UCAS

helping students into higher education

EXPERT GROUP REPORT FOR AWARD SEEKING ADMISSION TO THE UCAS TARIFF

OCR LEVEL 3 CERTIFICATE MATHEMATICS FOR ENGINEERING

Richard Skerrett and Dr Geoff Hayward
April 2009

CONTENTS PAGE

THE CONDUCT OF THE COMPARABILITY STUDY		**4**
SUMMARY AND RECOMMENDATIONS		**5**
SECTION 1: THE COMPOSITION OF THE EXPERT GROUPS		**8**
SECTION 2: OVERVIEW OF AWARD SEEKING ADMISSION TO THE TARIFF		**9**
2.1	Aims and purpose of the qualifications	9
2.2	History of the qualification	9
2.3	Entry requirements for the qualifications	10
2.4	Age of candidates	10
2.5	Guided Learning Hours (GLH)	10
2.6	Content and structure of the qualification	11
2.7	Assessment – procedures, methods and levels	12
2.8	Grading	12
2.9	Quality assurance processes	12
SECTION 3: OVERVIEW OF THE BENCHMARK AWARD		**14**
3.1	Aims and purpose of the qualification	14
3.2	History of the qualification	14
3.3	Entry requirements for the qualification	14
3.4	Age of candidates	14
3.5	Guided Learning Hours	15
3.6	Content and structure of the qualification	15
3.7	Assessment – procedures, methods and levels	15
3.8	Grading	16
3.9	Quality assurance systems and code of practice	18
SECTION 4: THE WORK OF THE EXPERT GROUP		**19**
4.1	Prior to the meeting	19
4.2	The Expert Group meeting	19
4.3	Comparison of aims	21
4.4	Determining size	22
4.5	Estimating relative demand - comparing assessment objectives	25
4.6	Estimating relative demand – comparing grade descriptions	26
4.7	Estimating relative demand – comparing assessment models	26
4.8	Aligning the grades	28
4.9	Domain scoring	29
4.10	Recommended allocation of UCAS Tariff points	30
APPENDIX 1	**Biographies of the Expert Group members**	**32**
APPENDIX 2	**The evidence considered**	**37**
APPENDIX 3	**Additional background information**	**38**

LIST OF TABLES **PAGE**

Table 1: OCR Mathematics for Engineering learning outcomes 11
Table 2: Edexcel GCE A level Core Mathematics and Mechanics units 15
Table 3: Edexcel GCE A level assessment objectives 15
Table 4: Mathematics A level uniform marks 16
Table 5: Domain scores 30

THE CONDUCT OF THE COMPARABILITY STUDY

In order to ensure a robust and transparent procedure for allocating UCAS Tariff Points to qualifications seeking admission to the framework, UCAS approached the University of Oxford, Department of Educational Studies for assistance in developing an appropriate methodology.

Acknowledging the problematic nature of comparability studies, and recognising that a mechanical procedure would not work, the Department proposed a procedure based on the premise that such comparisons can only be achieved through the exercise of collaborative judgement by an Expert Group.

Guidelines were drawn up for the composition of the Expert Group, the evidence that would need to be collected and examined and the choice of a benchmark qualification.

Procedures were developed for the conduct of the work of the Expert Group, including detailed sets of questions to be addressed at different stages in the process. Questions appropriate to the awards under consideration are selected and are used to guide, not constrain, the work of the Expert Group.

The judgements made by the Expert Group in this report are presented as suggested allocations of UCAS points which take account of the size and demand of the award seeking admission to the Tariff, and a candidate's level of attainment within that award. The guidelines also provide for an automatic review process to be conducted at a later stage in the light of further evidence. This latter point acknowledges the fact that both benchmark qualifications and those seeking admission to the Tariff may still be relatively new. Consequently, there may only be a relatively small amount of evidence (particularly candidate evidence) available at the time of the work of the Expert Group. There is, therefore, a need to review the decisions of the Group when more evidence becomes available and when HE admissions tutors have gained more experience of using the awards as entry qualifications.

The work of the Expert Group is subject to a quality assurance procedure by an independent auditor from higher education.

SUMMARY AND RECOMMENDATIONS

The Expert Group benchmarked the new OCR Level 3 Certificate in Mathematics for Engineering against the Edexcel Mathematics GCE A level. The OCR Certificate was developed by a Task Group of the Engineering Professors' Council in response to concern from HE that the Advanced Diploma in Engineering had insufficient Mathematics in its Principal Learning for progression to HE degree courses in Engineering. The Certificate is therefore available as an Additional and Specialist Leaning (ASL) qualification within the ASL catalogue of the Advanced Diploma in Engineering. It can also be taken as a freestanding qualification outside of an Advanced Diploma or as ASL of another Advanced Diploma. In reviewing it as part of the Advanced Diploma, the Group needed to bear in mind that the Principal Learning of the Engineering Diploma includes a Mathematics unit F563, which is insufficient in itself for progression to Engineering degree courses, and that the Certificate builds on this. The Certificate has two compulsory Components assessed by a total of three and a half hours of external examinations. Component Two is unusual in having a pre-release examination paper.

The Mathematics A level used for benchmarking purposes has six units (four compulsory and two optional) with nine hours of examinations, although from 2012 the number of units is likely to be reduced to four with a reduced burden of assessment. The version chosen for benchmarking contains the optional Mechanics units M1 and M2.

The aims of the two qualifications were thought to be very similar except that the Certificate in Mathematics for Engineering has explicit reference to an Engineering context. In terms of size the Certificate has been accredited as 180 GLH qualification, making it effectively only half an A level in size. While the quoted GLH matches that of GCE AS Mathematics, this is not a good comparison, as a significant amount of the content of the Certificate in Mathematics for Engineering matches the A2 Mathematics content and some matches content from Further Mathematics. Comparison of sizes is complicated by the fact that some of the AS core content of the Mathematics A level is covered in the Engineering Advanced Diploma Principal Learning unit F563.

The HE representatives welcomed the content of the Certificate in Mathematics for Engineering and felt that it would be useful in developing the mathematical skills necessary for progression to degree courses in Engineering. They considered the content to be substantial in size and broad in scope. It was, however, noted that there is a considerable disparity in the assessment time for the two qualifications, the Certificate attempting to test a very broad specification in 3.5 hours of written papers compared with nine hours for the A level. It was suggested that the allocated Guided Learning Hours for the OCR Certificate allow little time for consolidation, and that the fact that all the questions are set in an Engineering context potentially adds to the level difficulty. The limited number of questions on a broad syllabus makes it difficult for students and teachers to prepare for them.

However, the HE representatives were concerned both at the lack of depth of delivery implied by 180 GLH and the nature and size of the assessment. They judged 3.5 hours of

examinations to be less than adequate for the content, and were concerned to find limited use of unstructured questions by comparison with A level where 20-30% of units are unstructured. Judgments were hindered by the lack of assessment objectives and grade descriptors for the Certificate in Mathematics for Engineering. The Group understood that the Certificate will be graded A* - E and that it is intended that the grading should align with A level. However, the Group wanted formal confirmation of this from OFQUAL and OCR. OCR has since confirmed that the grade descriptors used for the OCR Level 3 Certificate in Mathematics for Engineering will be the same as those used for GCE A Level Mathematics. There was little information about the award of A* for the Certificate and the Group also requested clarification of this. OCR has since confirmed that A* will be awarded by taking extrapolated A* grades across a range of Mathematics units.

The domain scoring exercise showed virtually no difference between the two qualifications in terms of their utility for progression to HE and both scored well on Use and Apply and Numeracy Skills domains.

The Group then proceeded to recommend the allocation of UCAS Tariff points to the Certificate in Mathematics for Engineering. In many ways the two qualifications were judged to be a good match, and the size and level of content would suggest a Tariff score significantly in excess of the half A level implied by the GLH. The Group was clear that the Certificate is harder than AS and therefore worth more Tariff points, and the use of the A* - E grading suggests a parallel with A2.

However, the HE representatives were particularly concerned at the limited amount of assessment in relation to the breadth of content and at the lack of unstructured questions in the Certificate in Mathematics for Engineering. But the marking system might make it more difficult to achieve a good grade in the Certificate, as might the limited number of questions in respect of breadth of content.

The Group had concerns about the alignment of grades but was prepared to accept the alignment with A level grades provided this is backed up formally by OCR and OFQUAL. Confirmation of this has since been received from OCR. The Group also noted that no candidate evidence is available to date and that the information from OCR about assessment and grading is currently incomplete.

