Summary and Acknowledgements

Through its programme of course accreditation, IChemE aims to recognise and share best practice in the University education of Chemical Engineers. At the same time it seeks to promote development of the profession, by encouraging innovaton in course design and delivery.

These guidelines describe what IChemE requires of a degree course that is to be accredited.
A framework is given that sets standards and yet provides the flexibility to accommodate many different types of course. The process of accreditation is explained, and guidance is given on the documentation that the University must provide.

These guidelines have evolved from IChemE's long experience in accrediting degree courses across the world. The IChemE would like to extend its sincere appreciation to the many people from industry and academia who have assisted in this accreditation programme, and who have helped in drafting the revision of the guidelines.

CONTENTS

ACCREDITATION GUIDELINES

APPENDICES

1. Introduction

Chemical Engineering is changing, and nowhere is the need to take account of change more important than in the education of young engineers. It is essential that new graduates have the skills to perform in an ever wider variety of jobs and industries. Moreover, they must not only be able to learn quickly during their early careers, but also have the academic grounding "to last a lifetime".

University courses must communicate the relevance and excitement of our profession. Our aim to recruit the brightest and most innovative young people challenges us to provide them with an education that will stimulate and develop their talents. IChemE has responded to this challenge by concentrating on "learning outcomes" rather than the traditional method of specified course content. These guidelines summarise what the IChemE requires from a course, with the intention of leaving it to the University as far as possible to determine how the requirement is delivered.

1.1 Purpose of Accreditation

IChemE has accredited courses across the world for over forty years and currently accredits courses on five continents. The accreditation process seeks to:

- Stimulate improvement in chemical engineering education by encouraging new and innovative approaches;
- Provide a benchmark for education at the highest international standards; and
- Confirm that the graduates from such courses have acquired sufficient knowledge, understanding and skills to enable them to seek recognition as a member of IChemE and as a Chartered Chemical Engineer.

In meeting these objectives IChemE:

- Assesses courses against the learning outcomes described in Section 3 of this document; and
- Ensures that the responsible department has, and will continue to have, adequate resources to deliver the course.

1.2 Two Levels of Accreditation

In terms of providing the academic foundation for Corporate membership and registration as a Chartered Chemical Engineer[1] IChemE accredits degree courses at two levels:

- 'BEng(Hons)'[2] level - recognising mainstream degrees that provide a solid academic grounding; and
- 'MEng'[2] level - recognising degrees of the highest international standards that both deepen and broaden the knowledge base of their graduates.

Both courses provide a pathway to achieving Corporate membership of IChemE. Graduates of both courses will be required to demonstrate that they have acquired a period of relevant learning, training and experience (Continuing Academic and Professional Development CAPD) following graduation. Graduates with a degree accredited at BEng(Hons) level will however need to undertake a greater amount of CAPD (known as a 'Matching Section') to show that they have brought their academic competence to the level required of graduates from accredited MEng level courses. *Separate guidance on completing a Matching Section is available from IChemE.*

[1] *IChemE also accredits Diploma and Degree courses which provide the academic foundation for practice and registration as an Incorporated Engineer. These guidelines are available from IChemE upon request.*

[2] *The titles 'BEng(Hons)' and 'MEng' are those familiar in the UK context and, for convenience, are used throughout this document. However, accreditation is based on course outcomes and not course titles and other degree titles are used internationally.*

2. Learning Outcomes – Introduction and Philosophy

2.1 Introduction

Learning outcomes define the capabilities of individuals obtaining the degree qualification, typically in terms of outcome statements. A high-level statement might be

"is able to solve open ended engineering problems, often on the basis of limited and possibly contradictory information".

Such a statement can be supported by a cascade of lower-level statements specifying appropriate Intellectual Abilities, Practical Skills, General Transferable Skills and so on. This approach provides an effective framework giving both guidance and flexibility to course designers.

Clearly the learning outcomes of an undergraduate course in chemical engineering will represent the chief qualities that IChemE would expect the course to develop in a student who will go on to practise as a chemical engineer. Whilst the high-level outcome statements themselves define course objectives, somewhat more guidance is required by those designing or accrediting a particular undergraduate course.

2.2 Scope of the University Course

It is not practical for any one course to achieve all the learning outcomes that every chemical engineer might conceivably need. On the other hand an acceptable academic formation requires more than would fit a graduate for a single narrowly defined role. **The learning outcomes specified here comprise a package which is distinctive to chemical engineering, and which can be regarded as a minimum necessary requirement.**

The course can be broadened and/or deepened beyond the minimum requirements in many ways. There could be time for further studies in science or engineering, management, economics, languages or law, for example, depending on the interests and previous education of the students, and the length of the course. *This content is now referred to as 'complementary subjects'.*

Since the University course cannot equip graduates with all the skills they will need to deploy over an entire career, there will always remain a need for continued professional development and the University course should lay the foundations on which further education and training can build.

2.3 General Learning Outcomes

Students graduating from an accredited course in chemical engineering must have:

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

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

Practical Skills: they must possess relevant practical skills acquired through laboratory work, project work and use of computer software.

General Transferable Skills: they should have developed transferable skills (*such as communications, time management, team working, inter-personal*) that will be of value in a wide range of situations.

Section 3 describes these outcomes in terms of five broad areas of learning that must be present in all courses seeking accreditation. General transferable skills must be developed and integrated in an appropriate way within these five broad areas.

