Through its conduct of university degree programme accreditation, IChemE aims to recognise and share best practice in the university education of chemical and biochemical engineers. At the same time it seeks to promote development of the profession, by encouraging innovation in chemical engineering programme design and delivery.

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

These guidelines have evolved from IChemE’s long experience in accrediting degree programmes across the world. IChemE accredited degrees are recognised through mutual recognition agreements worldwide and by ECUK (consistent with the UK-SPEC regulation, issued March 2004).

IChemE would like to extend its sincere appreciation to the many people from industry and academia who have assisted in its worldwide accreditation activities, and who have helped in drafting this revision of the guidelines.
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A1 Learning outcomes: Underpinning mathematics and sciences
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1. Introduction

Chemical engineering continues to evolve rapidly as a profession. Nowhere is the need to take account of change more important than in the education and academic formation of engineers. It is essential that new graduates have the skills to perform in an ever-wider variety of roles and industries. Moreover, they must not only be equipped to contribute quickly during their early careers, but also have a quality academic grounding in chemical engineering principles ‘to last a lifetime’.

Our aim, to recruit the brightest and most innovative young people into the discipline, challenges us to provide them with an education that will stimulate and develop their talents. University degree programmes must communicate the relevance and excitement of our profession. IChemE responds to this challenge with its accreditation activity, through which educators benefit from our knowledge of best global practice in chemical engineering education. IChemE concentrates upon assessment of ‘learning outcomes’ (i.e. what is learnt by students) rather than traditional methods of specified degree programme content (i.e. what is taught to students).

These guidelines summarise what IChemE requires of an accredited degree programme, with the intention of leaving it to the university to determine how the requirement is met.

1.1 The value of accreditation – why universities seek IChemE accreditation

Fundamentally, IChemE accreditation provides benchmarking of academic programmes against high, internationally recognised standards. This is of increasing importance as the globalisation of engineering products and services demands greater confidence by employers in the skills and professionalism of the engineers they recruit.

A successfully accredited department:

- Will be able to offer students exchanges with other accredited departments knowing that the student experience will be of high quality and being able to ensure that such students’ academic formation meets IChemE’s requirements for professional qualification.

Graduates, themselves, strongly benefit from attending accredited programmes as accreditation links closely to professional qualification with IChemE (see 1.4). Our aim is to help chemical engineers who acquire sufficient knowledge, understanding and skills to enable them to seek recognition as a Corporate Member of IChemE and as a Chartered Chemical Engineer, the highest international qualification for professional chemical engineers.

IChemE’s accreditation process has many unique strengths which departments value:

- It is a rigorous process that uses panels of three trained, experienced, chemical engineering professionals to assess degree programmes. This provides a higher level of depth and penetration of the teaching programmes than can be achieved by typical pan-engineering accreditation processes.

- It is recognised and respected worldwide. IChemE has accredited programmes across the world for over 40 years and currently accredits over 150 programmes across the five continents.

- It is modern and innovative. Concepts of sustainability and ethics, appreciation of the bio interface, quality delivery of transferable skills etc are therefore expected.

- It assesses programmes against the Learning Outcomes achieved by students, regardless of entry levels and programme duration.

- It is grounded in a philosophy of continuous improvement. IChemE expects diversity and seeks to stimulate improvement in chemical engineering education by encouraging new and innovative approaches.
1.2 The international perspective

IChemE has an international perspective on chemical engineering education and holds a deep understanding of the different types of degree available to students in many countries.

IChemE fully appreciates that different countries may define degrees in differing ways: worldwide there are examples of 3, 4, 5 and even 6 year Bachelor programmes, some countries offer integrated Masters programmes (through efficient, integrated design of advanced study) or equivalent.

IChemE must therefore, in its assessments, focus on taught content delivered and, critically, the resultant learning outcomes achieved through study of a degree.

To help categorise our accreditation decisions IChemE takes no notice of degree name nor title and simply adopts a simple convention of Master level and Bachelor (Hons) level accreditations.

Details are outlined in 1.3.

1.3 Levels of accreditation award

IChemE accredits degree programmes at two levels:

‘Master level’
(also described as a second cycle degree under the Bologna process)
- Recognising Master level degrees of the highest international standards that provide advanced chemical engineering knowledge and skills.

‘Bachelor level’
(also described as a first cycle degree under the Bologna process)
- Recognising mainstream Bachelor level degrees that provide a solid academic foundation in chemical engineering knowledge and skills.

The exemplifying academic formation for qualification as a Chartered Chemical Engineer is an IChemE accredited ‘Master level’ degree in chemical engineering.

The academic formation requirement can flexibly be met in a variety of ways as illustrated below:

Accredited routes: exemplifying academic formation for Chartered Chemical Engineer

- **First cycle degree**
  1. Bachelor eg BEng (Hons); BE
  2. Integrated Master eg MEng; (some BE)
  3. Bachelor eg BEng (Hons); BE

- **Second cycle degree**
  1. Master eg MSc
  2. Work Based Further Learning

Important note

Neither ‘name or title’ nor ‘number of years duration’ of a degree programme has any bearing on the predicted achievement of accreditation status.

Accreditation is based solely on programme learning outcomes and not degree titles.

Different degree titles may commonly be used across the international community.
1.4 Accreditation – the link to professional recognition as a Chartered Chemical Engineer

Accredited degrees help provide graduates with a straightforward pathway to qualification as a Chartered Chemical Engineer (MIChemE).

Graduates with a Master level accredited degree will have met the formal educational requirements for Chartered status membership in full. Graduates will simply be required to demonstrate that they have acquired professional competency following a required and sufficient period of relevant training and experience (initial professional practice) post graduation.

Graduates with a Bachelor level accredited degree will, normally, need to provide evidence of further learning to the equivalent of Master level academic outcomes*. This further learning can be achieved through completion of a relevant postgraduate or second cycle qualification such as an MSc. The IChemE ‘Work Based Further Learning to Master level’ process provides an alternative route.

Footnote:

*Guidance on achieving further learning to Master level is available from IChemE. Full guidance on IChemE membership requirements is found at www.icheme.org/membership
2. An accreditation philosophy based upon learning outcomes

2.1 Introduction
IChemE’s accreditation decisions result from an evidence based assessment of the learning outcomes delivered by the degree programme.

IChemE considers that the quality of a degree programme is fundamentally linked to a high quality learning experience for students that delivers excellent attainment. This can only be evaluated through review of evidence of student achievement. IChemE therefore believes that measurement of time spent (credit hours) on individual course or module elements, while providing guidance regarding extent of taught content, is not a definitive measure of learning delivery. Likewise IChemE believes it can reasonably be expected that cohorts of high entry standard may, given a stretching curriculum and a demanding, well resourced teaching environment, be more likely to achieve higher levels of learning outcomes.

IChemE’s accreditation philosophy therefore takes into account all factors that influence delivery of learning outcomes.

2.2 About learning outcomes
Learning outcomes define the capabilities of individuals obtaining the degree qualification. Programme designers typically express them in the form of outcome statements.

A high-level outcome statement might be:

‘is able to solve open-ended chemical 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 etc. This approach provides an effective framework giving both guidance and flexibility to programme designers.

The learning outcomes of a chemical engineering programme will represent the important qualities that IChemE expects the programme to develop in a student who will go on to practise as a chemical engineer. Whilst the high-level outcome statements themselves define individual module/course objectives within the degree, somewhat more guidance is required by those designing or accrediting a particular programme.

2.3 Scope of chemical engineering degree programmes

It is not practical for any one programme to achieve all the learning outcomes that every chemical engineer might conceivably need. An acceptable academic formation requires more than would fit a graduate for a single, narrowly defined role.

The learning outcomes specified in this guidance comprise a package which is distinctive to chemical engineering, and which can be regarded as a minimum necessary requirement for IChemE accreditation.

Many degree programmes will broaden and deepen beyond the minimum requirements in many ways. These could be from within the chemical engineering discipline or through further studies in science or engineering, sustainability, management, economics, languages or law etc. The quantity of such study will depend on the interests and previous education of the students, as well as the length of the programme. Non-chemical engineering content is referred to as ‘complementary subject material’.

University degrees 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. Degree programmes should lay the foundations on which further education and training can build.
2.4 Entry standards

High quality chemical engineering degrees are demanding on students. While the IChemE accreditation process places greatest emphasis on the outcomes of a programme of study, input standards to the programme invariably remain an important factor. IChemE expects programme providers to maintain appropriate entry standards.

The study of underpinning mathematics and sciences in the early parts of a chemical engineering programme requires a satisfactory standard of knowledge in these discipline areas. IChemE will therefore assess entry standards for the local higher education system against defined international norms (e.g. as measured by International Baccalaureate, A-Level scores etc) and will expect the standards for entry to accredited chemical engineering courses to be at a relatively high level. This is particularly true for entry to Master level programmes.

IChemE therefore expects prospective students to hold secondary schooling qualifications in underpinning mathematics and sciences above minimum threshold entry standards.

Where these criteria are not adequately met, IChemE may require that special measures are in place. In some cases this will require a foundation year of preparation study (which will not be included in the subsequent accreditation review). In other cases clear evidence of additional remedial teaching within the programme will be required.

