Credits

This document was produced on behalf of the Degree Accreditation Committee by the Output Standards Working Party. Its authors were Professor Peter Hicks (Chair of the Working Party), Dr Michael Cunningham, Professor Erik Dagless, Professor Malcolm McCormick, Mr Tom Ridgman and Mr David Young. Support for the Working Party was provided by Ms Jane Black.
## CONTENTS

**IET HANDBOOK OF LEARNING OUTCOMES FOR BACHELORS AND MEng DEGREE PROGRAMMES** ................................................................. 1

**CONTENTS** ........................................................................................................... 3

**LEARNING OUTCOMES FOR BACHELORS AND MEng DEGREE PROGRAMMES** .......... 8

0. **INTRODUCTION** ................................................................................................. 8

1. **UNDERPINNING SCIENCE AND MATHEMATICS** .............................................. 10

  1.1 **Scientific Principles and Methodology** .............................................................. 10

      US1i **Knowledge and understanding of the scientific principles underpinning relevant current technologies, and their evolution.** .......... 10

      US1 **Knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, to enable appreciation of its scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies.** ............................................. 10

      US1m **A comprehensive understanding of the scientific principles of own specialisation and related disciplines;** ......................................... 10

      US2m **An awareness of developing technologies related to own specialisation.** ............................................................................. 10

  1.2 **Mathematics** .................................................................................................... 11

      US2i **Knowledge and understanding of mathematics necessary to support application of key engineering principles.** ........................................... 11

      US2 **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.** ......................................... 11

      US3m **A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.** ............................................................. 11

  1.3 **Integrated Engineering** .................................................................................. 13

      US3 **Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.** ................................................................. 13

      US4m **An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.** .............................................................................. 13
2. ENGINEERING ANALYSIS

2.1 Application of Engineering Principles

E1 Understanding of engineering principles and the ability to apply them to analyse key engineering processes.

E1m An ability to use fundamental knowledge to investigate new and emerging technologies.

2.2 Performance Classification and Modelling

E1i Ability to monitor, interpret and apply the results of analysis and modelling in order to bring about continuous improvement.

E3i Ability to use the results of analysis to solve engineering problems, apply technology and implement engineering processes.

E2 Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques.

2.3 Quantitive Methods and Computer Based Problem Solving

E2i Ability to apply quantitative methods and computer software relevant to their engineering technology discipline(s), frequently within a multidisciplinary context.

E3 Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems.

E2m Ability to apply mathematical and computer-based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

2.4 Systems

E4i Ability to apply a systems approach to engineering problems through the know-how of the application of the relevant technologies.

E4 Understanding of and ability to apply a systems approach to engineering problems.

E3m Ability to extract data pertinent to an unfamiliar problem, and apply in its solution using computer based engineering tools when appropriate.

3. DESIGN

D1i Define a problem and identify constraints.

D2i Design solutions according to customer and user needs.

D3i Use creativity and innovation in a practical context.

D4i Ensure fitness for purpose (including operation, maintenance, reliability etc).

D5i Adapt designs to meet their new purposes or applications.

D1 Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues.

D2 Understand customer and user needs and the importance of considerations such as aesthetics.

D3 Identify and manage cost drivers.
D4 Use creativity to establish innovative solution; .............................................23
D5 Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal; ........................................23
D6 Manage the design process and evaluate outcomes. ............................23
D1m Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations; .................................................................24
D2m Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.........................................................24

4. ECONOMIC, SOCIAL, AND ENVIRONMENTAL CONTEXT .............................. 26

S1i Knowledge and understanding of commercial and economic context of engineering processes. .................................................................26
S2i Knowledge of management techniques which may be used to achieve engineering objectives within that context........................................26
P6i Understanding of the principles of managing engineering processes. ......26
S3i Understanding of the requirement for engineering activities to promote sustainable development.................................................................26
S4i Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues....................................................26
S5i Understanding of the need for a high level of professional and ethical conduct in engineering. .................................................................26

S1 Knowledge and understanding of commercial and economic context of engineering processes; .................................................................26
S2 Knowledge of management techniques, which may be used to achieve engineering objectives within that context; ........................................26
S3 Understanding of the requirement for engineering activities to promote sustainable development; .................................................................26
S4 Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues; ....................................................26
S5 Understanding of the need for a high level of professional and ethical conduct in engineering. .................................................................26
S1m Extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately; .................................................................27
S2m The ability to make general evaluations of commercial risks through some understanding of the basis of such risks........................................27

5. ENGINEERING PRACTICE ............................................................................. 29

5.1 Materials and Components .........................................................................29

P1i Understanding of and ability to use relevant materials, equipment, tools, processes, or products.................................................................29
P1 Knowledge of characteristics of particular materials, equipment, processes, or products.................................................................................29
P1mA thorough understanding of current practice and its limitations, and some appreciation of likely new developments; .........................................................29
P2mExtensive knowledge and understanding of a wide range of engineering materials and components.................................................................29