3. Learning Outcomes in Chemical Engineering

The following five Learning Outcomes (defined by broad area of learning) must be achieved by graduates in all courses seeking accreditation at either BEng(Hons) or MEng level. More details of the Learning Outcomes for the key areas of 'Core Chemical Engineering' and 'Design' are given in Appendices A and B respectively and this section should be read in conjunction with them.

a) **Mathematics, underlying science (chemistry, physics, biology) and associated engineering disciplines.**
Graduates' knowledge and understanding should be of sufficient depth and breadth to underpin their chemical engineering education, to enable appreciation of its scientific and engineering context, and to support their understanding of future developments.

b) **Core Chemical Engineering (See Appendix A for further details).**
The main principles and applications of chemical engineering.
Graduates must be able to handle advanced problems in fluids and solids formation and processing. They must be able to apply chemical engineering methods to the analysis of complex systems within a structured approach to Safety, Health and Sustainability.

c) **Design (See Appendix B for further details).**
The creation of a process, product or plant to meet a defined need.
Graduates must display competence in chemical engineering design, which requires bringing together technical and other skills, the ability to define a problem and identify constraints, the employment of creativity and innovation. They must understand the concept of "fitness for purpose" and the importance of delivery.

d) **Social, environmental and economic context.**
Knowledge and ability to handle commercial and economic aspects, and also health, safety, environmental and other professional issues.
Graduates must be able to calculate and explain process, plant and project economics. They should appreciate the need for high ethical and professional standards, and understand how they are applied to issues facing engineers. They must be aware of the priorities and role of sustainable development. They must be aware of typical legal requirements on personnel, processes, plants and products relating to health, safety and environment.

e) **Engineering Practice.**
The practical application of engineering skills, combining theory and experience, together with the use of other relevant knowledge and skills.
Graduates must understand the ways in which engineering knowledge can be applied in practice, for example in:
- *Operations and management;*
- *Projects;*
- *Providing services or consultancy;*
- *Developing new technology.*

Typical learning outcomes might include the ability to deal with technical uncertainty, appreciation of the scope and value of technical literature, awareness of the nature of intellectual property, possession of workshop and laboratory skills, knowledge of the characteristics of particular equipment, processes or products, facility in the use of appropriate codes of practice and industry standards.
They should also have an appreciation of other relevant knowledge and skills, such as the ability to organise a project, knowledge of budgeting and financial control, appreciation of the roles of suppliers and contractors and the role of the market, and a knowledge of managerial and inter-personal skills.
[Note that this is an area of study that will be significantly developed after graduation, through learning and experience at work, and the expected level of attainment from an undergraduate course will naturally be that of a fresh graduate, not that of an experienced engineer.]

4. Attainment of Outcomes for BEng(Hons) and MEng Level Courses

4.1 Entry Standards

While the IChemE accreditation process places greatest emphasis on the outcomes of a course of study, input standards to the course are still an important factor and IChemE expects courses to maintain a high entry standard. *Entry qualifications to degree courses can change within countries and between countries. The current guidance on expected entry standards for accredited courses is provided separately.*

4.2 BEng(Hons) Level

A course accredited at the BEng (Hons) level will provide the learning outcomes described in Section 3 at a threshold level.

4.3 MEng Level

A course accredited at MEng level will provide the learning outcomes described in Section 3 at the BEng(Hons) level and will, in addition, provide some of these outcomes at *enhanced* ('in-depth') and *extended* ('breadth') levels. MEng courses will be distinguishable by the addition of the following outcomes:

- Enhanced (in-depth) knowledge and skills - increased depth and range of specialist knowledge including some advanced chemical engineering knowledge to the highest international standards;
- Extended (broadening) knowledge and skills – more chemical engineering (at BEng(Hons) level) and/or other science/technology, or other non-chemical engineering subjects such as business or languages;
- Application of enhanced/extended skills – a significantly improved appreciation of the application of enhanced and extended skills normally acquired through enhanced and extended project work;
- A greater extent of involvement with industry.

MEng level courses are characterised by greater depth and breadth of coverage, generally with less reliance on standardised solutions and empiricism. MEng graduates should have a greater ability to apply their knowledge and skills to solving, from first principles, complex problems not previously encountered.

Enhanced/extended skills will usually be covered by project work. To achieve the desired learning outcomes, an MEng course would normally include both group and individual project work. The course should include a major design exercise demonstrating that issues of complexity have been appropriately addressed (see Appendix B), the scope of which may be wider than in some BEng(Hons) courses. There should also be a second substantial open-ended project which stretches and develops students' problem solving and creative thinking capacities. This second project could be of an interdisciplinary nature with the following being examples:

- A research project linked to the department's own postgraduate research programmes, or undertaken at an industrial research laboratory/institute;
- The analysis of an industrial process, perhaps combining a period in industry with some analytical/theoretical work at the University;
- A theoretical project including a literature review and numerical analysis/computer modelling; or
- An interdisciplinary project.

The additional features which distinguish the MEng should not be "bolt on", but should be integrated throughout the latter years of the course where BEng(Hons)/MEng courses run in parallel, and throughout all four years of direct entry MEng courses.

Where BEng(Hons) and MEng courses run in parallel, with common earlier years, student progression to MEng level should be conditional on good academic performance. There should be appropriate and clear criteria to ensure this.

