QAA

Subject benchmark statement

Engineering

2006

ISBN 1 84482 526 4

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Linney Direct
Adamsway
Mansfield
NG18 4FN

Tel 01623 450788
Fax 01623 450629
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Preface

Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject or subject area. They also represent general expectations about standards for the award of qualifications at a given level in terms of the attributes and capabilities that those possessing such qualifications should have demonstrated.

This subject benchmark statement, together with others published concurrently, refers to the **bachelor's degree with honours**[1]. In addition, some statements provide guidance on integrated master's awards.

Subject benchmark statements are used for a variety of purposes. Primarily, they are an important external source of reference for higher education institutions when new programmes are being designed and developed in a subject area. They provide general guidance for articulating the learning outcomes associated with the programme but are not a specification of a detailed curriculum in the subject.

Subject benchmark statements also provide support to institutions in pursuit of internal quality assurance. They enable the learning outcomes specified for a particular programme to be reviewed and evaluated against agreed general expectations about standards. Subject benchmark statements allow for flexibility and innovation in programme design and can stimulate academic discussion and debate upon the content of new and existing programmes within an agreed overall framework. Their use in supporting programme design, delivery and review within institutions is supportive of the recent and ongoing move towards an emphasis on institutional responsibility for standards and quality.

Subject benchmark statements may also be of interest to prospective students and employers, seeking information about the nature and standards of awards in a given subject or subject area.

The relationship between the standards set out in this document and those produced by professional, statutory or regulatory bodies for individual disciplines will be a matter for individual institutions to consider in detail.

This subject benchmark statement represents a revised version of the original statement published in 2000. The review process was overseen by the Quality Assurance Agency for Higher Education (QAA) as part of a periodic review of all subject benchmark statements published in this year. The review and subsequent revision of the subject benchmark statement was undertaken by a group of subject specialists drawn from and acting on behalf of the subject community. The revised subject benchmark statement was subject to a full consultation with the wider academic community and stakeholder groups.

QAA publishes and distributes this subject benchmark statement and other subject benchmark statements developed by similar subject-specific groups.

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[1] This is equivalent to the honours degree in the Scottish Credit and Qualifications Framework (level 10) and in the Credit and Qualifications Framework for Wales (level 6)

Contents

Foreword

Since the publication of the original *Subject benchmark statement* for engineering in 2000 there have been a number of important publications in relation to professional and academic standards in engineering: the *Graduate Output Standard* produced by the Engineering Professors' Council (EPC) in December 2000 and the *UK Standard for Professional Engineering Competence* (UK-SPEC) by the Engineering Council UK (EC^{UK}) for both professional registration (December 2003) and the accreditation of higher education programmes (May 2004). The outcomes-based approach of the subject benchmark statement was certainly helpful in the development of these later documents to the extent that, after the publication of the UK-SPEC for the accreditation of higher education programmes, there was a strong feeling expressed by the academic subject community that there was a pressing need to review and rationalise these different standards documents.

EC^{UK} and EPC jointly approached the Quality Assurance Agency for Higher Education (QAA) about the need to align these existing documents. It was recognised that there was strong support from the academic community to work towards a single, unified standard. Once the arrangement for the review of subject benchmark statements had been finalised by QAA's Steering Group for Benchmarking, QAA invited EC^{UK} and EPC to form a review group for the subject benchmark statement for engineering. In putting together the group care was made to take account of representation by engineering bodies and stakeholders, including European and employer perspectives (see Appendix B). The approach to the revision of the subject benchmark statement has acknowledged and recognised the evolutionary nature of the output standards for engineering and the way in which the UK-SPEC adopted the general model of the subject benchmark statement while incorporating thinking and insights developed through EPC's work. This, coupled with the widespread acceptance of the UK-SPEC, led the review group to believe that the standard in the UK-SPEC could be adopted as the revised subject benchmark statement standard. In considering this approach, the review group gave particular consideration to the nature and status of non-accredited degree programmes. Initial feedback on this approach of adopting the UK-SPEC standard for the revised subject benchmark statement was supportive so the review group consulted on a revised subject benchmark statement drafted on this basis. The review group was very encouraged by responses to the consultation exercise and was left in no doubt that this was the best approach for the second edition of the subject benchmark statement.

