2 The specification overview

2a. OCR A Level in Further Mathematics B (MEI) (H645)

OCR's A Level in Further Mathematics B is a linear qualification in which all papers must be taken in the same examination series. To be awarded OCR's A Level in Further Mathematics B (MEI) learners must take one of three routes through the qualification, Route A, Route B or Route C.

Route A: Candidates must take the mandatory Core Pure and Mechanics Major papers and then one further optional minor paper. This paper must not be Mechanics Minor.
Route B: Candidates must take the mandatory Core Pure and Statistics Major papers and then one further optional minor paper. This paper must not be Statistics Minor.
Route C: Candidates must take the mandatory Core Pure paper and then three further minor optional papers.

Learners may **not** enter for Mechanics Major Y421 and Mechanics Minor Y431, Statistics Major Y422 and Statistics Minor Y432 or Mechanics Major Y421 and Statistics Major Y422.

Learners may take more than the required number of minor papers to increase the breadth of their course. For details of how their grade will be awarded, see Section 3g.

Content Overview

The qualification comprises one mandatory Core Pure paper and then a combination of optional papers:

- Core Pure content[1]
- Major options
  - Mechanics Major (Y421)[1]
  - Statistics Major (Y422)[1]
- Minor options
  - Mechanics Minor (Y431)[2]
  - Statistics Minor (Y432)[2]
  - Modelling with Algorithms (Y433)[2]
  - Numerical Methods (Y434)[2]
  - Extra Pure (Y435)
  - Further Pure with Technology (Y436)

The Overarching Themes must be applied along with associated mathematical thinking and understanding, across the whole of the subject content. See Section 2b.

[1]One third of the Core Pure content, and one half of the content of each major option can be co-taught with AS Further Mathematics. This material is labelled (a) throughout Sections 2c to 2e.

[2]These minor options can be co-taught with AS Further Mathematics.

Assessment Overview

Mandatory paper: Core Pure (Y420) 144 raw marks (180 scaled) 2 hour 40 mins Written paper	**50%** of total A level
Major Option 120 raw marks (120 scaled) 2 hour 15 mins Written paper	**33⅓%** of total A level
Minor Option 60 raw marks (60 scaled) 1 hour 15 mins Written paper (1 hour 45 mins Written paper for Y436)	**16⅔%** of total A level

2b. Content of A Level in Further Mathematics B (MEI) (H645)

This A level qualification builds on the skills, knowledge and understanding set out in the whole GCSE subject content for mathematics and the subject content for AS and A Level mathematics. Problem solving, proof and mathematical modelling will be assessed in further mathematics in the context of the wider knowledge which students taking A Level Further Mathematics will have studied.

A Level Further Mathematics B (MEI) is a linear qualification. Learners enter for the mandatory paper Core Pure (Y420) and then a combination of optional papers.

Route A: Candidates must take the mandatory Core Pure and Mechanics Major papers and then one further optional minor paper. This paper **must not** be Mechanics Minor.

Route B: Candidates must take the mandatory Core Pure and Statistics Major papers and then one further optional minor paper. This paper **must not** be Statistics Minor.

Route C: Candidates must take the mandatory Core Pure paper and then three further minor optional papers.

Learners may take more than the required number of minor papers to increase the breadth of their course. For details of how their grade will be awarded, see Section 3g.

Learners may **not** enter for Mechanics Major (Y421) and Mechanics Minor (Y431).

Learners may **not** enter for Statistics Major (Y422) and Statistics Minor (Y432).

Learners may **not** enter for Mechanics Major (Y421) and Statistics Major (Y422).

The content is listed below, under three headings:

1. Core Pure content

2. Major options
   - Mechanics Major (Y421)
   - Statistics Major (Y422)

3. Minor options
   - Mechanics Minor (Y431)
   - Statistics Minor (Y432)
   - Modelling with Algorithms (Y433)
   - Numerical Methods (Y434)
   - Extra Pure (Y435)
   - Further Pure with Technology (Y436)

The overarching themes should be applied, along with associated mathematical thinking and understanding, across every permissible combination of papers in this specification.

The applied optional papers (Mechanics Major, Mechanics Minor, Statistics Major, Statistics Minor and Modelling with Algorithms) should be regarded as applications of pure maths as well as ways of thinking about the world in their own right. The pure optional papers (Extra Pure and Further Pure with Technology) extend the content of the Core Pure paper. The Numerical Methods paper extends the range of non-analytic techniques for solving a wider class of problems from within pure mathematics. In all of these cases appropriate links should be made with the content of A Level Mathematics and the content of the Core pure paper in this A Level Further Mathematics.