5. Delivery Methods and Assessment

5.1 Delivery Methods

Various methods can be used to deliver a course satisfying the learning outcomes, depending on the style of teaching appropriate to the University and the students, the numbers of students taught and the varied nature of course content. The choice of methods is at the discretion of the University. The methods used could include: lectures; tutorials; laboratory and workshop sessions; problem-centred learning; distance learning; and computer-aided learning. In addition, courses may incorporate industrial placements, or study at other Universities at home or abroad (*but see 5.4*).

Whilst much of the teaching will be done by University staff, the use of external lecturers and supervisors is encouraged, where these can supply knowledge and experience not otherwise readily available. Examples might be in the supervision of design work, the presentation of case studies, or in the lecturing of special topics. However, it is expected that a University running an accredited course will employ a sufficient number of full-time staff, including qualified chemical engineers, for students to have reasonable access to them for instruction and guidance.

5.2 Assessment

The purpose of assessment by the University is to assure that individual students have attained the necessary learning outcomes, and that this attainment is at the appropriate level for the degree being awarded. Evidence for this assessment will generally be in the form of written work such as examination papers, assignments, projects and laboratory reports. For some parts of the course there may be an assessment of a student's oral presentation. It is expected that the University will have its own procedures for assessment and a robust Quality Assurance process to ensure that outcome standards are consistent and fair.

5.3 Evidence of Learning Outcomes

IChemE will look for evidence that students have attained the learning outcomes in the five areas outlined in Section 3.

Typical examples of direct evidence are:
- Examination papers with model answers and marked scripts;
- Project reports;
- Laboratory reports; and
- Design reports.

Typical examples of indirect evidence are:
- External Examiner's reports; and
- Quality Assurance reports external to the department.

5.4 Learning Periods away from the Home University

Many courses contain a period of learning away from the home university – either in industry or at another university. In cases where the period away from the home university contributes to the overall degree award, and hence to the outcomes relevant to accreditation, IChemE will look for strong evidence of:

- Clearly defined learning outcomes for the period;
- Suitability of the placement organisation;
- Rigorous standards of supervision;
- Rigorous assessment of the outcomes achieved by the student; and
- Quality assurance of the overall system of student placements.

Where the period away is spent in an industrial environment, examples of evidence might include:

- Project work or dissertations;
- Presentations and posters;
- Academic courses/modules undertaken during the period, for example by distance learning; and
- Continuing professional development courses.

Where the period away is spent at another University examples of evidence might include:

- Programme of studies completed when at the university; and
- Examples of assessed project work and/or examination papers.

In each case it is expected that the students would re-enter the course at a more advanced stage than when the period away began.

5.5 Resources

It is expected that appropriate human and physical resources will be in place to support the delivery of the course. The course questionnaire (Appendix C) seeks details of staff and laboratory, information technology and library facilities. An opportunity to meet staff and to view the facilities is included in the timetable for all accreditation visits.

6. Process of Accreditation

Beginning the Process and Application by Departments

Departments that already have accredited courses will receive a reminder from IChemE well before the expiry date of the existing accreditation(s) period, inviting the Department to submit the course(s) for re-accreditation.

Departments seeking new accreditation(s) can request this from IChemE at any time. For Departments unfamiliar with the accreditation process, IChemE is very willing to provide help and guidance at any stage and, in particular, encourages Departments to seek informal advice and guidance at an early stage.

Visit Arrangements

Accreditation visits are usually one day in length and are carried out by a team of three assessors who are Corporate Members of IChemE. IChemE staff will liaise with the University to agree a convenient date for the visit (normally during term-time when students are present) and to make logistical arrangements for the day of the visit such as timings, accommodation, travel etc. IChemE staff will distribute the documentation supplied by the University to the assessors prior to the visit and will liaise regarding any further materials or arrangements required prior to the visit.

Most accreditation visits are organised about six to nine months in advance to allow the University time to choose a suitable date and for arrangements to be made. The required documentation must be made available to IChemE at least two months before the visit date.

Documentation Required

The majority of the evidence showing that the required learning outcomes have been met will be in the form of documentation. Within reason the University may submit whatever documentation it considers suitable in support of this, but it is expected that this will normally include:

- The completed course questionnaire (Appendix C);
- A complete set of examination papers and model answers for all taught subjects;
- The current course syllabus including detailed descriptors of all formal teaching (it is expected that all departments will have this information in the form of a Course Handbook that can be provided to meet some or all of this requirement);
- Examples of the major project in design and perhaps other elements of the 'Design Portfolio'; and
- *For MEng level courses* – examples of the brief and scope of the 'second' major project that students are expected to complete.

IChemE will provide clear guidance to departments on the documents required and whether the documents are required in advance or can be made available during the visit. After the assessors have received the advance documents, and prior to the visit, they may identify a need for further information. In such cases IChemE will give the department as much notice as possible.

Criteria Used by Assessors

The assessors will seek evidence that the learning outcomes are being achieved by assessing the scope and depth of the examinations, projects, laboratory work and other learning activities completed by the students. The accreditation visit allows for time to view the resources that support this learning. The general questions that underpin the work of the assessors are:

- Is the entry profile to the courses satisfactory?
- Are the learning outcomes clearly defined and appropriate?
- Is the course structure and content appropriate to deliver the outcomes?
- Are there adequate resources to support the delivery of the outcomes?
- Are the outcomes achieved to an appropriate standard?

Assessors' Report

The assessors prepare a written report of their visit (see Appendix D) which covers not only whether the learning outcomes are met but also more general aspects of the visit, such as resources and discussions with staff and students. In addition, the assessors will seek to:

- Identify and commend strengths and good features of the course; and
- Identify areas where there may be scope to improve the course.