Another important feature of this second edition subject benchmark statement is the bringing together of the honours and integrated master's awards (MEng), as the MEng statement was originally published as a separate annex in 2002.

The review group is very grateful to all those who contributed to the discussions and who submitted comments to the consultation. We can be confident that this approach will be well received and believe the combined approach to standards will serve better the needs of our colleagues.

Professor David Bonner
Chair, Review group for the subject benchmark statement for engineering

Professor Kel Fidler
Chairman, Engineering Council UK

Professor Tony Unsworth
President, Engineering Professors' Council

General introduction

The QAA brief for the subject benchmark statement is to produce 'generic statements which represent general expectations about standards for the award of honours degrees in Engineering'.

This revised subject benchmark statement defines the academic standard expected of graduates with an engineering degree. The defined learning outcomes are those published by the Engineering Council UK (EC^{UK}) in the *UK Standard for Professional Engineering Competence* (UK-SPEC): *The Accreditation of Higher Education Programmes* (2004). These learning outcomes, also described by the engineering community as 'output standards', have evolved from the first edition of the *Subject benchmark statement* for engineering (QAA, 2000) and the Engineering Professors' Council (EPC) *Engineering Graduate Output Standard* (published 2000). By using the latest published learning outcomes from the EC^{UK} in this revised subject benchmark statement, programme providers can now use a single set of learning outcomes. The learning outcomes are expressed for the threshold level that engineering students would be expected to have attained upon graduation. It is anticipated that there will be many programmes where this threshold level will be exceeded.

This subject benchmark statement covers engineering degrees at the honours level and at the integrated master's level (MEng), as defined in *The framework for higher education qualifications in England, Wales and Northern Ireland* (FHEQ). The subject benchmark statement also includes guidance on the applicability of the learning outcomes to degrees designed as a basis for registration as an Incorporated Engineer (IEng). (Further guidance on the character and standards of Foundation Degrees can be found in the *Foundation Degree qualification benchmark.*)

Programme providers should be able to use subject benchmark statements to establish standards for a diverse range of programmes, which should encourage innovation and creativity in curriculum design. For programmes that are interdisciplinary in nature it will be appropriate to draw on a number of subject benchmark statements. It is important to note that the use of the subject benchmark statement in programme design is not sufficient to secure professional accreditation.

Nature and extent of the subject

Engineering is concerned with developing, providing and maintaining infrastructure, products, processes and services for society. Engineering addresses the complete life cycle of a product, process or service, from conception, through design and manufacture, to decommissioning and disposal, within the constraints imposed by the commercial, legal, social, cultural and environmental considerations. Engineering relies on three core elements, namely scientific principles, mathematics and 'realisation'. Scientific principles clearly underpin all engineering, while mathematics is the language used to communicate parameters, model and optimise solutions. Realisation encapsulates the whole range of creative abilities which distinguish the engineer from the scientist; to conceive, make and actually bring to fruition something which has never existed before. This creativity and innovation to develop economically viable and ethically sound sustainable solutions is an essential and distinguishing characteristic of engineering, shared by the many diverse, established and emerging disciplines within engineering.

The characteristics of engineering graduates

The creative way of approaching all engineering challenges is being seen increasingly as a 'way of thinking' which is generic across all disciplines. In order to operate effectively, engineering graduates thus need to possess the following characteristics. They will be rational and pragmatic, interested in the practical steps necessary for a concept to become reality. They will want to solve problems and have strategies for being creative, innovative and overcoming difficulties by employing their knowledge in a flexible manner. They will be numerate and highly computer literate, and capable of attention to detail. They will be cost and value-conscious and aware of the social, cultural, environmental and wider professional responsibilities they should display. They will appreciate the international dimension to engineering, commerce and communication. When faced with an ethical issue, they will be able to formulate and operate within appropriate codes of conduct. They will be professional in their outlook, capable of team working, effective communicators, and able to exercise responsibility.

