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Undergraduate Ellison Scholars Test Guide 2026

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Quick Links

For more details on the information in this section, please read through the full guidance.

- **Inspera Exam Portal Download Link:** Inspera Exam Portal Link
- **Your unique Login and Password:** These will be released via email after you have submitted your application.
- **Security PIN:** UG2026
- **Demo Test Link:** Please see the link to the demo test here
- **Access Arrangements Form:** Please see the link to the form here

1. Introduction

Inspera is the online platform we use for our proctored Ellison Scholars Test, which includes recording and invigilation. This document will provide you with the necessary information and guidance to prepare for your test and use Inspera effectively.

For your Ellison Scholars Test, please ensure you have the latest operating software installed on your device, Inspera needs to have a minimum of Windows 10 or Mac 10.14 to run properly.

To ensure you can complete your Ellison Scholars Test remotely under test conditions, the Inspera software will verify your identity and record your actions during the test. An invigilator will review this recording and report any potential misconduct to the Education & Scholarships Team. The Education & Scholarships team will then determine if any action is necessary.

2. What to expect in your test?

The Undergraduate Ellison Scholars Test will be available to sit at any point during the testing window: **9am, 1 July 2026 (UK time) to 5pm, 4 August 2026 (UK time).**

Once you have submitted your application form to the Undergraduate Ellison Scholars Programme, we will email you with your unique login details to sit the test. If you are unable to sit the test from **9am, 1 July 2026 (UK time) to 5pm, 4 August 2026 (UK time)**, please ensure you submit your form ahead of the application deadline of **31 July 2026** so that you have adequate time to receive your test login details and sit the Ellison Scholars Test. **The earlier you submit your application form, the more time you will have to complete the test.**

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The test consists of three sections, all of which you are required to complete. You may sit these separately and in any order, but you must make sure to complete all three sections before the deadline **5pm, 4 August 2026 (UK time).**

Calculators, dictionaries and external resources are not permitted. Any numerical reasoning required is designed to be completed without specialist tools.

You are encouraged to make use of a pen and paper.

The Ellison Scholars Test is designed to assess academic reasoning, problem-solving, and the ability to interpret information quickly and accurately. Most questions are multiple choice, but some may have open text numeric answers. All questions have a correct answer.

Section 1 - Cognitive Skills

Section 1 is designed to measure problem-solving, spatial, verbal and non-verbal reasoning skills.

Most questions are multiple choice, but some have open text numeric answers. All questions have one correct answer.

You have **20 minutes** to complete **60 questions.** You should spend **20 seconds** per question.

Section 2 - Critical Thinking and Problem Solving

Section 2 is designed to evaluate an applicant's critical thinking and logical problem-solving skills.

All questions are multiple choice.

You have **20 minutes** to complete **10 questions**. You should spend **2 minutes** per question.

Calculators are not permitted. You may use a pencil and paper to make notes.

For more information on what knowledge you need to sit section 2, please refer to Appendix A of this document.

Section 3 – Mathematical Knowledge and Reasoning

Section 3 is designed to assess a candidate's mathematical thinking, logic, and problem-solving skills.

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All questions are multiple choice.

You have **30 minutes** to complete **10 questions**. You should spend **3 minutes** per question.

Calculators are not permitted. You may use a pencil and paper to make notes.

For more information on what knowledge you need to sit section 3, please refer to Appendix B of this document.

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3. Requesting access arrangements

a. What are access arrangements?

Access arrangements may be requested by candidates with specific needs, such as learning difficulties, physical disabilities, or temporary injuries.

The Ellison Scholars test platform already includes the following accessibility features, which do not require a separate request:

- White text on black background
- Yellow text on black background
- Enlarged text





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b. Requesting extra time

Access arrangements may be requested through this form. A member of the team will review your access arrangement request and email you with the outcome. Requests for access arrangements must be submitted by **5pm, Friday 31 July 2026, (UK time)**. Any requests submitted after this date cannot be processed.

Candidates requesting access arrangements must provide the Education & Scholarships Team with evidence of their need. This should be an official document or communication from a doctor, school, or test centre, signed and clearly stating the reason for the need and the accommodation required. Any such evidence must be in English or translated to English.

In the case that candidates would require additional support beyond what is offered by the testing platform or set out by these guidelines, please contact: scholars@eit.org.

c. Qualifying needs

In most cases, 25% extra time is sufficient to cover a candidate's access requirements. You can request extra time only if you are normally provided with extra time for your public examinations, such as standardised tests.

Qualifying access needs:

- Autistic Spectrum Disorder (ASD)
- Sensory and/or Physical Needs (HI, MSI, PD and VI)
- Social, Emotional and Mental Health Needs (eg AD(H)D)
- Speech Language and Communication Needs (SLCN)
- Temporary injury

Please note that speaking English as a second language does not qualify as a learning difficulty.

Candidates should only request 50% extra time if they can provide clear evidence that 25% will not be sufficient. You can request 50% extra time only if you are normally provided with this amount of time for your public examinations, such as standardised tests.

Qualifying access needs:

- Any formally diagnosed medical condition such as a physical disability or sensory impairment which significantly hinders their speed of working
- Temporary injury

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4. Accessing the Inspera software

To access the Inspera software, download the Inspera Exam Portal prior to your test. You will find the link below – please note this is an automatic download, not a webpage. After clicking the link, you will find the software in your downloads folder:

Inspera Exam Portal Download Link: Inspera Exam Portal Link

This software allows you to sit the test whilst also recording your screen, audio from your microphone, and video from your webcam.

These recordings are made available to the Education & Scholarships Team to enable us to review them and verify that no misconduct has occurred. This software also prevents you from accessing any other documents/or websites on your computer during your test.

To prevent technical faults while using the Inspera Exam Portal from, ensure no other programs or applications are running in the background on your machine, including any antivirus software.