5.2 Workshop and Laboratory Skills.................................................................31
P2i Knowledge and understanding of workshop and laboratory practice. ........32
P2 Workshop and laboratory skills...................................................................32

5.3 Appropriate use of Engineering Knowledge...............................................33
P3i Knowledge and context in which engineering knowledge can be applied (eg operations and management, application and development of technology etc). .................................................................33
P3 Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology development, etc).................................................................33
P3m Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.........................................................34

5.4 Technical Information .................................................................................34
P4i Ability to use and apply information from technical literature...............34
P4 Understanding use of technical literature and other information sources..............................................................................................................34

5.5 Intellectual Property and Contracts ............................................................35
P5 Awareness of nature of intellectual property and contractual issues........35

5.6 Codes of Practice and Standards ............................................................35
P5i Ability to use appropriate codes of practice and industry standards.......35
P6 Understanding of appropriate codes of practice and industry standards........................................................................................................36

5.7 Quality ........................................................................................................36
P7i Awareness of quality issues and their application to continuous improvement.................................................................36
P7 Awareness of quality issues........................................................................36

5.8 Working with Uncertainty ........................................................................37
P8 Ability to work with technical uncertainty................................................37

Appendix A ......................................................................................................38
LEARNING OUTCOMES FOR BACHELORS AND MEng DEGREE PROGRAMMES

0. INTRODUCTION

In December 2003 the Engineering Council UK published the United Kingdom Standard for Professional Engineering Competence (UK-SPEC)¹ which defines the threshold standards of competence and commitment required for the registration of Chartered Engineers and Incorporated Engineers. UK-SPEC was revised in December 2008. Under UK-SPEC the decision to accredit a degree programme as satisfying the educational requirements for CEng or IEng registration will be made on the basis of the programme delivering learning outcomes that have been specified by the accrediting professional body.

Engineering is an enabling discipline which is expanding steadily as new knowledge is discovered and the range of degrees accredited by the Institution of Engineering and Technology (IET) is already very broad. In addition many practising engineers work in multi-disciplinary teams which require an understanding of a set of common engineering principles for accurate communication. The learning outcomes specified for IET accredited programmes have been developed to provide for variety and flexibility in the design of programmes and encourage innovation while maintaining a core understanding of engineering principles.

To enable expression of these different learning outcomes as a function of subject area they have been grouped under the themes listed in Table 1:

<table>
<thead>
<tr>
<th>THEME CODE</th>
<th>THEME</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>B</td>
<td>Electronic Engineering (Analogue/Digital)</td>
</tr>
<tr>
<td>C</td>
<td>Control and Instrumentation Engineering</td>
</tr>
<tr>
<td>D</td>
<td>Communication Engineering</td>
</tr>
<tr>
<td>E</td>
<td>Manufacturing Systems Engineering</td>
</tr>
<tr>
<td>F</td>
<td>Digital Systems Engineering</td>
</tr>
<tr>
<td>G</td>
<td>Computer Systems Engineering</td>
</tr>
<tr>
<td>H</td>
<td>Software Engineering/Computer Science</td>
</tr>
</tbody>
</table>

Table 1. List of Themes

It is important to emphasise that these theme headings do not amount to prescriptive degree curricula but are exemplars for traditional sub-disciplines accredited by the Institution of Engineering and Technology. Thus a degree with the title “Electrical Engineering and Electronics” might be expected to produce graduates who are capable of demonstrating the learning outcomes in the themes coded A, B, C, D, F and perhaps, to a lesser extent, G and H.


Modified by the policy working party 2009 to include IEng UK-SPEC learning outcomes.
The Academic Accreditation Committee encourages the development of innovative courses for example to address new and emergent technologies or meet new market demands. It will expect the organisation requesting accreditation for a particular degree programme to identify which elements of the above themes are brought together to make up the programme. It is unlikely that a programme containing none of these themes would be accredited by the Institution, although the Committee is always prepared to consider modifications or extensions to the table.

Sections 1 to 5 list the five learning outcomes in engineering as defined in the Engineering Council publication “The Accreditation of Higher Education Programmes”. In each case a statement of the UK-SPEC generic learning outcomes is followed by the discipline-specific exemplars that have been developed by the Institution. Where necessary the discipline-specific exemplars are expressed separately for each of the sub-discipline themes.

