li> <li>interpret graphs of linear, quadratic, cubic, reciprocal and exponential functions</li> <li>solve associated equations approximately by graphical methods</li> <li>estimate gradients of curves by drawing tangents</li> </ul>                                         |                                                                                                                                                                                                                                                                                                                                                  |
| <b>26. Function notation</b>   | <ul style="list-style-type: none"> <li>use function notation, e.g. <math>f(x) = 3x - 5</math>, <math>f: x \mapsto 3x - 5</math>, to describe simple functions</li> <li>find inverse functions <math>f^{-1}(x)</math></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                  |
| <b>27. Coordinate geometry</b> | <ul style="list-style-type: none"> <li>demonstrate familiarity with Cartesian coordinates in two dimensions</li> <li>find the gradient of a straight line</li> <li>calculate the gradient of a straight line from the coordinates of two points on it</li> <li>calculate the length and the coordinates of the midpoint of a line segment from the coordinates of its end points</li> <li>interpret and obtain the equation of a straight line graph in the form <math>y = mx + c</math></li> <li>determine the equation of a straight line parallel to a given line</li> <li>find the gradient of parallel and perpendicular lines</li> </ul> | <p>e.g. find the equation of a line parallel to <math>y = 4x - 1</math> that passes through <math>(0, -3)</math></p> <p>e.g. find the gradient of a line perpendicular to <math>y = 3x + 1</math></p> <p>e.g. find the equation of a line perpendicular to one passing through the coordinates <math>(1, 3)</math> and <math>(-2, -9)</math></p> |

| Theme or topic                       | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Notes/examples                                                                                                                                                                                                                                                                                                                                                                                                                 |
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| <b>28. Geometrical terms</b>         | <ul style="list-style-type: none"> <li>use and interpret the geometrical terms: point; line; plane; parallel; perpendicular; bearing; right angle, acute, obtuse and reflex angles; interior and exterior angles; similarity and congruence</li> <li>use and interpret vocabulary of triangles, special quadrilaterals, circles, polygons and simple solid figures</li> <li>understand and use the terms: centre, radius, chord, diameter, circumference, tangent, arc, sector and segment</li> </ul> | <p>Includes the following terms:</p> <p>Triangles: equilateral, isosceles and scalene (including right-angled triangles).</p> <p>Quadrilaterals: square, rectangle, kite, rhombus, parallelogram, trapezium.</p> <p>Polygons: Regular and irregular polygons; pentagon, hexagon, octagon, decagon.</p> <p>Simple solid figures: cube, cuboid, prism, cylinder, pyramid, cone, sphere; face, surface, edge, vertex and net.</p> |
| <b>29. Geometrical constructions</b> | <ul style="list-style-type: none"> <li>measure lines and angles</li> <li>construct a triangle, given the three sides, using a ruler and pair of compasses only</li> <li>construct other simple geometrical figures from given data, using a ruler and protractor as necessary</li> <li>construct angle bisectors and perpendicular bisectors using a pair of compasses as necessary</li> <li>read and make scale drawings</li> <li>use and interpret nets</li> </ul>                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>30. Similarity and congruence</b> | <ul style="list-style-type: none"> <li>solve problems and give simple explanations involving similarity and congruence</li> <li>calculate lengths of similar figures</li> <li>use the relationships between areas of similar triangles, with corresponding results for similar figures, and extension to volumes and surface areas of similar solids</li> </ul>                                                                                                                                       | <p>Includes showing that two triangles are similar or showing that two triangles are congruent (using correct congruence condition SSS, SAS, ASA, RHS).</p> <p>Includes use of scale factor.</p>                                                                                                                                                                                                                               |