For Apple Mac users, we strongly recommend disabling Siri before launching Inspera Exam Portal. To do so, follow these steps:

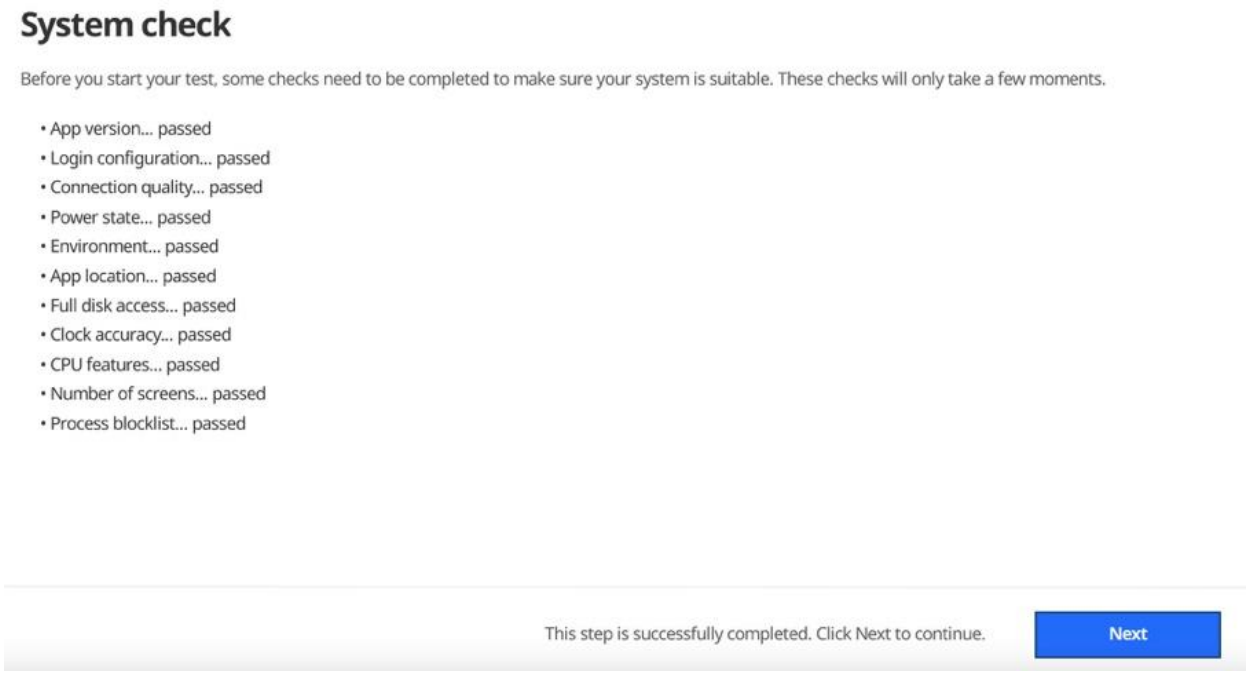
- Open System Preferences from your dock or menu bar.
- Select "Siri" in the bottom row of the menu.
- Under "Siri," uncheck "Enable Ask Siri" to turn off Siri completely.
- Additionally, make sure the Dictate IM function is not activated.

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5. Testing the software on your system

Please ensure you download and test the Inspera Exam Portal software as soon as possible, and no less than 72 hours before your Ellison Scholars Test. A system check will be conducted prior to you logging in to ensure compatibility and functionality.

Completing this will allow you to verify your computer's compatibility and address any issues that arise. Additionally, it will give you a chance to test the software's functionality. Make sure to report any issues at least 24 hours before you plan to take your test.



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6. Prior to your Ellison Scholars Test

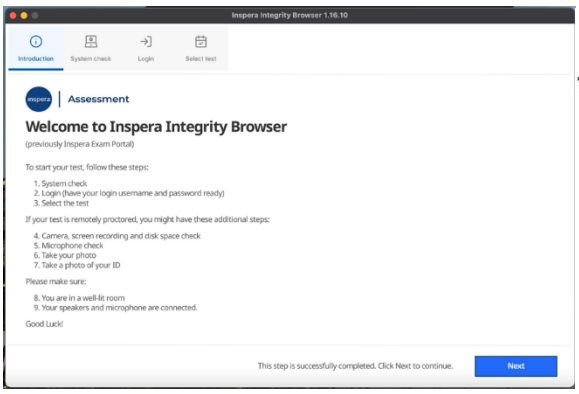
a. Test Environment

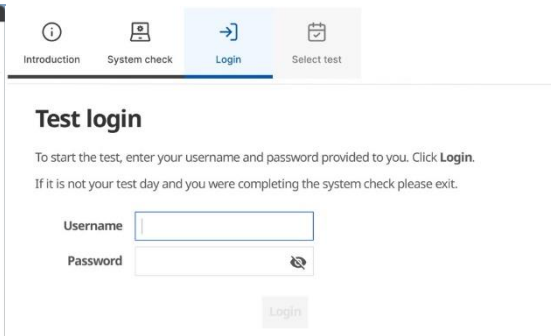
- **Lighting:** Ensure your camera has sufficient light without glare to function properly during the test.
- **Noise:** Since your microphone will record throughout the test, be in a quiet environment with minimal noise.
- **Headphones and Head Coverings:** Do not wear headphones during the test. Simple foam earplugs are allowed, but show them to the camera before the test starts. Head coverings are not permitted unless for religious reasons.
- **Other People:** You must be alone in the room for the entire test. The system will flag if another person appears in the video or if any conversation is detected. Communicating with others during the test may be considered misconduct.
- **Food and Drink:** You can have food and drink during the test, but ensure to have them ready from the start.

b. Logging In

In order to take the Ellison Scholars Test, you will need to launch the Inspera Exam Portal from your desktop. Inspera will then run through the compatibility and environment checks.

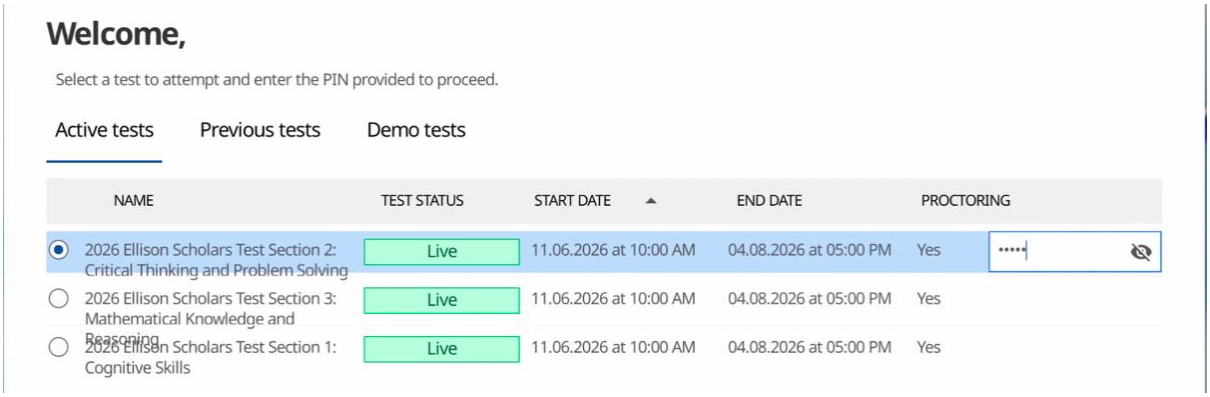
When prompted please enter the username and password provided to you via email.