The present document must be read in the context of the two UK-SPEC documents mentioned previously1,2. These identify the MEng degree and the Bachelors (usually BEng) honours degree with further learning as recognised routes that can be followed to achieve registration as an Incorporated Engineer or Chartered Engineer. Desired learning outcomes have been defined for both the Bachelors (usually BEng) honours degree and the MEng degree and these can be found in the Engineering Council publication “The Accreditation of Higher Education Programmes”. They are repeated in the relevant sections of the present document and have been colour coded to enable them to be readily identified. Thus the learning outcomes in blue boxes (or double outline) apply to Bachelors degrees leading to Incorporated Engineer. Learning outcomes in pale green boxes (or dotted line) apply to both the BEng honours and MEng degrees whereas those in purple boxes (or continuous line) are characteristic of the enhanced outcomes expected of MEng graduates. The MEng graduates will be expected to solve a substantial range of engineering problems and will have acquired this ability through involvement in industrial and group design projects which will have had a greater degree of industrial involvement than those in the Bachelors degree. These activities should give students greater capacities for independent action, accepting responsibilities, formulating ideas proactively, planning and developing strategies, implementing and executing agreed plans, leading and managing teams, evaluating achievement against specification and plan and decision making.

Degree programmes have aims and expected learning outcomes and these are normally captured in programme specifications. The course units or modules of which the programme is composed are similarly specified in terms of their aims and learning outcomes and these must necessarily be congruent with the aims and learning outcomes for the programme as a whole.

One of the primary goals of accreditation is to verify that the aims and learning outcomes of a degree programme and its constituent components are consistent with the standards expected of a professional engineer. This task reduces to one of mapping and auditing the declared outcomes for the programme against the UK-SPEC learning outcomes and thereby ensuring that all of the facets required of a chartered engineer are developed in the graduate.

In preparing for accreditation, departments will need to provide a commentary explaining how this mapping is achieved as well as supplying evidence which demonstrates convincingly that graduates from the programme have achieved the desired learning outcomes. Following an accreditation visit a report will be prepared highlighting the strengths and weaknesses of the programme and, where necessary, identifying any action points that will need to be addressed before accreditation can be confirmed.

Further details of the accreditation process can be found in the relevant IET accreditation guidelines.

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2 QAA Engineering Benchmark Review Group Draft 6
1. Underpinning Science and Mathematics

1.1 Scientific Principles and Methodology

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

**US1i Knowledge and understanding of the scientific principles underpinning relevant current technologies, and their evolution.**

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

**US1 Knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, to enable appreciation of its scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies.**

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**US1m A comprehensive understanding of the scientific principles of own specialisation and related disciplines;**

**US2m An awareness of developing technologies related to own specialisation.**

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

**Themes A-H**
- Electricity and magnetism
- Electromagnetic theory
- Circuit Theory
- Basic Coherent and non-coherent optics,
- Properties of materials
- Heat and Thermodynamics
- Basic quantum theory
- Fundamentals of mechanics
- Basic fluid mechanics
- Vibrations and waves
1.2 Mathematics

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

**US2i Knowledge and understanding of mathematics necessary to support application of key engineering principles.**

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

**US2 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.**

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**US3m A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.**

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8). A more detailed guide to the mathematical principles that relate to specific themes can be found in Appendix A.
Themes A-H (table 1, page 8)

- Mental approximation
- Algebraic manipulation
- Dimensional analysis
- Solution of simultaneous and quadratic equations
- Complex numbers
- Trigonometry
- Differential & integral calculus
- Line, area & volume integrals
- Probability & statistical analysis
- Vector algebra
- Exponential, hyperbolic & inverse functions
- Fourier analysis
- Laplace transforms
- Z transforms
- Convolution
- Matrix methods
- Solution of ordinary & partial differential equations
- Taylor & McLaurin’s series
- 120 degree operator
- Vector calculus
- Bessel functions
- Discrete mathematics (Sets & logic etc.)
- Boolean algebra (Switching theory)
- Number systems & codes
- Permutations and combinations
- Probability & statistical analysis
- Discrete probability
- Bayes rule
- Analytical geometry
- Recursion
- Algorithmic strategies
- Fundamental algorithms
- Complexity classes P & NP
- Asymptotic analysis
- Proof techniques
- Graphs and trees
- Optimisation methods
- Neural networks
1.3 Integrated Engineering

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

**US3** Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**US4m** An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

These learning outcomes will usually be in the form of the following:

- Project management
- Human factors
- Finance and accounting
- Environmental and health & safety management
- Students are expected to demonstrate an interest in such related fields and to be able to “borrow” ideas and techniques as appropriate
2. ENGINEERING ANALYSIS

2.1 Application of Engineering Principles

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

\[E1\] Understanding of engineering principles and the ability to apply them to analyse key engineering processes.

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

\[E1m\] An ability to use fundamental knowledge to investigate new and emerging technologies.