Engineering at bachelor's and master's levels

There is general agreement among the UK engineering community, professional and academic, that the EC^{UK} accreditation critieria meet the general expectations for an honours degree in engineering. On this basis an honours degree will correspond to the generic qualifications descriptor for the honours degree in the FHEQ. Graduates from both accredited and non-accredited degree programmes will be expected to have achieved the academic standard as set out in this subject benchmark statement.

An MEng is an integrated master's programme in engineering which provides an extended and enhanced programme of study; it is designed to attract the more able student. The period of study is typically equivalent to at least four years of academic learning (five years in Scotland) and the programme of study should be both broader and deeper than a corresponding BEng Hons.

The MEng is different in principle from an MSc in engineering. MSc programmes in engineering are typically designed as stand-alone programmes to extend the depth of study in a relatively closely-defined discipline. In the future they are likely to find further application as qualifications to certify advanced or updated learning. MEng programmes are usually designed, with reference to UK-SPEC, as a preparation for professional practice. There should be increased breadth and depth of study beyond that of a corresponding BEng Hons, and an increased emphasis on industrial relevance. Project work within an MEng programme would include both an individual research/design project and a more wide-ranging group project with strong industrial involvement. Increased breadth can be provided by study of additional technical subjects and by study of, for example, business, management and industrial topics. Increased depth can be provided by both specific study at master's level and integrative study of work already undertaken at honours degree level (Level H). These components may typically be distributed throughout the later stages of an integrated programme of study, with relevant learning outcomes associated with the integration of broad technical aspects, and with working in a cooperative venture.

The MEng should not be designed or perceived as simply an 'add-on' year to a BEng Hons. The programme of study should be designed as an integrated whole from entry to completion, although some of the earlier parts may be delivered in common with a parallel BEng Hons. Transfer between programmes leading to BEng Hons and MEng programmes is usually possible. Progression to MEng programmes should be subject to performance criteria that indicate likely progression to the more demanding outcomes expected for the award of a master's degree.

It is important to note that there are a number of different routes that the MEng might take. The FHEQ identifies the outcomes required for the award of master's degrees. While not prescribing the amount of work that is assessed at master's level these requirements would be unlikely to be achieved if only the equivalent of half of an academic year had been studied at master's level. Programme designers should ensure that students awarded an MEng will have undertaken adequate work at master's level to warrant this qualification. It is likely that this will be equal to at least the equivalent of one academic year of study assessed at master's level and this will normally be distributed over more than one year of study. It is acknowledged, however, that there are ongoing discussions in relation to the Bologna Process about whether the student who graduates with an integrated MEng has met the requirements of the Dublin descriptors for second cycle awards. At the time of writing it is the general UK view that, providing the integrated MEng programme satisfies the characteristics described above, then this is the case.

Engineering degrees and professional practice

There are many different types of engineering degree programme, but all are designed to equip their graduates with knowledge, understanding and skills which will enable them to begin a professional career in some aspect of engineering or technology. Not all graduates will proceed in this way, for these attributes also make them attractive to many different sorts of employer in industry, finance, consultancy, and the public services. For those who do, membership of a professional engineering institution and registration with EC^{UK} as a Chartered Engineer or IEng are not obligatory. However, many graduates do seek these forms of professional recognition, and EC^{UK}'s requirements for registration incorporate a competence framework which is applicable to most forms of professional engineering employment[1]. Engineering degrees provide the intellectual foundations for eventual professional registration, which will be developed after graduation by a mixture of work-related education and training and on-the-job experience.