| Theme or topic      | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Notes/examples                                                                                                                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>31. Symmetry</b> | <ul style="list-style-type: none"> <li>recognise rotational and line symmetry (including order of rotational symmetry) in two dimensions</li> <li>recognise symmetry properties of the prism (including cylinder) and the pyramid (including cone)</li> <li>use the following symmetry properties of circles:               <ul style="list-style-type: none"> <li>(a) equal chords are equidistant from the centre</li> <li>(b) the perpendicular bisector of a chord passes through the centre</li> <li>(c) tangents from an external point are equal in length</li> </ul> </li> </ul>                                                                                                                                                                                                                    | Includes properties of triangles, quadrilaterals and circles directly related to their symmetries.                                                                     |
| <b>32. Angles</b>   | <ul style="list-style-type: none"> <li>calculate unknown angles and give simple explanations using the following geometrical properties:               <ul style="list-style-type: none"> <li>(a) angles at a point</li> <li>(b) angles at a point on a straight line and intersecting straight lines</li> <li>(c) angles formed within parallel lines</li> <li>(d) angle properties of triangles and quadrilaterals</li> <li>(e) angle properties of regular and irregular polygons</li> <li>(f) angle in a semi-circle</li> <li>(g) angle between tangent and radius of a circle</li> <li>(h) angle at the centre of a circle is twice the angle at the circumference</li> <li>(i) angles in the same segment are equal</li> <li>(j) angles in opposite segments are supplementary</li> </ul> </li> </ul> | <p>Candidates will be expected to use the correct geometrical terminology when giving reasons for answers.</p> <p>Angle properties of polygons includes angle sum.</p> |

| Theme or topic         | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Notes/examples                                                                                                                                               |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>33. Loci</b>        | <ul style="list-style-type: none"> <li>use the following loci and the method of intersecting loci for sets of points in two dimensions which are:               <ul style="list-style-type: none"> <li>(a) at a given distance from a given point</li> <li>(b) at a given distance from a given straight line</li> <li>(c) equidistant from two given points</li> <li>(d) equidistant from two given intersecting straight lines</li> </ul> </li> </ul>                                                                                                                             |                                                                                                                                                              |
| <b>34. Measures</b>    | <ul style="list-style-type: none"> <li>use current units of mass, length, area, volume and capacity in practical situations and express quantities in terms of larger or smaller units</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                   | Convert between units including units of area and volume.<br>e.g. between $\text{mm}^2$ and $\text{cm}^2$ or between $\text{cm}^3$ , $\text{m}^3$ and litres |
| <b>35. Mensuration</b> | <ul style="list-style-type: none"> <li>solve problems involving:               <ul style="list-style-type: none"> <li>(a) the perimeter and area of a rectangle and triangle</li> <li>(b) the perimeter and area of a parallelogram and a trapezium</li> <li>(c) the circumference and area of a circle</li> <li>(d) arc length and sector area as fractions of the circumference and area of a circle</li> <li>(e) the surface area and volume of a cuboid, cylinder, prism, sphere, pyramid and cone</li> <li>(f) the areas and volumes of compound shapes</li> </ul> </li> </ul> | Formulae will be given for the surface area and volume of the sphere, pyramid and cone.                                                                      |