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

Theme A: Electrical Engineering

Understand and apply mathematical, scientific and engineering principles and tools to the analysis, synthesis, performance assessment, critical appraisal and evaluation of electrical engineering processes and systems including:

- Circuit theory for the steady-state and transient solution of direct current, single-phase ac and symmetrical and asymmetrical polyphase circuits
- Analogue and digital electronics and associated components
- Electromagnetic and electrostatic fields
- Measuring equipment and transducers
- Electronic Devices
- Static and rotating electrical machines
- Power conversion and drive systems
- Electromagnetic compatibility (EMC)
- Mathematical modelling
Theme B: Electronic Engineering (Analogue/Digital)
Apply physical principles and quantitative methods to the development of abstract models for electronic components including
- Passive components (e.g. resistors, capacitors and inductors)
- Semiconductor devices (e.g. diodes, bipolar junction transistors)
- Field effect transistors and operational amplifiers.
Demonstrate an understanding of the trade-off between the complexity of the abstract model and its ability to accurately predict device behaviour.
Demonstrate a knowledge and understanding of the range of applicability of abstract models of electronic components and their fundamental limitations in linear and non-linear circuit applications.

Theme C: Control and Instrumentation Engineering
Understand and apply mathematical, scientific and engineering principles and tools for the analysis, synthesis, performance assessment, critical appraisal and evaluation of control systems including:
- Circuit theory for steady state and transient solution of direct and alternating current circuits
- Analogue and digital electronics and associated components
- Active and passive filters and signal processing
- Operational amplifiers and feedback control
- “Classical” control theory
- Stability criteria – Root locus, Bode, Nyquist, Routh Hurwitz
- Application of Z transforms
- Measuring equipment and transducers
- Electronic devices
- Mathematical modelling

Theme D: Communication Engineering
Demonstrate a knowledge and understanding of communication principles and an ability to apply them to the analysis of communication systems, including:
- Fundamental concepts of information theory
- Application of Fourier analysis
- Communication channels (wired and wireless)
- Analogue and digital signals and systems
- Electromagnetic propagation and antennas
- Concept of the radio spectrum
- Modulation and coding techniques
- Organisation and operation of communications networks
- Network architectures and protocols
- Principles of cellular communications and mobile systems
- Noise in communications systems
Theme E: Manufacturing Systems Engineering
Demonstrate the ability to apply manufacturing engineering principles to select the optimum processes for manufacturing components and assemblies, taking into account the design requirements, nature of customer demand and the level of investment available.

Theme F: Digital Systems Engineering
Demonstrate an understanding of:
- Electronic components, digital circuits and logic families and an ability to characterise them.
- Ability to use combinatorial and sequential logic circuits.
- Basic computer structure (microcomputer and DSP) and an ability to use computers in real-time applications.
- Number systems and their application.
- Ability to use VLSI systems and techniques.

Theme G: Computer Systems Engineering
Demonstrate an understanding of:
- Architecture and organisation
- Fundamentals of programming
- Programming languages
- Principles of operating systems
- Real time systems
- Distributing computing
- Software engineering
- Human-computer interaction
- Cryptography
- Graphics and visual computing
- Computational methods

Theme H: Software Engineering/Computer Science
Apply computing theory including
- Those listed above in Theme G and the following:
  - Requirements elicitation and analysis
  - Formal description and specification techniques
  - Software design
  - System models
  - Software tools and development environments
  - Prototyping and evolution
  - Integration of software components verification and validation
  - Software documentation
  - Information management
  - Information models and systems
  - Database systems
2.2 Performance Classification and Modelling

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

| E1i | Ability to monitor, interpret and apply the results of analysis and modelling in order to bring about continuous improvement. |
| E3i | Ability to use the results of analysis to solve engineering problems, apply technology and implement engineering processes. |

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

| E2 | Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques. |

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

Theme A: Electrical Engineering

See Learning Outcome E1, Theme A.

Theme B: Electronic Engineering (Analogue/Digital)

Apply analytical methods (i.e. circuit theory) and modelling techniques (i.e. electronic device models) to the identification, classification and description of electronic circuits and their performance in response to a range of externally applied stimuli. The range of circuits should include:

- Amplifiers
- Signal Generators and Waveshaping Circuits
- Power Supplies and Voltage Reference Circuits
- Mixed Analogue-Digital Circuits
- Optoelectronic Devices and Circuits
Theme C: Control and Instrumentation Engineering
See Learning Outcome E1, Theme C.

Theme D: Communication Engineering
Apply mathematical methods and modelling techniques to the analysis of communications systems, in particular digital systems and networks.

Theme E: Manufacturing Systems Engineering
Demonstrate the ability to design and evaluate manufacturing systems at three levels:
- Strategic level including topics such as international productivity and cost comparisons, location decisions, make versus buy etc.
- Factory level covering different types of operations such as job shop, cell, flow line, continuous process etc. Use modelling and simulation software to compare alternatives for different levels of customer demand in terms of volume and variety.
- Machine level looking at inner loop and outer loop control, cell control systems, for example this might include basic familiarity with FMS software management techniques, robotic/automation capabilities and CNC programming.