Professional engineering occupations have many different characteristics. A useful broad distinction is the one the engineering profession makes between Chartered Engineers and IEngs. Both use creativity and innovation and are involved in activities such as design, production, construction, operation, and disposal. Both are also likely to be involved in commercial and technical management. However, Chartered Engineers are likely to be more concerned with the development and application of new technologies, concepts, techniques, and services, while IEngs will be particularly concerned with the application and management of current technology. Most engineering degrees are designed particularly to lay the foundations for one or other of these two types of career.

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[1] See UK-SPEC 2003. UK-SPEC sets out five main areas of competence, each covering a number of different aspects:

A Use of general and specialist engineering knowledge and understanding
B Application of appropriate theoretical and practical methods
C Technical and commercial leadership and management
D Effective interpersonal and communication skills
E Commitment to professional standards and recognition of obligations to society and environment.

Professional accreditation of academic programmes

The majority of engineering degree programmes are designed with a view to their being accredited by a professional engineering institution. This is how the engineering profession confirms that a programme of study provides the knowledge, understanding and skills necessary to underpin eventual professional competence. The focus of accreditation is primarily on the outcomes achieved. Factors which have a bearing on these, such as approaches to teaching and learning, assessment strategies, human and material resources, quality assurance arrangements, and entry profiles will all be examined.

EC^{UK} sets the overall requirements for accreditation, and licenses the professional engineering institutions to undertake the accreditation within these, interpreting them as appropriate for their own sector of the profession. Accreditation is a rigorous process which has been refined over many years and is well recognised and respected. With the steady growth in international mutual recognition accords, it is gaining increasing currency as a transferable measure of degree standards.

Engineering is an enabling discipline which continues to expand steadily to embrace an ever-increasing range of knowledge and skills. While the majority of programmes are accredited, universities are always likely to design programmes which, because of their breadth or novelty, do not align with the current accreditation requirements of any one professional body. The acceptance and encouragement of novelty in programme design is one of the challenges confronting professional bodies in articulating their requirements and maintaining standards. Accreditation is not intended to discourage innovation in programme design. This is particularly the case for multidisciplinary or interdisciplinary programmes. Mechanisms exist for organising a joint accreditation visit involving several professional institutions where appropriate, and the current framework of accreditation standards is broad enough to accommodate a range of such programmes.

The international context for standards

UK engineers are engaged in projects all over the world, and many will spend time working overseas. Engineering underpins most exported goods and many services. The export of engineering services alone earns the UK a net £2 billion a year, more than any other service activity outside the financial sector.

Higher education (HE) is equally a global activity. UK universities have long attracted students from all over the world, in engineering as in all other subjects. This is only one part of the flow of students around the world, as many countries are actively promoting their HE systems worldwide. Within Europe, the Bologna Process has given added impetus to promoting mobility within a European Higher Education Area, with the associated development of a European Higher Education Qualification Framework.

There is therefore an increasing interest in the outcomes of different countries' engineering degrees. Since 1989, the UK has been a member of international accords, comprising the engineering degree accreditation bodies in a number of English-speaking countries, who agreed to recognise each others' accreditation decisions. As the number of countries interested in joining these accords has grown, to include several Asian and some European countries, so interest has shifted from the accreditation process to the outcomes of accredited programmes.

There have been similar developments within Europe. The drive within the Bologna process to develop a European Higher Education Qualification Framework has drawn attention to the importance of learning outcomes, as much as of programme structures or length. Engineering has been a pilot area in this respect. An EU-funded project, EURACE, in which the UK is participating, has developed a framework for accreditation of engineering degrees, within which national accreditation systems could sit. This would facilitate mutual recognition of accreditation decisions. This includes a set of statements of learning outcomes strongly influenced by the UK-SPEC.