The Group agreed that some measure of uplift from the score for GCE AS (Grade A – 60) was necessary to reflect the greater content and challenge and the strong utility for progression to HE. However, a Tariff score equivalent to that for A level (Grade A – 120) would not be justified on grounds of size and assessment arrangements. It was therefore proposed to establish Grade A for the Certificate in Mathematics for Engineering at the midpoint between AS and A level ie Grade A – 90. The following Tariff points were recommended:

OCR Level 3 Certificate in Mathematics for Engineering

Grade	Tariff points
A*	TBC
A	90
B	75
C	60
D	45
E	30

The Group felt that it currently had insufficient evidence concerning the award of A* for the Certificate in Mathematics for Engineering to recommend the allocation of Tariff points at this stage. By numerical extrapolation a score of 105 could be arrived at for A*, but the Group would wish to receive a definitive statement from OFQUAL or OCR on the award of A* in the Certificate in Mathematics for Engineering before confirming this provisional recommendation. OCR has since confirmed that A* will be awarded by taking extrapolated A* grades across a range of Mathematics units.

All the Group's recommendations are provisional and will need to be the subject of review when sufficient candidate evidence is available for the Certificate in Mathematics for Engineering.

The recommendations were confirmed as appropriate by both the Tariff Reference and Advisory Groups and endorsed by the UCAS Board in September 2009.

SECTION 1: THE COMPOSITION OF THE EXPERT GROUPS

The following individuals with expert knowledge and experience of the qualifications under consideration in this study were selected to form the Expert Group:

- Bob Coombes, North Devon College
- Geoff Goss, London South Bank University
- Dr Tim Scott, University of Hull
- Mick Jennings, Edexcel
- Mara Bogdanovic, OCR
- Ken Barley, OCR

UCAS staff acted as facilitators and secretaries for the meetings, ensuring that the Group worked systematically through the procedures.

The whole process was overseen and quality assured by Dr Geoff Hayward, an independent higher education based consultant.

CVs of the experts within the group are attached as Appendix 1.

SECTION 2: OVERVIEW OF AWARD SEEKING ADMISSION TO THE TARIFF

2.1 Aims and purpose of the qualifications

The main aim of the qualification is to promote the teaching and learning of mathematics appropriate to engineering, post GCSE, in schools and colleges.

The aims of the specification are to enable candidates to:

- study the theory of mathematics and then apply this theory in a variety of engineering contexts
- develop their understanding of mathematics mathematical processes and the application of mathematics in a way that promotes confidence and fosters enjoyment
- develop abilities to reason logically and recognise incorrect reasoning, to generalise and to construct mathematical proofs
- extend their range of mathematical skills and techniques and use them in more difficult, unstructured engineering problems
- develop an understanding of coherence and progression in mathematics and of how different areas of mathematics can be connected to solve engineering problems;
- recognise how a situation may be represented mathematically and understand the relationship between 'real world' engineering problems and mathematical models and how these can be refined and improved
- use mathematics as an effective means of communication within an engineering context;
- read and comprehend mathematical arguments and articles concerning applications of mathematics in an engineering context
- acquire the skills needed to use technology such as calculators and computers effectively, recognise when such use may be inappropriate and be aware of limitations;
- develop an awareness of the relevance of mathematics to the field of engineering, to the world of work and to society in general
- take increasing responsibility for their own learning and the evaluation of their own mathematical development.

Broad Objectives

The broad objectives in designing the scheme have been to include a sufficient range of applied mathematical topics to allow schools and colleges to deliver a course to suit the requirements of potential engineering students.

The Level 3 Certificate is a 'stand-alone' linear qualification and can be used as Additional Specialist Learning for the Diploma in Engineering, the Diploma in the Construction and the Built Environment and the Diploma in Manufacturing.

2.2 History of the qualification

The Engineering Professors' Council (EPC) established a Mathematics Working Group (MWG) in 2001 to improve the general standard of mathematics of entrants to university engineering degree courses. Upon the announcement of the 14-19 Engineering Diploma in

2007, the EPC was alarmed by the poor mathematics content for students intending to progress onto engineering degrees. As a result, EPC set up a focus group of the MWG called the Maths Task Group (MTG) to address the issue.

The Maths Task Group developed the Mathematics for Engineering Certificate based on the Loughborough University Mathematics Foundation Course and worked in partnership with OCR to obtain accreditation for the certificate. Further information about the history and rationale behind the development of the award can be found in Appendix 3.

The certificate was available for first teaching in September 2008.

2.3 Entry requirements for the qualifications

This qualification is available to anyone who is capable of reaching the required standards. It has been developed free from any barriers that restrict access or progression thereby supporting equality and diversity.

It is advisable that anyone embarking upon this course should previously have studied GCSE Mathematics at higher tier or equivalent and/or be fully familiar with such mathematical content.

The mathematics within this unit can be taught and applied within the contexts of engineering, construction, science and manufacturing, particularly with the Diplomas for Engineering, Manufacturing and Product Design, or Construction and the Built Environment. It is recommended that the teaching of this qualification should be integrated with the teaching of relevant principal learning units.

All centre staff involved in the assessment or delivery of this qualification should understand the requirements and match them to the needs and capabilities of individual learners before entering them as candidates for this qualification. There is no requirement for learners to achieve any qualification before progressing onto this qualification although, as a general guide, learners with qualification profiles comparable to Level 2 of the National Qualifications Framework (NQF) will normally be at A level suitable for entry onto a programme leading to this qualification. Individuals should be considered equally for entry whether they hold certificates easily recognisable against the NQF or present more varied profiles for consideration.

2.4 Age of candidates

This qualification is suitable for learners aged 16 – 19 or 19 + that are:

- studying in preparation for employment in the engineering sector at technician level
- wishing to gain a level 3 qualification to support further study in FE and HE in the engineering sector
- wishing to gain a level 3 qualification to support further study in FE and HE in any other sector or subject area.

2.5 Guided Learning Hours (GLH)

Level 3 Certificate in Mathematics for Engineering is 180 guided learning hours in total.

2.6 Content and structure of the qualification

The certificate aims to provide the mathematical knowledge and skills needed for the study of engineering. From the knowledge and understanding of the theory, candidates should develop the ability to develop models and solve problems in the context of engineering.

Practical engineering examples are included to assist the understanding and application of certain mathematical techniques.

The content of qualification covers ten learning outcomes as outlined below:

Table 1: OCR Mathematics for Engineering learning outcomes

Learning outcomes		Assessment criteria		Weight
1	Understand the idea of mathematical modelling	1.1 1.2	Identify the assumptions made in establishing a specific mathematical model Describe and use the modelling cycle	15 – 25
2	Be familiar with a range of models involving change, and growth and decay.	2.1 2.2 2.3	Use mathematical functions related to growth and decay Solve problems involving exponential growth and decay Set up and solve a differential equation to model a physical situation	5 - 14
3	Understand the use of trigonometry to model situations involving oscillations	3.1 3.2	Solve problems in engineering requiring knowledge of trigonometric functions. Relate trigonometrical expressions to situations involving oscillations.	5 - 14
4	Understand the mathematical structure of a range of functions and be familiar with their graphs	4.1 4.2	Identify and describe functions and their graphs Analyse functions represented by polynomial equations	5 – 14
5	Know how 2-D and 3-D coordinate geometry is used to describe lines, planes and conic sections within engineering design and analysis	5.1 5.2 5.3	Use equations of straight lines, circles, conic sections, and planes Calculate distances Distance between two points in 2D and 3D space; distance between a point and a line or a plane Describe relationships between lines in 3D	3 – 10
6	Know how to use differentiation and integration in the context of engineering analysis and problem solving	6.1 6.2 6.3	Calculate the rate of change of a function Use derivatives to locate and classify stationary points of a function of one variable Find definite and indefinite integrals of functions Use integration to find areas and volumes	10 – 20
7	Understand the methods of linear algebra. Know how to use algebraic processes	7.1 7.2 7.3 7.4	Solve engineering problems using vector methods Use matrices to solve two simultaneous equations in two unknowns Solve problems involving arithmetic and geometric sequences and series Use inequalities Manipulate complex numbers	5 – 15
8	Understand how to describe engineering situations using statistics and use probability as a measure of likelihood	8.1 8.2 8.3	Summarise a set of data Describe a random sample and how it might be taken Use methods of probability to help solve engineering problems	5 – 15
9	Construct rigorous mathematical arguments and proofs in engineering contexts	9.1 9.2 9.3	Use precise statements, logical deduction and inference Manipulate mathematical expressions Construct extended arguments to handle substantial problems.	3 – 10

10	Comprehend translations of common realistic engineering contexts into mathematics	10.1	Read critically and comprehend substantial mathematical arguments or examples of applications	5 - 15
Total				**100%**

The weighting is expressed as a range of marks within which marks on any given paper must lie. So the weighting on various elements will vary from paper to paper and different learning outcomes will be weighted differently on different papers. This approach is consistent with that taken for A Level Mathematics.