The report, minus the final recommendation, is passed to the University for comments on its factual accuracy before being passed to the IChemE's Accreditation Committee for formal consideration. The decision of the Accreditation Committee (who meet every three months) is normally reported to the University within one week of their meeting.

Range of Possible Outcomes

Accreditation Committee may make a range of possible decisions:

- Accredit/re-accredit the course(s) for a period of between one and five years;
- Accredit/re-accredit the course(s) for a period of between one and five years, subject to certain criteria being addressed within a given timeframe;
- Defer a decision for further information/clarification of certain issues; or
- Do not accredit/re-accredit.

Strictly speaking, a new course cannot be fully accredited until it has produced some graduates. To deal with this, such courses can receive '*Provisional Accreditation*'. '*Provisional Accreditation*' refers to a course that fully meets the requirements for accreditation but has yet to produce the first cohort of graduates. 'Full' accredited status (at the appropriate level) will automatically be granted by Council following the graduation of the first cohort, subject to there being no significant changes to the course.

Appeals Procedure

IChemE maintains an appeals procedure for Universities who wish to appeal against irregularities in the process of accreditation. Details are available from IChemE upon request.

Post-Accreditation Visit

Following the award of accreditation the University will be sent a certificate to formally acknowledge the accredited status of the course(s). There will be ongoing contact between IChemE and the university in terms of accreditation policy developments during the period of accreditation. The Membership Department of IChemE will liaise with the University regarding student services, membership and related activities.

All accredited universities are encouraged to contribute to the development and implementation of accreditation policy and to share good practice in chemical engineering education. For example, IChemE seeks to identify senior and experienced academic staff from as wide a range of departments as possible, on an international basis, to join the Panel of Accreditation Assessors.

How Are Assessors Chosen?

IChemE maintains a Panel of Assessors, comprising both academics and industrialists, who are regularly trained to ensure a current knowledge of the accreditation process and requirements. All accreditation teams are approved by the Chairman of Accreditation Committee using the following criteria wherever possible:

- One assessor should be a member of Accreditation Committee;
- Not more than one assessor should be 'new' i.e. with no previous visit experience;
- The team will always comprise at least one academic and one industrialist;
- The team will include members with expertise appropriate to the courses being considered (e.g. biochemical engineering); and
- For re-accreditation visits, one assessor should have been a member of the panel for the previous visit (*although this can sometimes be difficult to arrange*).

Departments do not normally have the right to select or approve the membership of the team of Assessors. However, if there are exceptional circumstances that concern the department (for example a perceived conflict of interest with an Assessor) then these concerns should be communicated in writing at the earliest possible opportunity to the senior IChemE staff responsible for accreditation and/or the Chairman of Accreditation Committee.

7. Guidance on Duration and Content

7.1 Introduction

Decisions on whether a course is accredited, and at what level, will be taken on the basis of achievement of learning outcomes. Accredited courses may have various titles, content or duration (depending, for example on entry level qualifications) and could operate in a wide variety of learning environments.

Although IChemE seeks to avoid prescription in these aspects, some broad guidance is useful for both departments and assessors. However, it should be stressed that the following metrics on course duration and content are for guidance and are not mandatory. A significant difference from these metrics would not in itself preclude accreditation, but in such cases the department would be expected to justify the differences and provide compelling evidence that the required outcomes have been met.

In order to provide a common measure of course content, and on the assumption that most courses have a modular and credit-based structure, it has been assumed that a typical year of full-time study comprises 120 credits. Most departments should be able to convert their own measures of course content to this basis, but in cases where there are difficulties in interpretation IChemE will provide guidance.

7.2 Course Duration

It is expected that courses seeking accreditation at BEng(Hons) level will normally comprise at least three years of full-time study (or an equivalent period of part-time study) while courses seeking MEng level accreditation will normally require four years of full-time study (or an equivalent period of part-time study).

7.3 BEng(Hons) Level Courses

Learning outcomes must be achieved in five broad areas, as defined in Section 3 and Appendices A and B. Courses may also include a range of other 'Complementary Subjects', as defined in Section 2. In terms of guidance on weightings, these areas can be simplified to:

- '**Basic Sciences and Mathematics**' (delivering the learning outcomes in 'Mathematics, underlying science and associated engineering disciplines);
- '**Chemical Engineering**' (delivering the five learning outcomes specified in Section 3: 'Core Chemical Engineering', 'Design', 'Social, Environmental and Economic Context' and 'Engineering Practice'); and
- '**Complementary Subjects**'.

In order to encourage diversity and innovation in accredited courses the following guidance is given in terms of suggested minimum and maximum number of credits for each year of study.

	Year 1	Year 2	Year 3
Basic Sciences and Mathematics	40 credits min	Discretionary	Discretionary
Chemical Engineering	50 credits min	60 credits min	60 credits min
Complementary Subjects	30 credits max	Discretionary	Discretionary
Total	*120 credits*	*120 credits*	*120 credits*

Within 'Chemical Engineering' there should be a significant and identifiable design component (the 'Design Portfolio'). This should include a major project that is normally undertaken in the final year and is normally weighted at 20 credits minimum (see Appendix B for further information).

7.4 MEng Level Courses

Years 1 and 2

Many MEng courses may have first and second years common with BEng(Hons) courses. The guidance for BEng(Hons) level courses given above therefore applies to these years.