| Theme or topic                       | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Notes/examples                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>36. Trigonometry</b>              | <ul style="list-style-type: none"> <li>interpret and use three-figure bearings</li> <li>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</li> <li>solve trigonometrical problems in two dimensions involving angles of elevation and depression</li> <li>extend sine and cosine functions to angles between <math>90^\circ</math> and <math>180^\circ</math></li> <li>solve problems using the sine and cosine rules for any triangle and the formula<br/> <math display="block">\text{area of triangle} = \frac{1}{2} ab \sin C</math> </li> <li>solve simple trigonometrical problems in three dimensions</li> </ul> | <p>Measured clockwise from the north, i.e. <math>000^\circ</math>–<math>360^\circ</math>.</p> <p>e.g. Find the bearing of <math>A</math> from <math>B</math> if the bearing of <math>B</math> from <math>A</math> is <math>125^\circ</math></p> <p>Angles will be quoted in, and answers required in, degrees and decimals of a degree to one decimal place.</p> <p>Calculations of the angle between two planes or of the angle between a straight line and plane will not be required.</p> |
| <b>37. Vectors in two dimensions</b> | <ul style="list-style-type: none"> <li>describe a translation by using a vector represented by <math>\begin{pmatrix} x \\ y \end{pmatrix}</math>, <math>\vec{AB}</math> or <math>\mathbf{a}</math></li> <li>add and subtract vectors</li> <li>multiply a vector by a scalar</li> <li>calculate the magnitude of a vector <math>\begin{pmatrix} x \\ y \end{pmatrix}</math> as <math>\sqrt{x^2 + y^2}</math></li> <li>represent vectors by directed line segments</li> <li>use the sum and difference of two vectors to express given vectors in terms of two coplanar vectors</li> <li>use position vectors</li> </ul>                                                                                                          | <p>Vectors will be printed as <math>\vec{AB}</math> or <math>\mathbf{a}</math> and their magnitudes denoted by modulus signs, e.g. <math> \vec{AB} </math> or <math> \mathbf{a} </math>.</p> <p>In their answers to questions candidates are expected to indicate <math>\mathbf{a}</math> in some definite way, e.g. by an arrow <math>\vec{AB}</math> or by underlining as follows <u>a</u>.</p>                                                                                            |

| Theme or topic             | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Notes/examples                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>38. Matrices</b>        | <ul style="list-style-type: none"> <li>display information in the form of a matrix of any order</li> <li>solve problems involving the calculation of the sum and product (where appropriate) of two matrices, and interpret the results</li> <li>calculate the product of a matrix and a scalar quantity</li> <li>use the algebra of <math>2 \times 2</math> matrices including the zero and identity <math>2 \times 2</math> matrices</li> <li>calculate the determinant <math> \mathbf{A} </math> and inverse <math>\mathbf{A}^{-1}</math> of a non-singular matrix <math>\mathbf{A}</math></li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>39. Transformations</b> | <ul style="list-style-type: none"> <li>use the following transformations of the plane: reflection (M), rotation (R), translation (T), enlargement (E) and their combinations</li> <li>identify and give precise descriptions of transformations connecting given figures</li> <li>describe transformations using coordinates and matrices</li> </ul>                                                                                                                                                                                                                                                     | <p>If <math>M(a) = b</math> and <math>R(b) = c</math> the notation <math>RM(a) = c</math> will be used.</p> <p>Invariants under these transformations may be assumed.</p> <p>Singular matrices are excluded.</p>                                                                                                                                                                                                                                                                                                                                                                                |
| <b>40. Probability</b>     | <ul style="list-style-type: none"> <li>calculate the probability of a single event as either a fraction or a decimal</li> <li>understand that the probability of an event occurring = <math>1 -</math> the probability of the event not occurring</li> <li>understand relative frequency as an estimate of probability</li> <li>calculate the probability of simple combined events using possibility diagrams and tree diagrams where appropriate</li> </ul>                                                                                                                                            | <p>Probabilities should not be given as ratios.</p> <p>Problems could be set involving extracting information from tables or graphs.</p> <p>e.g. <math>P(\text{blue}) = 0.8</math>, find <math>P(\text{not blue})</math></p> <p>e.g. use results of experiments with a spinner to estimate the probability of a given outcome</p> <p>e.g. use probability to estimate from a population</p> <p>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.</p> |