2.7 Assessment – procedures, methods and levels

The OCR Level 3 Certificate in Mathematics for Engineering is assessed through two components:

Component 1
A question paper of different length questions and mark allocations.
Candidates answer all questions of this externally assessed exam.
60% of the total marks, 2 hrs written paper - 60 marks

Component 2
A question paper of different length questions and mark allocations.
Candidates answer all questions of this externally assessed exam.
40% of the total marks, 1.5 hours written paper - 40 marks

The question paper for Component 2 is based on pre-release material which will consist of an engineering related case study. Students will not be able to take an annotated copy into the exam but they will be given a new copy of the case study in the exam. This will enable students to familiarise themselves with any technical language related to the case and allow them to identify areas within the specification that might relate to the case. Calculators are allowed in both papers.

2.8 Grading

A candidate's mark for each of the assessment components taken will be combined in the appropriate weighting to give the candidate's total mark for the specification. The candidate's grade will be determined by this total mark.

The Level 3 Certificate in Mathematics for Engineering is awarded on the scale A*-E. Grades are awarded on certificates. However, results for candidates who fail to achieve the minimum grade (E) will be recorded as unclassified (U) and this is not certificated.

Candidates must complete both assessment components in the same examination series. There are no restrictions on the number of times a candidate may re-sit this qualification. As this is a linear qualification, candidates will need to re-sit both components.

2.9 Quality assurance processes

Examiner recruitment

Examiner recruitment takes place in accordance with JCQ policy and the Ofqual Code of Practice. The Code of Practice specifically applies to GCSE, GCE and AEA examinations, but OCR intends to apply it in full to this Certificate.

Question setting

The Principal Examiner sets an initial draft of both papers and mark schemes. These are revised independently by two revisers. The Principal Examiner produces a second draft of the papers and mark schemes, taking into account the comments of the revisers. The second drafts of the papers are considered at a QPEC meeting, which is attended by the Principal Examiner, revisers, chair of examiners and awarding body officer, in line with the QCA Code of Practice, and final drafts are agreed.

Standardisation of marking

Following the sitting of the examination the Principal Examiner will mark some scripts using the version of the mark scheme agreed at the QPEC. He will then propose changes to the mark scheme, variations etc in the light of the students' responses. For this specification it is anticipated that, initially, numbers will be quite low and that the Principal Examiner will be able to mark all of the scripts. In line with OCR procedures, a second marker, with appropriate qualifications and experience, will be appointed to the specification to discuss the mark scheme with the Principal Examiner at this stage, and to check a sample of the marking of the Principal Examiner. This second person is likely to be one of the revisers. This procedure goes considerably beyond that required by the Ofqual Code of Practice (Section 4.7).

Award meeting

The award meeting will be chaired by the OCR staff chair of examiners with responsibility for Mathematics. The award committee will include the Principal Examiner, at least one member (as well as the chair) who is also involved in awarding related GCE Mathematics units, and may include others with particular expertise relevant to the award. This is in line with the Ofqual Code of Practice (Section 6.7/8). The award will be done using professional judgement, and using archive scripts at the notional grade A* and at grade E from relevant Mathematics units from the June 2009 session and statistical information about the prior attainment of candidates, as is the case for GCE awards for all awarding bodies.

SECTION 3: OVERVIEW OF THE BENCHMARK AWARD

3.1 Aims and purpose of the qualification

The qualification has been designed for schools and colleges to produce courses which will encourage students to:

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

3.2 History of the qualification

This series of units is the replacement for earlier Advanced Subsidiary GCE and Advanced GCE in Mathematics and Further Mathematics.

3.3 Entry requirements for the qualification

Students embarking on Advanced Subsidiary and Advanced GCE study in Mathematics are expected to have covered all the material in the GCSE Mathematics Higher Tier. This material is regarded as assumed background knowledge and will not be tested by questions focused directly on it. However, it may be assessed within questions focused on other material from the relevant specification.

3.4 Age of candidates

There is no age restriction.

Edexcel's access policy concerning recruitment to their qualifications is that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

3.5 Guided Learning Hours

The A level is designed to be delivered in 360 guided learning hours.

3.6 Content and structure of the qualification

The specification is designed to allow students to follow a number of pathways to achieve the award. For the purposes of this work, the Expert Group focused their deliberations on the following Core Mathematics and Mechanics units.

Table 2: Edexcel GCE A level Core Mathematics and Mechanics units

Unit	Summary of unit content
Core Mathematics	
C1	Algebra and functions; coordinate geometry in the (x, y) plane; sequences and series; differentiation; integration.
C2	Algebra and functions; coordinate geometry in the (x, y) plane; sequences and series; trigonometry; exponentials and logarithms; differentiation; integration.
C3	Algebra and functions; trigonometry; exponentials and logarithms; differentiation; numerical methods.
C4	Algebra and functions; coordinate geometry in the (x, y) plane; sequences and series; differentiation; integration; vectors.
Mechanics	
M1	Mathematical models in mechanics; vectors in mechanics; kinematics of a particle moving in a straight line; dynamics of a particle moving in a straight line or plane; statics of a particle; moments.
M2	Kinematics of a particle moving in a straight line or plane; centres of mass; work and energy; collisions; statics of rigid bodies.

3.7 Assessment – procedures, methods and levels

- All six units are assessed via a 1.5 hour written paper
- Thus a total assessment time of 9 hours
- C1 is the only non-calculator paper
- All questions are compulsory and have varying mark allocations
- Each unit is marked out of 75 and each unit is equally weighted at 16.7% of the entire award.

Candidates are assessed upon their ability to meet five assessment objectives as outlined in Table 3.

Table 3: Edexcel GCE A level assessment objectives

Assessment Objective: The assessment will test students' ability to:		Minimum weighting
AO1	recall, select and use their knowledge of mathematical facts, concepts and techniques in a variety of contexts	40%
AO2	construct rigorous mathematical arguments and proofs through use of precise statements, logical deduction and inference and by the manipulation of mathematical expressions, including the construction of extended arguments for handling substantial problems presented in unstructured form	40%
AO3	recall, select and use their knowledge of standard mathematical models to represent situations in the real world recognise and understand given representations involving standard models present and interpret results from such models in terms of the original situation, including discussion of the assumptions made and refinement of such models	10%
AO4	comprehend translations of common realistic contexts into mathematics use the	5%

	results of calculations to make predictions, or comment on the context and, where appropriate, read critically and comprehend longer mathematical arguments or examples of applications	
AO5	use contemporary calculator technology and other permitted resources (such as formulae booklets or statistical tables) accurately and efficiently understand when not to use such technology, and its limitations. Give answers to appropriate accuracy	5%

3.8 Grading

The minimum uniform marks required for each grade for each unit are as follows:

Table 4: Edexcel GCE A level uniform marks

Unit grade	A	B	C	D	E
Maximum uniform mark = 100	80	70	60	50	40

Students who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–39.

The grading, awarding and certification of this qualification comply with the requirements of QCA's GCSE/GCE Code of Practice for courses starting in September 2008. The AS qualification is graded and certificated on a five-grade scale from A to E, whilst the full GCE Advanced level is graded on a six-point scale A* to E. Individual unit results will be reported.

To be awarded an A* students will need to achieve an A on the full GCE Advanced level qualification and an A* aggregate (90%) of the A2 units. Students whose level of achievement is below the minimum judged by Edexcel to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

The following grade descriptions indicate the level of attainment characteristic of grades A, C and E at Advanced GCE. They give a general indication of the required learning outcomes at the specified grades. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

Grade A

Students recall or recognise almost all the mathematical facts, concepts and techniques that are needed, and select appropriate ones to use in a wide variety of contexts.

Students manipulate mathematical expressions and use graphs, sketches and diagrams, all with high accuracy and skill. They use mathematical language correctly and proceed logically and rigorously through extended arguments or proofs. When confronted with unstructured problems they can often devise and implement an effective solution strategy. If errors are made in their calculations or logic, these are sometimes noticed and corrected.

Students recall or recognise almost all the standard models that are needed, and select appropriate ones to represent a wide variety of situations in the real world. They correctly refer results from calculations using the model to the original situation; they give sensible interpretations of their results in the context of the original realistic situation. They make intelligent comments on the modelling assumptions and possible refinements to the model.

Students comprehend or understand the meaning of almost all translations into mathematics of common realistic contexts. They correctly refer the results of calculations back to the given context and usually make sensible comments or predictions. They can distil the essential mathematical information from extended pieces of prose having mathematical content. They can comment meaningfully on the mathematical information.

Students make appropriate and efficient use of contemporary calculator technology and other permitted resources, and are aware of any limitations to their use. They present results to an appropriate degree of accuracy.

Grade C

Students recall or recognise most of the mathematical facts, concepts and techniques that are needed, and usually select appropriate ones to use in a variety of contexts.

Students manipulate mathematical expressions and use graphs, sketches and diagrams, all with a reasonable level of accuracy and skill. They use mathematical language with some skill and sometimes proceed logically through extended arguments or proofs. When confronted with unstructured problems they sometimes devise and implement an effective and efficient solution strategy. They occasionally notice and correct errors in their calculations.