Years 3 and 4

Guidance is given for these two years in combination to reflect the integration of the distinguishing features of the MEng within a course. Where courses are more than 4 years in length, the guidance is appropriate for the final two years of the course.

Chemical Engineering[1]	80 credits minimum
Enhanced Study[2]	40 credits minimum
Extended Study[3]	80 credits maximum
Application of enhanced/extended skills[4]	20 credits minimum
Total	*240 credits*

[1]Much of the 'Chemical Engineering' content could overlap with that of a BEng (Hons) level course. It must include a significant design component and a major project, as for BEng (Hons) level.

[2]There may be some overlap between advanced subjects (for example specialist topics that would be covered at the end of a BEng (Hons) course) that could be included within 'Chemical Engineering' or could be included within 'Enhanced Study'. There must however be a minimum content that is clearly at a more advanced level than the BEng (Hons) threshold – this is a key distinguishing feature of an MEng level course.

[3]'Extended Study' could include 'Complementary Subjects' (see Section 2) at an appropriate level and/or some further Chemical Engineering subjects at a BEng (Hons) level.

[4]'Application of enhanced/extended skills' will normally involve project work (see Section 4.3) and could involve a major project, up to 60 credits, allowing scope for both development of personal skills and in-depth technical studies.

Appendix A: Learning Outcomes in Core Chemical Engineering

Students graduating from an accredited course in chemical engineering must have demonstrated the learning outcomes (Knowledge and Understanding, Intellectual Abilities, Practical Skills and General Transferable Skills) in five fields, of which one is Core Chemical Engineering. The high-level learning outcome for graduating students in this field is that:

They must be able to handle advanced problems in fluids and solids formation and processing. They must be able to apply chemical engineering methods to the analysis of complex systems within a structured approach to Safety, Health and Sustainability.

The learning outcomes listed in this Appendix provide the platform upon which the graduate will build a career in an environment which, for the most part, will be interdisciplinary. During the course, a certain level of knowledge must be gained together with an appropriate approach to its deployment. This will lay the foundations for developing the key Chemical Engineering skills which differentiate the chemical engineer both from other engineers and from applied scientists in chemistry, materials or biology.

It is desirable that throughout the course the students should gain an understanding of the broad range of applications of the material being taught. Chemical Engineers work with systems as small as a molecule and as large as the biosphere, as fast as a detonation and as slow as (some) nuclear decays, and in their education should acquire the ability to analyse, model quantitatively and synthesise at the appropriate scale. It is expected that through study of a range of applications, they will come to understand, and be able to apply, the principles of Chemical Engineering as readily to biomaterials as to crude oil, and as readily to water purification as to protein separation.

This appendix must be read in conjunction with the descriptions of the other four areas of study, as they are closely linked.

1) Fundamentals

Graduating students must have an understanding of the thermodynamic and transport properties of fluids, solids and multiphase systems.

They must understand the principles of momentum, heat and mass transfer, and be able to apply them to problems involving flowing fluids and multiple phases.

They must be able to apply thermodynamic analysis to processes with heat and work transfer. They must understand the principles of chemical thermodynamics, and be able to apply them to phase behaviour, and to systems with chemical reaction. They must understand the principles of chemical reaction engineering.

2) Applied quantitative methods and computing

For tackling chemical engineering problems, students must be familiar with, and able to apply, a range of appropriate tools such as dimensional analysis and mathematical modelling. They must appreciate the role of empirical correlation and other approximate methods. They must be competent in the use of numerical and computer methods in calculating results. In general, specialised knowledge of computer/IT hardware is not required, the emphasis here is given to the use of software in solving chemical engineering problems.

3) Process and product technology

Students must understand and be able to apply methods to analyse the characteristics and performance of mixing, separation, and similar processing steps. They should understand processes involving (bio-)chemical or microbiological change and formation processes for supramolecular structures (e.g. emulsions, fine particles).

They must understand the principles on which processing equipment operates, and be able to apply methods to determine equipment size and performance.

They must understand and be able to estimate the effect of processing steps upon the state of the material being processed, and on the end-product in terms of its composition, morphology and functionality.

4) Systems

The appreciation of complexity, and the ability to deploy techniques to handle it (the systems approach), is regarded as an important learning outcome of the study of core chemical engineering.

Students must understand the principles of batch and continuous operation and criteria for process selection. They must understand the interdependence of elements of a complex system, be able to integrate processing steps into a sequence and apply analysis techniques such as balances (mass, energy) and pinch. They must have an understanding of system dynamics, and be able to determine the characteristics and performance of measurement and control functions.

They must understand the principles of risk and safety management, and be able to apply techniques for the assessment and abatement of process and product hazards.

They must understand the principles of sustainability. They must be able to apply techniques for analysing, throughout the lifecycle, the interaction of process, product and plant with the environment.

Appendix B: Learning Outcomes in Design

1. SUMMARY

Chemical engineering design is the creation of process, product or plant, to meet a defined need. Learning about design is an essential part of accredited chemical engineering courses, and the usual teaching and assessment mechanism is course-work. To demonstrate that the specified design skills ("learning outcomes") have been acquired, students should accumulate portfolios of design work as they progress through the course, which will demonstrate their ability to handle a range of process, product and plant design problems. Individual exercises can vary in nature and complexity and could include joint projects with students from a different discipline, work carried out at an industrial location under supervision, or relevant experimental programmes, for example. The level of achievement for each exercise should be appropriate to the stage reached in the course. The portfolio approach will encourage integration of design work into the taught course and provide the student with a wide variety of design experience.

