



Subject benchmark statement

Engineering: Draft for consultation

September 2014

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How can I use this document?

This document is a subject benchmark statement for engineering, that defines what can be expected of a graduate in the subject, in terms of what they might know, do and understand at the end of their studies.

You may want to read this document if you are:

- involved in the design, delivery and review of programmes of study in engineering or related subjects
- a prospective student thinking about studying engineering, or a current student of the subject, to find out what may be involved
- an employer, to find out about the knowledge and skills generally expected of a graduate in engineering.

Explanations of unfamiliar terms used in this subject benchmark statement can be found in QAA's glossary.¹

¹ The QAA glossary is available at: www.qaa.ac.uk/about-us/glossary.

About subject benchmark statements

Subject benchmark statements form part of the UK Quality Code for Higher Education (the Quality Code) which sets out the Expectations that all providers of UK higher education reviewed by QAA are required to meet.² They are a component of *Part A: Setting and maintaining academic standards*, which includes the Expectation that higher education providers 'consider and take account of relevant subject benchmark statements' in order to secure threshold academic standards.³

Subject benchmark statements describe the nature of study and the academic standards expected of graduates in specific subject areas, and in respect of particular qualifications. They provide a picture of what graduates in a particular subject might reasonably be expected to know, do and understand at the end of their programme of study.

Subject benchmark statements are used as reference points in the design, delivery and review of academic programmes. They provide general guidance for articulating the learning outcomes associated with the programme but are not intended to represent a national curriculum in a subject or to prescribe set approaches to teaching, learning or assessment. Instead, they allow for flexibility and innovation in programme design within a framework agreed by the subject community. Further guidance about programme design, development and approval, learning and teaching, assessment of students, and programme monitoring and review is available in *Part B: Assuring and enhancing academic quality* of the Quality Code in the following Chapters:⁴

- *Chapter B1: Programme design, development and approval*
- *Chapter B3: Learning and teaching*
- *Chapter B6: Assessment of students and the recognition of prior learning*
- *Chapter B8: Programme monitoring and review.*

For some subject areas, higher education providers may need to consider other reference points in addition to the subject benchmark statement in designing, delivering and reviewing programmes. These may include requirements set out by professional, statutory and regulatory bodies, national occupational standards and industry or employer expectations. In such cases, the subject benchmark statement may provide additional guidance around academic standards not covered by these requirements.⁵ The relationship between academic and professional or regulatory requirements is made clear within individual statements, but it is the responsibility of individual higher education providers to decide how they use this information. The responsibility for academic standards remains with the higher education provider who awards the degree.

Subject benchmark statements are written and maintained by subject specialists drawn from and acting on behalf of the subject community. The process is facilitated by QAA. In order to ensure the continuing currency of subject benchmark statements, QAA initiates regular reviews of their content, five years after first publication, and every seven years subsequently.

² The Quality Code, available at www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code, aligns with the *Standards and Guidelines for Quality Assurance in the European Higher Education Area*, available at: www.engu.eu/wp-content/uploads/2013/06/ESG_3edition-2.pdf.

³ *Part A: Setting and maintaining academic standards*, available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-a.

⁴ Individual Chapters are available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-b.

⁵ See further *Part A: Setting and maintaining academic standards*, available at: www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/quality-code-part-a.

Relationship to legislation

Higher education providers are responsible for meeting the requirements of legislation and any other regulatory requirements placed upon them, for example by funding bodies. The Quality Code does not interpret legislation nor does it incorporate statutory or regulatory requirements. Sources of information about other requirements and examples of guidance and good practice are signposted within the subject benchmark statement where appropriate. Higher education providers are responsible for how they use these resources.⁶

Equality and diversity

The Quality Code embeds consideration of equality and diversity matters throughout. Promoting equality involves treating everyone with equal dignity and worth, while also raising aspirations and supporting achievement for people with diverse requirements, entitlements and backgrounds. An inclusive environment for learning anticipates the varied requirements of learners, and aims to ensure that all students have equal access to educational opportunities. Higher education providers, staff and students all have a role in, and responsibility for, promoting equality.

Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to learning. In addition, disabled students and non-disabled students are offered learning opportunities that are equally accessible to them, by means of inclusive design wherever possible and by means of reasonable individual adjustments wherever necessary.

⁶ See further the *UK Quality Code for Higher Education: General Introduction*, available at: www.qaa.ac.uk/publications/information-and-guidance/publication?PubID=181#.

About this subject benchmark statement

This subject benchmark statement refers to bachelor's degrees with honours and master's degrees in engineering.⁷

This version of the statement forms its second edition, following initial publication in 2000 and review and revision in both 2006 and 2010.⁸

The statement is aligned to, and should be read in conjunction with, the Engineering Council publication *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence* (third edition).⁹

Note on alignment with higher education sector coding systems

Programmes of study which use this subject benchmark statement as a reference point are generally classified under the following codes in the Joint Academic Coding System (JACS):

All codes under H (Engineering).¹⁰

Summary of changes from the previous subject benchmark statement (2010)

QAA has worked closely with the Engineering Council to ensure that this draft statement takes account of the review and revision of the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*, which was completed in May 2014. The draft statement reaffirms the link between the benchmark statement and the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*, and includes additional explanatory information regarding this link.

Other changes made are as follows:

- extension of the scope of the document to include master's degrees other than the integrated master's (typically MSc degrees)
- contextual updates, including the embedding of information on the international context (previously contained in a separate section)
- various minor edits to improve clarity and readability.

⁷ Bachelor's degrees are at level 6 in *The framework for higher education qualifications in England, Wales and Northern Ireland* (2008) and level 10 in the *Scottish Credit and Qualifications Framework* (2001), and master's degrees are at level 7 and level 11 respectively.

⁸ Further information is available in the *Recognition scheme for subject benchmark statements*, available at: www.qaa.ac.uk/publications/information-and-guidance/publication?PubID=190#.

⁹ *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*, available at: www.engc.org.uk/ahep.

¹⁰ Further information about JACS is available at: www.hesa.ac.uk/content/view/1776/649/.

1 Introduction

1.1 The purpose of this statement is to describe the academic standards expected of graduates of bachelor's degrees with honours and master's degrees in engineering. It also describes the attributes and capabilities that engineering graduates will have, and the nature of teaching, learning and assessment in engineering.

1.2 This statement is to be read in conjunction with the Engineering Council's *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence* - derived from the UK Standard for Professional Engineering Competence (UK-SPEC) - which sets out the output standards required of engineering programmes accredited for professional registration.

1.3 Since 2006, the engineering community has agreed that the academic standards expected of engineering graduates are the same as the learning outcomes for graduates of Engineering Council accredited degrees, as set out in the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*. For this reason a separate list of standards is not provided in this benchmark statement. Instead readers are referred to the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*. Additional information is provided about how the Accreditation of Higher Education Programmes output standards can be interpreted in the context of academic standards.

1.4 The advantages of this approach include enabling higher education providers to work from a single point of reference to meet academic and professional standards, and minimising the danger of conflicting interpretations, either in higher education providers or accrediting agencies.

1.5 It is acknowledged that, while most engineering degree programmes in the UK are accredited, and completing an accredited degree makes the subsequent process of professional engineer registration more straightforward, such accreditation is not a requirement. This benchmark statement applies equally to accredited and unaccredited programmes. Graduates of all engineering degree programmes are expected to achieve the academic standards described.

1.6 Programme providers use this statement to establish standards for a diverse range of programmes, hence encouraging innovation and creativity in curriculum design. It is important to note that the use of the subject benchmark statement on its own in programme design is not sufficient to secure professional accreditation for the programme.

1.7 For joint or interdisciplinary programmes it may be appropriate to draw on a number of subject benchmark statements. This document is still an essential reference point for the engineering component of the programme.

1.8 Given the general understanding that technology is the product of engineering, reference to engineering and engineering degrees should be taken to include technology in this document.

2 Nature and extent of the subject

2.1 Engineering drives technological, economic and social progress. It deals with the delivery of practical solutions to problems, which includes addressing some of the greatest challenges and opportunities of our rapidly evolving world. Engineers apply their understanding, knowledge, experience, skills and know-how to create social and economic value.