| Theme or topic                                     | Subject content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Notes/examples                                                                                                                    |
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| <b>41. Categorical, numerical and grouped data</b> | <ul style="list-style-type: none"> <li>collect, classify and tabulate statistical data</li> <li>read, interpret and draw simple inferences from tables and statistical diagrams</li> <li>calculate the mean, median, mode and range for individual and discrete data and distinguish between the purposes for which they are used</li> <li>calculate an estimate of the mean for grouped and continuous data</li> <li>identify the modal class from a grouped frequency distribution</li> </ul>                                                                                                                                       |                                                                                                                                   |
| <b>42. Statistical diagrams</b>                    | <ul style="list-style-type: none"> <li>construct and interpret bar charts, pie charts, pictograms, simple frequency distributions, frequency polygons, histograms with equal and unequal intervals and scatter diagrams</li> <li>construct and use cumulative frequency diagrams</li> <li>estimate and interpret the median, percentiles, quartiles and interquartile range for cumulative frequency diagrams</li> <li>calculate with frequency density</li> <li>understand what is meant by positive, negative and zero correlation with reference to a scatter diagram</li> <li>draw a straight line of best fit by eye.</li> </ul> | For unequal intervals on histograms, areas are proportional to frequencies and the vertical axis is labelled 'Frequency density'. |

## 7. Mathematical notation

The list which follows summarises the notation used in Cambridge's mathematics examinations. Although primarily directed towards Advanced Level, the list also applies, where relevant, to examinations at Cambridge O Level.

### 1. Set Notation

|                       |                                                                                 |
|-----------------------|---------------------------------------------------------------------------------|
| $\in$                 | is an element of                                                                |
| $\notin$              | is not an element of                                                            |
| $\{x_1, x_2, \dots\}$ | the set with elements $x_1, x_2, \dots$                                         |
| $\{x: \dots\}$        | the set of all $x$ such that ...                                                |
| $n(A)$                | the number of elements in set $A$                                               |
| $\emptyset$           | the empty set                                                                   |
| $\mathcal{U}$         | the universal set                                                               |
| $A'$                  | the complement of the set $A$                                                   |
| $\mathbb{N}$          | the set of natural numbers, $\{1, 2, 3, \dots\}$                                |
| $\mathbb{Z}$          | the set of integers $\{0, \pm 1, \pm 2, \pm 3, \dots\}$                         |
| $\mathbb{Z}^+$        | the set of positive integers $\{1, 2, 3, \dots\}$                               |
| $\mathbb{Z}_n$        | the set of integers modulo $n$ , $\{0, 1, 2, \dots, n-1\}$                      |
| $\mathbb{Q}$          | 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, $\{x \in \mathbb{Q}: x \geq 0\}$ |
| $\mathbb{R}$          | 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 $\{x \in \mathbb{R}: x \geq 0\}$      |
| $\mathbb{R}^n$        | 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 $\{x \in \mathbb{R}: a \leq x \leq b\}$                     |
| $[a, b)$              | the interval $\{x \in \mathbb{R}: a \leq x < b\}$                               |
| $(a, b]$              | the interval $\{x \in \mathbb{R}: a < x \leq b\}$                               |
| $(a, b)$              | 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                            |
| $<, <<$           | is less than, is much less than               |
| $\leq, \nlessgtr$ | is less than or equal to, is not greater than |
| $>, >>$           | is greater than, is much greater than         |
| $\geq, \nlessgtr$ | is greater than or equal to, is not less than |
| $\infty$          | 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 $b$                                                                                |
| $\sum_{i=1}^n a_i$           | $a_1 + a_2 + \dots + a_n$                                                                              |
| $\sqrt{a}$                   | the positive square root of the real number $a$                                                        |
| $ a $                        | 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 $n \in \mathbb{N}$ , $0 \leq r \leq n$            |
|                              | the binomial coefficient $\frac{n(n-1)\dots(n-r+1)}{r!}$ , for $n \in \mathbb{Q}$ , $r \in \mathbb{N}$ |