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Formulae and statistical tables

Some formulae will be available to learners in the examination, in a separate formulae booklet. A list of these formulae can be found in Section 5d. This list also contains the statistical tables which will be available to learners in the examination.

Use of calculators

Learners are permitted to use a scientific or graphical calculator for all papers. Generally, calculators are subject to the rules in the document *Instructions for Conducting Examinations*, published annually by JCQ (www.jcq.org.uk).

It is expected that calculators available in the assessment will include the following features:

- An iterative function such as an ANS key.
- The ability to perform calculations, including inversion, with matrices up to at least order 3×3.
- The ability to compute summary statistics and access probabilities from the binomial, Poisson and Normal distributions.

The Further Pure with Technology optional paper has different rules, requiring learners to have additional technology. In the examination for the Further Pure with Technology learners have access to a spreadsheet, graph-drawing software, a computer algebra system and a programming language on a computer or calculator.

Calculators with spreadsheets and graph-drawing functionality are permitted in all examination papers, but this functionality is only **required** in the Further Pure with Technology, where it may be available on either a computer or a calculator.

Generally, permitted calculators may be used for any function they can perform. When using calculators, learners should bear in mind the following:

1. Learners are advised to write down explicitly any expressions, including integrals, that they use the calculator to evaluate.
2. Learners are advised to write down the values of any parameters and variables that they input into the calculator. Learners are not expected to write down data transferred from question paper to calculator.
3. Correct mathematical notation (rather than "calculator notation") should be used; incorrect notation may result in loss of marks.

In the Numerical Methods optional paper, candidates are expected to show evidence of working through methods rather than just writing down solutions provided by equation solvers or numerical differential or integration functions on calculators.

Example for Numerical Methods:
Show that the equation $x^5 - 5x + 1 = 0$ has a root in the interval $[0, 1]$.

Using a calculator equation solver to find the three real roots 1.44, 0.2 and -1.54 and stating that one of them lies in the required interval would not be awarded marks. An acceptable method would be to evaluate $x^5 - 5x + 1$ at 0 and 1 and explain that the change of sign indicates that there is a root in the interval.

These are not restrictions on a learner's use of a calculator when tackling the question, e.g. for checking an answer or evaluating a function at a given point, but it is a restriction on what will be accepted as evidence of a complete method.

Use of technology

It is expected that learners will have used appropriate technology including mathematical graphing tools and spreadsheets when studying A Level Further Mathematics B (MEI). Several options have their own requirements for generic software which learners will have used; the content sections give more detail, including what is expected in the examination. In general, learners are not expected to be familiar with particular software, nor will they be expected to use the syntax associated with particular software but examination questions may include output from software which learners will need to complete or

interpret. However, the Numerical Methods optional paper will also assess learners' ability to write some spreadsheet formulae; the Further Pure with Technology optional paper will assess learners' ability to use a computer algebra system, a graph plotter, a spreadsheet and a programming language on a computer or calculator in the examination.

Use of a computer in Further Pure with Technology

Learners require access to a computer and/or calculator with suitable software in the examination for Further Pure with Technology (Y436). Details of the software requirements and lists of approved software and approved programming languages may be found in Appendix 5e.

Any computer or calculator used in the examination must not be connected to any other computer or device, including a printer, whether wirelessly or by cable.

The learner must not have access to any stored files or documents at the beginning of the examination, but must be able to save and access files or documents produced during the examination.

Simplifying expressions

It is expected that learners will simplify algebraic and numerical expressions when giving their final answers, even if the examination question does not explicitly ask them to do so.

- $80\frac{\sqrt{3}}{2}$ should be written as $40\sqrt{3}$.
- $\frac{1}{3-\sqrt{2}}$ should be written as $\frac{3+\sqrt{2}}{7}$.
- $\frac{1}{2}(1+2x)^{-\frac{1}{2}} \times 2$ should be written as either $(1+2x)^{-\frac{1}{2}}$ or $\frac{1}{\sqrt{1+2x}}$.
- $\ln 2 + \ln 3 - \ln 1$ should be written as $\ln 6$.
- The equation of a straight line should be given in the form $y = mx + c$ or $ax + by = c$ unless otherwise stated.

The meanings of some instructions used in examination questions

In general, learners should show sufficient detail of their working and reasoning to indicate that a correct method is being used. The following command words are used to indicate when more, or less, specific detail is required.

Exact

An exact answer is one where numbers are not given in rounded form. The answer will often contain an irrational number such as $\sqrt{3}$, e or π and these numbers should be given in that form when an exact answer is required. The use of the word 'exact' also tells learners that rigorous (exact) working is expected in the answer to the question.

e.g. Find the exact solution of $\ln x = 2$.