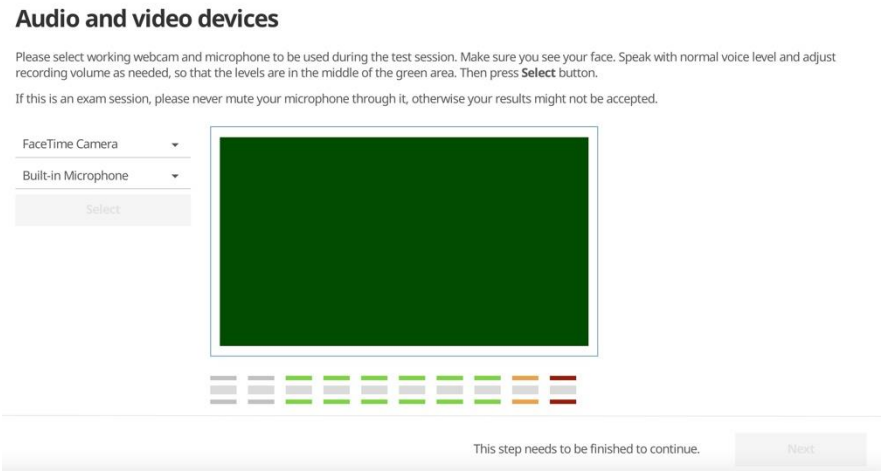


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Select your test, and enter the security PIN: **UG2026**



Before commencing your test, Inspera will also run through some proctoring checks (e.g., webcam and microphone).



Once these steps have been completed, you can begin the test. The test time will only start counting down once you press start, so you won't lose any time if you encounter difficulties logging in or starting the test.

Your test must be completed by **5pm, 4 of August 2025 (UK time)**. Please check the time difference based on your own country's time zone as this may differ.

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c. ID Checks

At the beginning of the test, as part of the proctoring checks, Inspera will ask you to take a photo of yourself, and then hold up an ID to the camera to confirm your identity. There are two acceptable forms of ID (listed in order of preference):

1. A photo Driving License or other government issued photo ID
2. A passport

Your ID picture will be securely stored on Inspera servers located within the EU. Only the Education & Scholarships Team can access it, and it will be securely deleted once your test result is confirmed.



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7. Taking the Ellison Scholars Test

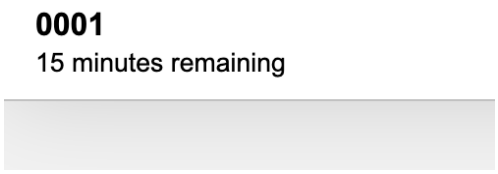
a. Overview

The Ellison Scholars Test is comprised of three sections:

- **Section 1 lasts for 20 minutes.**
- **Section 2 lasts for 20 minutes.**
- **Section 3 lasts for 30 minutes.**

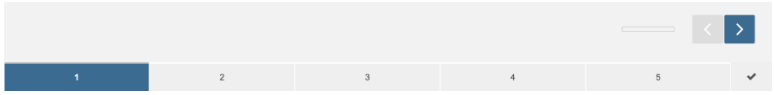
Each section can be sat at different times. Once you start a section, you must complete it. You cannot pause a section once you have begun.

Once you click start to a section, the test duration will count down in the top left corner of the screen. Please refer to this timer, rather than the clock, as it is the most accurate way to track your remaining time.

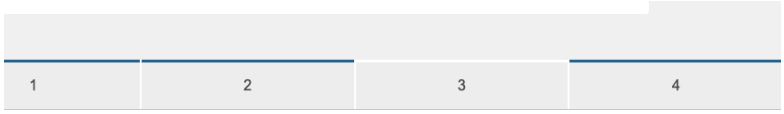


b. Functionality

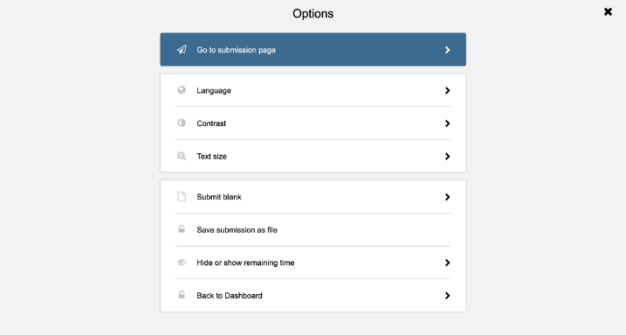
The question numbers will appear at the bottom of the screen, allowing you to navigate between questions as often as you like.



The final screen is a summary page, showing which questions you have attempted and any you haven't answered. You can flag questions to revisit at any time, which will be marked as such on the bottom of the screen, and on the summary page. Unanswered questions will also appear without the blue line above the number, indicating they are still to be completed.



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You can adjust the text size using the options menu in the top right corner of the screen.