**4. Functions**

|                                        |                                                                                                 |
|----------------------------------------|-------------------------------------------------------------------------------------------------|
| $f$                                    | function $f$                                                                                    |
| $f(x)$                                 | the value of the function $f$ at $x$                                                            |
| $f: A \rightarrow B$                   | $f$ is a function under which each element of set $A$ has an image in set $B$                   |
| $f: x \mapsto y$                       | the function $f$ maps the element $x$ to the element $y$                                        |
| $f^{-1}$                               | the inverse of the function $f$                                                                 |
| $g \circ f$ ; $gf$                     | the composite function of $f$ and $g$ which is defined by $(g \circ f)(x)$ or $gf(x) = g(f(x))$ |
| $\lim_{x \rightarrow a} f(x)$          | the limit of $f(x)$ as $x$ tends to $a$                                                         |
| $\Delta x$ ; $\delta x$                | an increment of $x$                                                                             |
| $\frac{dy}{dx}$                        | the derivative of $y$ with respect to $x$                                                       |
| $\frac{d^n y}{dx^n}$                   | the $n$ th derivative of $y$ with respect to $x$                                                |
| $f'(x)$ , $f''(x)$ , ..., $f^{(n)}(x)$ | the first, second, ..., $n$ th derivatives of $f(x)$ with respect to $x$                        |
| $\int y \, dx$                         | indefinite integral of $y$ with respect to $x$                                                  |
| $\int_a^b y \, dx$                     | 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**

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

**7. Complex Numbers**

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

**8. Matrices**

|                   |                                                   |
|-------------------|---------------------------------------------------|
| $\mathbf{M}$      | a matrix $\mathbf{M}$                             |
| $\mathbf{M}^{-1}$ | the inverse of the square matrix $\mathbf{M}$     |
| $\mathbf{M}^T$    | 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                     |
| $ \mathbf{a} $                       | the magnitude of $\mathbf{a}$                                                       |
| $ \overrightarrow{AB} $              | 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 $B$                                                                |
| $P(A)$              | probability of the event $A$                                                                          |
| $A'$                | complement of the event $A$ , the event 'not $A$ '                                                    |
| $P(A B)$            | 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.                                                       |
| $x_1, x_2, \dots$   | observations                                                                                          |
| $f_1, f_2, \dots$   | frequencies with which the observations $x_1, x_2, \dots$ occur                                       |
| $p(x)$              | the value of the probability function $P(X=x)$ of the discrete random variable $X$                    |
| $p_1, p_2, \dots$   | probabilities of the values $x_1, x_2, \dots$ of the discrete random variable $X$                     |
| $f(x), g(x), \dots$ | the value of the probability density function of the continuous random variable $X$                   |
| $F(x), G(x), \dots$ | the value of the (cumulative) distribution function $P(X \leq x)$ of the random variable $X$          |
| $E(X)$              | expectation of the random variable $X$                                                                |
| $E[g(X)]$           | expectation of $g(X)$                                                                                 |
| $\text{Var}(X)$     | variance of the random variable $X$                                                                   |
| $G(t)$              | the value of the probability generating function for a random variable which takes integer values     |
| $B(n, p)$           | binomial distribution, parameters $n$ and $p$                                                         |
| $N(\mu, \sigma^2)$  | normal distribution, mean $\mu$ and variance $\sigma^2$                                               |
| $\mu$               | population mean                                                                                       |
| $\sigma^2$          | population variance                                                                                   |
| $\sigma$            | population standard deviation                                                                         |
| $\bar{x}$           | sample mean                                                                                           |
| $s^2$               | unbiased estimate of population variance from a sample,<br>$s^2 = \frac{1}{n-1} \sum (x - \bar{x})^2$ |
| $\phi$              | probability density function of the standardised normal variable with distribution $N(0, 1)$          |
| $\Phi$              | corresponding cumulative distribution function                                                        |
| $\rho$              | linear product-moment correlation coefficient for a population                                        |
| $r$                 | linear product-moment correlation coefficient for a sample                                            |
| $\text{Cov}(X, Y)$  | covariance of $X$ and $Y$                                                                             |

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## 8. Other information

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### 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/examsOfficers](http://www.cie.org.uk/examsOfficers)**

### 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 can be found in the *Cambridge Guide to Making Entries*.

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