2.5 General learning outcomes

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

Knowledge and understanding: They must 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, safety, 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, individual and group project work, in design, and use of software resources. Evidence of group working and of participation in a major substantive project is expected.

General transferable skills: They must have developed and demonstrate ability to integrate transferable skills (such as communications, time management, team working, inter-personal, effective use of IT including information retrieval skills) that will be of value in a wide range of situations.
3. Learning outcomes in a chemical engineering context

The following broad areas of learning must be clearly taught in all programmes seeking IChemE accreditation:

(i) Underpinning mathematics and science (chemistry, physics, biology)

Students’ knowledge and understanding of mathematics and science 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. It is expected that this underpinning material should be taught in an engineering context and, where appropriate, a chemical engineering context.

Refer to appendix A1 for further detail.

(ii) Core chemical engineering

The main principles and applications of chemical engineering.

Students must be able to handle 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. The teaching of a minimum core of safety topics must be evident and emphasise the fact that the pursuit of excellence in safety demands a mature culture and attitude.

Departments should demonstrate high standards of appreciation of Safety, Health and Environment (SHE) in their teaching and operations within laboratories and pilot plants.

Refer to appendix A2 for further detail.
(iii) Engineering practice

The practical application of engineering skills, combining theory and experience, together with the use of other relevant knowledge and skills.

Graduates of accredited programmes must understand the ways in which chemical engineering knowledge can be applied in practice, for example, in: operations and management; projects; providing services or consultancy; developing new technology.

Departments should demonstrate high standards of appreciation of Safety, Health and Environment (SHE) in their teaching and operations within laboratories and pilot plants and project work.

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. Graduates 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 knowledge of managerial and inter-personal skills.

(Note that such areas of knowledge 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).

Refer to appendix A3 for further detail.

(iv) Design and design practice

The creation of a process, product or plant to meet a defined need.

Students 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.

Departments should demonstrate high standards of appreciation of Safety, Health and Environment (SHE) within their teaching of design and related project work.

Refer to appendix A4 for further detail.

(v) Embedded learning (sustainability, SHE, ethics)

Students must acquire the knowledge and ability to handle broader implications of work as a chemical engineer. These include sustainability aspects; safety, health, environmental and other professional issues including ethics; commercial and economic considerations etc.

Graduates must be able to calculate and explain process, plant and project economics. They should also 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.

It is expected that this material is consistently built upon and themes reinforced throughout the degree.

Refer to appendix A5 for further detail.

(vi) Embedded learning (general transferable skills)

Chemical engineers must develop general skills that will be of value in a wide range of business situations. These include development of abilities within problem solving, communication, effective working with others, effective use of IT, persuasive report writing, information retrieval, presentational skills, project planning, self learning, performance improvement, awareness of the benefits of continuing professional development etc.

IChemE expects degree programmes to be designed so that they provide the opportunity to acquire and develop these skills and will seek to ensure demonstration and commitment to this objective.

Refer to appendix A6 for further detail.
(vii) Advanced chemical engineering

The distinguishing feature of a Master level programme is the teaching of materials beyond that typically provided for in undergraduate Bachelor programmes. Such 'advanced chemical engineering' courses take various forms, all of which are to be found in Master level programmes.

These are:

**Depth**
Courses that provide students with a deeper penetration of knowledge and understanding than has previously been acquired from a first exposure to a topic earlier in the degree programme, taught to Bachelor level standard. Such advanced courses must therefore have **clearly distinguishable pre-requisites** of taught study from earlier in the curriculum plan. (Where long course/modules exist due allowance will be made to address this principle concept).

*Refer to appendix A7 for further detail.*

**Breadth**
Chemical engineering is also a vast field. This means that there is great opportunity for programme designers to design varied curricula reflecting certain fields and interests. IChemE welcomes this and therefore expects Master level programmes to include courses/modules that can clearly be described as advanced breadth of study. These are courses that expose students to topics additional to those that would normally be considered as core chemical engineering but that are valuable to further developing their chemical engineering formation.

*Refer to appendix A7 for further detail.*

**Advanced chemical engineering practice**
Graduates of Master level programmes are characterised by having (i) thorough understanding of current practice and its limitations (ii) extensive knowledge and understanding of a wide range of chemical engineering processes and process equipment and, critically, (iii) an ability to apply chemical engineering techniques taking account of a range of technical, commercial and industrial constraints. This application may have been demonstrated through research projects, industrial projects etc.

*Refer to appendix A3 for further detail.*

**Advanced design practice**
Graduates of Master level programmes would be characterised by (i) having a comprehensive understanding of design processes and methodologies and (ii) an ability to apply and adapt them in unfamiliar situations and, critically, (iii) the ability to generate an innovative design for processes, systems and products to fulfil new needs. This application may be demonstrated through a major design project or may form part of a major research project.

*Refer to appendix A4 for further detail.*

(viii) Complementary learning
IChemE expects students to also gain the benefits of a rounded education and allows programme designers to have the flexibility to allow students to follow additional beneficial courses such as languages, management related studies, history and culture etc.

These courses, nor their content, are not formally assessed by IChemE, but rigour in their teaching and assessment is expected.
4. Assessment of learning outcomes

4.1 Guidance on duration and content of chemical engineering programmes

4.1.1 Introduction

Decisions on whether a programme is accredited, and at what level, will be taken solely on the basis of achievement of learning outcomes against defined standards. Accredited programmes 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 on content is useful for both departments and assessors. (However, it should be stressed that the metrics on duration and content given within section 4 are for guidance. 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 learning outcomes have been met).

In order to provide a common measure of content, and on the assumption that most programmes have a modular credit-based structure, it has been assumed that a typical year of full-time study comprises 60 European Credit Transfers (ECTS). [It is expected that departments will be able to convert their own measures of programme content to the ECTS framework basis. For example 1 ECTS credit = 2 UK credits. In cases where there are difficulties in interpretation IChemE will provide guidance].

As a guide 1 ECTS unit is equivalent to approximately 20 hours of student learning.

4.1.2 Minimum programme duration

As a general guidance IChemE expects that for degree entrants meeting our baseline entry standards (refer 2.4):

– integrated programmes seeking accreditation at Master level will normally comprise at least four academic years of full-time study (or an equivalent period of part-time study), defined as approximately 240 ECTS.
– programmes seeking Bachelor level accreditation will normally comprise at least three academic years of full-time study (or an equivalent period of part-time study), defined as approximately 180 ECTS.
– a conventional second cycle degree programme (e.g. MSc in chemical engineering), delivering Further Learning to Master Level, will normally comprise a minimum content of 90 ECTS.

IChemE stresses that output standards achieved are more important than length of study.
4.1.3 Minimum programme content

IChemE specifies that learning outcomes must be delivered across key broad areas of learning, as defined in section 3 and the supporting appendices A1-7.

In order to maintain threshold standards, while encouraging diversity and innovation in accredited programmes, the following guidance on minimum content is provided:

IChemE Accreditation: minimum credit allocation guidance

Credit basis = European Credit Transfer System (ECTS)

<table>
<thead>
<tr>
<th></th>
<th>Master level</th>
<th>Bachelor level</th>
<th>Further Learning to Master level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underpinning mathematics and science</td>
<td>20 (~8%)</td>
<td>20 (~11%)</td>
<td></td>
</tr>
<tr>
<td>Core chemical engineering</td>
<td>85 (~35%)</td>
<td>85 (~47%)</td>
<td></td>
</tr>
<tr>
<td>Engineering practice</td>
<td>10 (~4%)</td>
<td>10 (~5%)</td>
<td></td>
</tr>
<tr>
<td>Design practice</td>
<td>10 (~4%)</td>
<td>10 (~5%)</td>
<td></td>
</tr>
<tr>
<td>Embedded learning (SHE, sustainability)</td>
<td>Sufficient demonstration</td>
<td>Sufficient demonstration</td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Embedded learning (Transferable skills)</td>
<td>Sufficient demonstration</td>
<td>Sufficient demonstration</td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Advanced chemical engineering (depth)</td>
<td>30 (~13%)</td>
<td>30 (~13%)</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering (breadth)</td>
<td>15 (~6%)</td>
<td>15 (~6%)</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering practice</td>
<td>10 (~4%)</td>
<td>10 (~17%)</td>
<td></td>
</tr>
<tr>
<td>Including advanced chemical engineering design practice</td>
<td>10 (~4%) + 5 (~2%)</td>
<td>5 (~11%)</td>
<td></td>
</tr>
<tr>
<td>Total specified content</td>
<td>185 (~77%)</td>
<td>125 (~70%)</td>
<td>60 (~67%)</td>
</tr>
</tbody>
</table>

Advisory notes:

All credit counts are on an exclusive basis. Therefore total content of whole courses or modules cannot be accounted for twice nor appear under two categories of learning. If departments consider that it is appropriate for content of courses/modules be allocated across categories of learning, this is acceptable, provided full explanation of rationale is provided to IChemE.

Embedded materials

It is expected that courses throughout a programme include, illustrate and reinforce aspects of sustainability, SHE and, where possible ethics. It is expected that a wide variety of delivery methods are used throughout so that students acquire the range of interpersonal and management skills etc to equip them to the modern engineering workplace.
4.2 Distinguishing features of Master level programmes

Master level degree programmes are also referred to as second cycle degrees. They are clearly differentiated from Bachelor level (first cycle) programmes and are characterised by delivering advanced learning through the study of advanced topics often in combination with exposure to broader and deeper material not encountered in earlier study. Graduates will therefore have an ability to apply their knowledge and skills to solving, from first principles, complex problems not typically encountered in Bachelor level work.