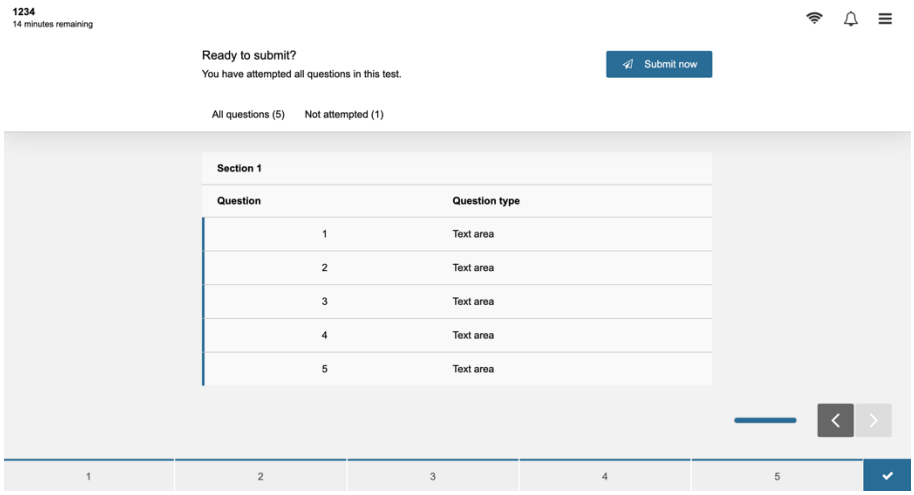
Other things to note:

- Copy and paste functionality works as usual, but must be done via keyboard shortcuts rather than right-clicking the mouse.
- Inspera will automatically save your work every minute or so.
- You are **not** permitted to print the test.
- You are **not** permitted to use an additional monitor.
- You will not be able to exit the Inspera browser or switch to another page for the duration of the test.
- You are permitted to use paper, pens, and pencils during the test.

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8. Submitting your Ellison Scholars Test

a. Submission

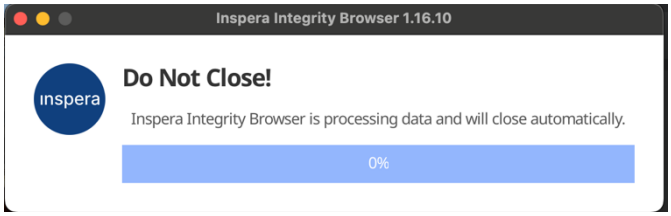


When you're ready to submit your answers, click the submit button on the final summary screen. You can access this page by clicking the tick icon in the bottom right corner of the screen.

If your test time expires, you will automatically be taken to this screen and won't be able to access any other test pages.

After pressing submit, you will see a percentage bar indicating that the Inspera Exam Portal is closing and your data is being processed. Once this ends, your microphone, camera, and screen will no longer be recorded.

Please do not attempt to close this window. It works in the background to upload the remainder of your test, but nothing further will be recorded.



All three sections must be completed to finish the Ellison Scholars Test.

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b. Issues

i. Loss of internet

If you lose internet during the test, Inspera will continue to run and save your test locally on your computer. If your internet connection is restored by the end of the test, you should be able to submit normally, although it may take slightly longer to upload.

If, however, you are still unable to connect to the internet, please email **scholars@eit.org**. You will be supplied with a password to re-enter the test. Once you have received the password, follow the below instructions:

1. Go to the menu in the top right and choose "Save submission as file".
2. Enter the password. and then click save submission.
    a. Mac: the download is confirmed, and you will see information on where to find the file on the computer.
    b. Windows: the download is not confirmed, but the file can be found in the standard download folder - usually C:\Users\\Downloads.
3. Exit the Inspera Exam Portal, confirm by clicking "Quit", but please do not leave the Inspera Exam Portal until you have successfully completed the above steps.
4. Find the file at the download location and email it to: **scholars@eit.org** – we can then upload this submission on your behalf.
5. The file name is similar to "Cand_0001-test_12345678.ia", please note you will not be able to open this document on your computer.

You can change your Wi-Fi and reconnect while staying within the secure test settings by clicking the Wi-Fi symbol in the bottom right corner of the screen. Ensure you try to reconnect and submit via Inspera before attempting to save or download your submission.

ii. Loss of access

If you are logged out of your test, please relaunch Inspera and attempt to continue your test. It is likely you will not be able to regain access, if so, please email **scholars@eit.org** as soon as possible.

Please include as much information as you can about the issue you are experiencing and screen shots (where you are able) so the team can help resolve your issue as quickly as possible.

Please ensure you remain in test conditions throughout, as your video may still be recording.

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iii. Other issue troubleshooting

- **If Inspera is unable to access your webcam**, check in your computer settings that: your computer is allowing apps to use your camera; you do not have multiple camera sources; and your antivirus is not blocking Inspera.
- **If Inspera is showing a red error screen**, please try logging out and back in – if you are unable to do so, please email us at scholars@eit.org as soon as possible. Please note that the time will keep running whilst you are logged out of the exam.
- **If Inspera has closed because the screen is too dark**, the webcam may be blocked, or the room too dark. Please ensure you are in a well-lit room with no obstructions to your camera and re-open Inspera.

- **If Inspera is not opening from your desktop icon**, please right-click the desktop icon and ‘run as administrator’.

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9. Test Results

Please note that individual test results will not be released to you at any stage of the selection process.

10. Getting support

If you have any further questions while testing your system or taking the Ellison Scholars Test, please email **scholars@eit.org**

11. Complying with guidelines

All online proctored tests are recorded and reviewed by the Education & Scholarships Team. Please ensure you comply with all the guidelines outlined above. Remember, the Education & Scholarships Team has the right to void the test and rescind any scholarship offer if evidence of misconduct is found.

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Appendix A: Critical Thinking and Problem Solving

This appendix sets out knowledge requirements for Section 2: Critical Thinking and Problem Solving.

Candidates are advised to read through these specifications carefully to ensure they are aware of all topics and areas that might be covered in the test.

Number concepts

- simple fractions
- place value (for example, knowing that the '5' in '7654' indicates '50')
- ideas about percentages (for example, the idea that 1% could be thought of as '1 in every 100', and that if 20% of a cake has been eaten, then 80% of it must be left)

Numerical operations

- the four rules of number (addition, subtraction, multiplication, division)
- percentage operations (for example, if something was sold at £10, and is now advertised at '20% off', how much would the customer pay?)
- calculations in everyday contexts (complex calculations with fractions and decimals are not required)
- calculation of an average (mean)

Quantities

- time and the calendar
- money
- measures

Knowledge of the following relationships is also required:

1 km = 1000 m 1 m = 100 cm 1 cm = 10 mm 1 kg = 1000 g

Sometimes questions may use other common units of measurement (e.g. feet, tonnes, gallons), but knowledge of numerical relationships between these (e.g. 12 inches = 1 foot) is **not** required.