The standards

The UK-SPEC sets out a competence framework for engineering professionals which, as we have seen, is applicable to all those in graduate engineering occupations. It provides for engineering degree programmes to be accredited if they provide the learning outcomes which will underpin eventual professional competence. The required learning outcomes are set out in the UK-SPEC: *The Accreditation of Higher Education Programmes* published by EC^{UK} in 2004 and can be found as Appendix A to this document. They were developed from the previous *Subject benchmark statement* for engineering (QAA, 2000), and refined the general and specific learning outcomes which that contained. The development reflects the newly formulated UK-SPEC competence standards, with their increased emphasis on issues such as sustainable development and ethics.

The learning outcomes described in the UK-SPEC, and reproduced in Appendix A, are applicable to all degrees providing a foundation for engineering registration. The learning outcomes of a bachelor's degree with honours, the most widely undertaken programme, provide a basis for employment, research or for further study to master's level. Graduates from these programmes who wish to become Chartered Engineers will need to undertake further learning to master's level. The learning outcomes for integrated masters' degrees are designed to ensure that graduates will have acquired the educational foundation for registration as Chartered Engineers. The learning outcomes set out in the UK-SPEC for degree programmes designed particularly as a basis for registration as an IEng (IEng degrees) are also included in Appendix A.

The statements are threshold statements; they describe the general expectations for what should be achieved by all those who graduate from these programmes. It is recognised, however, that most students will reach a higher level of attainment.

The standards do not constitute a prescribed curriculum. Programme providers have complete freedom over the way they design their programmes to deliver these outcomes. Moreover, the balance between the different outcomes, particularly the specific learning outcomes, will vary according to the nature and aims of individual degree programmes.

Some degrees will be designed as joint degrees, combining engineering with another subject such as business studies or a foreign language. In this case the outcome statements will still be an essential reference point for the engineering component of the programme. Other degrees may be genuinely interdisciplinary, but even for these the outcome statements equally provide a reference point, and should enable them to be accredited if desired.

The UK-SPEC requirements have been framed to be potentially applicable to all types of engineering degrees, in the same way as the original subject benchmark statements. Like those, they offer a framework for the design and development of all engineering degree programmes, whether or not accreditation is sought for these. They identify the subject matter of these programmes, and provide information to stakeholders about the content and standard of graduate output. For all these reasons, and because a single statement minimises the danger of conflicting interpretations, either in universities or in accrediting agencies, it is appropriate for the UK-SPEC output standards to serve also as the *Subject benchmark statement* for engineering.

Teaching, learning and assessment

There should be a holistic approach to the design of the curriculum. The methods of teaching, learning and assessment should be constructed so that the learning activities and assessment tasks are aligned with the learning outcomes that are intended in the programme.

Teaching and learning

Existing engineering programmes have been developed over many years and deploy a diverse range of learning, teaching and assessment methods to enhance and reinforce the student learning experience. This diversity of practice is a strength of the discipline. Whichever methods are employed, strategies for teaching, learning and assessment should deliver opportunities for the achievement of the learning outcomes, demonstrate their attainment and recognise the range of student backgrounds. The methods of delivery and the design of the curriculum should be updated on a regular basis in response to generic and discipline-specific developments, taking into account educational research, changes in national policy, industrial practice and the needs of employers.

Curriculum design must be informed by research, scholarship and an understanding of the potential destinations of graduates, and include the use of industrially-relevant applications of engineering. For students to achieve a satisfactory understanding of engineering the expectation is that they will have significant exposure to hands-on laboratory work and substantial individual project work. The curriculum should include both design and research-led projects, which would be expected to develop in graduates both independence of thought and the ability to work effectively in a team. Teaching needs to be placed within the context of social, legal, environmental and economic factors relevant to engineering.