Advanced material provides learning outcomes at greater levels of depth and breadth than delivered at Bachelor level. These are:

- **Depth** in knowledge and skills - increased depth and range of specialist knowledge including advanced chemical engineering knowledge to the highest international standards;
- **Breadth** in knowledge and skills – increased range of chemical engineering and related topics;
- **Development** and applications of skills – increased skills (both subject-specific skills and transferable skills) acquired through enhanced and extended project work.

In addition there may be further study of complementary subjects – including other science/technology, or other non-chemical engineering subjects such as business or languages.

IChemE expects Master level degree programmes to have strong involvement and interaction with industry and to provide greater industry relevant exposure of students than Bachelor level programmes.

In some countries Bachelor level and Master level programmes are run as combined first and second cycle programmes, e.g. the UK integrated Master MEng degrees. In these cases IChemE expects features which distinguish the Master level programme to be integrated throughout the latter years of the programme. In addition, student progression to the second cycle (Master level) should be conditional on a demonstration of good academic performance. There should be appropriate and clear criteria to ensure this. Such Master level graduates will be equipped with advanced depth and breadth of knowledge and understanding of chemical engineering skills.

Integrated Master programmes should include a major process plant design exercise demonstrating that issues of complexity have been appropriately addressed (see appendix A4), the scope of which may be wider than in Bachelor level programmes.

These programmes should also include a second substantial open-ended project, which stretches and develops students’ problem solving and creative thinking capacities. This second project could be one of the following:

- Research linked to the department’s own postgraduate research programmes, or undertaken research at an industrial research laboratory/institute (this could be conducted as an interdisciplinary project).
- Analysis of an industrial process, perhaps combining a period in industry with some analytical or theoretical work at the university.
- A theoretical project including a literature review with subsequent data analysis/computer modelling.

4.3 Distinguishing features of Bachelor level programmes

Bachelor level degree programmes are also referred to as first cycle degrees. A programme accredited at the Bachelor level will provide the learning outcomes described in section 3 at a threshold level. IChemE makes no specification regarding advanced chemical engineering content of these programmes and leaves provision and inclusion of any such advanced content entirely at the discretion of the programme designers.

To be accredited at this level Bachelor programmes must necessarily deliver a satisfactory design portfolio, supported by individual and group project work.

4.4 Distinguishing features of programmes providing Further Learning to Master level (e.g. MSc)

MSc programmes in chemical engineering are typically of specialist character.

IChemE has clearly specified the minimum levels of advanced programme content required to meet its accreditation criteria (refer 4.1.3).

In order to maintain standards of academic formation for Chartered Chemical Engineer qualification IChemE specifies that:

A chemical engineering MSc must contain a minimum of 5 ECTS advanced design practice. This enables a graduate holding a non-accredited chemical engineering degree to meet the requisite academic formation following successful completion of the MSc.
4.5 Taught delivery methods and departmental practice for student assessment

4.5.1 Delivery methods

Various methods can be used to deliver a programme satisfying the learning outcomes, depending on the style of teaching appropriate to the university and the students, the number of students taught and the varied nature of 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, programmes may incorporate industrial placements, or study at other universities at home or abroad.

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.

4.5.2 Assessment

The purpose of assessment by a 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 programme there should be an assessment of a student’s oral presentation.

It is expected that the university will have its own formal procedures for assessment and maintain a robust quality assurance process to ensure that outcome standards are consistent and fair.

4.6 Evidence of achievement learning outcomes

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

Typical examples of direct evidence are:

- examination papers, together with model answers and marked scripts
- project reports
- laboratory reports
- design project reports
- industrial placement reports

Typical examples of indirect evidence are:

- external examiner’s reports
- audits
- quality assurance reports external to the department.

4.7 Learning periods away from the home university

Many programmes contain an assessed period of learning away from the home university – either in industry or at another university.

In cases where the assessed period away from the home university contributes to the overall degree award, and hence to the learning outcomes relevant to accreditation, IChemE will look for strong, clear evidence of:

- defined learning outcomes for the period away
- 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 assessed 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 away (distance learning)
- continuing professional development courses

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

- programme of studies completed when at the university
- examples of assessed project work and/or examination papers

In each case it is expected that the students would re-enter the degree programme at a more advanced stage than when the period away began.
4.8 Resources, including professional membership

It is expected that appropriate human and physical resources will be in place to support the delivery of the programme.

IChemE holds the view that academic staff have a hugely important role in exemplifying professional behaviours to students. It therefore expects that at least 50% of senior faculty (e.g. professors, associate professors) hold professional level registration with a recognised professional body.

It is expected that a department running an accredited degree will employ a sufficient number of full-time academic staff, including qualified chemical engineers, for students to have reasonable access to them for instruction and guidance.

The IChemE degree programme questionnaire seeks details of staff resources and laboratory, information management and learning facilities. An opportunity to meet staff and to view the facilities is included in the timetable for all accreditation visits.

4.9 Safety culture

IChemE insists that students on accredited degree programmes must be instilled with appropriate attitudes to SHE. The demonstration or otherwise of an adequate safety culture within a department will form part of the IChemE assessment.

4.10 Ethics culture

IChemE recognises that modern chemical engineering degrees need to include an emphasis on ethical considerations. These include, for example, recognition of the ethical responsibilities of engineers, development of appropriate attitudes to ethical issues in relation to engineering, discussion of the ethical dilemma in engineering, justification of the ethical stance.
5. Preparation for accreditation

5.1 Preparing the submission documentation

IChemE is usually first approached by a senior university official regarding possible accreditation. Once IChemE receives a formal request the department and IChemE agree initial suitability of the degree programme for an accreditation assessment. A provisional date is then agreed between the department and IChemE for an assessment visit (typically 6 months later). The department should immediately appoint a member of staff responsible for the whole accreditation process including the timely and comprehensive submission of documentation ahead of the visit. Document preparation needs to be rigorous and it is advised that sufficient time (usually some months) is made available for this activity.

IChemE recommends that submissions are sent on clearly indexed DVD/CDs (4 copies). The submission comprises (i) the degree programme questionnaire and (ii) Supporting documentation. Some materials may be sent in hard copy (e.g. design reports) if this is easier to manage.

Well-referenced electronic submissions (DVD/CD) are helpful and welcomed. 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 to provide this or, alternatively, make arrangements for this to be available for review during the assessors’ visit.

5.1.1 Degree programme questionnaire

The degree programme questionnaire is a critical document and provides a structure for the department to comprehensively collate all essential descriptive information on the degree programme for advance assessment by IChemE.

The degree programme questionnaire should be completed in full and submitted to IChemE two to three (2-3) months ahead of the visit. Refer to appendix B for the structure of the degree programme questionnaire.

5.1.2 Supporting documentation

Supporting documentation must also be provided by the department along with the programme questionnaire(s) (electronically where possible). This is material which:

(i) provides actual detail of the curriculum (the taught syllabus, programme handbook) and typically includes:
- list of subjects with syllabus, target learning outcomes for each
- descriptors of all teaching and showing sequence of all taught subjects
- major research/design projects including scope, assessment (individual/group) and marking schedules

(ii) provides evidence of a valid cross-section (high, middle, low) of the learning outcomes actually achieved by students. Evidence should be drawn from all parts of the degree programme and typically include:
- complete set of examination papers (past 2 years)
- marking schemes
- external assessment
- design projects (3 examples)
- research projects (3 examples)
- laboratory work
- teaching assessments etc.

Important note:

Careful consideration should be made by the department to ensure that it is clear to IChemE which programmes are being assessed and which programmes have multiple/parallel content. Experience tells us that it is helpful if departments present this information with great clarity in their submissions.

5.2 Preparing the department

It is good practice for senior university staff to be briefed ahead of the visit. Likewise department staff and students should also be briefed adequately to include the purpose, aims and possible outcomes from the IChemE assessment.

During the visit key staff should be readily available to meet the assessors. This includes programme owners, advisors, laboratory managers, safety managers and others deemed appropriate by the department.
5.3 Preparing for the assessors’ visit

The department may wish to provide additional supporting documentation for the assessors to examine in support of their assessment. Such material could be made available for the visit and might include:

- brief CVs of academic staff including professional associations
- management structure
- industry involvement
- how sustainable development, ethics, safety etc are embedded in the programme
- additional student materials etc

A serviced meeting room should be prepared and made available to the assessors for their private reviews and deliberations. This room should ideally contain all supporting documentation provided to the assessors for their perusal. (Name badges for assessors and staff are helpful).
6. The accreditation assessment process

6.1 Visit planning
Accreditation visits are two days minimum in length. Visits to universities seeking first accreditation may take three days.

Visits are normally conducted by a team of three trained assessors (two academics, one industrialist) who are all Chartered Chemical Engineers. IChemE staff will liaise with the university to agree a convenient date for the visit during term-time, to agree the structure of the visit, and to make logistical arrangements for the visit such as timings, accommodation, travel etc.