Theme F: Digital Systems Engineering
- Model the components in digital circuits to analyse both circuit and logic behaviour and determine their performance.
- Model simple and complex combinatorial and sequential logic circuits to determine speed, area, power consumption, etc.
- Model and analyse a computer's performance in real-time systems and to analyse real-time responsiveness.
- Apply number systems as appropriateness in hardware and software systems.
- Analyse VLSI circuits to determine speed, area, power consumption, etc.

Theme G: Computer Systems Engineering
- Demonstrate an understanding of the main areas of the body of knowledge in computer engineering and be able to exercise critical judgement across a wide range of issues involving performance trade-offs, implicit in systems engineering, between hardware and software – in particular to be able to use appropriate metrics at the systems, sub-system and component level to predict and evaluate total system performance.

Theme H: Software Engineering/Computer Science
Design an integrated system including as appropriate
- Demonstrate an understanding of the main areas of the body of knowledge in software engineering and be able to exercise critical judgement across a wide range of issues involving performance trade-offs and the use of appropriate metrics at the system, sub-system and component level to predict and evaluate total system performance.

2.3 Quantitive Methods and Computer Based Problem Solving
In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:
Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

- **E3** Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems.

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

- **E2m** Ability to apply mathematical and computer-based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

### Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

#### Theme A: Electrical Engineering

Understand, apply, select and challenge appropriate quantitative methods and computer software tools for the evaluation, analysis and solution of electrical engineering problems and situations. Examples include:
- Iterative techniques
- Nodal and mesh analysis
- Matrix inversion

#### Theme B: Electronic Engineering (Analogue/Digital)

Use quantitative methods and appropriate computer software tools to solve engineering problems involving the analysis of electronic circuits. The types of analysis will generally include the following:
- DC operating point and transfer characteristic
- AC transfer characteristic
- Transient analysis (time domain)
- Spectral analysis (frequency domain)
- Noise analysis
- Sensitivity analysis (optimisation)
Theme C: Control and Instrumentation Engineering
Understand, apply, select and challenge appropriate quantitative methods and computer software tools to the evaluation, analysis and solution of control engineering problems and situations. Examples include:
- Transfer function analysis
- Stability analysis

Theme D: Communication Engineering
Apply quantitative methods and appropriate computer software tools (e.g. spreadsheets, MATLAB) to the analysis and solution of problems in communication systems.

Theme E: Manufacturing Systems Engineering
Demonstrate the ability to apply quantitative methods and computer software to solve problems and evaluate alternatives for:
- Production control techniques such as MRP, JIT and OPT and have a knowledge of highly integrated ERP packages.
- Incentive, reward and motivation schemes and management techniques that optimise the contribution of each individual towards the organisation's goals.
- Quality management techniques including metrology, statistical methods and design of experiments.
- Performance Measurement techniques such as OEE, Productivity Measures, Balanced Scorecard and how these should be used for driving improved performance.

Theme F: Digital Systems Engineering
- Use schematic entry, hierarchy, hardware description, and finite state design tools to represent a complex digital design.
- Simulate at the functional and timing level to verify the correct working of a digital design.
- Use software tools to synthesise and implement a digital design in a variety of programmable implementation styles.
- Use development tools to design, program, implement and test real-time systems with time critical behaviour.
- Use advanced VLSI design tools in the implementation of integrated circuits.

Theme G: Computer Systems Engineering
Demonstrate an understanding of critical analysis and application of a range of concepts, principles and practices of computer engineering in the context of loosely specified problems, showing competent judgement in the selection of metrics, tools and techniques.

Theme H: Software Engineering/Computer Science
Demonstrate an understanding of critical analysis and application of a range of concepts, principles and practices of software engineering in the context of loosely specified problems, showing competent judgement in the selection of metrics, tools and techniques.

2.4 Systems
In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

**E4i** Ability to apply a systems approach to engineering problems through the know-how of the application of the relevant technologies.

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

**E4** Understanding of and ability to apply a systems approach to engineering problems.

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**E3m** Ability to extract data pertinent to an unfamiliar problem, and apply in its solution using computer based engineering tools when appropriate.

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page 8).

**Theme A: Electrical Engineering**

Apply the concepts associated with Learning Outcomes E1 (Theme A) and E3 (Theme A) to the design application and utilization of electrical and electronic equipment with emphasis on a systems approach to real world problems and applications.

**Theme B: Electronic Engineering (Analogue/Digital)**

Demonstrate a knowledge and understanding of system-on-chip design methodologies and apply them to the top-down design of electronic systems.

**Theme C: Control and Instrumentation Engineering**

Apply the concepts associated with Learning Outcomes E1 (Theme C) and E3 (Theme C) to the design, application and utilization of control equipment with emphasis on a systems approach to real world problems and applications.

**Theme D: Communication Engineering**

Apply a systems approach to the analysis and design of communication systems.

**Theme E: Manufacturing Systems Engineering**

Apply a systems approach to the analysis and design of manufacturing systems.
Theme F: Digital Systems Engineering
Demonstrate an understanding of and an ability to apply top-down digital design methods in the synthesis of a digital system.