Space and spatial reasoning

- area (including the calculation of the area of a rectangle)
- perimeter (including calculation)
- volume (including the calculation of the volume of a box)

Tables and graphs

- extracting information from graphs and charts
- extracting information from tables

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Appendix B: Mathematical Knowledge and Reasoning

SUBSECTION 1

*This subsection sets out the **mathematical knowledge** requirement for Section 3: Mathematical Knowledge and Reasoning. The content of Part 1 is almost all covered within the pure mathematics specification of an AS level in mathematics, and the content of Part 2 is almost all covered within a Higher-Level GCSE mathematics course.*

There is some duplication of content across Parts 1 and 2.

Candidates are advised to read through these specifications carefully to ensure they are aware of all topics and areas that might be covered in the test.

Part 1

MM1. Algebra and functions

MM1.1 Laws of indices for all rational exponents.

MM1.2 Use and manipulation of surds.

Simplifying expressions that contain surds, including rationalising the denominator.

For example: simplifying $\frac{\sqrt{5}}{3+2\sqrt{5}}$ and $\frac{3}{\sqrt{7}-2\sqrt{3}}$

MM1.3 Quadratic functions and their graphs; the discriminant of a quadratic function; completing the square; solution of quadratic equations.

MM1.4 Simultaneous equations: analytical solution by substitution, e.g. of one linear and one quadratic equation.

MM1.5 Solution of linear and quadratic inequalities.

MM1.6 Algebraic manipulation of polynomials, including:

a. Expanding brackets and collecting like terms
b. Factorisation and simple algebraic division (by a linear polynomial, including those of the form $ax + b$, and by quadratics, including those of the form $ax^2 + bx + c$)
c. Use of the Factor Theorem and the Remainder Theorem

MM1.7 Qualitative understanding that a function is a many-to-one (or sometimes just a one-to-one) mapping.

Familiarity with the properties of common functions, including $f(x) = \sqrt{x}$ (which always means the 'positive square root') and $f(x) = |x|$

MM2. Sequences and series

MM2.1 Sequences, including those given by a formula for the n^{th} term and those generated by a simple recurrence relation of the form $x_{n+1} = f(x_n)$

MM2.2 Arithmetic series, including the formula for the sum of the first *n* natural numbers.

MM2.3 The sum of a finite geometric series.

The sum to infinity of a convergent geometric series, including the use of $|r| < 1$

MM2.4 Binomial expansion of $(1 + x)^n$ for positive integer n, and for expressions of the form $\big(a + f(x)\big)^n$ for positive integer n and simple $f(x)$.
The notations $n!$ and $\binom{n}{r}$.

MM3. Coordinate geometry in the (x,y)-plane

MM3.1 Equation of a straight line, including:

a. $y - y_1 = m(x - x_1)$
b. $ax + by + c = 0$

Conditions for two straight lines to be parallel or perpendicular to each other. Finding equations of straight lines given information in various forms.

MM3.2 Coordinate geometry of the circle, using the equation of a circle in the forms:

a. $(x - a)^2 + (y - b)^2 = r^2$
b. $x^2 + y^2 + cx + dy + e = 0$

MM3.3 Use of the following circle properties:

a. The perpendicular from the centre to a chord bisects the chord.
b. The tangent at any point on a circle is perpendicular to the radius at that point.
c. The angle subtended by an arc at the centre of a circle is twice the angle subtended by the arc at any point on the circumference.
d. The angle in a semicircle is a right angle.
e. Angles in the same segment are equal.
f. The opposite angles in a cyclic quadrilateral add to $180°$.
g. The angle between the tangent and chord at the point of contact is equal to the angle in the alternate segment.

MM4. Trigonometry

MM4.1 The sine and cosine rules, and the area of a triangle in the form $\frac{1}{2}ab\sin C$.

The sine rule includes an understanding of the 'ambiguous' case (angle–side–side).

Problems might be set in 2 or 3 dimensions.

MM4.2 Radian measure, including use for arc length and area of sector and segment.

MM4.3 The values of sine, cosine and tangent for the angles: 0°, 30°, 45°, 60°, 90°.

MM4.4 The sine, cosine and tangent functions; their graphs, symmetries, and periodicity.

MM4.5 Knowledge and use of the equations:

a. $\tan\theta = \frac{\sin\theta}{\cos\theta}$

b. $\sin^2\theta + \cos^2\theta = 1$

MM4.6 Solution of simple trigonometric equations in a given interval (this may involve the use of the identities in 4.5).

For example: $\tan x = -\frac{1}{\sqrt{3}}$ for $-\pi < x < \pi$

$\sin^2(2x + \frac{\pi}{3}) = \frac{1}{2}$ for $-2\pi < x < 2\pi$

$12\cos^2 x + 6\sin x - 10 = 2$ for $0^\circ < x < 360^\circ$

MM5. Exponentials and logarithms

MM5.1 $y = a^x$ and its graph, for simple positive values of a.

MM5.2 Laws of logarithms:

a. $a^b = c \iff b = \log_a c$

b. $\log_a x + \log_a y = \log_a(xy)$

c. $\log_a x - \log_a y = \log_a\left(\frac{x}{y}\right)$

d. $k\log_a x = \log_a(x^k)$

including the special cases:

e. $\log_a\left(\frac{1}{x}\right) = -\log_a x$

f. $\log_a a = 1$

Questions requiring knowledge of the change of base formula will not be set.

MM5.3 The solution of equations of the form $a^x + b$, and equations which can be reduced

to this form, including those that need prior algebraic manipulation.

For example: $3^{2x} = 4$ and $25^x - 3 \times 5^x + 2 = 0$

MM6. Differentiation

MM6.1 The derivative of $f(x)$ as the gradient of the tangent to the graph $y = f(x)$ at a point.

a. Interpretation of a derivative as a rate of change.

b. Second-order derivatives.

c. Knowledge of notation: $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, $f'(x)$, and $f^n(x)$

Differentiation from first principles is excluded.

MM6.2 Differentiation of x^n for rational n, and related sums and differences. This might require some simplification before differentiating.

For example, the ability to differentiate an expression such as $\frac{(3x+2)^2}{x^{\frac{1}{2}}}$

MM7.3 Applications of differentiation to gradients, tangents, normals, stationary points (maxima and minima only), strictly increasing functions [if $f'(x) > 0$] and strictly decreasing functions [if $f'(x) < 0$]. Points of inflexion will not be examined, although a qualitative understanding of points of inflexion in the curves of simple polynomial functions is expected.