2.2 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, recycling, and disposal, within the constraints imposed by economic, legal, social, cultural and environmental considerations.

2.3 Engineering relies on three core elements, namely scientific principles, mathematics, and 'realisation'. Scientific principles 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 - and to create Intellectual Property, associating invention with commercial or social value. This creativity and innovation to develop economically viable and ethically sound sustainable solutions is an essential and distinguishing characteristic of engineering, shared across the many diverse, established and emerging subjects within the discipline.

2.4 Engineers based in the UK or working for UK registered businesses are engaged in projects all over the world, and many will spend time working overseas in other offices, in production units or on construction sites. Engineering underpins most exported goods and many services. This is one of the attractions for many people to a career in engineering. Higher education is equally a global activity. UK universities have long attracted international students, in engineering as in all other subjects. UK students are also attracted to undertake all or part of their studies overseas. There is therefore an increasing interest in the outcomes of different countries' engineering programmes.

2.5 The UK is a member of international accords, comprising engineering degree accreditation bodies in a number of countries, who agree to recognise each other's accreditation decisions.¹¹ Accredited UK programmes are also aligned to the international EUR-ACE® framework.¹² Such accords and frameworks help engender comparability of international programmes (often termed 'substantial equivalence') for registration purposes, and encourage mobility and diversity across the student body and the profession as a whole. They are of growing importance with employers as a means by which to assure the skills and professionalism of engineering graduates from UK programmes.

¹¹ See for example, the Washington Accord for degree programmes leading eventually to registration as a Chartered Engineer www.washingtonaccord.org/washington-accord, the Sydney Accord for Incorporated Engineers www.washingtonaccord.org/sydney, and the Dublin Accord for Engineering Technicians www.washingtonaccord.org/dublin.

¹² For further information see www.enaee.eu/eur-ace-system/eur-ace-framework-standards and www.engc.org.uk/education--skills/accreditation/european-accreditation.

3 The characteristics of engineering graduates

3.1 The creative way of approaching all engineering challenges is being seen increasingly as a 'way of thinking' which is generic across all engineering disciplines. In order to operate effectively, engineering graduates thus need to possess the following characteristics. They will:

- be pragmatic, taking a systematic approach and the logical and practical steps necessary for, often complex, concepts to become reality
- seek to achieve sustainable solutions to problems and have strategies for being creative, innovative and overcoming difficulties by employing their skills, knowledge and understanding in a flexible manner
- be skilled at solving problems by applying their numerical, computational, analytical and technical skills, using appropriate tools
- be risk, cost and value-conscious, and aware of their social, cultural, environmental, health and safety, and wider professional responsibilities
- be familiar with the nature of business and enterprise in the creation of economic and social value
- appreciate the global dimensions of engineering, commerce and communication
- be able to formulate and operate within appropriate codes of conduct, when faced with an ethical issue
- be professional in their outlook, capable of team working, effective communicators, and able to exercise responsibility and sound management approaches.

4 Engineering degrees as preparation for professional practice

4.1 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. The possession of an engineering degree is seen by many employers as an essential indication that these attributes have been achieved. Successful graduates from engineering programmes are highly sought after.

4.2 Accredited engineering degrees provide the foundations for eventual professional registration. Professional recognition as an Incorporated Engineer or Chartered Engineer is achieved through membership of a professional engineering institution and registration with the Engineering Council. The formation process for an engineering professional continues after graduation through a mixture of work-related education, training and professional development and on-the-job experience, enabling the demonstration of competence and commitment.

4.3 Professional engineering occupations have many different characteristics, and much engineering activity is undertaken by teams of engineers. The breadth of roles available is reflected to some extent in the differences between the work of Incorporated Engineers and Chartered Engineers. Incorporated Engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation. Chartered Engineers develop solutions to engineering problems using new or existing technologies, through creativity, change and innovation and/or they may have technical accountability for complex systems with significant levels of risk.