Students recall or recognise most of the standard models that are needed and usually select appropriate ones to represent a variety of situations in the real world. They often correctly refer results from calculations using the model to the original situation; they sometimes give sensible interpretations of their results in the context of the original realistic situation. They sometimes make intelligent comments on the modelling assumptions and possible refinements to the model.

Students comprehend or understand the meaning of most translations into mathematics of common realistic contexts. They often correctly refer the results of calculations back to the given context and sometimes make sensible comments or predictions. They distil much of the essential mathematical information from extended pieces of prose having mathematical content. They give some useful comments on this mathematical information.

Students usually make appropriate and efficient use of contemporary calculator technology and other permitted resources, and are sometimes aware of any limitations to their use. They usually present results to an appropriate degree of accuracy.

Grade E

Students recall or recognise some of the mathematical facts, concepts and techniques that are needed, and sometimes select appropriate ones to use in some contexts.

Students manipulate mathematical expressions and use graphs, sketches and diagrams, all with some accuracy and skill. They sometimes use mathematical language correctly and occasionally proceed logically through extended arguments or proofs.

Students recall or recognise some of the standard models that are needed and sometimes select appropriate ones to represent a variety of situations in the real world. They sometimes correctly refer results from calculations using the model to the original situation; they try to interpret their results in the context of the original realistic situation.

Students sometimes comprehend or understand the meaning of translations in mathematics of common realistic contexts. They sometimes correctly refer the results of calculations back to the given context and attempt to give comments or predictions. They distil some of the essential mathematical information from extended pieces of prose having mathematical content. They attempt to comment on this mathematical information.

Students often make appropriate and efficient use of contemporary calculator technology and other permitted resources. They often present results to an appropriate degree of accuracy.

3.9 Quality assurance systems and code of practice

Examiner recruitment

In accordance with JCQ policy.

Question setting

The Principal Examiner sets an initial draft of a whole unit paper. This is then moderated at a QPEC meeting and a final draft agreed.

Standardised examining

Following the sitting of the examination the principal examiner will mark some scripts using the latest version of the mark scheme. He will then propose changes to the mark scheme, variations etc in the light of the students' responses. A pre-standardisation meeting is usually held with the team leader where a final mark scheme is agreed. The chief examiner would be present to agree any changes or alterations to the scheme. The standardisation meeting will then be held to explain the scheme to the examiners. At Edexcel, this process would be carried out remotely for some units. All these processes are in accordance with the JCQ code of practice.

Grade review

As examinations are marked on-line the team leaders can monitor examiners in real time. Throughout the marking process examiners are monitored and towards the end of the marking process a final check is made to ensure that no examiners are outside board tolerances. No further checks are made after the award has taken place.

The grading meeting (award meeting) is done with a panel consisting of all principal examiners and all chief examiners to ensure consistency across the different options. Awarding decisions are made on a unit by unit basis and a final check is made at the end to ensure that the overall award is in line with previous years and statistical expectations.

SECTION 4: THE WORK OF THE EXPERT GROUP

4.1 Prior to the meeting

Prior to the meeting preparatory work was carried out. Pre-meeting papers were distributed, requiring members of the Group to compare the aims, content, study hours, relative size and assessment models of the OCR Level 3 Certificate in Mathematics for Engineering with the Edexcel Advanced GCE in Mathematics using Mechanics units M1 and M2 for the purpose of comparison. Members were also asked to undertake preliminary scoring of these qualifications against UCAS Tariff domains.

4.2 The Expert Group meeting

The meeting opened with presentations from the OCR Chair of Examiners for the OCR Level 3 Certificate in Mathematics for Engineering and the Edexcel Subject Officer for Advanced GCE in Mathematics. These provided an overview of the qualifications and allowed members of the Group to seek clarification about their design and structure.

The OCR Chair of Examiners explained the history of the development of the OCR Level 3 Certificate in Mathematics for Engineering. It stemmed from a concern by Higher Education about the Mathematics content of the new Advanced Diploma in Mathematics announced in 2007. The Engineering Professors' Council (EPC) set up a Task Group of its Mathematics Working Group (MWG) to address the issue of mathematics content for students wishing to progress from the Advanced Diploma in Engineering to Engineering degrees. The Mathematics Task Group developed the Level 3 Certificate in Mathematics for Engineering based on the Loughborough University Science and Engineering Foundation Course.

It was noted that the Principal Learning of the Advanced Diploma in Engineering contains a Mathematics unit F563, but this provides insufficient Mathematics for progression to Engineering degree courses. It does, however, provide a basis on which the Certificate in Mathematics for Engineering (H860) builds. The latter is certificated as a standalone Additional and Specialist Learning (ASL) qualification in the ASL catalogue for the Advanced Diploma in Engineering, but is also available as a standalone qualification independent of the Diploma. It is suitable for learners (16-19 or 19+) who are:

- Studying in preparation for employment in the Engineering sector at technician level
- Wishing to gain A level 3 qualification to support further study in FE and HE in the engineering sector
- Wishing to gain A level 3 qualification to support further study in FE and HE in any other sector or subject area.

The Chair of Examiners commented that the aims of the qualifications are similar, the main difference being the Engineering context of the OCR Level 3 Certificate in Mathematics for Engineering. It was suggested that it is a moot point whether this contextual approach makes the qualification broader than the GCE A level or more limited.

Initial views were expressed that there is a great deal of content in the Level 3 Certificate and that the 180 Guided Learning Hours (GLH) as specified by QCA seem inadequate to do

justice to the wide range of material. While the quoted GLH matches that of GCE AS Mathematics, this is not a good comparison other than by size, as a significant amount of the content of the Certificate in Mathematics for Engineering matches the A2 Mathematics content and some matches content from Further Mathematics. Comparison of sizes is complicated by the fact that some of the AS core content of the Mathematics A level is covered in the Engineering Advanced Diploma Principal Learning unit F563. The version of GCE A level Mathematics chosen for benchmarking contains the optional Mechanics units M1and M2, while the Certificate in Mathematics for Engineering contains a significant amount of Statistics and even a little Decision Mathematics.

It was noted that the question paper for Component 2 is based on pre-release material consisting of an Engineering case study. Students will not be able to take an annotated copy into the examination but will be given a new copy of the case study.

The Chair of Examiners gave his initial view that the Certificate in Mathematics for Engineering is very comparable in standard to the Edexcel GCE A level in Mathematics but that it probably has more than half the content of the A level and the provision of contexts in the Mathematics for Engineering specification adds an extra dimension to that qualification.

The Subject Officer for Edexcel GCE A level Mathematics outlined the aims, content and structure of the qualification as detailed in Section 3 above. He provided an initial summary of the comparison of the two qualifications and suggested that the OCR Certificate in Mathematics for Engineering is very heavy in content and contains many pure topics which appear in the Further Pure units of the Edexcel A level. The Certificate has a sizeable amount of Statistics and Probability, most of which is to be found in S1, and to some extent S2, of A level, and also has Linear Programming which is found in D1 of the A level. The Edexcel qualification with the two optional Mechanics units, as used for this benchmarking exercise, has much more Mechanics than the Certificate in Mathematics for Engineering.

It was noted that there is a considerable disparity in the assessment time for the two qualifications, the Certificate attempting to test a very broad specification in 3.5 hours of written papers compared with nine hours for the A level. It was suggested that the OCR Certificate requires speed and allows little time for consolidation, and that the fact that all the questions are set in an Engineering context adds considerably to the degree of difficulty.

In preliminary discussion it was put to the Group that, as the Certificate in Mathematics for Engineering is graded A*- E, and A* in A level is awarded solely on the basis of A2 achievement, this would suggest that the regulator regards the Certificate as an A2-type qualification. The mapping of Mathematics qualifications is difficult because of the complexity of the different versions of Mathematics A level, the distribution of content across AS and A2, and the existence of Further Mathematics AS and A level. Members discussed the likely delivery of the Certificate in Mathematics for Engineering and felt that it is likely to be delivered in the second year of post-compulsory study (Year 13). For Advanced Diploma students, while it is not obligatory to have completed unit F563 first, it would be unlikely that candidates would not have completed it.

The Group discussed the concerns about the volume of content in the Certificate in Mathematics for Engineering in relation to the stated 180 GLH and members expressed the view that students would need to be very able to cover the content in the time. Linked to this was an initial concern that the 3.5 hours of assessment of the Certificate suggested very compressed assessment for a wide range of material. It was explained that the Certificate is designed to be more in line with the new A levels with reduced assessment. It was noted that in comparing the structure and assessment arrangements of the two qualifications, it must be borne in mind that the current Edexcel Mathematics A level still contains six units. Following concern about the burden of assessment, many other A levels have already been restructured into four units and the volume of assessment reduced. Mathematics A level will not change until 2012 at which point it would be reasonable to assume a reduction in the burden of assessment.