IChemE staff will distribute the documentation supplied by the university to the assessors for review in advance of the visit and will liaise regarding any further materials or arrangements required prior to the visit. Accreditation visits are organised about six to nine months in advance. This allows the university time to prepare a comprehensive submission and for arrangements to be planned. The required documentation must be made available to IChemE at least two months before the visit date.

Refer to appendix D for a typical visit schedule

6.2 Selection of assessors
IChemE maintains a panel of trained assessors. The panel comprises both academics and industrialists who have current knowledge of the accreditation process and requirements. Prior to a visit, assessor teams are approved by the Chair of Accreditation Committee using the following criteria:

- all assessors will have received IChemE training
- not more than one assessor should be ‘new’ i.e. with no previous visit experience
- teams will include assessors with appropriate international experience from our worldwide assessor pool
- teams will always comprise at least one academic and one industrialist
- teams will, if possible, include members with expertise appropriate to the programmes being considered (e.g. biochemical engineering)

For re-accreditation visits, IChemE will, if appropriate, strive to ensure that one assessor should have been a member of the panel for the previous visit (although this cannot be guaranteed).

Departments do not have the right to select or approve the membership of the assessor team. Should there be 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 the Chair of Accreditation Committee.

6.3 The role of IChemE’s assessors
The assessors’ primary role is to seek evidence to verify that the target 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:

- are the entry qualifications profiles of students satisfactory?
- are the learning outcomes clearly defined and are they appropriate?
- is the programme structure and content appropriate to deliver the learning outcomes?
- are the resources to support the delivery of the learning outcomes adequate?
- are the learning outcomes achieved to an appropriate standard?

Assessors will often request to see additional materials during their visit. Departments are respectfully requested to be prepared for, and accommodating of, reasonable requests.

6.4 The assessors’ report
The assessors prepare a concluding written report of their visit.

The primary purpose of this assessors’ report is to summarise how they have (or have not) been able to verify whether the learning outcomes are met. The assessors’ report includes a summary of general aspects of the visit, such as resources, safety culture and discussions with staff and students, which impact upon the delivery of those learning outcomes.

In addition, the assessors will seek to:

- identify and commend strengths and good features within the programme; and
- identify areas where there may be scope to improve the programme.

- propose recommendations to the Accreditation Committee on the future accreditation status of the degree programme(s) offered.

The assessors’ report, minus the assessor panel’s accreditation recommendation, will be passed to the university for comments on its factual accuracy before being forwarded to IChemE’s Accreditation Committee for review.

Refer to appendix C for the format of the assessors’ report
7. Accreditation outcomes

7.1 Accreditation decision process
The Accreditation Committee will formally review the assessors’ report, together with the accreditation recommendation of the assessor panel for final decision. The Accreditation Committee is comprised of IChemE assessors and exists to ensure maintenance of standards and consistency of decision-making.

Decisions of the Accreditation Committee (which meet every three months) are normally communicated to the department within one week of their meeting. Occasionally, further information or clarification may need to be sought before a final accreditation decision is made (normally at the subsequent meeting).

7.2 Accreditation outcomes
Decisions are based foremost on maintaining benchmark standards of academic formation.

In addition, IChemE will seek to help departments, providing advice and counsel to support continuous improvement of their programmes. IChemE also seeks to commend and share educational best practice amongst the community of accredited departments worldwide.

In some instances IChemE may defer an accreditation decision for further information/clarification of certain issues by the department.

7.2.1 Decisions
Accreditation Committee may make a range of possible decisions:

- **Accredit/re-accredit the programme(s)**
  Such accreditations may be valid for a period up to a maximum of five years. Accreditation is effective from the date of student cohort entry to the first year of the programme in the academic year that IChemE visits. It is not possible for an accreditation award to be retrospective.

- **Accredit/re-accredit the programme(s) subject to conditions**
  Such accreditations will be dependent upon the university meeting requirements set by IChemE following its review of the assessors’ report.
  These conditions will be programme specific. Exemplar conditions have included further report submissions, changes to course modules, demonstration of stronger safety culture etc.

- **To not accredit/re-accredit**
  In this instance IChemE will advise why the programme has failed to be accredited and will, upon request, provide remedial support to the university.

7.2.2 Conditions
IChemE may make accreditations subject to conditions. These are binding on the university and must be complied with, within the indicated timeframe, if accreditation is to be maintained and valid.

7.2.3 Recommendations
In the majority of cases IChemE may additionally make recommendations to the university.

These are not mandatory but are offered in the spirit of providing help and sharing of best practice in chemical engineering education. Adoption by the university of these recommendations is encouraged and expected.

7.3 After the accreditation decision
Following an accreditation award the department will be sent a certificate to formally acknowledge the accredited status of the programme(s).

There will be ongoing contact between IChemE and the department in terms of accreditation policy developments during the period of accreditation. IChemE’s qualifications department will liaise with the department regarding policy changes, student services, membership and related activities.

Similarly, departments must inform IChemE of substantive changes to the curriculum or resources that impact upon the delivery of the accredited programme.

All departments with accredited degree programmes 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. In addition, it is considered to be normal practice that the department, with the help of IChemE, encourages uptake of student membership amongst the cohort.

7.4 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.

Appeals against accreditation decisions may be considered at the discretion of the IChemE Accreditation Committee.
8. Further information about application

8.1 About application
Departments seeking new accreditation(s) can request this from IChemE at any time. 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.

Departments that already have accredited programmes will automatically receive a reminder from IChemE well before the expiry date of the existing accreditation period, inviting the department to submit their degree programme(s) for re-accreditation.

8.2 Costs
IChemE will expect all reasonable assessor expenses with respect to travel, accommodation and subsistence to be covered by the requesting university.

IChemE levies a modest administration charge to universities for its accreditation services.

Current costs may be obtained by contacting IChemE.

8.3 Timeline
All accreditation applications are unique, dependent upon the size and scope of the accreditation exercise being undertaken and the familiarity of the department with IChemE processes.

A reasonable expectation is that the whole process from project initiation to formal decision takes 9–12 months.
List of appendices

A1 Learning outcomes: Mathematics and underpinning sciences

A2 Learning outcomes: Core chemical engineering (including core process safety)

A3 Learning outcomes: Engineering practice and advanced engineering practice

A4 Learning outcomes: Design practice and advanced design practice

A5 Learning outcomes: Essential embedded learning in sustainability, SHE, Ethics

A6 Learning outcomes: Essential embedded learning in transferable skills

A7 Learning outcomes: in advanced chemical engineering
  – Advanced chemical engineering (breadth)
  – Advanced chemical engineering (depth)

B Degree programme questionnaire

C Accreditation assessors’ report form

D Typical schedule for an assessment visit
## Appendix A1

### Learning outcomes

#### Underpinning mathematics and sciences

Students' knowledge and understanding of mathematics and science 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. It is expected that this underpinning material should be taught in an engineering context and, where appropriate, a chemical engineering context.

Illustration of generic Bachelor and Master Level learning outcomes

<table>
<thead>
<tr>
<th>Underpinning mathematics and sciences</th>
<th>Bachelor level</th>
<th>Master level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge and understanding of the scientific principles underpinning relevant current technologies, and their evolution.</td>
<td>Knowledge and understanding of the scientific principles underpinning relevant current technologies, and their evolution.</td>
</tr>
<tr>
<td></td>
<td>Knowledge and understanding of mathematics necessary to support application of key engineering principles.</td>
<td>Knowledge and understanding of mathematics necessary to support application of key engineering principles.</td>
</tr>
<tr>
<td></td>
<td>Plus</td>
<td>Plus</td>
</tr>
<tr>
<td></td>
<td>A comprehensive understanding of the scientific principles of chemical engineering and related disciplines.</td>
<td>A comprehensive understanding of the scientific principles of chemical engineering and related disciplines.</td>
</tr>
<tr>
<td></td>
<td>An awareness of developing technologies related to chemical engineering.</td>
<td>An awareness of developing technologies related to chemical engineering.</td>
</tr>
<tr>
<td></td>
<td>A comprehensive knowledge and understanding of mathematical and computer models relevant to the chemical engineering discipline, and an appreciation of their limitations.</td>
<td>A comprehensive knowledge and understanding of mathematical and computer models relevant to the chemical engineering discipline, and an appreciation of their limitations.</td>
</tr>
<tr>
<td></td>
<td>An understanding of concepts from a range of areas, including some outside engineering, and the ability to apply them effectively in engineering projects.</td>
<td>An understanding of concepts from a range of areas, including some outside engineering, and the ability to apply them effectively in engineering projects.</td>
</tr>
</tbody>
</table>
### Course/unit: Mathematics 1
**University code, credits (ECTS)**
- CHE 1234 15 ECTS

**Aims**
To provide the background mathematics and IT skills required for subsequent chemical engineering courses in mathematically oriented topics. Engineering applications are to be introduced where relevant.

**Syllabus**
(Described by department)

**Learning outcomes**
- Differentiate functions of one or more variables.
- Solve first and second order ordinary differential equations.
- Expand functions in series form.
- Perform matrix operations.
- Manipulate partial derivatives.
- Manipulate complex numbers.
- Obtain numerical solutions to problems in important engineering subject areas.
- Apply programming skills to solve relevant problems.