The correct answer is e^2 and not $7.389\,056$.

e.g. Find the exact solution of $3x = 2$.

The correct answers are $x = \frac{2}{3}$ or $x = 0.\dot{6}$, not $x = 0.67$ or similar.

Show that

Learners are given a result and have to get to the given result from the starting information. Because they are given the result, the explanation has to be sufficiently detailed to cover every step of their working.

e.g. Show that the curve $y = x \ln x$ has a stationary point $\left(\frac{1}{e}, -\frac{1}{e}\right)$.

Determine

This command word indicates that justification should be given for any results found, including working where appropriate.

State, Write down

These command words indicate that neither working nor justification is required.

In this question you must show detailed reasoning.

When a question includes this instruction learners must give a solution which leads to a conclusion showing a detailed and complete analytical method. Their solution should contain sufficient detail to allow

the line of their argument to be followed. This is not a restriction on a learner's use of a calculator when tackling the question, e.g. for checking an answer or evaluating a function at a given point, but it is a restriction on what will be accepted as evidence of a complete method.

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In these examples below variations in the structure of the answers are possible, for example; giving the integral as $\ln(x+\sqrt{x^2-16})$ in example 2, and different intermediate steps may be given.

Example 1:
Express $-4+2\mathrm{i}$ in modulus-argument form.

The answer is $\sqrt{20}(\cos 2.68+\mathrm{i}\sin 2.68)$, but the learner *must* include the steps $|-4+2\mathrm{i}|=\sqrt{16+4}=\sqrt{20}$, $\arg(-4+2\mathrm{i})=\pi-\tan^{-1}(0.5)=2.68$. Using a calculator in complex mode to convert to modulus-argument form would not result in a complete analytical method.

Example 2:
Evaluate $\int_4^5 \frac{1}{\sqrt{x^2-16}}\mathrm{d}x$.

The answer is $\ln(2)$, but the learner *must* include at least $\lim_{a\to 4}\left[\operatorname{arcosh}\left(\frac{X}{4}\right)\right]_a^5$ and the substitution $\ln\left(\frac{5}{4}+\sqrt{\frac{25}{16}-1}\right)-\ln(1+\sqrt{0})$. Just writing down the answer using the definite integral function on a calculator would therefore not be awarded any marks.

Example 3:
Solve the equation $2x^3-11x^2+22x-15=0$.

The answer is $1.5, 2\pm\mathrm{i}$, but the learner *must* include steps to find a real root or corresponding factor, find the factor $(2x-3)$ and factorise the cubic then solve the quadratic. Just writing down the three roots by using the cubic equation solver on a calculator would not be awarded any marks.

Hence
When a question uses the word 'hence', it is an indication that the next step should be based on what has gone before. The intention is that learners should start from the indicated statement.

e.g. You are given that $\mathrm{f}(x)=2x^3-x^2-7x+6$. Show that $(x-1)$ is a factor of $\mathrm{f}(x)$. Hence find the three factors of $\mathrm{f}(x)$.

Hence or otherwise is used when there are multiple ways of answering a given question. Learners starting from the indicated statement may well gain some information about the solution from doing so, and may already be some way towards the answer. The command phrase is used to direct learners towards using a particular piece of information to start from or to a particular method. It also indicates to learners that valid alternative methods exist which will be given full credit, but that they may be more time-consuming or complex.

e.g. Show that $(\cos x+\sin x)^2=1+\sin 2x$ for all x. Hence, or otherwise, find the derivative of $(\cos x+\sin x)^2$.

You may use the result
When this phrase is used it indicates a given result that learners would not always be expected to know, but which may be useful in answering the question. The phrase should be taken as permissive; use of the given result is not *necessarily* required.

Plot
Learners should mark points accurately on graph paper provided in the Printed Answer Booklet. They will either have been given the points or have had to calculate them. They may also need to join them with a curve or a straight line, or draw a line of best fit through them.
e.g. Plot this additional point on the scatter diagram.

Sketch (a graph)
Learners should draw a diagram, not necessarily to scale, showing the main features of a curve. These are likely to include at least some of the following.

- Turning points
- Asymptotes
- Intersection with the y-axis

- Intersection with the x-axis
- Behaviour for large x (+ or –)

Any other important features should also be shown.

E.g. Sketch the curve with equation $y = \frac{1}{(x-1)}$.

Draw

Learners should draw to an accuracy appropriate to the problem. They are being asked to make a sensible judgement about the level of accuracy which is appropriate.

e.g. Draw a diagram showing the forces acting on the particle.

e.g. Draw a line of best fit for the data.

Other command words

Other command words, for example "explain" or "calculate", will have their ordinary English meaning.