The HE representatives stressed the need for HE entrants for engineering courses to have a grounding in algebra and suggested that it is challenging for students to develop sufficient algebraic skills. It was thought that the Mathematics within the Engineering Diploma Principal Learning starts at a very low level but does include a significant amount of the core Mathematics AS content, especially calculus, and even includes the A2 topic of partial fractions.

4.3 Comparison of aims

The Group considered the aims of the two qualifications, and felt them to be very similar. The following aims for the Certificate in Mathematics for Engineering show the points of difference highlighted in italics:

To enable candidates to:

- Study the theory of mathematics and then apply this theory in a variety of engineering contexts;
- Develop their understanding of mathematics and mathematical processes and *the application of mathematics* in a way that promotes confidence and fosters enjoyment
- Develop abilities to reason logically and recognise incorrect reasoning, to generalise and to construct mathematical proofs
- Extend their range of mathematical skills and techniques and use them in more difficult, unstructured *engineering* problems
- Develop an understanding of coherence and progression in mathematics and of how different areas of mathematics can be connected
- Recognise how a situation may be represented mathematically and understand the relationship between 'real world' *engineering* problems and mathematical models and how these can be refined and improved
- Use mathematics as an effective means of communication *within an engineering context*;
- Read and comprehend mathematical arguments and articles concerning applications of mathematics *in an engineering context*
- Acquire the skills needed to use technology such as calculators and computers effectively, recognise when such use may be inappropriate and be aware of limitations;

- Develop an awareness of the relevance of mathematics *to the field of engineering*, to the world of work and to society in general
- Take increasing responsibility for their own learning and the evaluation of their own mathematical development.

The aims of GCE A level Mathematics are to encourage students to:

- Develop their understanding of mathematics and mathematical processes in a way that promotes confidence and fosters enjoyment
- Develop abilities to reason logically and recognise incorrect reasoning, to generalise and to construct mathematical proofs
- Extend their range of mathematical skills and techniques and use them in more difficult, unstructured problems
- Develop an understanding of coherence and progression in mathematics and of how different areas of mathematics can be connected
- Recognise how a situation may be represented mathematically and understand the relationship between 'real-world' problems and standard and other mathematical models and how these can be refined and improved
- Use mathematics as an effective means of communication
- Read and comprehend mathematical arguments and articles concerning applications of mathematics
- Acquire the skills needed to use technology such as calculators and computers effectively, recognise when such use may be inappropriate and be aware of limitations.

The Group judged that the aims of the two qualifications are very nearly the same, the main difference being that some of the aims of the Certificate in Mathematics for Engineering are specifically targeted to an Engineering context.

4.4 Determining size

Comparison of Guided Learning Hours

Given the almost identical aims of the two qualifications, the Group had concerns about the huge differential of the qualifications in terms of Guided Learning Hours (GLH) - 180 GLH for the Certificate in Mathematics for Engineering compared with 360 GLH for GCE A level. The Group tended to the view that the GLH for the Certificate is not representative of its content and demand and might be a perverse effect of the certification process.

The Group was clear that the published GLH for the Certificate in Mathematics for Engineering as only 50% of A level does not reflect the extent and range of the content in the specification. While the Mathematics AS qualification matches the Certificate in Mathematics for Engineering precisely in terms of GLH, this is not a good comparison as a significant amount of the content of the Certificate matches the A2 Mathematics content and some matches content from Further Mathematics.

Comparison of content

The Engineering Principal Learning unit F563, Mathematical techniques and applications for engineers, has some content which is included in AS Mathematics. The Certificate in

Mathematics for Engineering builds on this content, and also lists a number of specific engineering contexts to be tested in examinations. AS Mathematics topics like the use of radians, arc length and area of sectors, sec, cosec and cot, sine and cosine rule, simple trigonometrical formulae, a whole section on elementary calculus (which also includes differentiation and integration of trigonometrical functions) and some statistics that is a little above GCSE level, are all included in F563 and are built on in the Certificate in Mathematics for Engineering. It includes content from a large number of different AS and A2 units.

The A level Mathematics specification that the Certificate is being compared with has optional units M1 and M2, much of which is covered by the Certificate, but the latter also has a significant amount of Statistics in it, and even a little Decision Mathematics. The 180 GLH Certificate has a number of unique points, but these mainly relate to particular applications relating to engineering. The A level Mathematics specification with the M1 & M2 option with 360 GLH may be expected to have a considerable amount of extra content. However, the difference in overall content is very much smaller than might be thought from the GLH quoted.

The following is a breakdown of the Edexcel GCE A level, with M1 and M2 as the optional units, annotated to indicate how much of this is covered in the Engineering Diploma. (AC stands for Assessment Criteria.)

C1

1 Algebra and functions – all, but partly in F563
2 Coordinate geometry in the (x, y) plane – all in AC 5.1
3 Sequences and series – part in F563, arithmetic series in AC 7.3
4 Differentiation – part in F563, work on tangents and normals etc in AC 5.3
5 Integration – covered in F563

C2

1 Algebra and functions – some in F563, Factor and Remainder theorem etc in AC 4.2
2 Coordinate geometry in the (x, y) plane – work on circles in AC5.1
3 Sequences and series – in AC 7.3
4 Trigonometry – mainly in F563, solution of trigonometrical equations etc in AC 3.1
5 Exponentials and logarithms – some in F563, all except for change on base in AC 2.1
6 Differentiation – max/min in F563, all but increasing and decreasing functions AC 6.2
7 Integration – all except trapezium rule in F563. Trap rule not in Level 3 Certificate.

C3

1 Algebra and functions – algebraic fractions in F563, functions in AC4.1, modulus function omitted, combinations of transformations and graphs in AC4.1
2 Trigonometry – sec, cosec and cot on F563, together with identities, though nothing about their graphs. Inverse trig functions not mentioned in Certificate, nor double angle formulae
3 Exponentials and logarithms – exponential work in AC2.2
4 Differentiation – sin, cos, exponential and logarithm in F563, product, quotient and function of a function in AC6.1. Implicit differentiation not mentioned.
5 Numerical methods – not included in Certificate

C4

1 Algebra and functions – algebraic fractions and partial fractions on B563
2 Coordinate geometry in the (x, y) plane – parametric equations not in Certificate
3 Sequences and series – use of Binomial series in AC7.3, not specified if rational *n* is included
4 Differentiation – not included
5 Integration – volume of revolution in AC6.4, integration by parts and partial fractions in AC6.3, first order differential equation sin AC2.3, numerical integration not included
6 Vectors – most, including applications in AC7.1

M1

1 Mathematical models in Mechanics – similar to AC 1.1
2 Vectors in Mechanics – AC7.1 indicates that vectors can be used in engineering problems
3 Kinematics of a particle moving in a straight line – in B563, though graphical work may not be included
4 Dynamics of a particle moving in a straight line or plane – AC1.1 includes Newton's Laws of Motion, though not connected particles. Friction is included in AC1.1
5 Statics of a particle – not included
6 Moments – not included

M2

The Certificate in Mathematics for Engineering also contains the following additional Mechanics content, not included in the Edexcel M1 or M2 units:

AC 1.1 Hooke's Law (M3 section 2),
AC 3.1 Work on oscillations in mechanical and electrical contexts, though SHM is not specifically mentioned,
AC 6.3 Relationship between acceleration, velocity and displacement for linear and angular motion (M3 part of section 4),

The Certificate in Mathematics for Engineering also contains the following Further Pure Mathematics content:

AC 2.3 First order differential equations, requiring direct integration, separation of variables and integrating factor techniques (FP1 section 5),
AC 2.3 Second order differential equations, including with initial conditions (FP1 part of section 6)
AC 5.1 Conic sections (FP2 part of section 1),
AC 7.2 Using matrices to solve simultaneous equations (FP3 part of section 2),
AC 7.5 Manipulation and use of complex numbers (FP1 part of section 3).

The Certificate in Mathematics for Engineering also contains the following Statistics content:

AC 8.1 Summarising sets of data (AC8.1) is similar to work in S1 section 2,
AC 8.2 Sampling is similar to work in S3 section 2,
AC 8.3 Basic probability is similar to S1 section 3, the normal distribution to S1 section 6 and the work on Binomial and Poisson distributions similar to S2 section 1.

AC 7.4 The work on inequalities, extending to linear programming, is similar to D1 section 5, excluding Simplex.

The judgment on the relative size of the qualifications is complicated by the fact that some of the AS core content of Mathematics A level is covered in the Principal Learning unit F563, though this is largely built on in the Certificate in Mathematics for Engineering.

Virtually all of the AS Mathematics core (C1 and C2) is included, partly in F563 but mainly in the Certificate. Much of the content of the A2 Mathematics core is included in the Certificate. The comparison with the M1 and M2 options at in A level Mathematics shows that not all the A level Mechanics is included in the Certificate, though it does have a significant amount of Statistics content and a little part of Decision Maths content. The 90 minute pre-release paper will explore a small part of the content in some depth; the two hour written paper will sample the rest of the content, in varying depths. It seems likely that, for each examination for the Certificate in Mathematics for Engineering, topics will be examined in varying depths, and that the overall balance will be much the same as for A level Mathematics.