**Embedded learning (SHE, economic, societal, ethical)**

**Embedded transferable skill development (skills and personal qualities)**

### Course/unit: Engineering chemistry
**University code, credits (ECTS)**
- CHE 1002 15 ECTS

**Aims**
To give students a basic understanding of physical and organic chemistry, with particular emphasis on atomic and molecular structure, chemical bonding, phase and chemical equilibria, reaction kinetics and the fundamentals of processes with heat and work transfer. To apply reaction rate kinetics to the design of chemical reactors.

**Syllabus**
(Described by department)

**Learning outcomes**
- Explain relationships between atomic and molecular structure and properties.
- Draw Lewis Structures for chemical species and determine the ionic/covalent character of chemical bonds.
- Use VSEPR Model, Valence-Bond and Molecular Orbital Theory to predict electron arrangement, molecular shape. Derive simple differentiated and integrated rate equations for series, parallel and reversible chemical reactions. Perform basic calculations in phase and chemical equilibria. Apply models describing the PVT behaviour of gases.

### Course/unit: Foundation engineering mechanics
**University code, credits (ECTS)**
- CHE 1005 5 ECTS

**Aims**
Provide appreciation of engineering mechanics from a conceptual view. It is aimed at technologists from non-mechanical disciplines who will meet mechanical and rotational systems in their work.

**Syllabus**
(Described by department)

**Learning outcomes**
- Ability to interpret basic engineering applications.
- Ability to organise ideas of mechanics in a form suitable for problem solving.
- Able to apply basic principles in mechanics in a form suitable for problem solving.
- Solve realistic engineering problems.
- etc.

**Embedded learning (SHE, economic, societal, ethical)**

**Embedded transferable skill development (skills and personal qualities)**
Appendix A2

Learning outcomes

Core chemical engineering (including core process safety)

Students graduating from an accredited programme 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 programme, 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 programme 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.

(i) 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 equilibrium and 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.

(ii) 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. Specialised knowledge of IT hardware is not required; the emphasis here is given to the use of software in solving chemical engineering problems.

(iii) 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 processed for supra-molecular 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.

(iv) 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 inter-dependence 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.
(v) Process safety

From a learning outcomes perspective, students must develop their depth of learning in categories of awareness, understanding and in-depth knowledge of the subject. The primary intent should be to provide all undergraduates with an appropriate level of exposure to each topic. This will range from a brief introduction of some topics to a more thorough understanding of principles with appropriate examples and case studies. The depth and breadth of knowledge should increase according to the level of the degree programme.

A guiding principle will be to prepare an undergraduate for first entry to employment recognising that an employer will usually expect some basic knowledge of each topic from graduates at all levels. Learning should take into account the four principal areas where chemical engineers find employment – design, construct and commission (and deconstruct), operate and maintain, and the working environment (office/site/neighbours). Master level graduates will be expected to display a greater knowledge and maturity. The methodology should be generic and not just relate to that used by a particular company or industry sector. There is a crossover with other learning, for example environmental abatement techniques, plant economics (and ancillary subjects such as cost benefit analysis and life cycle costing) need to be included either under this heading or elsewhere in chemical engineering programmes.

Some topics may be delivered in a formal teaching mode and others through application in the design project and/or final year research project. The development of SHE topics will normally be progressive within the programme structure, although the particular phases where topics are introduced may vary.

On completion of their degree programme graduates must know and understand:

– the inherent nature of safety and loss prevention, and the principal hazard sources in chemical and related processes – including flammability, explosivity, toxicity.

– the importance of environmental sustainability, and the principal aspects of environmental impact – air, water, land, and integrated eco-systems.

– methods of identifying process hazards (e.g. HAZOP), and of assessing environmental impact, with quantification appropriate to the programme level.

– how to apply science and engineering process calculations to safety and environmental issues.

– the legislative framework and how it is applied to the management of safety, health and environment in industry, from the perspectives of operators, designers, constructors and in offices.

– specialist aspects of safety and environmental issues, such as noise, hazardous area classification, relief and blowdown, fault tree analysis, with depth appropriate to the level of the programme.

– how to influence SHE behaviour and culture in the workplace. For example, by the recognition of the value of risk assessment and of incident and near miss reporting, investigation and management as a means of achieving continuous improvement in SHE performance.
Core process safety

IChemE expects that all accredited chemical engineering degrees must contain a minimum core content – 5 ECTS - of process safety materials, in order to ensure exposure of students to the key principles in this critical area. One suggestion for such content is illustrated below, though should not be considered definitive.

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Safety and loss prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 2003</td>
</tr>
<tr>
<td>Aims</td>
<td>To provide introduction to hazard identification and quantification as applicable to process plant.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>(Described by department)</td>
</tr>
</tbody>
</table>

### Learning outcomes

- **Specific underpinning core chemical engineering**
  - Understand the general tools used in designing safe processes.
  - Able to perform simple hazard ID exercises.
  - Able to make assessments of event frequency, magnitude and effect.
  - Understand how risk assessment is carried out.
  - Understand the concept of LOPA.
  - Be aware of legislation governing safety in design and operation of chemical plant etc.

- **Embedded learning (SHE, economic, societal, ethical)**
- **Embedded transferable skill development (skills and personal qualities)**
  - Able to recognise and apply good and bad safety practice.
  - Understand the need to lead by example.
### Learning outcomes examples - Core chemical engineering

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Chemical thermodynamics</th>
<th>Reactors</th>
<th>Separation processes 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 2003 5 ECTS</td>
<td>CHE 2011 5 ECTS</td>
<td>CHE 2005 5 ECTS</td>
</tr>
<tr>
<td>Aims</td>
<td>Develop the laws of TD into working equations relating phase compositions for equilibrium systems and to apply these to separation and chemical processes.</td>
<td>Demonstrate how chemical reactor design algorithms can be adapted for different types of reactor and familiarise students with the operational aspects of industrial reactors including rate limitation.</td>
<td>Acquire the basic principles of distillation, adsorption and evaporation and know how to apply these to practical situations.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
</tr>
<tr>
<td>Learning outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core chemical engineering</td>
<td>Qualitatively interpret phase diagrams for binary and tertiary mixtures. Quantitatively predict the phase behaviour of complex systems involving ideal or real liquids. Determine chemical equilibria for real mixtures. Devise procedures for calculating dew, bubble, flash points for multicomponent systems involving real liquids and gases. etc.</td>
<td>Understand basic concepts of reactor design. Understand the approach to more complex reactor design using numerical methods. Acquire in-depth knowledge of important catalytic processes. Understand catalyst deactivation and the role of promoters. Determine rate-limiting steps in catalytic reactors. etc.</td>
<td>Know how to carry out preliminary equipment selection for evaporators and absorbers. Able to develop solutions to problems in evaporators and absorbers i.e. to develop necessary sets of mass and heat balances together with rate and equilibrium reactions. Understand that mass transfer operations require combined use of equilibrium and mass balances. etc.</td>
</tr>
<tr>
<td>Embedded learning (SHE, economic, societal, ethical)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded transferable skill development (skills and personal qualities)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Learning outcomes

Engineering practice and advanced engineering practice

The practical application of engineering skills, combining theory and experience, together with the use of other relevant knowledge and skills. Graduates of accredited programmes must understand the ways in which chemical engineering knowledge can be applied in practice, for example in: operations and management; projects; providing services or consultancy; developing new technology.

Departments should demonstrate high standards of appreciation of Safety, Health and Environment (SHE) in their teaching and operations within laboratories, pilot plants and project work.

Illustration of generic Bachelor and Master level learning outcomes

<table>
<thead>
<tr>
<th>Engineering practice</th>
<th>Master level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bachelor level</strong></td>
<td><strong>Master level</strong></td>
</tr>
<tr>
<td>- Understanding of and ability to use relevant materials, equipment, tools, processes, or products.</td>
<td>- Understanding of and ability to use relevant materials, equipment, tools, processes, or products.</td>
</tr>
<tr>
<td>- Knowledge and understanding of workshop and laboratory practice.</td>
<td>- Knowledge and understanding of workshop and laboratory practice.</td>
</tr>
<tr>
<td>- Knowledge of contexts in which chemical engineering knowledge can be applied (e.g. operations and management, application and development of technology etc).</td>
<td>- Knowledge of contexts in which chemical engineering knowledge can be applied (e.g. operations and management, application and development of technology etc).</td>
</tr>
<tr>
<td>- Ability to use and apply information from technical literature.</td>
<td>- Ability to use and apply information from technical literature.</td>
</tr>
<tr>
<td>- Ability to use appropriate codes of practice and industry standards.</td>
<td>- Ability to use appropriate codes of practice and industry standards.</td>
</tr>
<tr>
<td>- Understanding of the principles of managing chemical engineering processes.</td>
<td>- Understanding of the principles of managing chemical engineering processes.</td>
</tr>
<tr>
<td>- Awareness of quality issues and their application to continuous improvement.</td>
<td>- Awareness of quality issues and their application to continuous improvement.</td>
</tr>
<tr>
<td></td>
<td>Plus</td>
</tr>
<tr>
<td></td>
<td>- A thorough understanding of current practice and its limitations, and some appreciation of likely new developments.</td>
</tr>
<tr>
<td></td>
<td>- Extensive knowledge and understanding of a wide range of chemical engineering processes and process equipment.</td>
</tr>
<tr>
<td></td>
<td>- Ability to apply chemical engineering techniques taking account of a range of commercial and industrial constraints.</td>
</tr>
</tbody>
</table>
# Learning outcomes examples – Chemical engineering practice