Features of teaching and learning within an MEng programme that set it apart from a BEng Hons include deepening of technical understanding, additional emphasis on team/group working, an increase in the use of industrially-relevant applications of engineering analysis, and an enhanced capability for independent learning and work. While some of these may in part be included within some BEng Hons programmes, and can be developed through formal teaching and interactive classroom learning, within MEng programmes case studies, design work and projects are typically utilised more extensively especially during the final year when they build upon the learning of the previous years. These differences in programme design encourage and expect graduating MEng students to have greater capacities for independent action, accepting responsibilities, formulating ideas proactively, dealing with open-ended and unfamiliar problems, planning and developing strategies, implementing and executing agreed plans, leading and managing teams where required, evaluating achievement against specification and plan, and decision making. The inclusion of such elements within the design of programmes should aid in preparing students for subsequent leading roles in technical and/or managerial activities. Periods of work in industry may also be used to supplement the formal study through, for example, sandwich courses. Such programmes may well be of extended duration to ensure that all of the academic requirements and components have been covered.

All degree programmes in engineering provide guidance and support for their students but there is an expectation that MEng students will be increasingly self-reliant particularly during the later stages of their programme.

Teaching and learning resources, and other help and advice, are available from the Higher Education Academy (HEA) - Engineering Subject Centre at www.engsc.ac.uk

Assessment

An implication of defining output standards for engineering degrees is that, normally, all students graduating with such degrees will be able to demonstrate that they have achieved these standards. Programme providers need to make clear how this is ensured.

Assessment is the means by which students are measured against benchmark criteria and should also form a constructive part of the learning process. There should be a programme level approach to assessment that ensures output standards are met.

Further information and guidance on assessment has been published by the HEA - Engineering Subject Centre, *Assessment of Learning Outcomes*. This work aligns with the *Subject benchmark statement* for engineering.

Appendix A - UK-SPEC: The Accreditation of Higher Education Programmes (EC^{UK}, 2004)[2]

General Learning Outcomes

Graduates with the exemplifying qualifications, irrespective of registration category or qualification level, must satisfy the following criteria:

Knowledge and Understanding: they must be able to demonstrate their knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics. They must have an appreciation of the wider multidisciplinary engineering context and its underlying principles. They must appreciate the social, environmental, ethical, economic and commercial considerations affecting the exercise of their engineering judgement.

Intellectual Abilities: they must be able to apply appropriate quantitative science and engineering tools to the analysis of problems. They must be able to demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs. They must be able to comprehend the broad picture and thus work with an appropriate level of detail.

Practical skills: they must possess practical engineering skills acquired through, for example, work carried out in laboratories and workshops; in industry through supervised work experience; in individual and group project work; in design work; and in the development and use of computer software in design, analysis and control. Evidence of group working and of participation in a major project is expected. However, individual professional bodies may require particular approaches to this requirement.

General transferable skills: they must have developed transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT [information technology] facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD [continuing professional development].

Specific Learning Outcomes in Engineering

Graduates from accredited programmes must achieve the following five learning outcomes, defined by broad areas of learning. As set out here, the outcomes apply to accredited programmes at Bachelor (Honours) level leading to CEng registration. See pages 13 and 15 for an explanation of how they might be applied to accredited MEng degrees and to accredited Bachelor's degrees leading to IEng registration, respectively.

The weighting given to these different broad areas of learning will vary according to the nature and aims of each programme.

Underpinning science and mathematics, and associated engineering disciplines, as defined by the relevant engineering institution

- Knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, to enable appreciation of its

[2] This is an extract from Part Two (*Output standards for accredited engineering programmes*) and has been reproduced by kind permission of the EC^{UK}.

scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies;

- Knowledge and understanding of mathematical principles necessary to underpin their education in their engineering discipline and to enable them to apply mathematical methods, tools and notations proficiently in the analysis and solution of engineering problems;
- Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.

Engineering Analysis

- Understanding of engineering principles and the ability to apply them to analyse key engineering processes;
- Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques;
- Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems;
- Understanding of and ability to apply a systems approach to engineering problems.