It was the judgment of the HE representatives that the breadth of content and extent of Engineering-related applications will make the Certificate in Mathematics for Engineering a very good preparation for and introduction to Engineering degree courses. However, while the HE representatives welcomed the content of the Certificate and felt that it would help to address the issues of lack of mathematical skills, they had serious reservations about the extent to which the assessment would cover the full breadth of the specification and about how the qualification will in practice be delivered by schools and colleges if only funded for 180 GLH.

The HE representatives were also concerned about potential overlap between the Certificate in Mathematics for Engineering and Mathematics A level in cases where students take both qualifications. This problem is not helped by the flexibility to take different options within Mathematics A level and the difficulty for HEIs in obtaining information about which units have been taken within A level. It was agreed that the issue of potential overlap should be noted, but should be a matter for indicative HE entry requirements and is not a consideration which can be handled by the UCAS Tariff itself.

4.5 Estimating relative demand - comparing assessment objectives

The assessment objectives for the Edexcel Mathematics A level are set out in Section 3 above. Assessment objectives have not yet been included in the Certificate in Mathematics for Engineering, but the Group was informed that it has been decided that these will be the same as for A level Mathematics. This seemed appropriate given the similarity of the aims of the two specifications. The OCR Certificate has published Learning Outcomes which are different in nature from Assessment Objectives. These are detailed in Section 2 above.

Members noted that Mathematics is a highly sequential subject and that the learning outcomes need to be assessed as the student develops mathematical skills.

4.6 Estimating relative demand – comparing grade descriptions

There are published grade descriptors for the Mathematics GCE A level indicating the level of attainment characteristic of grades A, C and E. These are detailed in Section 3D.8 above.

There are no published grade descriptions in the specification for the Certificate in Mathematics for Engineering, but the Group was informed that it is intended to grade it on an A* - E scale as for the A2 component of A level using similar descriptors. OCR will archive work at grades A and E and also at A* to establish standards.

The Group discussed the award of A* and noted the issues surrounding its use for entry to HE. While a Tariff points score of 140 has been approved for A* at A level, HE has been advised to use this with caution and it is not expected that HE will initially require applicants to achieve A*. A similar situation would be likely to apply to A* grade in the Certificate in Mathematics for Engineering. It was noted that the current Edexcel Mathematics A level is still an old-style A level and in its current assessment does not have questions aimed at A* standard.

The Group noted that the Certificate in Mathematics for Engineering is currently not fully developed in respect of grading, and that there are currently no criteria for grade boundaries nor is there information about the use of UMS marks and their conversion into grades as in A level. OCR advises that there will be a 60/40 weighting between Components 1 and 2 in the Certificate in Mathematics for Engineering. This is a linear rather than a unitised qualification, and it will therefore be possible to aggregate marks from both components and convert them into grades without the use of UMS which in this situation would be irrelevant.

While it was understood that the regulator will be expecting the same standards to apply as for A level, the Group felt that it had insufficient information about these matters and asked the Principal Examiner to obtain written clarification from OCR. The Group agreed to make the assumption that the Certificate in Mathematics for Engineering will be graded in the same way as A level, subject to confirmation of this from OCR.OCR has since confirmed that the Certificate will be graded A* - E s for GCE A level Mathematics and the grade descriptors will be the same as those used for GCE A level Mathematics. OCR has confirmed that grades will be awarded by determining grade boundaries using inspection combined with professional judgement with reference to standards for comparable A Level Mathematics units.

The Group noted that it will be necessary to review its provisional judgments on grading once sufficient candidate evidence is available.

4.7 Estimating relative demand – comparing assessment models

The Group proceeded to consider the assessment models of both qualifications. The Edexcel Mathematics A level consists of four compulsory units (two at AS and two at A2) and two optional units (either one at AS and one at A2 or two at AS). All units are externally assessed by means of a 90 minute written paper, giving a total assessment time of nine hours. All questions are compulsory and have varying mark allocations. The questions tend to be

shorter in the AS. Each unit is marked out of 75 and each unit is equally weighted at 16.7% of the overall award. The UMS mark scheme is used to arrive at the overall grade. The revised Mathematics A level specification from 2012 is likely to have a reduced assessment time eg to six hours overall.

The OCR Certificate in Mathematics for Engineering consists of a 60 mark two hour examination for Component One and a 40 mark 90 minute examination with pre-release question paper for Component Two. Both examinations are marked externally and both assess the whole specification, though care will be taken to ensure there is little or no overlap. The OCR Chair of Examiners explained that these papers are both structured at roughly one mark for every two minutes. The Edexcel A level papers have 75 marks for 90 minutes, which is one mark every 1.2 minutes. This implies that the Certificate in Mathematics for Engineering questions should have a lower value than similar A level questions – one mark on the Certificate is worth about 1.66 marks on A level, or a question worth five marks on A level should be worth about three marks on the Certificate. This could potentially suggest that it is more difficult to get marks on the OCR Certificate than at A level. Analysis suggested that there is a significant amount of work needed to gain one mark in the Certificate and it was judged that this made it more difficult to achieve a Grade A.

The HE representatives considered that the paper for Component One of the Certificate in Mathematics for Engineering is quite straightforward. It was noted that the pre-release Component Two examination question paper is a special feature of that qualification and typically used for vocational qualifications and for Geography. Candidates are not allowed to take annotated copies of the question paper into the examination room and are given a new copy. The HE representatives thought that this examination is demanding and welcomed the pre-release approach.

However, they had two significant concerns about the assessment of the Certificate in Mathematics for Engineering. Firstly the HE representatives felt that the overall length of the assessment of the Certificate is insufficient compared with the current nine hours for GCE A level (while taking into account the likely reduction in assessment burden of Mathematics A level from 2012). They considered the content of the Certificate to be wide-ranging and nearly as extensive as the Mathematics A level and doubted the adequacy of the assessment in this context. There were concerns that the depth of assessment might suffer consequently and about the coverage of skills.

The second concern related to Component Two. While they felt the content to be very useful, they were concerned about the efficacy of the assessment in respect of the range of content. There was discussion about the extent to which teachers might be able to predict questions and teach to them on the basis of the pre-release material and there was some concern that pre-release might make this examination easier. The HE representatives felt that the amount of time for the pre-release of the question paper was important, and clarification would be sought from OCR after the meeting. A substantial period of time was deemed preferable. OCR has confirmed that centres will be provided with pre-release material a maximum of one month before the scheduled examination date. This will allow teachers sufficient time to familiarise their students with the required information without distorting what will be taught.

The Group noted that most of the content of A level is assessed. The Certificate in Mathematics for Engineers has ten Learning Outcomes each of which has approximately three at sublevel. Not all of the sublevel outcomes are assessed in each examination cycle and the assessment time necessarily limits the number of questions. The HE representatives would like there to be more time for assessment and a greater coverage of the syllabus, including more assessment of mathematical techniques.

The Group considered the nature of the questions in Component One of the Certificate in Mathematics for Engineering in comparison with the A2 component of A level. They both tend to be broken into three parts, but A level Mathematics has a higher proportion of unstructured questions (estimated at 25-30%) introduced to provide evidence for the top grades. By comparison the questions in the Certificate in Mathematics for Engineering are very structured and more akin to AS questions in style. There is less opportunity to demonstrate fluency across a range of mathematical skills. However, this greater structuring is potentially counterbalanced by the greater difficulty in obtaining an A grade as referred to above.

The HE members concluded that, while they were happy with the content of the Certificate in Mathematics for Engineers, they were concerned at the time constraints and adequacy of the assessment arrangements and noted that some of the matters identified would need to be worked out by OCR in respect of the first award of the Certificate in Mathematics for Engineers. The HE representatives would like to see more unstructured questions in the Certificate in Mathematics for Engineering, more evidence of the assessment of breadth and greater coverage of the very wide syllabus.

The Group also briefly considered the use of calculators in the examination room for both qualifications. It was the HE view that it is very useful for there to be examinations at which calculators are not permitted. For Mathematics A level one of the AS examinations out of three is non-calculator and calculators are allowed for all A2 examinations. This includes programmable calculators although their use must be shown. There are no restrictions on calculators for the Certificate in Mathematics for Engineering.

4.8 Aligning the grades

The Group was informed that it is the intention of the regulator that the grades A* - E for the Certificate in Mathematics for Engineering should align directly with the equivalent grades for A level. The Group was happy to accept this assurance, but sought formal confirmation of the position from OCR subsequent to the meeting.OCR has since confirmed that grade descriptors for the OCR Level 3 Certificate in Mathematics for Engineering will be the same as those used for GCE A Level Mathematics.