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Chemical engineering practice – laboratory projects 2</th>
<th>Computer applications</th>
<th>Industry visit and follow up project</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 2032 10 ECTS</td>
<td>CHE 2034 5 ECTS</td>
<td>CHE 3178 2 ECTS</td>
</tr>
<tr>
<td>Aims</td>
<td>Develop problem-solving skills by experimentation through a series of short and long projects on chemical engineering unit processes.</td>
<td>Develop knowledge of how to use IT software and models to solve chemical engineering problems.</td>
<td>Develop exposure to full-scale process industry through a structured site visit.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
</tr>
<tr>
<td>Learning outcomes</td>
<td>Engineering practice</td>
<td>Computer applications</td>
<td>Industry visit and follow up project</td>
</tr>
<tr>
<td></td>
<td>Analyse experimental results/data taking account of error and uncertainty.</td>
<td>Understand how to make prudent use of computer applications such as Excel and MathCAD in the solution of chemical engineering problems.</td>
<td>Understand practical aspects of plant construction and layout.</td>
</tr>
<tr>
<td></td>
<td>Operate and evaluate lab equipment.</td>
<td>Know how to use the Aspen Engineering Suite.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan experiments to solve chemical engineering problems.</td>
<td>Able to draw plant layouts and dimensioned drawings (plans and elevations of equipment).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Embedded learning (SHE, economic, societal, ethical)</td>
<td>Respond to safety, legal and environmental issues involved in performing laboratory experiments.</td>
<td>Develop an appreciation for the need for excellent safety practice in the industrial environment.</td>
</tr>
<tr>
<td></td>
<td>Appreciate importance of procedures governing activities undertaken.</td>
<td>Know how to use electronic information sources.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prepare technical reports and give oral presentation in compliance with guidelines.</td>
<td>Demonstrate competence in the use of a range of software for graphics, data analysis and presentations.</td>
<td></td>
</tr>
</tbody>
</table>
### Course/unit

<table>
<thead>
<tr>
<th>University code, credits (ECTS)</th>
<th>Research dissertation</th>
<th>Industry project</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 4006 20 ECTS</td>
<td>CHE 3000 15 ECTS</td>
<td></td>
</tr>
</tbody>
</table>

#### Aims
- Develop students’ understanding of the methods of research through the identification, planning and execution of an appropriate research project in a chosen subject area.
- To expose the student to industry based case study linked to technology research, design or process plant operation.

#### Syllabus
- The project involves an extensive research study, commencing with a feasibility study and concluding with a final formal report (the dissertation) on the work undertaken. Students are asked to choose a research topic from a selection of laboratory-based and computational projects offered by different academic supervisors, and often work closely with a postgraduate or postdoctoral researcher or industry. (Described by department)

#### Learning outcomes

<table>
<thead>
<tr>
<th>Advanced chemical engineering practice</th>
<th>Carry out a critical assessment of the published literature in areas appropriate to the area of the research.</th>
<th>Gained experience of extending themselves in difficult territory with open-ended work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry out a critical assessment of the published literature in areas appropriate to the area of the research.</td>
<td>Write an initial feasibility study reviewing the published literature, using suitable citation and referencing formats.</td>
<td>Developed a specialist knowledge base in one or more specific areas of chemical engineering.</td>
</tr>
<tr>
<td>Analyse a scientific or technological problem.</td>
<td>Devise or select and apply appropriate methods to investigate the problem.</td>
<td></td>
</tr>
<tr>
<td>Record or select and apply appropriate methods to investigate the problem.</td>
<td>Record and analyse results.</td>
<td></td>
</tr>
<tr>
<td>Draw appropriate conclusions from the results.</td>
<td>Discuss the purpose of a research project and its significance in relation to relevant previous work reported in literature.</td>
<td></td>
</tr>
</tbody>
</table>

#### Embedded learning (SHE, economic, societal, ethical)
- Communicate the work and its outcomes in a variety of formats – report, poster and academic paper.

#### Embedded transferable skill development (skills and personal qualities)
- Carry out literature search using library and IT facilities.

- Gained experience of real time project management – setting targets, critical evaluation, communication of interim and final outcomes.
Appendix A4

Learning outcomes
Design practice and advanced design practice

(i) 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 degrees, and the usual teaching and assessment mechanism is coursework. 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.

(ii) Introduction
IChemE is keen to encourage the development of new forms of design teaching and evaluation, to meet the changing requirements of the profession. In chemical engineering terms, design means the creation of a system, process, product, or plant to meet an identified need.

Design is an essential component of all IChemE accredited degrees 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 transferable skills such as communication and team working,
- 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.
(iii) Learning outcomes

On completion of their chemical engineering degree graduates must know and understand 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
- appreciation of public perception and concerns

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
- justification of the choices and decisions taken

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

How to take a systems approach to design appreciating:

- complexity
- interaction
- integration

How to work in a team understanding and managing the processes of:

- peer challenge
- planning, prioritising and organising team activity
- the discipline of mutual dependency

How to communicate externally to:

- acquire input information
- present and defend chosen design options and decisions taken

(iv) Delivery mechanisms

Delivery mechanisms will be a mixture of:

- teaching and examination for particular skills and techniques used in the design process
- coursework 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 programme
- 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 coursework the most appropriate delivery mechanism
- 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

(v) 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
- a range of technical knowledge has been quantitatively and correctly applied
- a systems approach has been adopted to handle complexity, interaction and integration
- the design process itself has been competently managed by the student whether individually or within a team
- 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
- the evidence must demonstrate achievement to a level appropriate to the stage reached in the programme with a substantive proportion being at an advanced level

The following 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.
### Process design challenge:

<table>
<thead>
<tr>
<th>Assignment A</th>
<th>Assignment B</th>
<th>Assignment C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1000 tpd air separation plant</td>
<td>A slow-release analgesic capsule</td>
<td>Troubleshooting a batch distillation</td>
</tr>
</tbody>
</table>

**Structure**
- Student group project at university location.
- One student, in collaboration with pharmacy department.
- One student – 8 week supervised summer placement at xxx

### Learning outcomes: (know and understand)

#### 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.

#### The design process
- Select a novel membrane/cryogenic process.
- Choice of a suitable model system for laboratory experiment.
- Formulation of the capsule

#### 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.

#### The systems approach
- Pinch analysis of the process.
- Regulatory and product safety assessment.

#### Team working
- Role in team, working to deadline.
- Working with pharmacologists to obtain samples and develop protocols.

#### Communication
- Group project report, with individual sections. Team presentation to chemical engineering department.
- Individual report, vetted by pharmacy department. Joint presentation with pharmacy department.
- Written report to university, also available to company. Oral presentation to plant and technical department.

#### Delivery
- Process design meets constraints. Discussion of economic sensitivity.
- Programme for further development of product.
- Ranking of different options.
### Illustration of generic Bachelor and Master level learning outcomes

<table>
<thead>
<tr>
<th>Design and design practice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bachelor level</strong></td>
</tr>
<tr>
<td>Graduates will need the knowledge, understanding and skills to:</td>
</tr>
<tr>
<td>- Define a problem and identify constraints.</td>
</tr>
<tr>
<td>- Design solutions according to customer and user needs.</td>
</tr>
<tr>
<td>- Use creativity and innovation in a practical context.</td>
</tr>
<tr>
<td>- Ensure fitness for purpose (including operation, maintenance, reliability etc).</td>
</tr>
<tr>
<td>- Adapt designs to meet their new purposes or applications.</td>
</tr>
<tr>
<td><strong>Master level</strong></td>
</tr>
<tr>
<td>Graduates will need the knowledge, understanding and skills to:</td>
</tr>
<tr>
<td>- Define a problem and identify constraints.</td>
</tr>
<tr>
<td>- Design solutions according to customer and user needs.</td>
</tr>
<tr>
<td>- Use creativity and innovation in a practical context.</td>
</tr>
<tr>
<td>- Ensure fitness for purpose (including operation, maintenance, reliability etc).</td>
</tr>
<tr>
<td>- Adapt designs to meet their new purposes or applications.</td>
</tr>
<tr>
<td><strong>Plus</strong></td>
</tr>
<tr>
<td>- Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.</td>
</tr>
<tr>
<td>- Ability to generate an innovative design for processes, systems and products to fulfill new needs.</td>
</tr>
</tbody>
</table>
## Learning outcomes examples – Chemical engineering design practice