Design

Design is the creation and development of an economically viable product, process or system to meet a defined need. It involves significant technical and intellectual challenges and can be used to integrate all engineering understanding, knowledge and skills to the solution of real problems. Graduates will therefore need the knowledge, understanding and skills to:

- Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues;
- Understand customer and user needs and the importance of considerations such as aesthetics;
- Identify and manage cost drivers;
- Use creativity to establish innovative solutions;
- Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal;
- Manage the design process and evaluate outcomes.

Economic, social, and environmental context

- Knowledge and understanding of commercial and economic context of engineering processes;
- Knowledge of management techniques which may be used to achieve engineering objectives within that context;
- Understanding of the requirement for engineering activities to promote sustainable development;

- Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;
- Understanding of the need for a high level of professional and ethical conduct in engineering.

Engineering Practice

Practical application of engineering skills, combining theory and experience, and use of other relevant knowledge and skills. This can include:

- Knowledge of characteristics of particular materials, equipment, processes, or products;
- Workshop and laboratory skills;
- Understanding of contexts in which engineering knowledge can be applied (eg operations and management, technology development, etc);
- Understanding use of technical literature and other information sources;
- Awareness of nature of intellectual property and contractual issues;
- Understanding of appropriate codes of practice and industry standards;
- Awareness of quality issues;
- Ability to work with technical uncertainty.

Applicability of Output Standards to MEng degrees

Graduates from an accredited integrated MEng degree will have the general and specific learning outcomes described here and will have some of these to enhanced and extended levels. Crucially, they will have the ability to integrate their knowledge and understanding of mathematics, science, computer-based methods, design, the economic, social and environmental context, and engineering practice to solve a substantial range of engineering problems, some of a complex nature. They will have acquired much of this ability through involvement in individual and group design projects, which have had a greater degree of industrial involvement than those in Bachelors degree programmes.

General Learning Outcomes

The range of general learning outcomes described for graduates from Bachelors programmes will also apply to graduates from MEng programmes. In respect of general transferable skills, the following enhanced outcomes should be expected of MEng graduates:

- The ability to develop, monitor and update a plan, to reflect a changing operating environment;
- The ability to monitor and adjust a personal programme of work on an on-going basis, and to learn independently;
- An understanding of different roles within a team, and the ability to exercise leadership;

- The ability to learn new theories, concepts, methods etc in unfamiliar situations.

Specific Learning Outcomes

In respect of the specific learning outcomes, MEng graduates will also be characterised by some or all of the following (the balance will vary according to the nature and aims of each programme):

Underpinning science and mathematics, etc.

- a comprehensive understanding of the scientific principles of own specialisation and related disciplines;
- an awareness of developing technologies related to own specialisation;
- a comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations;
- an understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

Engineering Analysis

- Ability to use fundamental knowledge to investigate new and emerging technologies;
- Ability to apply mathematical and computer-based models for solving problems in engineering, and the ability to assess the limitations of particular cases;
- Ability to extract data pertinent to an unfamiliar problem, and apply in its solution using computer based engineering tools when appropriate.

Design

- Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations;
- Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.

Economic, social and environmental context

- Extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately;
- The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

Engineering Practice

- A thorough understanding of current practice and its limitations, and some appreciation of likely new developments;
- Extensive knowledge and understanding of a wide range of engineering materials and components;
- Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.

Applicability of Output Standards to IEng Programmes

IEng programmes will have an emphasis on developing and supporting the know-how necessary to apply technology to engineering problems and processes, and to maintain and manage current technology at peak efficiency.

A programme accredited for IEng will have the general learning outcomes described earlier in this document.

Specific Learning Outcomes

In relation to the specific learning outcomes, this focus on the application of developed technology and the attainment of know-how means that accredited IEng Bachelors degree programmes will have a different emphasis from those for intending Chartered Engineers. In particular, they are likely to give a greater weighting to developing a knowledge and understanding of engineering practice and processes, and to have less focus on analysis. Design will still be a significant component, especially in integrating a range of knowledge and understanding, but the emphasis will be on designing products, systems and processes to meet defined needs.