However, there was further discussion about how relatively easy it might be to achieve Grade A in each qualification. The A level assessment is currently based on six units with a total of nine hours of examinations. The assessment of the Certificate in Mathematics for Engineering is based on only two examinations. The Group considered that it is difficult to obtain a good grade with only two examinations covering a wide syllabus. This also makes it more difficult for students and teachers to predict the questions.

It was also noted that there is flexibility to re-take one or more units in the Mathematics A level in order for candidates to improve their performance. Re-takes are possible for the Certificate in Mathematics for Engineering, but most components must be re-taken at the same sitting. This suggests a greater degree of criticality in the assessment of the Certificate.

The Group considered whether in the circumstances it could align the grades of the two qualifications with confidence. There were felt to be some difficulties over this in the absence of assessment objectives and grading criteria for the Certificate in Mathematics for Engineering. The Group re-visited the question of unstructured questions (25-30% of A2 in A level Mathematics) and noted that it would be possible to obtain a good grade in the Certificate without the candidate having tackled unstructured questions. This suggested a need to proceed with caution.

However, it was also noted that the six examinations in Mathematics A level, each covering relatively small chunks of learning, might be easier and students are likely to have a good idea of what the questions will cover. It might be more difficult for candidates for the Certificate in Mathematics for Engineering to do well because of the breadth of the syllabus and limited assessment. There were also concerns about the basis for the award of A* for the Certificate.

While these factors could potentially be thought to counterbalance each other, they give reason to doubt that the level of demand represented by each grade is the same in each qualification. Their concerns particularly related to the Certificate as a standalone qualification rather than Advanced Diploma ASL building on unit F563.

The Group concluded that, in addition to the statement to be requested from OCR as above, OFQUAL should be asked to clarify that Grade A in the Certificate in Mathematics for Engineering is intended to be the same level of award as Grade A in A level, as was understood to be the case for Advanced Diploma Principal Learning. It would be prepared to regard the grades of the two qualifications as aligning providing that statements to this effect are forthcoming from OCR and OFQUAL.

4.9 Domain scoring

The Group then proceeded to review the domain scoring undertaken by members in advance of the meeting.

The chart below shows the scores for Tariff domains based on the Group as a whole and the HE members only. The overall scores showed a close similarity between the two qualifications with aggregate mean scores from the Group as a whole of 21.2 for the Certificate in Mathematics for Engineering and 21.0 for Mathematics A level. For the HE members only the order was reversed slightly with scores of 19.2 for the Certificate and 19.5 for A level.

Unsurprisingly both qualifications scored well in respect of Use and Apply and Numeracy Skills but scored very low on Literacy and Language Skills, Personal and Social Skills and

Vocational and Practical Skills There was no domain where there was any substantial difference in score between the two qualifications and from this exercise they could be deemed effectively equal in their utility for progression to HE.

Table 5: Domain scores

Domain Element	Mean Score – All reps		Mean Score – HE reps only	
	Maths for Engineering	A evel	Maths for Engineering	A level
Use and apply	4.2	4.2	3.9	3.9
Application and analysis of ideas, knowledge and theory	3.3	3.4	2.9	3.1
Synthesis and evaluation	2.4	2.5	1.8	2.1
Logical and critical thinking	3.1	3.2	2.5	2.9
Literacy and language skills	0.8	0.8	1.0	1.0
Numeracy skills	4.4	4.6	4.1	4.3
Personal and social skills	0.1	0.1	0.1	0.1
Learning skills	1.8	1.8	1.7	1.8
Vocational and practical skills	1.1	0.4	1.3	0.4
TOTAL	**21.2**	**21.0**	**19.2**	**19.6**

4.10 Recommended allocation of UCAS Tariff points

The Group then proceeded to recommend the allocation of UCAS Tariff points to the Certificate in Mathematics for Engineering.

In terms of content the Group was impressed by the breadth of coverage of the Certificate, representing a significant part of A level and mapping against A2 units and Further Pure Mathematics units in some cases. The qualification is graded A*–E suggesting an equivalence to A2 in the view of the regulator. The Certificate has considerable utility for progression to Engineering degree courses in the view of the HE representatives, and this is demonstrated in the domain scores which are virtually on a par with Mathematics A level. In many ways the two qualifications were judged to be a good match, and the above factors would suggest a Tariff score significantly in excess of half of an A level (which is the score for an AS qualification). The Group was clear that the Certificate is harder than AS and therefore worth more Tariff points.

However, the Guided Learning Hours are only 180 compared with 360 for A level. It was the Group's opinion that this was unrealistically low for the volume and breadth of the content. While the qualification clearly is larger than this, there could be concerns about delivery if funding is only for 180 GLH. The HE representatives were particularly concerned at the limited amount of assessment for the breadth of content and at the lack of unstructured questions. However, the marking system might make it more difficult to achieve a good grade in the Certificate as might the limited number of questions in respect of a breadth of content.

The Group had concerns about the alignment of grades but was prepared to accept the assertion of alignment with A level grades provided this is backed up formally by OCR and OFQUAL. The Group also noted that no candidate evidence is available to date and that the

information from OCR about assessment and grading is currently incomplete. The Group's recommendation is therefore provisional and subject to review when evidence is available.

The Group agreed that some measure of uplift from the score for GCE AS (Grade A – 60) was necessary to reflect the greater content and challenge and the strong utility for progression to HE. It was also necessary to acknowledge the difficulty for candidates in being assessed on a broad range of content through a limited number of examination questions and the criticality of assessment without the flexibility for re-sitting units as in A level. However, a Tariff score equivalent to that for A level (Grade A – 120) would not be justified on grounds of size and assessment arrangements. It was therefore proposed to establish Grade A for the Certificate in Mathematics for Engineering at the midpoint between AS and A level ie Grade A – 90. In order to keep in synchronisation with the steps between grades in A level and to provide equal increments from one grade to the next, the following Tariff points were recommended:

OCR Level 3 Certificate in Mathematics for Engineering

Grade A	90
Grade B	75
Grade C	60
Grade D	45
Grade E	30

The Group felt that it currently had insufficient evidence concerning the award of A* for the Certificate in Mathematics for Engineering to recommend the allocation of Tariff points at this stage. By numerical extrapolation a score of 105 could be arrived at for A*, but the Group would wish to receive a definitive statement from OFQUAL or OCR on the award of A* in the Certificate in Mathematics for Engineering before confirming this provisional recommendation. OCR has since confirmed that A* will be awarded by taking extrapolated A* grades across a range of Mathematics units.

All the Group's recommendations are provisional and will need to be the subject of review when sufficient candidate evidence is available for the Certificate in Mathematics for Engineering.

APPENDIX 1 BIOGRAPHIES OF THE EXPERT GROUP MEMBERS

UCAS COMPARABILITY STUDY

Outline Biography of Expert Group Member

Name: **Ken Barley**

Current Position: Chair of Examiners

Organisation: OCR

Qualifications: B Sc, M Ed

Brief Biography

Education
1968-1971 Kings' College, London 1st Class Honours B Sc degree in Mathematics
1971-1972 Manchester University Research in Astophysics
1984-1985 Leicester University School of Education, M Ed

Employment
1972-1976 Sowerby Bridge Grammar School, Calderdale
Teacher of Mathematics

1976-1979 Matthew Murray High School, Leeds
Second in Maths Dept

1979-2003 Montagu School, Kettering
1979-1992 Head of Maths Dept
1985-1992 Also Senior Teacher
1992-2003 Deputy Head
Responsibilities varied, but included Finance (inc GM status), staff recruitment and deployment and timetabling, work with Governors, admissions and appeals.

2003- Staff Chair of Examiners for Maths, Functional Skills and RS
Duties include chairing question paper setting and awarding meetings

UCAS COMPARABILITY STUDY

Outline Biography of Expert Group Member

Name: **Robert Coombes**

Current Position: Programme Leader Engineerig & Manufacturing Studies

Organisation: North Devon College

Qualifications: BSc HNC Electrical & Electronic Eng. Cert Ed, ONC Eng.

Brief Biography

Programme leader for Engineering & Manufacturing Sudies in the Department of Technology & Computing at North Devon College. I have direct management resposibilities for our programmes from level 2 through to Level 4. Programme manager for:FdSc in Electronics & Communications, FdSc in Mecanical Design & Manufacture, FdSc in Digital Technology.
I am currently teaching HE modules: Analytical Methods, Electrical & Electronic Principles and Electronics. Stage two modules including Instrumentation and Control, Control Principles, Electronic Systems and support UoP Project work at stage three.
In preveious academic years have taught other modules including Communication systems and Software Engineering. The majority of my teaching requires students to be able to deal with a significant amount of mathematical materials in a variety of forms including paper based, computer assisted simulations or problems solving.
I've taught sinse 1984, at all levels in FE, including access course (year 0) mathematics and 3 mathematics, and for the much of this time delivered Engineering HE modules.
For ten years, until 1984 worked up to Assistant Senior Technician at Oxford Brookes formally Oxford Polytechnic, in the Department of Engineering, where I worked with the teaching staff on consultancy and work associated with final year and post graduate projects. First teaching post was at West Oxfordshire College til 1999 when I moved to North Devon College.
Recently (Dec 2008) been successful in a KTEN Knowledge Transfer Exchange Node from New Engineering Foundation of £150000 to research the impact of University projects and research, and local industry in North Devon.
I've had an Industrial placement at TDK Lambda UK during the summer (2007)
Improving the teaching of mathematics and science to engineers Pilot project for the DFES / Standards Unit.(2005)
Subject specialist in the application of mathematics software, CAD/CAM and the application of ECAD simulation software.