2. INTRODUCTION

The IChemE is keen to encourage the development of new forms of design teaching and evaluation, to meet the changing needs of the profession.

Engineering design is the recognition and understanding of a basic need and the creation of a system to satisfy that need (*C V Starkey, Engineering Design Decisions, Edward Arnold, 1992*). In chemical engineering terms this means the creation of a process, product, or plant to meet the need.

Design is an essential component of all IChemE accredited courses and serves to:

- Develop an integrated approach to chemical engineering;
- encourage the application of chemical engineering principles to problems of current and future industrial relevance including sustainable development, safety, and environmental issues;
- encourage students to develop and demonstrate creative and critical powers by requiring choices and decisions to be made in areas of uncertainty;
- encourage the development of professional communication skills and team working; and
- give students confidence in their ability to apply their technical knowledge to real problems.

Chemical engineering design is concerned with:

- Process design – synthesis of unit operations into a manufacturing process to meet a specification.
- Process troubleshooting/debottlenecking – takes existing hardware and process line-up and analyses particular problems for which the solutions require innovative process or equipment changes.
- Equipment design – the design of specific and complex equipment items to deliver a process or product objective, e.g. extruder, distillation column, etc.
- Product design – puts together performance characteristics in a product to meet a specification e.g. polymer film, slow release capsules, most foods, toiletries, beverages, etc.
- Product troubleshooting – takes existing products and analyses particular problems for which the solution requires an understanding of material properties and the influence of the manufacturing process on them.
- System design – where creativity, broad range thinking, and systems integration are needed to design a system to meet a specification, e.g. manufacturing supply chain, effluent handling system, transportation system, safety auditing system, recycling system, site utility system, product distribution system.

The approach to teaching design should encourage students to take a wide perspective on problems and to develop their powers of synthesis, analysis, creativity and judgement as well as clarity of thinking. The objective is to provide the undergraduate with the context and framework for the application of the scientific, technical and other knowledge which is taught elsewhere in the course.

It is anticipated that the requirements for teaching design are unlikely to be met by a single design project, the preference being for appropriate design problems and exercises to be set throughout the course. These should provide an increasing challenge as the student progresses through the course, and also offer the opportunity to tackle different types of design problem.

The ability to take a broad view when confronted with complexity arising from the interaction and integration of the different parts of a system is a key requirement of chemical engineering designers. The appreciation of complexity, and the deployment of techniques to handle it (e.g. material and energy balance, pinch technology and life cycle analysis) are known as the "systems approach", and must form part of design teaching. Demonstrating the learning outcomes associated with the systems approach will require at least part of the portfolio to comprise a major design exercise in which complexity issues are addressed.

3. LEARNING OUTCOMES

On completion of their chemical engineering degree course graduates must know and understand:

(i) The importance of identifying the objectives and context of the design in terms of:
- The business requirements;
- The technical requirements;
- Sustainable development;
- Safety, health and environmental issues; and
- Appreciation of public perception and concerns.

(ii) That design is an open ended process lacking a pre-determined solution which requires:
- Synthesis, innovation and creativity;
- Judgemental choices on the basis of incomplete and contradictory information;
- Decision making;
- Working with constraints and multiple objectives; and
- Justification of the choices and decisions taken.

(iii) How to deploy their chemical engineering knowledge using rigorous calculation and results analysis to arrive at and verify the realism of the chosen design.

(iv) How to take a systems approach to design appreciating:
- Complexity;
- Interaction; and
- Integration.

(v) How to work in a team understanding and managing the processes of:
- Peer challenge;
- Planning, prioritising and organising team activity; and
- The discipline of mutual dependency.

(vi) How to communicate externally to:
- Acquire input information; and
- Present and defend chosen design options and decisions taken.

(vii) The fundamental importance of delivering a complex piece of work on time which is fit for purpose.

4. DELIVERY MECHANISMS

Delivery mechanisms will be a mixture of:

- Teaching and examination for particular skills and techniques used in the design process; and
- Course work to assess the application of taught skills under guidance.

It should be noted that:

- The expectation is that the students will accumulate a portfolio of design work as they progress through the course, each component being assessed at the appropriate stage in the course;
- The portfolio should show evidence of achievement of the learning outcomes in various types of design. At least part of the portfolio must comprise a major design exercise demonstrating that complexity issues have been appropriately addressed;
- The nature of the learning outcomes makes course work the most appropriate delivery mechanism; and
- Individual exercises can vary in nature, and could include joint projects with students from a different discipline, work carried out on industrial location under supervision, or relevant experimental programmes.

5. ASSESSMENT

The objective of the assessment is to ensure that students reach an acceptable level of competence. To meet this objective each student will be required to submit evidence relating to their achievements. This could take the form of reports, log books, plans, drawings, computer programmes and other written material. Additionally, oral presentation is expected and should include cross-questioning.

Each student's submission should show evidence:

- That the design problems have been defined in the context of their objectives of creativity, judgement and decision making;
- That a range of technical knowledge has been quantitatively and correctly applied;
- That a systems approach has been adopted to handle complexity, interaction and integration;
- That the design process itself has been competently managed by the student whether individually or within a team; and
- That the objectives have been properly considered in reaching the final design.

In addition:

- The written reporting must be clear and relevant, and include necessary supporting calculations; and
- The evidence must demonstrate achievement to a level appropriate to the stage reached in the course with a substantive proportion being at an advanced level.

The Annex will aid the interpretation of these requirements.