MM7. Integration

MM7.1 Definite integration as related to the 'area between a curve and an axis'. The difference between finding a definite integral and finding the area between a curve and an axis is expected to be understood.

MM7.2 Finding definite and indefinite integrals of x^n for n rational, $n \neq 1$, and related sums and differences, including expressions which require simplification prior to integrating.

For example: $\int (x+2)^2 dx$ and $\int \frac{(3x-5)^2}{x^{\frac{1}{2}}} dx$

MM7.3 An understanding of the Fundamental Theorem of Calculus and its significance to integration. Simple examples of its use may be required in the forms:

a. $\int_a^b f(x)\,dx = F(b) - F(a)$, where $F'(x) = f(x)$

b. $\frac{d}{dx}\int_a^x f(x)\,dx = f(x)$

MM7.4 Combining integrals with either equal or contiguous ranges.

For example: $\int_2^5 f(x)\,dx + \int_2^5 g(x)\,dx = \int_2^5 [f(x) + g(x)]\,dx$

$\int_2^4 f(x)\,dx + \int_4^3 f(x)\,dx = \int_2^3 f(x)\,dx$

MM7.5 Approximation of the area under a curve using the trapezium rule; determination of whether this constitutes an overestimate or an underestimate.

MM7.6 Solving differential equations of the form $\frac{dy}{dx} = f(x)$

MM8. Graphs of functions

MM8.1 Recognise and be able to sketch the graphs of common functions that appear in this specification: these include lines, quadratics, cubics, trigonometric functions, logarithmic functions, exponential functions, square roots, and the modulus function.

MM8.2 Knowledge of the effect of simple transformations on the graph of $y = f(x)$ with positive or negative value of *a* as represented by:

a. $y = af(x)$
b. $y = f(x) + a$
c. $y = f(x + a)$
d. $y = f(ax)$

Compositions of these transformations. Knowledge and use of the notation $f(g(x))$.

MM8.3 Understand how altering the values of m and c affects the graph of $y = mx + c$

MM8.4 Understand how altering the values of a, b and c in $y = a(x + b)^2$ affects the corresponding graph.

MM8.5 Use differentiation to help determine the shape of the graph of a given function, including:

a. finding stationary points (excluding inflexions)
b. when the graph is increasing or decreasing

MM8.6 Use algebraic techniques to determine where the graph of a function intersects the coordinate axes; appreciate the possible numbers of real roots that a general polynomial can possess.

MM8.7 Geometric interpretation of algebraic solutions of equations; relationship between the intersections of two graphs and the solutions of the corresponding simultaneous equations.

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Part 2

M1. Units

M1.1 Use standard units of mass, length, time, money and other measures.

Use compound units such as speed, rates of pay, unit pricing, density and pressure, including using decimal quantities where appropriate.

M1.2 Change freely between related standard units (e.g. time, length, area, volume/capacity, mass) and compound units (e.g. speed, rates of pay, prices, density, pressure) in numerical and algebraic contexts.

M2. Numbers

M2.1 Order positive and negative integers, decimals and fractions.

Understand and use the symbols: $=$, $\neq$, $<$, $>$, $\leq$, $\geq$.

M2.2 Apply the four operations (addition, subtraction, multiplication and division) to integers, decimals, simple fractions (proper and improper) and mixed numbers – any of which could be positive and negative.

Understand and use place value.

M2.3 Use the concepts and vocabulary of prime numbers, factors (divisors), multiples, common factors, common multiples, highest common factor, lowest common multiple, and prime factorisation (including use of product notation and the unique factorisation theorem).

M2.4 Recognise and use relationships between operations, including inverse operations.

Use cancellation to simplify calculations and expressions.

Understand and use the convention for priority of operations, including brackets, powers, roots and reciprocals.

M2.5 Apply systematic listing strategies. (For instance, if there are *m* ways of doing one task and for each of these tasks there are *n* ways of doing another task, then the total number of ways the two tasks can be done in order is $m \times n$ ways.)

M2.6 Use and understand the terms: *square*, *positive* and *negative square root*, *cube* and *cube root*.

M2.7 Use index laws to simplify numerical expressions, and for multiplication and division of integer, fractional and negative powers.

M2.8 Interpret, order and calculate with numbers written in standard index form (standard form); numbers are written in standard form as $a \times 10^n$, where $1 \leq a < 10$ and *n* is an integer.

M2.9 Convert between terminating decimals, percentages and fractions.

Convert between recurring decimals and their corresponding fractions.

M2.10 Use fractions, decimals and percentages interchangeably in calculations.

Understand equivalent fractions.

M2.11 Calculate exactly with fractions, surds and multiples of π.

Simplify surd expressions involving squares, e.g. $\sqrt{12} = \sqrt{4 \times 3} = \sqrt{4}\sqrt{3} = 2\sqrt{3}$, and rationalise denominators; for example, candidates could be asked to rationalise expressions such as: $\frac{3}{\sqrt{7}}$, $\frac{5}{3+2\sqrt{3}}$, $\frac{7}{2-\sqrt{3}}$, $\frac{3}{\sqrt{5}-\sqrt{2}}$

M2.12 Calculate with upper and lower bounds, and use in contextual problems.

M2.13 Round numbers and measures to an appropriate degree of accuracy, e.g. to a specified number of decimal places or significant figures.

Use inequality notation to specify simple error intervals due to truncation or rounding.

M2.14 Use approximation to produce estimates of calculations, including expressions involving π or surds.

M3. Ratio and proportion

M3.1 Understand and use scale factors, scale diagrams and maps.

M3.2 Express a quantity as a fraction of another, where the fraction is less than 1 or greater than 1.

M3.3 Understand and use ratio notation.

M3.4 Divide a given quantity into two (or more) parts in each given *part*:*part* ratio.

Express the division of a quantity into two parts as a ratio.

M3.5 Apply ratio to real contexts and problems, such as those involving conversion, comparison, scaling, mixing and concentrations.

Express a multiplicative relationship between two quantities as a ratio or a fraction.

M3.6 Understand and use proportions.

Relate ratios to fractions and to linear functions.

M3.7 Identify and work with fractions in ratio problems.

M3.8 Define percentage as 'number of parts per hundred'.

Interpret percentages and percentage changes as a fraction or a decimal and interpret these multiplicatively.