Similar learning outcomes will apply to accredited Higher National and Foundation Degree programmes, with particular strengths emphasised in any Further Learning undertaken to satisfy the academic requirements for IEng registration.

Underpinning science and mathematics, etc.

- Knowledge and understanding of the scientific principles underpinning relevant current technologies, and their evolution;
- Knowledge and understanding of mathematics necessary to support application of key engineering principles.

Engineering Analysis

- Ability to monitor, interpret and apply the results of analysis and modelling in order to bring about continuous improvement;
- Ability to apply quantitative methods and computer software relevant to their engineering technology discipline(s), frequently within a multidisciplinary context;
- Ability to use the results of analysis to solve engineering problems, apply technology and implement engineering processes;
- Ability to apply a systems approach to engineering problems through know-how of the application of the relevant technologies.

Design

Graduates will need the knowledge, understanding and skills to:

- Define a problem and identify constraints;
- Design solutions according to customer and user needs;
- Use creativity and innovation in a practical context;
- Ensure fitness for purpose (including operation, maintenance, reliability etc);

- Adapt designs to meet their new purposes or applications.

Economic, social and environmental context

- Knowledge and understanding of commercial and economic context of engineering processes;
- Knowledge of management techniques which may be used to achieve engineering objectives within that context;
- Understanding of the requirement for engineering activities to promote sustainable development;
- Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;
- Understanding of the need for a high level of professional and ethical conduct in engineering.

Engineering Practice

- Understanding of and ability to use relevant materials, equipment, tools, processes, or products;
- Knowledge and understanding of workshop and laboratory practice;
- Knowledge of contexts in which engineering knowledge can be applied (eg operations and management, application and development of technology etc);
- Ability to use and apply information from technical literature;
- Ability to use appropriate codes of practice and industry standards;
- Understanding of the principles of managing engineering processes;
- Awareness of quality issues and their application to continuous improvement.

Appendix B - Membership of the review group for the subject benchmark statement for engineering

Professor Helen Atkinson	University of Leicester (nominated by the Office of Science and Technology)
Janet Berkman	EEF
Professor David Bonner (Chair)	University of Hertfordshire
Dr Sarah Carpenter	The Higher Education Academy - Engineering Subject Centre
Professor Graham Davies	University of Birmingham (nominated by Royal Academy of Engineering)
Professor John Dickens	The Higher Education Academy - Engineering Subject Centre
Günter Heitmann	Technical University Berlin
Professor Fred Maillardet	Engineering Professors' Council
Professor Alistair Sambell	University of Northumbria
Mr Richard Shearman	Engineering Council UK
Mr David Young (deceased)	Universities UK

Observer

Professor Ian Freeston	Engineering Council UK

Appendix C - Engineering benchmarking group membership

Details provided below are as published in the original Subject benchmark statement for engineering (2000)

Dr R Best	South Bank University
Professor D Bonner	University of Hertfordshire
Mr R Chinn	WS Atkins Consultants Ltd
Dr W Cousins	University of Ulster
Dr T Davies	University of the West of England, Bristol
Professor K Fidler	The University of York
Professor E Fisher	University of Newcastle upon Tyne
Professor J Flower *	University of Warwick
Professor D Green	University of Glasgow
Mr D Heffer	Southampton Institute
Dr D Morrey	Oxford Brookes University
Dr D Pollard (Chair)	University of Surrey
Dr R Prager	University of Cambridge
Professor A Purvis	University of Durham
Professor N Syred	University of Wales, Cardiff
Professor G Taylor	Leeds Metropolitan University
Professor C Thomas	University of Birmingham

* (resigned due to ill health)

The Quality Assurance Agency for Higher Education
Southgate House
Southgate Street
Gloucester
GL1 1UB

Tel 01452 557000
Fax 01452 557070
Email comms@qaa.ac.uk
Web www.qaa.ac.uk

QAA114 06/06