4.4 Not all graduates will proceed with a professional career in this way, and the attributes of engineering graduates also make them attractive to many different sorts of employer - in industry, finance, consultancy and the public services - and as entrepreneurs in their own right.

5 Professional accreditation of academic programmes

5.1 An Engineering Council accredited bachelor's degree with honours is regarded as one of the exemplifying qualifications for professional registration as an Incorporated Engineer, and may be accredited as partially meeting the educational base requirements for registration as a Chartered Engineer. Qualifications that exemplify the required knowledge and understanding for professional registration as a Chartered Engineer include an Engineering Council accredited integrated master's (MEng) or an accredited bachelor's degree with honours in engineering plus an appropriate master's degree accredited by a licensed professional engineering institution.

5.2 The majority of engineering degree programmes are designed with a view to being accredited by a professional engineering institution on behalf of the Engineering Council. 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, which allows for innovation in programme design within the outcomes framework. Factors which have a bearing on these, such as approaches to teaching and learning, assessment strategies, human and material resources, and quality assurance arrangements are all considered as part of the accreditation process. Accreditation may typically be granted for a period of up to five years, after which re-accreditation is required.¹³

¹³ For further information, see the Engineering Council Website www.engc.org.uk.

6 Engineering at bachelor's degree with honours and master's degree levels

These descriptions are based on the Preambles provided in Annex A of the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence*.¹⁴

Bachelor's degree with honours level

6.1 A bachelor's degree with honours in engineering may be accredited as fully meeting the education requirements for professional registration as an Incorporated Engineer (IEng), or as partially meeting the requirement for professional registration as a Chartered Engineer (CEng). For this reason, most bachelor's degrees with honours in engineering will fall into one of the two following categories. Unaccredited degrees may align with either of the below.

- Bachelor's degree with honours programmes in engineering accredited for IEng have an emphasis on the development and attainment of the know-how necessary to apply technology to engineering problems and processes, and to maintain and manage current technology, sometimes within a multidisciplinary engineering environment.
- Bachelor's degree with honours programmes in engineering accredited for CEng develop the ability to apply a thorough understanding of relevant science and mathematics to the analysis and design of technical solutions.

Master's level

6.2 Integrated master's (MEng) degrees go beyond the bachelor's degree with honours to provide a greater range and depth of specialist knowledge, within a research and industrial environment, as well as a broader and more general academic base. Such programmes provide both a foundation for leadership, and a wider appreciation of the economic, legal, social, ethical and environmental context of engineering.

6.3 The integrated master's (MEng) programme of study is designed as an integrated whole from entry to completion, although some of the earlier parts may be delivered in common with a parallel bachelor's degree with honours. Integrated master's (MEng) degrees meet the expectations of the qualifications descriptor for master's degrees in *The framework for higher education qualifications in England, Wales and Northern Ireland* and the *Frameworks for Higher Education Qualifications in England Wales and Northern Ireland*, with the additional period of study at the lower level meeting the expectations of the bachelor's degree with honours descriptors. This generally includes involving study equivalent to at least four full-time academic years (five in Scotland), of which study equivalent to at least one full-time academic year is at the higher level. Progression to integrated master's (MEng) programmes is subject to performance criteria that indicate likely progression to the more demanding outcomes expected for the award of a master's degree. Transfer between programmes leading to bachelor's degrees with honours and integrated master's (MEng) programmes is usually possible within a higher education provider. Integrated master's (MEng) degrees are compatible with the completion of the second cycle within the overarching European Framework FQ-EHEA.

6.4 Master's degrees in engineering other than the integrated master's (typically MSc degrees) vary in nature and purpose. Some offer the chance to study in greater depth particular aspects or applications of a broader discipline in which the graduate holds a bachelor's degree with honours. Others bring together different engineering disciplines or

¹⁴ See www.engc.org.uk/ahep.aspx.

subdisciplines in the study of a particular topic, or engineering application, while a further category is truly multidisciplinary. Master's programmes also provide an opportunity to integrate the technical and non-technical aspects of engineering and to develop a commitment to professional and social responsibility and ethical codes.

7 The standards

7.1 Readers are referred to the Engineering Council *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence* for full details of the academic standards for bachelor's degrees with honours and master's degrees in Engineering.