Theme G: Computer Systems Engineering
Demonstrate the competencies involved in problem identification, analysis, design and development of a computer system, together with relevant and appropriate documentation. This work must show an understanding of a range of problem solving and evaluation skills, together with an ability to marshal supporting evidence in favour of the chosen approach.
In addition, demonstrate an understanding of the construction and design of systems which are nested hierarchies of other systems.

Theme H: Software Engineering/Computer Science
Demonstrate the competencies involved in problem identification, analysis, design and development of a software system, together with relevant and appropriate documentation. This work must show an understanding of a range of problem solving and evaluation skills, together with an ability to marshal supporting evidence in favour of the chosen approach.
In addition, demonstrate an understanding of the construction and design of systems which are nested hierarchies of other systems.
3. 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.

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to:

- **D1i** Define a problem and identify constraints.
- **D2i** Design solutions according to customer and user needs.
- **D3i** Use creativity and innovation in a practical context.
- **D4i** Ensure fitness for purpose (including operation, maintenance, reliability etc).
- **D5i** Adapt designs to meet their new purposes or applications.

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

- **D1** Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues;
- **D2** Understand customer and user needs and the importance of considerations such as aesthetics;
- **D3** Identify and manage cost drivers;
- **D4** Use creativity to establish innovative solution;
- **D5** Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal;
- **D6** Manage the design process and evaluate outcomes.
In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

<table>
<thead>
<tr>
<th>D1m</th>
<th>Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations;</th>
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<tbody>
<tr>
<td>D2m</td>
<td>Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.</td>
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</tbody>
</table>

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

**All Themes**

(i) Use a structured design process such as:
   - Neutral Problem Statement
   - A hierarchy of Requirement and Design Specifications
   - Selection of Evaluation Criteria
   - Reviewing of alternative approaches and selection and development of Concepts
   - Detail Design, and where appropriate the integration of detail design across a number of technologies and/or design groups
   - Verification and Test planning
   - Manufacturing Implementation
   - Product Launch
   
either using and demonstrating competence in each step or demonstrating why it is not relevant for the specific project.

(ii) Demonstrate familiarity with common tools and techniques, as appropriate, such as:
   - Material selectors
   - Process selectors
   - CAE techniques
   - Design for manufacture and assembly
   - Product costing and value analysis
   - Innovation and creativity tools
   - Quality function deployment
   - Reliability and integrity analysis, including techniques such as failure mode effect analysis (FMEA), fault tree analysis (FTA) and hazard and operability analysis (HAZOP)

(iii) Understand the concepts of new product development / project management such as:
   - Project planning and management
   - Configuration and change management
   - Concurrent engineering
- Team working
- Health and safety management
- Risk management – including financial, political, environmental and safety risks
- Supply chain management
- Product planning
- Design quality management
4. ECONOMIC, SOCIAL, AND ENVIRONMENTAL CONTEXT

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

- **S1i** Knowledge and understanding of commercial and economic context of engineering processes.
- **S2i** Knowledge of management techniques which may be used to achieve engineering objectives within that context.
- **P6i** Understanding of the principles of managing engineering processes.
- **S3i** Understanding of the requirement for engineering activities to promote sustainable development.
- **S4i** Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.
- **S5i** Understanding of the need for a high level of professional and ethical conduct in engineering.

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

- **S1** Knowledge and understanding of commercial and economic context of engineering processes;
- **S2** Knowledge of management techniques, which may be used to achieve engineering objectives within that context;
- **S3** Understanding of the requirement for engineering activities to promote sustainable development;
- **S4** Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;
- **S5** Understanding of the need for a high level of professional and ethical conduct in engineering.
In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**S1m** Extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately;

**S2m** The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

**All Themes**

(i) Knowledge and understanding of commercial and economic context of engineering processes such as:
   - The market including customer, supplier and competitor relationships and issues including types of contracts which may be entered into and ethical business behaviour
   - Technology management and exploitation
   - Business planning
   - Finance including management accounting

(ii) Knowledge of management techniques which may be useful to achieve engineering objectives within a commercial and economic context, such as:
   - Project management,
   - Risk management
   - Decision making
   - Operations management

(iii) Understanding of the requirement for engineering activities to promote sustainable development such as:
   - Sustainable design and manufacture
   - Waste management and recycling
   - National, EU and world legislation

(iv) Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, environment and risk such as:
   - Data Protection Act
   - Freedom of Information Act
   - Health and safety legislation and regulation
   - Functional safety and safety critical systems with applicable Standards (e.g. IEC 61508)
   - Environmental legislation
• Contract law
• Copyright and patent law
• Professional and product liability

(v) Understanding the need for a high level of professional and ethical conduct in engineering such as:
• Professional Body Code of Conduct (e.g. IET Rules of Conduct)
• Ethical theory
• Awareness of ethical dilemma by means of case studies
5. ENGINEERING PRACTICE

5.1 Materials and Components

This involves the practical application of engineering skills, combining theory and experience, and the use of other relevant knowledge and skills.