ANNEX

This Table presents examples of three different assignments at an advanced level, any of which might form part of the design portfolio. The Table shows how various aspects of the work, described in the written or oral reporting, may provide evidence of the learning outcomes.

Challenge	*Process design: A 1000 tpd air separation plant*	*Product design: A slow-release analgesic capsule*	*Equipment design: Troubleshooting a batch distillation*
Structure	Student group project at University location.	One student, in collaboration with Dept of Pharmacy.	One student – 8 week supervised summer placement at xxx.
Learning outcome: Know and understand			
1. Objectives in context	Identify economic, technical and Environmental criteria for process selection.	Set performance targets with producer and consumer constraints.	Identify company's cost and operational targets.
2. The design process	Select a novel membrane/ Cryogenic process.	Choice of a suitable model system for laboratory experiment. Formulation of the capsule.	Advise on the advantages and disadvantages of a variety of possible new column internals.
3. Deployment of technical knowledge	Process design of the main cryogenic cooler using ASPEN.	Design and perform analgesic diffusion experiment, and interpret data for capsule design.	Short-cut, and computer simulation of column. Identify problem with internals.
4. The systems approach	Pinch analysis of the process.	Regulatory and product safety assessment.	
5. Team working	Role in team, working to deadline.	Working with pharmacologists to obtain samples and develop protocols.	
6. Communication	Group project report, with individual sections. Team presentation to Chem Eng Dept.	Individual report, vetted by Pharmacy Dept. Joint presentation with Pharmacy Dept.	Written report to university, also available to company. Oral presentation to plant and Technical Department.
7. Delivery	Process design meets constraints. Discussion of economic sensitivity.	Programme for further development of product.	Ranking of different options.

APPENDIX C: COURSE QUESTIONNAIRE

Name of University:

Department:

Address:

Head of Department:

Signature:

Contact for Accreditation Visit:
(please give full contact details – including telephone and e-mail)

List of course(s) for which accreditation is sought:

Course Title	*Level of Accreditation Sought (BEng / MEng)*	*Date Introduced*	*Currently Accredited? Yes/No*

The amount of information provided in each section of this form is at the discretion of the department but should be as concise as possible. The form is available in electronic format to assist in completion.

1. Course Philosophy and High Level Objectives

Please give an overview of the high level objectives of the course and any particular course specialisations.

2. Course Entry Standards

Please provide details of the entry standards policy in place for the course. For Universities in the UK and Ireland the assessors will be provided with confidential copies of entry standards questionnaires submitted to IChemE in recent years.

3. Learning Outcomes

Please describe how the learning outcomes are achieved in the five areas described in Section 3 of the Guide and how Transferable Skills are achieved in the course. Please ensure that the Assessors can identify clearly which parts of the curriculum contribute to the outcomes (and at what stage in the course). This Section can be usefully cross-referenced to the detailed course, class and module descriptors that are contained in the Student Handbook that should be submitted with this Questionnaire.

If you are submitting a number of courses for accreditation that are essentially variations on a common 'core', please indicate clearly the common core and the nature of the variations in each case.

a) Mathematics, Underlying Science and Associated Engineering Disciplines

b) Core Chemical Engineering

c) Design

d) Social, Environmental and Economic Context

e) Engineering Practice

Transferable Skills (Please describe how the course develops transferable skills)

4. Learning Outcomes – MEng Level

For courses seeking accreditation at the MEng level please detail how the course satisfies the following additional criteria:

4.1 Enhanced (Deepening) nature of the course (*Please give details of subject coverage*)

4.2 Extended (Broadening) nature of the course (*Please give details of subject coverage*)

4.3 Application of enhanced/extended skills *(Please include details of the scope and outcomes of the second major project*)

5. Overall Course Structure and Weightings

Please give an overview of the weightings of the course structure against the broad areas as defined in Sections 7.3 and 7.4 of the Questionnaire. If possible, use a basis of 120 credits of study per year and convert your course metrics to this. Provide the numerical weightings in the tabular form shown below, modified if necessary for different course durations in terms of Years. If necessary, provide additional brief explanatory notes.

BEng (Hons) Level Courses	**Year 1**	**Year 2**	**Year 3**
Basic Sciences and Mathematics			
Chemical Engineering			
Complementary Subjects			
Total Credits			
Design content within 'Chemical Engineering'			

MEng Level Courses	**Year 1**	**Year 2**	**Years 3 & 4**
Basic Sciences and Mathematics			-
Chemical Engineering			
Complementary Subjects			
Enhanced Study	-	-	
Extended Study	-	-	
Application of enhanced/extended skills	-	-	
Total Credits			
Design content within 'Chemical Engineering'			

6. Study Away from Home University

If the course contains a period of study away from the home University, please describe how the learning outcomes are defined, delivered, assessed and quality assured.

7. Assessment and Quality Assurance

Please summarise the assessment strategy and the academic quality assurance to ensure that outcome standards are consistently and fairly assessed.

8. Teaching and Support Staff

Please provide a full list of all teaching staff giving details of position (e.g. Professor, Senior Lecturer etc.), name and academic/professional qualifications (e.g. PhD, BSc) and grade of IChemE membership (if appropriate). Indicate and quantify (approximately) any part-time appointments.

Position	*Name and Academic/Professional Qualifications*	*Grade of IChemE Membership*

Other teaching input to the course:
Number of staff from other departments who teach your students:
Number of graduate students used to assist with teaching:

Number of Support Staff
Technical:
Secretarial and Administrative:

9. Resources

Laboratory Facilities

Please give details of the range and number of laboratory rigs/experiments available for use by the students.