Express one quantity as a percentage of another. Compare two quantities using percentages.

Work with percentages greater than 100%.

Solve problems involving percentage change, including percentage increase/decrease, original value problems and simple interest calculations.

M3.9 Understand and use direct and inverse proportions, including algebraic representations.

Recognise and interpret graphs that illustrate direct and inverse proportion.

Set up, use and interpret equations to solve problems involving direct and inverse proportion (including questions involving integer and fractional powers).

Understand that x is inversely proportional to y is equivalent to x is proportional to $\frac{1}{y}$.

M3.10 Compare lengths, areas and volumes using ratio notation.

Understand and make links to similarity (including trigonometric ratios) and scale factors.

M3.11 Set up, solve and interpret the answers in growth and decay problems, including compound interest, and work with general iterative processes.

M4. Algebra

M4.1 Understand, use and interpret algebraic notation; for instance: ab in place of $a \times b$; $3y$ in place of $y + y + y$ and $3 \times y$; a^2 in place of $a \times a$; a^3 in place of $a \times a \times a$; a^2b in place of $a \times a \times a$; $\frac{a}{b}$ in place of $a \div b$.

M4.2 Use index laws in algebra for multiplication and division of integer, fractional, and negative powers.

M4.3 Substitute numerical values into formulae and expressions, including scientific formulae.

Understand and use the concepts and vocabulary: *expressions*, *equations*, *formulae*, *identities*, *inequalities*, *terms* and *factors*.

M4.4 Collect like terms, multiply a single term over a bracket, take out common factors, and expand products of two or more binomials.

M4.5 Factorise quadratic expressions of the form $x^2 + bx + c$, including the difference of two squares.

Factorise quadratic expressions of the form $ax^2 + bx + c$, including the difference of two squares.

M4.6 Simplify expressions involving sums, products and powers, including the laws of indices.

Simplify rational expressions by cancelling, or factorising and cancelling. Use the four rules on algebraic rational expressions.

M4.7 Rearrange formulae to change the subject.

M4.8 Understand the difference between an equation and an identity.

Argue mathematically to show that algebraic expressions are equivalent.

M4.9 Work with coordinates in all four quadrants.

M4.10 Identify and interpret gradients and intercepts of linear functions ($y = mx + c$) graphically and algebraically.

Identify pairs of parallel lines and identify pairs of perpendicular lines, including the relationships between gradients.

Find the equation of the line through two given points, or through one point with a given gradient.

M4.11 Identify and interpret roots, intercepts and turning points of quadratic functions graphically.

Deduce roots algebraically and turning points by completing the square.

M4.12 Recognise, sketch and interpret graphs of:

a. linear functions
b. quadratic functions
c. simple cubic functions
d. there reciprocal function: $y = \frac{1}{x}$ with $x \neq 0$
e. the exponential function: $y = k^x$ for positive values of k
f. trigonometric functions (with arguments in degrees: $y = \sin x$, $y = \cos x$, $y = \tan x$ for angles of any size

M4.13 Interpret graphs (including reciprocal graphs and exponential graphs) and graphs of non-standard functions in real contexts to find approximate solutions to problems, such as simple kinematic problems involving distance, speed and acceleration.

M4.14 Calculate or estimate gradients of graphs and areas under graphs (including quadratic and other non-linear graphs) and interpret results in cases such as distance–time graphs, speed–time graphs and graphs in financial contexts.

M4.15 Set up and solve, both algebraically and graphically, simple equations including simultaneous equations involving two unknowns; this may include one linear and one quadratic equation.

Solve two simultaneous equations in two variables (linear/linear or linear/quadratic) algebraically.

Find approximate solutions using a graph.

Translate simple situations or procedures into algebraic expressions or formulae; for example, derive an equation (or two simultaneous equations), solve the equation(s) and interpret the solution.

M4.16 Solve quadratic equations (including those that require rearrangement) algebraically by factorising, by completing the square, and by using the quadratic formula.

Know the quadratic formula: $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Find approximate solutions of quadratic equations using a graph.

M4.17 Solve linear inequalities in one or two variables.

Represent the solution set on a number line, or on a graph, or in words.

M4.18 Generate terms of a sequence using term-to-term or position-to-term rules.

M4.19 Deduce expressions to calculate the n^{th} term of linear or quadratic sequences.

M5. Geometry

M5.1 Use conventional terms and notation: points, lines, line segments, vertices, edges, planes, parallel lines, perpendicular lines, right angles, subtended angles, polygons, regular polygons and polygons with reflection and/or rotational symmetries.

M5.2 Recall and use the properties of angles at a point, angles on a straight line, perpendicular lines and opposite angles at a vertex.

Understand and use the angle properties of parallel lines, intersecting lines, triangles and quadrilaterals.

Calculate and use the sum of the interior angles, and the sum of the exterior angles, of polygons.

M5.3 Derive and apply the properties and definitions of special types of quadrilaterals, including square, rectangle, parallelogram, trapezium, kite and rhombus.

Derive and apply the properties and definitions of various types of triangle and other plane figures using appropriate language.

M5.4 Understand and use the basic congruence criteria for triangles (SSS, SAS, ASA, RHS).

M5.5 Apply angle facts, triangle congruence, similarity, and properties of quadrilaterals to results about angles and sides.

M5.6 Identify, describe and construct congruent and similar shapes, including on coordinate axes, by considering rotation, reflection, translation and enlargement (including fractional and negative scale factors).

Describe the changes and invariance achieved by combinations of rotations, reflections and translations.

Describe translations as 2-dimensional vectors.

M5.7 Know and use the formula for Pythagoras' theorem: $a^2 + b^2 = c^2$

Use Pythagoras' theorem in both 2 and 3 dimensions.

M5.8 Identify and use conventional circle terms: *centre, radius, chord, diameter, circumference, tangent, arc, sector* and *segment* (including the use of the terms *minor* and *major* for arcs, sectors and segments).

M5.9 Apply the standard circle theorems concerning angles, radii, tangents and chords, and use them to prove related results:

a. angle subtended at the centre is twice the angle subtended at the circumference
b. angle in a semicircle is 90°
c. angles in the same segment are equal

d. angle between a tangent and a chord (alternate segment theorem)
e. angle between a radius and a tangent is 90°
f. properties of cyclic quadrilaterals

M5.10 Solve geometrical problems on 2-dimensional coordinate axes.