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Chemical engineering design</th>
<th>Design project</th>
<th>Equipment design</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 1007 5 ECTS</td>
<td>CHE 2004 10 ECTS</td>
<td>CHE 2207 5 ECTS</td>
</tr>
<tr>
<td><strong>Aims</strong></td>
<td>Provide basic framework of principles for calculating mass/energy balances for various operations and processes. Provide an introduction to equipment design.</td>
<td>Introduce approaches to more complex and open-ended design tasks that require a student to deal with data uncertainty. Develop knowledge of the economic and business considerations within which technical decisions must be made.</td>
<td>Provide an understanding of the mechanical and constructional aspects of equipment design and to apply these in practice.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
</tr>
<tr>
<td><strong>Learning outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical engineering design practice</td>
<td>Solve material balance problems for multiple stage process operations. Identify principal successive steps required in the start of a process design. Explain how the principles of mass/energy balances, fluid flow, TD and separations are interrelated and combined in the design of equipment and composite plant. etc.</td>
<td>Able to use standard flowsheeting package for analysis of flowsheet and subsystems. Undertake design of selected pieces of equipment. Describe and use procedures for synthesis and integration of flowsheet systems associated with the manufacture of a specified product. Explain appropriate use of methods for screening, analysis and detailed synthesis. etc.</td>
<td>Able to identify correct type of equipment for common duties. Understand and apply techniques for the correct sizing of equipment. Understand the selection and limitations of various materials of construction. Develop a mechanical design for selected process equipment. etc.</td>
</tr>
<tr>
<td>Embedded learning (SHE, economic, societal, ethical)</td>
<td>Calculate economic performance using NPV, IRR methods.</td>
<td>Awareness of the need for compliance with regulations and standard codes of design.</td>
<td></td>
</tr>
<tr>
<td>Embedded transferable skill development (skills and personal qualities)</td>
<td>Develop group-working skills emphasising importance of inter-group communication and responsibility.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Course/unit | Major design project – group
---|---
University code, credits (ECTS) | CHE 3000 15 ECTS
Aims | Give a detailed knowledge of the design of a process from the conceptual stage through to detailed design applying chemical engineering principles and skills acquired from other courses. Students are expected to demonstrate creativity and critical powers in making choices and decisions in some areas of uncertainty.
Syllabus | Industrial panel specifies design objectives, usually manufacture of given tonnage of a nominated chemical. Detailed objectives are agreed between module leader and sponsoring company selected in rotation from the industrial panel. Students, working individually and in groups, are supervised by academic ‘project managers’ who assist in definition of the task(s) to be confirmed.
Learning outcomes | 
Advanced chemical engineering design practice | Develop a detailed knowledge of the design of a process from the conceptual stage through to detailed design. Apply chemical engineering skills acquired from other courses and evaluate the consequences of uncertainty of data, equipment performance and applicability of the rigorous calculation procedures.
Embedded learning (SHE, economic, societal, ethical) | Assess and evaluate design alternatives as part of the synthesised design with respect to process safety, environmental impact and economic viability.
Embedded transferable skill development (skills and personal qualities) | Appreciate the benefits and difficulties of working in a team. Gain experience of presentation of technical material in extended written reports and orally to industry sponsors.
Appendix A5

Learning outcomes

Essential embedded learning: sustainability, SHE, ethics

Students must acquire the knowledge and ability to handle broader implications of work as a chemical engineer. These include sustainability aspects; safety, health, environmental and other professional issues including ethics; commercial and economic considerations etc. It is expected that this material is consistently built upon and themes reinforced throughout the degree.

Illustration of generic Bachelor and Master level learning outcomes

<table>
<thead>
<tr>
<th>Sustainability (economic, social and environmental context)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bachelor level</strong></td>
</tr>
<tr>
<td>– Knowledge and understanding of commercial and economic context of chemical engineering processes.</td>
</tr>
<tr>
<td>– Knowledge of management techniques which may be used to achieve chemical engineering objectives within that context.</td>
</tr>
<tr>
<td>– Understanding of the requirement for chemical engineering activities to promote sustainable development.</td>
</tr>
<tr>
<td>– Awareness of the framework of relevant legal requirements governing chemical engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.</td>
</tr>
<tr>
<td>– Understanding of the need for a high level of professional and ethical conduct in chemical engineering.</td>
</tr>
</tbody>
</table>

Plus

– Extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately.

– The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.
### SHE basics
- Flammability
- Explosivity
- Toxicity
- Ecosystems (atmospheric, aqueous, solid and integrated)
- Bio-hazards
- COSHH
- Thermal radiation

### SHE integral with other technical topics
- Principles of dispersion of pollutants (with maths and mass, heat and momentum transfer)
- Energy conservation and the global impact of the process industries.
- Principles of process containment (particularly in biotechnology)

### Management related SHE topics
- Risk assessment and management
- Safe systems of work
- History of SHE for process industries
- SHE element in engineers social responsibility
- Introduction to statutory requirements in SHE; national and international

### Bachelor level SHE topics
- Inherent safety
- Environmental impact assessment
- Integrated pollution control
- Safety in plant operation, maintenance and modification
- Identification of Hazards (HAZID)
- Risk assessment and QRA including frequency estimation, criteria, inherent safety
- Good manufacturing practice (GMP) for production of GMOs
- Principles of area classification
- Principles of plant safety including ESD, isolation, fire protection, plant layout, pressure hazards, reaction hazards, fires and explosions

### SHE topics
- Behaviour of gaseous and vapour releases
- Dispersion in water
- Physics and effects of noise
- Particle behaviour and dust explosions
- Pressure relief, venting and flaring
- Choice of plant construction materials and corrosion /erosion protection
- Runaway reactions
- Multiphase properties
- Case studies to illustrate SHE hazards consequences and prevention

### Advanced SHE topics (depth and breadth)
- Health and safety law and codes of practice
- Environmental regulation
- Human factors and human error in safety and reliability
- Social responsibility
- Further HAZOP
- Safety and reliability including fault tree analysis
- Communicating SHE objectives

### Management related SHE topics
- Application of environmental impact assessment (EIA) and Hazard and operability studies (HAZOP) to design project
- Prevention and control in SHE; management systems and the management of SHE
- Principles of loss prevention
- Life cycle analysis
- Cost benefit principles in SHE control; (e.g. BATNEEC, BPEO, ALARP or equivalents)
- Legislative framework, relevant codes and standards for loss prevention (e.g. Control of Major Hazards, Control of Hazardous Substances)
- Waste minimisation

### Further SHE topics
- Further advanced methods for estimating effects
- Advanced dispersion (air, water, ground)
- Principles of eco-systems; evaluating eco-system effects

### Further SHE topics
- Further management of SHE; management systems, standards, procedures and auditing
- Further safety related standards and codes and their application (e.g. NFPA)
- Product stewardship in relation to transportation and the environment
- Clean technology and the holistic approach
- Regulation of genetically modified organisms (GMO’s)
- Economic impact of SHE
- SHE incident and near-miss reporting, investigation and management
Appendix A6

Learning outcomes

Essential embedded learning: transferable skills

Chemical engineers must develop general skills that will be of value in a wide range of business situations. These include development of abilities within problem solving, communication, effective working with others, effective use of IT, persuasive report writing, information retrieval, presentational skills, project planning, self learning, performance improvement, awareness of the benefits of continuing professional development etc.

IChemE expects programme courses to be designed so that they provide the opportunity to acquire and develop these skills and will seek to ensure demonstration and commitment to this objective.
Learning outcomes
Advanced chemical engineering

The distinguishing feature of a Master level programme is the teaching of materials beyond that typically provided for in undergraduate Bachelor programmes. Such ‘advanced chemical engineering’ takes two forms and learning outcomes delivered should be assessed against both categories of learning. These are:

Depth
IChemE expects Master level programmes to include courses/modules that can clearly be described as advanced depth of chemical engineering study. These are courses that provide students with a deeper penetration of knowledge and understanding than has previously been acquired from a first exposure to a topic earlier in the degree programme, taught to Bachelor level standard. Such advanced courses must therefore have clearly distinguishable pre-requisites of taught study from earlier in the curriculum plan.

For example, Advanced process control would be a course having a Bachelor level process control course as a pre-requisite.

Breadth
Chemical engineering is also a vast field. This means that there is great opportunity for programme designers to design varied curricula reflecting certain fields and interests. IChemE welcomes this and therefore expects Master level programmes to include courses/modules that can clearly be described as advanced breadth of study. These are courses that expose students to topics additional to those that would normally be considered as core chemical engineering but that are valuable to further developing their chemical engineering formation.

IChemE has published a Technical roadmap for 21st century chemical engineering *. This broad ranging publication highlights six issue areas of critical global importance where chemical engineers will have enormous influence:

- health, safety, environment
- sustainable technology
- energy
- food and drink
- water
- biosystems

The exposure of students to topics in chemical engineering relating to these issue areas is welcomed. Provision of such course modules can provide excellent opportunity for advanced breadth of chemical engineering study.

*Downloadable at www.icheme.org/TechnicalRoadmap
### Learning outcomes examples – Advanced chemical engineering (depth)

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Advanced biochemical engineering</th>
<th>Molecular basis for product and process engineering</th>
<th>Advanced mass transfer methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 4123 5 ECTS</td>
<td>CHE 3054 3 ECTS</td>
<td>CHE 3178 5 ECTS</td>
</tr>
</tbody>
</table>

**Aims**
- Appraise the significant issues of product recovery, isolation and purification specific to biotechnology.
- Evaluate less common means of separation that are not normally covered in chemical engineering undergraduate syllabi.
- Explore the relationship between molecular structure, intermolecular interactions, self-association and the occurrence of various condensed phases in products and processes.
- Develop students’ understanding of and skills for conceptual design of separation processes.