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

\[ P1i \quad \text{Understanding of and ability to use relevant materials, equipment, tools, processes, or products.} \]

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

\[ P1 \quad \text{Knowledge of characteristics of particular materials, equipment, processes, or products.} \]

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

\[ P1m \quad \text{A thorough understanding of current practice and its limitations, and some appreciation of likely new developments;} \]

\[ P2m \quad \text{Extensive knowledge and understanding of a wide range of engineering materials and components.} \]

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

**Themes A – G**

(i) Demonstrate competence in:
- Acquired engineering skills
- Combining theory and experience
- Other relevant knowledge and skills

and an ability to apply these competencies to practical engineering processes, situations and problems.
(ii) Demonstrate knowledge and understanding of the operating principles of essential test and measurement equipment, including instruments for the measurement of:

- DC and AC voltage, current and power
- Electrical resistance, capacitance and inductance
- Time and frequency

and an ability to apply these instruments to practical engineering processes, situations and problems.

Additional competencies that are specific to individual themes are listed below:

**Theme A: Electrical Engineering**

- Appreciating the characteristics, properties and applications of materials applicable to electrical engineering equipment and manufacturing
- Acquiring knowledge of engineering processes used in electrical engineering equipment and applications.

**Theme B: Electronic Engineering (Analogue/Digital)**

Demonstrate knowledge and understanding of the equipment, materials and processes employed in the design, production and testing of electronic circuits and systems, including:

- Specialised test and measurement equipment such as oscilloscopes, function generators, spectrum analysers and semiconductor parametric test equipment
- Electronic Design Automation tools
- Semiconductor Integrated Circuit (IC) fabrication technology
- PCB production and hybrid technologies
- Automated Test Equipment (ATE)

**Theme C: Control and Instrumentation Engineering**

- Appreciating the characteristics, properties and applications of materials applicable to control and instrumentation engineering equipment and manufacturing
- Acquiring knowledge of engineering processes used in control and instrumentation engineering equipment and applications.

**Theme D: Communication Engineering**

Demonstrate knowledge and understanding of the equipment, materials and processes employed in the design, production and testing of communications systems, including:

- Specialised test and measurement equipment such as signal generators, network analysers, spectrum analysers, frequency counters and power meters
- Electronic Design Automation tools
- MMIC fabrication technology
- Antennas and waveguides
- Fibre optic communications equipment
Theme E: Manufacturing Systems Engineering
Identify and understand the capabilities of a broad range of standard production equipment for example:

- Machining centres
- Robots
- Metal forming equipment
- Joining and cutting processes and equipment
- Process and light assembly equipment

The student should be able to operate at least one manual machine tool and write a programme for a computer-controlled device.

Theme F: Digital Systems Engineering
Demonstrate knowledge and understanding of the equipment, materials and processes employed in the design, production and testing of digital systems, including:

- PCB’s and their performance at high frequency, modern manufacturing methods for PCB’s and packaging and assembly methods
- Logic analysers and high frequency oscilloscopes and linked operation of these to carry out complex testing work
- Performance of connections on PCB structures and signal path matching
- Operation of driver circuits to meet signalling or protocol standards on busses or backplanes
- VLSI circuit manufacturing processes and impact on and performance at sub-micron levels
- Microcomputer development systems for designing and testing a real-time application
- Electronic Design Automation Tools

Theme G: Computer Systems Engineering
Demonstrate knowledge and understanding of:

- Software implementation methods for compilers, interpreters, operating systems, device drivers etc.
- Methods for implementing computer simulators to assess computer performance using conventional languages, hardware description or specialist languages

Theme H: Software Engineering/Computer Science
Demonstrate knowledge and understanding of:

- Programming fundamentals
- Operating systems
- Software tools, development environments, libraries and reusable components

5.2 Workshop and Laboratory Skills
In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:
**P2i  Knowledge and understanding of workshop and laboratory practice.**

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

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**P2  Workshop and laboratory skills.**

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**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

**Theme A: Electrical Engineering**

Demonstrate understanding of workshop and laboratory skills:

- Health, safety and environmental considerations and appropriate risk assessment
- Metrology; measurement and calibration
- Electrical circuit protection; Fuses, MCB’s & RCD’s
- Performance testing
- Engineering drawing and CAD
- Non destructive testing

**Theme B: Electronic Engineering (Analogue/Digital)**

Work safely in a workshop or laboratory environment while using:

(i) A range of tools and techniques related to the assembly of electronic circuits and systems, including:

- Printed circuit board assembly (component selection and insertion)
- Soldering
- Circuit prototyping techniques (e.g. wire-wrapping)
- Simple metal working (drilling, bending, fastening)