M5.11 Know the terminology *faces*, *surfaces*, *edges* and *vertices* when applied to cubes, cuboids, prisms, cylinders, pyramids, cones, spheres and hemispheres.

M5.12 Interpret plans and elevations of 3-dimensional shapes.

M5.13 Use and interpret maps and scale drawings. Understand and use three-figure bearings.

M5.14 Know and apply formulae to calculate:

a. the area of triangles, parallelograms, trapezia
b. the volume of cuboids and other right prisms.

M5.15 Know the formulae:

a. circumference of a circle $= 2\pi r = \pi d$
b. area of a circle $= 2\pi^2$
c. volume of a right circular cylinder $= \pi r^2 h$

Formulae relating to spheres, pyramids and cones will be given if needed. Use formulae to calculate:

a. perimeters of 2-dimensional shapes, including circles
b. areas of circles and composite shapes
c. surface area and volume of spheres, pyramids, cones and composite solids

M5.16 Calculate arc lengths, angles and areas of sectors of circles.

M5.17 Apply the concepts of congruence and similarity in simple figures, including the relationships between lengths, areas and volumes.

M5.18 Know and use trigonometric ratios:

$$\sin\theta = \frac{opposite}{hypotenuse} \qquad \cos\theta = \frac{adjacent}{hypotenuse} \qquad \tan\theta = \frac{opposite}{adjacent}$$

Apply these to find angles and lengths in right-angled triangles and, where possible, general triangles in 2- and 3-dimensional figures.

Know the exact values of $\sin\theta$ and $\cos\theta$ for $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ$.

Know the exact values of $\tan\theta$ and $\cos\theta$ for $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ$.

Candidates are not expected to recall or use the sine or cosine rules.

M5.19 Apply addition and subtraction of vectors, multiplication of vectors by a scalar, and diagrammatic and column representations of vectors.

Use vectors to construct geometric arguments and proofs.

M6. Statistics

M6.1 Interpret and construct tables, charts and diagrams, including:

a. two-way tables, frequency tables, bar charts, pie charts and pictograms for categorical data
b. Vertical line charts for ungrouped discrete numerical data
c. Tables and line graphs for time series data

Know the appropriate use of each of these representations.

M6.2 Interpret and construct diagrams for grouped discrete data and continuous data:

a. Histograms with equal and unequal class intervals
b. Cumulative frequency graphs

Know the appropriate use of each of these diagrams.

Understand and use the term *frequency density*.

M6.3 Calculate the *mean*, *mode*, *median* and *range* for ungrouped data.

Find the modal class; calculate estimates of the range, mean and median for grouped data, and understand why these are estimates.

Describe a population using statistics.

Make simple comparisons.

Compare data sets using like-for-like summary values.

Understand the advantages and disadvantages of summary values.

Calculate estimates of mean, median, mode, range, quartiles and interquartile range from graphical representation of grouped data.

Use the median and interquartile range to compare distributions.

M6.4 Use and interpret scatter graphs of bivariate data.

Recognise correlation, and know that it does not indicate causation.

Draw estimated lines of best fit.

Interpolate and extrapolate apparent trends whilst knowing the dangers of so doing.

M7. Probability

M7.1 Analyse the frequency of outcomes of probability experiments using tables and frequency trees.

M7.2 Apply ideas of randomness, fairness and equally likely events to calculate expected outcomes of multiple future experiments.

Understand that if an experiment is repeated, the outcome may be different.

M7.3 Relate relative expected frequencies to theoretical probability, using appropriate language and the '0 to 1' probability scale.

M7.4 Apply the property that the probabilities of an exhaustive set of outcomes sum to one.

Apply the property that the probability of an exhaustive set of mutually exclusive events sum to one.

M7.5 Enumerate sets and combinations of sets systematically, using tables, grids, Venn diagrams and tree diagrams. Candidates are not expected to know formal set theory notation.

M7.6 Construct theoretical possibility spaces for single and combined experiments with equally likely outcomes and use these to calculate theoretical probabilities.

M7.7 Know when to add or multiply two probabilities and understand conditional probability.

Calculate and interpret conditional probabilities through representation using expected frequencies with two-way tables, tree diagrams and Venn diagrams.

Understand the use of tree diagrams to represent outcomes of combined events:

a. When the probabilities are independent of the previous outcome
b. When the probabilities are dependent on the previous outcome.

SUBSECTION 2

*This subsection sets out the **mathematical reasoning** requirements for Section 3: Mathematical Knowledge and Reasoning. Mathematical reasoning tests the candidate's ability to think mathematically: the questions will focus on testing the candidate's ability to*

*understand, and construct mathematical arguments in a variety of contexts. It will draw on the mathematical knowledge outlined in **SUBSECTION 1** above.*

The Logic of Arguments

Arg1 Understand and be able to use mathematical logic in simple situations:

- The terms **true** and **false**;
- The terms **and**, **or** (meaning **inclusive or**), **not**;
- Statements of the form:
  if A then B
  A if B
  A only if B
  A if and only if B
- The **converse** of a statement;
- The **contrapositive** of a statement;
- The relationship between the truth of a statement and its converse and its contrapositive.

Note: candidates will **not** be expected to recognise or use symbolic notation for any of these terms, nor will they be expected to complete formal truth tables.

Arg2 Understand and use the terms **necessary** and **sufficient**.

Arg3 Understand and use the terms **for all**, **for some** (meaning **for at least one**), and **there exists**.

Arg4 Be able to negate statements that use any of the above terms.

Mathematical Proof

Prf1 Follow a proof of the following types, and in simple cases know how to construct such a proof:

- Direct deductive proof ('Since A, therefore B, therefore C, ..., therefore Z, which is what we wanted to prove.');
- Proof by cases (for example, by considering even and odd cases separately);
- Proof by contradiction;
- Disproof by counterexample.

Prf2 Deduce implications from given statements.

Prf3 Make conjectures based on small cases and then justify these conjectures.

Prf4 Rearrange a sequence of statements into the correct order to give proof for a statement.

Prf5 Problems requiring a sophisticated chain of reasoning to solve.

Identifying Errors in Proofs

Err1 Identifying errors in purported proofs.

Err2 Be aware of common mathematical errors in purported proof; for example, claiming ‘if , then ’ or assuming ‘if , then ’ neither of which are valid deductions.

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