UCAS COMPARABILITY STUDY

Outline Biography of Expert Group Member

Name: **Dr VGA Goss**

Current Position: Senior Lecturer

Organisation: LSBU

Qualifications: PhD, MSc, BEng (hons), ONC, City and Guilds

Brief Biography

I am Course Director for BEng (hons) Mechanical Engineering (full and part-time modes). Since taking over the course inn 2005, I implemented substantial changes, which led to the programme being accredited by IMechE for CEng status.

My major teaching duties are as follows:
Applied Mechanics level 1
Dyamics level2
Dynamics level 3
First Year mathematics for BEng

I also carry out substantial teaching in the following units:
Sustainable Engineering Design level 2
Machine Drives and Mechatronics level 2
Fuid Mechanics level 3

Research:
I have publications on Elastic rod theory, History of Mechanics, Biomechanics and Tractor Seat vibrations, as follows.

Publications:

- Cook, D, Mileva, K, James, D, Bowtell, J, Zaidell,L, Goss,VGA (2008) Transmissibility of vibration based acceleration during whole-body vibration training, Accepted for Publication.
- Goss, VGA (2008) The history of the planar elastica: insights into mechanics and scientific method, Science and Education, In Press.
- Duke, M, Goss, VGA., (2007) Investigation of tractor driver seat performance with non-linear stiffness and on-off damper, Biosystems Engineering.
- Goss, VGA, van der Heijden, GHM, Neuikirch,S, Thompson JMT (2005) Experiments on Snap Buckling, Hysteresis, and Loop Formation in twisted Rods, Experimental Mechanics, 45 (2), 101-111.
- van der Heijden GHM, Neukirch, S, Goss, VGA, Thompson, JMT (2003) Instability and self-contact phenomena in the writhing of clamped rods, International Journal of Mechanical Sciences, 45 (1), 161-196.
- Goss,VGA., Gears governors, millwrights, and maths (in preparation)

Higher education:
PhD: 1997-2003 (part-time mode) Nonlinear Dynamics -- experiments and mathematical analysis of bent and twisted rods
MSc: 1994-1996 (part-time mode) Nonlinear Dynamics
BEng: 1990-1994 (part-time mode) Mechanical Engineering

UCAS COMPARABILITY STUDY

Outline Biography of Expert Group Member

Name: **Dr Tim Scott**

Current Position: Senior Lecturer in Applied Mathematics

Organisation: University of Hull

Qualifications: BSc, PhD (London), MInstP, CPhys, FIMA, CMath, FHEA

Brief Biography

I am currently Head of the Centre for Mathematics at the University of Hull. The Centre is attached to the Department of Engineering and, in addition to engineering modules, provides undergraduate and postgraduate modules in mathematics to students across the Faculty of Science and the Centre for Educational Studies. I also have additional responsibilities for coordinating the Science Foundation Year and, as Faculty Admissions Tutor, overseeing undergraduate admissions to the Faculty of Science.

Apart from various Department and Faculty responsibilities, I am an elected member of the University Senate and deputy chairman of the University Student Recruitment Committee. I also chair a sub-group of this committee which considers policy on the recognition of new qualifications.

Before joining the University of Hull in 1993, I was with the United Kingdom Atomic Energy Authority (1981 - 1993). Prior to that, I held postdoctoral appointments at the University of Durham and the University of Southern California.

My interests are in environmental and industrial applications of mathematics and numerical methods, and the concepts and principles for the teaching of mathematics to non-specialists. Publications are mainly in theoretical physics and engineering.

UCAS COMPARABILITY STUDY

Outline Biography of Expert Group Member

Name: **Mick Jennings**

Current Position: Chief Examiner for AS/A level Mechanics

Organisation: Edexcel

Qualifications: B A Mathematics PGCE

Brief Biography

I have been examining for about 30 years at O level ,GCSE , AS and A level in Statistics, Pure Mathematics and Mechanics. I have worked for a number of exam boards but about 15 years ago I was appointed as a Principal Examiner at Edexcel for AS/A level and more recently, 4 years ago, as the Chief Examiner for Mechanics. I have overall responsibility for the setting and marking of the five Mechanics units M1 - M5 that are currently offered and also run feedback meetings for teachers on the mechanics units.

My day job is teaching and I have 33 years of experience. I have taught in a number of state grammar schools and 6th Form colleges but for the past 20 years I have been and am currently Head of Mathematics at the Royal Grammar School, Guildford where I lead a department of 13 staff.

Over the yearsI have taught on many intensive student revision courses for AS/A level, both residential and one day, but more recently have concentrated on providing i day INSET courses for teachers on the teaching of C1 - C4, M1 and M2. I have written a number of AS and A level Revision Guides for Letts and currently am one of the authors and the chief editor for the new Heinemann series of Mechanics textbooks - M1 has already been published, M2 is about to be and M3, M4, and M5 are due by the summer.

APPENDIX 2THE EVIDENCE CONSIDERED

OCR Mathematics for Engineering

Course Handbook

Specimen Papers

Edexcel GCE in Mathematics

For purposes of this work only Units C1–C4, M1 and M2 were considered

Specification

Sample Assessment Materials

Mathematical Formulae and Statistical Tables

Tutor and Student Guidance

APPENDIX 3 ADDITIONAL BACKGROUND INFORMATION

The Engineering Professors' Council (EPC) created a Mathematics Working Group in 2001 to improve the general standard of mathematics of entrants to university engineering degree courses. In 2007 it formed a special sub-group – the Maths Task Group (MTG) – to address the perceived deficiencies in the mathematics content within the Advanced Diploma in Engineering. The MTG consists of representatives drawn from the EPC, Higher Education Academy's Engineering Subject Centre, RAEng, NCETM, MEI, EDDP, OCR and QCA.

The purpose of the Mathematics for Engineering (M4E) certificate is to provide the mathematics necessary to enable Advanced Diploma in Engineering students to progress onto university degree courses in engineering and related studies. It thus mirrors A level mathematics but with a more focused content. It is anticipated that only a minority of students dedicated to a career in engineering via university will choose to take this certificate.

The certificate is based on the long-standing and very successful Loughborough University Foundation Course in Mathematics which has been used to prepare students without traditional A level mathematics to enter Loughborough's wide range of engineering and technology courses. This course is taught in the equivalent of 90 GLH. There are many examples of students entering through this route subsequently achieving better results than those with traditional A level mathematics.

M4E is designed as an Additional and Specialist Learning (ASL) unit to complement the mathematics taught in the Principal Learning (PL) unit of the Diploma. The 180 GLH allocated to the certificate should thus be augmented by the 60 GLH allocated within the PL. It is also assumed that the Diploma students selecting to take this option would be guided to take an Extended Project containing significant mathematics, further boosting the gross GLH count.

While the M4E curriculum is inevitably very close to that of A level Mathematics, a distinctive feature is the development of a growing range of 'Exemplars' which are designed to demonstrate the mathematics from each curriculum topic being used in real industrial applications. These exemplars are all supported by industrial companies and written by practising engineers with support from the Mathematics Task Group. They are available on the RAEng website and are already being used by the current Diploma students.

The M4E examination is designed in two parts. Part A is a conventionally structured test of mathematical principles with 12 short questions. Part B is different. The MTG were keen to encourage testing *understanding* rather than knowledge recall within the students and so conceived the idea of setting a technical scenario some weeks in advance of the examination. (This scenario setting was seen as essential in order not to disadvantage students who may not have come across that particular area of engineering during their diploma studies.) Four unseen and relative unstructured questions are then set under examination conditions. A pilot workshop was run in June 2008 to test this process and 17 students studying on foundation (year zero) courses or the equivalent from five universities completed both Parts A and B under test conditions. Inevitably the students found the approach of Part B demanding as it

was quite new to them, but they recognised the value of such an approach if accompanied by 'contextualised' teaching'.

The content and orientation of the M4E curriculum has been demonstrated by the decision to recommend it for inclusion in other diploma lines, such as Manufacturing and Construction and the Built Environment. This led to M4E being offered as a Free Standing Unit in the Diploma Catalogue. However, it has been clearly recognised that M4E builds on the PL unit in the Engineering Diploma and would not be taken by those studying other diploma lines without them having previously studied this PL unit. For this reason the PL unit from the Engineering Diploma has been added to the Diploma Catalogue as ASL available on other diplomas