(ii) A range of equipment to perform measurements and procedures of relevance to analogue electronic engineering, including:

- Electronic component characterisation and testing
- DC characterisation and testing of electronic circuits (dc voltage and current measurements; input and output resistance; gain; power consumption)
- Characterisation and testing of electronic circuits in the time domain (measurement of period and delay; transient response)
- Characterisation and testing of electronic circuits in the frequency domain (measurement of amplitude and phase; frequency response)

**Theme C: Control and Instrumentation Engineering**

See Learning Outcome P2, Theme A.
Theme D: Communication Engineering
Demonstrate proficiency in the use of high speed oscilloscopes and network analysers

Theme E: Manufacturing Systems Engineering
Demonstrate proficiency in:
- The handling of engineering information. This ranges from interpreting engineering specifications, standards and drawings either in paper or electronic format to preparing and ensuring the effectiveness of process instruction sheets for operators.
- The ability to critique design proposals from a manufacturing perspective and contribute to design for manufacture teams.
- Using expert knowledge. Manufacturing is a multi-disciplinary subject and it is important that students understand the limitations of their own knowledge and where to search for greater expertise.
- Integrating the narrow expert view into the wider practical problem.

Theme F: Digital Systems Engineering
Demonstrate proficiency in the use of:
- High speed oscilloscopes and logic analysers
- Microcomputer/DSP development tools
- Digital CAD tools, including PCB, programmable components and VLSI implementation styles (i.e. all the tools listed in association with Learning Outcome P1 Theme F)

Theme G: Computer Systems Engineering
Demonstrate practical knowledge of designing a method to evaluate and assess the performance of a computer system against its design requirements.

Theme H: Software Engineering/Computer Science
Demonstrate practical knowledge of designing a method to evaluate and assess the performance of a software system against its design requirements

5.3 Appropriate use of Engineering Knowledge
In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

P3i Knowledge and context in which engineering knowledge can be applied (eg operations and management, application and development of technology etc).

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, must be able to demonstrate:

P3 Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, application and development of technology etc).
operations and management, technology development, etc).

In addition, MEng graduates, who fully satisfy the academic requirements of CEng registration, may be characterised by the following attributes:

**P3m Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.**

**Discipline-Specific Exemplars**

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page6).

**All Themes**

Understanding of the professional engineering principles applicable to the management of engineering projects as well as operation and maintenance of industrial processes. This requires a working knowledge of:

- Manufacturing processes
- Written and oral communications
- Plant, process and product whole life cycles and applicable design criteria
- Plant and equipment monitoring and performance assessment
- Product testing
- Reliability engineering including analysis and process improvement
- Product research and development
- Financial control and capital expenditure appraisal
- Planning and time control
- Management of health and safety – Hazard and risk analysis
- Environmental management

**5.4 Technical Information**

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

**P4i Ability to use and apply information from technical literature.**

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

**P4 Understanding use of technical literature and other information sources.**
Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

All Themes A – H
Familiarity in obtaining, searching and interpreting technical literature and other documentation from various sources.

5.5 Intellectual Property and Contracts

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

P5 Awareness of nature of intellectual property and contractual issues.

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page8).

All Themes
Awareness of the nature, relevance and implications of legal frameworks including:
- UK contract law
- Intellectual property rights
- European and international

5.6 Codes of Practice and Standards

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

P5i Ability to use appropriate codes of practice and industry standards.

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:
P6  Understanding of appropriate codes of practice and industry standards.

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page 8).

All Themes

An understanding of the requirements of engineering documentation including:

- Customer specifications
- Industrial engineering specifications
- Engineering codes of practice
- Engineering standards (British, European and International)

5.7 Quality

In order to fully meet the learning outcomes to fully satisfy the academic requirements of Incorporated Engineer (IEng), graduates must be able to demonstrate:

P7i  Awareness of quality issues and their application to continuous improvement.

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

P7  Awareness of quality issues.

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page 8).

All Themes

Appreciation of the principles of quality systems and their application to the manufacture of electrical and electronic engineering components and systems:

- Applicable standards e.g. ISO 9001:2000
- Total Quality Management (TQM)
- Quality tools and control systems
- Inspection
- Document control (including revision control processes)
• Material and component specification and traceability

5.8 Working with Uncertainty

Students graduating from a Bachelor (Honours) level programme, leading to CEng registration, and MEng graduates, must be able to demonstrate:

P8 Ability to work with technical uncertainty.

Discipline-Specific Exemplars

To establish if the above learning outcomes is being achieved, accreditors will seek to determine whether graduates can demonstrate appropriate competence in areas that are substantially equivalent to those listed below for the Themes in Table 1 (page 8).

All Themes

Ability to manage technical uncertainty:
• Scenario analysis and identification of credible options
### Appendix A

This matrix relates to Learning Outcomes US2 and US3m of the IET Handbook

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IET Learning Outcomes handbook June 2012, 21/06/2012
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