Information Technology Facilities
Please give details of the IT facilities available to students.

Library Facilities
Please give details of the library facilities available to students.

10. Course Developments and Innovations
Please highlight any recent or planned developments to the course(s) and also any features of the course(s) which you particularly wish to draw attention to.

11. Any Additional Information

12. Statistics of Student Numbers and Awards
Please complete the attached spreadsheet. Modify (add/delete) the number of Years as appropriate.

Notes
'New Admissions' are students admitted to the course for the first time.
Population = New Admissions + Proceed from Previous Year + Repeat
'Awards and Classification':
- Where students are graduating from more than one course (for example at BEng(Hons) Level and at MEng Level, identify the awards for each course;
- Where a different system of classifying awards is used, please replace the given categories of Honours degree with your own system and, if possible, provide a comment on approximate equivalencies.

STUDENT STATISTICS

	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
Year 1					
New Admissions					
Population					
Fail/Withdraw					
Repeat					
Proceed to next year					
Award					
Year 2					
New Admissions					
Population					
Fail/Withdraw					
Repeat					
Proceed to next year					
Award					
Year 3					
New Admissions					
Population					
Fail/Withdraw					
Repeat					
Proceed to next year					
Award					
Year 4					
New Admissions					
Population					
Fail/Withdraw					
Repeat					
Proceed to next year					
Award					
Year 5					
New Admissions					
Population					
Fail/Withdraw					
Repeat					
Award					
Awards and Classification					
First					
Second Class, Upper					
Second Class, Lower					
Third					
Other					
Total					

APPENDIX D: ACCREDITATION ASSESSORS' REPORT

STRICTLY CONFIDENTIAL

Name of University:

Department:

Address:

Head of Department:

Title of courses assessed:
(please state the length of each course)

Date of Assessors' Visit:

Names of Assessors:	(1)	(Lead Assessor)
	(2)	
	(3)	

Signatures of Assessors:	(1)
	(2)
	(3)

Please return this completed report within three weeks of the visit to:

Accreditation Officer
Qualifications Department
The Institution of Chemical Engineers
Davis Building
165-189 Railway Terrace
Rugby
CV21 3HQ

Please provide detailed comments on the following aspects of the course(s) after reference to the course questionnaire, the course material, and after the formal visit.

Introduction
Comment on any special features of the course and any other aspects that will help to set the context for the accreditation

2. Entry Requirements
Comment on the entry criteria and profiles (including the years at which students are admitted to the course), the entry numbers and trends, and the strategy for attracting students to the course.

3. Learning Outcomes
Describe how the learning outcomes are achieved in the five areas specified in Section 3, and how Transferable Skills are achieved in the course:

a) Mathematics, Underlying Science and Associated Engineering Disciplines

b) Core Chemical Engineering

c) Design

d) Social, Environmental and Economic Context

e) Engineering Practice

Transferable Skills

4. Learning Outcomes – MEng Level
For courses seeking accreditation at the MEng level describe how the learning outcomes are achieved in the following areas.

4.1 Enhanced (Deepening) nature of the course (*Give details of subject coverage*).

4.2 Extended (Broadening) nature of the course (*Give details of subject coverage*).

4.3 Application of enhanced/extended skills (*Give details of the scope and outcomes of the second major project*).

4.4 Progression to MEng

For courses that have BEng(Hons) and MEng in parallel, comment on the criteria for progession to MEng level.

5. Overall Course Structure and Weightings

Give an overview of the weightings of the course structure against the broad areas as defined in Sections 7.3 and 7.4 of the Questionnaire. If possible, use a basis of 120 credits of study per year.
This information should have been provided in the Course Questionnaire, but you should confirm it using your own judgement and interpretations.

BEng (Hons) Level Courses

	Year 1	**Year 2**	**Year 3**
Basic Sciences and Mathematics			
Chemical Engineering			
Complementary Subjects			
Total Credits			
Design content within 'Chemical Engineering'			

MEng Level Courses

	Year 1	**Year 2**	**Years 3 & 4**
Basic Sciences and Mathematics			-
Chemical Engineering			
Complementary Subjects			
Enhanced Study	-	-	
Extended Study	-	-	
Application of enhanced/extended skills	-	-	
Total Credits			
Design content within 'Chemical Engineering'			

6. Study Away from Home University

If the course contains a period of study away from the home University, comment on how the learning outcomes are defined, delivered, assessed and quality assured.

7. Assessment and Quality Assurance
Comment on the assessment strategy and the academic quality assurance to ensure that outcome standards are consistently and fairly assessed.

8. Resources
Comment on the adequacy of resources to support delivery of the course:

a) Academic Staff

b) Technical and Administrative Support

c) Laboratory Facilities

d) Library Facilities

e) Information Technology Facilities

f) Any other resources not covered above

9. Discussions

Highlight any issues that arose during discussions with the following groups during the visit:

9.1 Discussions with Staff

9.2 Discussions with Students

10. Innovative Features and Developments

Are there any aspects of the courses(s) that merit highlighting due to their novel or innovative nature?

11. Conclusions

12. Recommendations (For Accreditation Committee only)

Please identify clearly any recommendations that are:
'Conditional' – i.e. certain issues must be addressed within a specified time scale.
and/or
'Provisional' – i.e. a new course that has yet to produce the first cohort of graduates.