7.2 For the purposes of this benchmark statement, the output standards set out in the *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence* should be interpreted as threshold academic standards. It is anticipated that most students will exceed the threshold level.

7.3 The *Accreditation of Higher Education Programmes: UK Standard for Professional Engineering Competence* includes two sets of output standards for bachelor's degrees with honours - one for programmes accredited for IEng registration, and another for programmes accredited for CEng registration. Where programmes are unaccredited, they should be aligned to either the IEng or the CEng pathway.

8 Teaching, learning and assessment

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

Teaching and learning

8.2 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 subject. Whichever methods are employed, strategies for teaching, learning and assessment 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 are updated on a regular basis in response to generic and subject-specific developments, taking into account educational research, changes in national policy, industrial practice and the needs of employers.

8.3 Curriculum design is informed by relevant examples of current developments, reflecting appropriate research, scholarship, and industrial practice, and an understanding of the potential destination of graduates. For students to achieve a satisfactory understanding of engineering, the expectation is that they have significant exposure to hands-on laboratory work and substantial individual and group project work. The curriculum includes both design and research-led projects, which develop in graduates both independence of thought and the ability to work effectively in a team. Teaching and learning needs to be placed within the context of social, ethical, legal, environmental and economic factors relevant to engineering.

8.4 Features of teaching and learning within an integrated master's (MEng) programme are that they build upon a bachelor's degree with honours through the deepening of technical understanding, additional emphasis on team/group working, increase in the use of industrially relevant applications of engineering analysis, and an enhanced capability for independent learning and work. Case studies, design work and projects are generally utilised more extensively, especially towards the end of the programme when they build upon earlier learning. The inclusion of such elements within the design of integrated master's (MEng) programmes prepares 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. Where this is the case, programmes may be of extended duration to ensure that all of the academic requirements and components have been covered.

8.5 Teaching and learning for other master's degrees (typically MSc degrees) depends to a large extent on the focus of the programme, but may include increased specialisation, breadth or depth of subject material.

8.6 There is an expectation that master's students will be increasingly self-reliant, particularly during the later stages of their programme.

8.7 Teaching and learning resources specific to engineering, and other help and advice, are available from the Higher Education Academy.¹⁵

¹⁵ Higher Education Academy: www.heacademy.ac.uk.

Assessment

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

8.9 Assessment is the means by which students are measured against benchmark criteria and also forms a constructive part of the learning process. In other words, it is both summative and formative. There is a programme-level approach to assessment that ensures output standards are met. Further information and guidance on assessment and feedback is available from the Higher Education Academy.

Appendix: Membership of the benchmarking and review groups for the subject benchmark statement for Engineering

Membership of the review group for the subject benchmark statement for Engineering (2014)

Dr Rob Best	London South Bank University and Accreditation of Higher Education Programmes steering group
Professor David Cleland	Queen's University, Belfast
Dr Gill Cooke	Higher Education Academy and Coventry University
Professor Kel Fidler (Chair)	Fellow of the Royal Academy of Engineering, formerly Vice-Chancellor and Chief Executive of Northumbria University and Chairman of the Engineering Council
Dr Alistair Greig	University College London
Dr Daphne O'Doherty	Cardiff University
Professor Alistair Sambell	Edinburgh Napier University
Dr Catherine Kerfoot	Quality Assurance Agency for Higher Education

Professional, statutory and regulatory body representative

Deborah Seddon	Engineering Council
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Employer representatives

Nicola Price	Rolls Royce
Dr Mike Cook	Buro Happold Ltd and Royal Academy of Engineering

Membership of the review group for the subject benchmark statement for Engineering benchmark (2006)

Details provided below are as published in the second edition of the subject benchmark statement.

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	Higher Education Academy Engineering Subject Centre
Professor Graham Davies	University of Birmingham (nominated by Royal Academy of Engineering)
Professor John Dickens	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
Professor Ian Freeston (observer)	Engineering Council UK

Membership of the original benchmarking group for Engineering (2000)

Details provided below are as published in the original subject benchmark statement.

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)	

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