**Syllabus**
(Described by department) (Described by department) (Described by department)

**Learning outcomes**

**Advanced chemical engineering (depth)**
- Understand the significant issues of product recovery, isolation and purification specific to biotechnology.
- Evaluate less common means of separation that are not normally covered in chemical engineering undergraduate syllabi.
- Apply problem solving skills to design bioprocessing unit operations.
- To understand the links between molecular structure and inter-molecular interactions.
- To understand how intermolecular interactions give rise to molecular properties in various states of condensed matter.
- Apply this understanding to the design and engineering of processes and products.
- Develop and demonstrate knowledge and understanding of the principles of operation of common separation technologies and conceptual design of separation processes (distillation, absorption, membrane separations).
- Apply short-cut and rigorous models for distillation analysis and design.
- Design distillation processes and sequences for energy-efficient operation.
- Design and analyse azeotropic distillation columns and sequences using graphical tools and boundary value methods.

**Embedded learning (SHE, economic, societal, ethical)**

**Embedded transferable Skill development (skills and personal qualities)**

Demonstrate problem-solving skills and competence in the use of chemical engineering software, including Pro II.
### Learning outcomes examples – Advanced chemical engineering (breadth)

<table>
<thead>
<tr>
<th>Course/unit</th>
<th>Food process engineering</th>
<th>Nuclear chemistry</th>
<th>Water pollution control</th>
</tr>
</thead>
<tbody>
<tr>
<td>University code, credits (ECTS)</td>
<td>CHE 4123 5 ECTS</td>
<td>CHE 5454 3 ECTS</td>
<td>CHE 4017 5 ECTS</td>
</tr>
<tr>
<td><strong>Aims</strong></td>
<td>To introduce the technical challenges and engineering issues associated with processing of foodstuffs.</td>
<td>To introduce nuclear chemistry and explore technical challenges associated with handling radioactive materials and processes.</td>
<td>To introduce the topics of pollution, toxicity, eutrophication, oxygen depletion, in the context of waste water discharges.</td>
</tr>
<tr>
<td><strong>Syllabus</strong></td>
<td>(Described by department)</td>
<td>(Described by department)</td>
<td>(Described by department)</td>
</tr>
<tr>
<td><strong>Learning outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Advanced chemical engineering (breadth)</strong></td>
<td>Understand how to carry out thermal processing calculations to meet microbial sterility in foodstuffs.</td>
<td>Acquire foundational expertise to perform process development calculations on basis of specific nuclear, radiochemical data and parameters.</td>
<td>Understand the effects on the environment from discharge of liquid effluents.</td>
</tr>
<tr>
<td></td>
<td>Carry out unsteady state heat transfer calculations to the freezing of foodstuffs.</td>
<td>Knowledge of the various possibilities to detect various nuclear radiations.</td>
<td>Understand the legal framework for discharge of liquid effluents.</td>
</tr>
<tr>
<td></td>
<td>Acquire knowledge of the principles of hygiene, microbial and pest control, specialist materials, cleaning and sterilisation programmes associated with food manufacture.</td>
<td>Understand the possible applications of closed and open radiation sources in technological, chemical and medical fields.</td>
<td>Have in-depth knowledge of the two most common biological treatment processes.</td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td>Insight in principles and definitions within the radiation hygiene.</td>
<td>etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge to analyse the strengths and weaknesses of the use of nuclear and radiochemical methods.</td>
<td></td>
</tr>
<tr>
<td><strong>Embedded learning (SHE, economic, societal, ethical)</strong></td>
<td>Understand food regulation and the principles of HACCP.</td>
<td></td>
<td>Understand the legal framework for discharge of liquid effluents.</td>
</tr>
<tr>
<td><strong>Embedded transferable skill development (skills and personal qualities)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Degree programme questionnaire

Section A – General information

If more than one degree programme is being considered, supply individual forms only where the programmes are substantially different in terms of structure and content. Otherwise, minor variations between programmes should be clearly identified within a single submission form.

A.1 Name of university:

A.2 Academic unit (department/school):

A.3 Head of academic unit:

A.4 Address:

A.5 Key contact details (of staff member responsible for accreditation submission):

A.6 Title of degree programme(s) to be assessed:

A.7 Scheduled date of assessors’ visit:

Please return this completed degree programme questionnaire, together with supporting materials at least two months prior to the arranged assessor panel visit to: accreditation@icheme.org (and/or the appropriate IChemE office)
Section B –
Degree programme details

B.1 Programme context and objectives
Provide information on the high level objectives of the programme and upon any other aspects that will help to set
the context for the accreditation assessment:

B.2 Entry requirements
Provide information on entry criteria and profiles (including the years at which students are admitted to the
programme), the entry numbers and trends, and comment on the strategy for attracting students to the
programme:

B.3 Summary of the programme content and structure
Provide the weightings of the programme structure against the defined categories. Use a basis of 60 ECTS credits
per year of study (converting locally used metrics to this standard as necessary):

<table>
<thead>
<tr>
<th>Credit basis</th>
<th>Programme credit allocation</th>
<th>IChemE minimum credit guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>European credit transfer system (ECTS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underpinning mathematics and science</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Core chemical engineering</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Engineering practice</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Design practice</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Embedded learning (SHE, sustainability, ethics)</td>
<td></td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Embedded learning (transferable skills)</td>
<td></td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Advanced chemical engineering (depth)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering (breadth)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering practice</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Including advanced chemical engineering design practice</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Complementary subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub total of IChemE specified content (minimum)</td>
<td></td>
<td>125 - Bachelor; 185 - Integrated Master; 60 - MSc</td>
</tr>
<tr>
<td>Total programme content</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Advisory note: All credit counts are on an exclusive basis. Therefore total content of whole courses or modules
cannot be accounted for twice nor appear under two categories of learning. If departments consider that it is
appropriate for content of courses/modules be allocated across categories of learning, this is acceptable, provided
full explanation of rationale is provided to IChemE.
B.4 Learning outcomes

B.4.1 Achievement of learning outcomes

*Illustrate how learning outcomes are achieved in the following specified categories:*

B.4.1.1 Mathematics, underlying science and associated engineering disciplines

B.4.1.2 Core chemical engineering (include core process safety)

B.4.1.3 Engineering practice

B.4.1.4 Design practice

B.4.1.5 Embedded learning (SHE, sustainability, ethics)

B.4.1.6 Embedded learning (transferable skills)

For Master level accreditation:

B.4.1.7 Advanced chemical engineering (depth)

*Indicate pre-requisite studies*

B.4.1.8 Advanced chemical engineering (breadth)

B.4.1.9 Advanced chemical engineering practice (including advanced design practice)

B.4.2 Study away from home University (academic/industry)

B.5 Innovative features

*Highlight any aspects of the programme that have novel or innovative nature:*

B.5.1 Teaching practice

B.5.2 Programme design

B.6 Safety culture

*Comment upon the safety culture existing within the academic unit:*
B.7  Assessment and quality assurance

Provide pertinent details of the assessment strategy, and the quality assurance in place, to ensure outcome standards are consistently and fairly assessed. Include information on progression:

B.7.1 Philosophy and methods of assessment

B.7.2 Quality assurance mechanisms

B.7.3 Compensation strategy (management of student progression)

B.8  Resources

Provide information on the resources available to support delivery of the programme:

B.8.1 Academic staff

B.8.2 Technical and administrative support

B.8.3 Student learning facilities

B.8.4 Laboratory facilities

B.8.5 Information management facilities (IT, library)

B.8.6 Any other resources not covered above

B.9  Developments

Provide key changes made, or planned, which may impact upon the educational provision of this programme within the academic unit:

B.9.1 Recent developments

B.9.2 Future plans

B.10  Additional information
## Required supplementary statistics

### S.1 Student population

<table>
<thead>
<tr>
<th>Entry year</th>
<th>Admissions</th>
<th>Progression rate</th>
<th>Latest graduate cohort (this indicates historical progression since entry)</th>
<th>Current population (this shows recent recruitment and retention trends)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2</td>
<td></td>
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<td>Year 3</td>
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<td>Year 4</td>
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<tr>
<td>Year 5</td>
<td></td>
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</tr>
</tbody>
</table>

### S.2 Degree awards and classifications

<table>
<thead>
<tr>
<th>Classification</th>
<th>Latest graduate cohort</th>
<th>Previous graduate cohort</th>
<th>Preceding graduate cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
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</tbody>
</table>
Appendix C
Accreditation assessors’ report

STRICTLY CONFIDENTIAL

Accreditation assessors’ report form

This Report MUST be completed and submitted to IChemE within 3 weeks of the assessment visit

Section A – General information
A.1 Name of university:

A.2 Academic unit (department/school):

A.3 Head of academic unit:

A.4 Address:

A.5 Key contact details (of staff member responsible for accreditation submission):

A.6 Title of degree programme(s) assessed:

A.7 Date of visit:

A.8 Names of assessors:
A.8.1 Academic assessor

A.8.2 Industry assessor

A.8.3 Third assessor

A.9 Signatures of assessors:
This assessment has been conducted in line with current IChemE accreditation guidelines and provides an independent verification of the information provided by the submitting academic unit, and has sought to objectively and effectively examine the quality of the chemical engineering provision of the assessed degree programme.
A.9.1 Lead assessor

A.9.2 Assessor #2

A.9.3 Assessor #3

Please return this completed report within 3 weeks of the visit to: accreditation@icheme.org
Section B – Assessment of the degree programme

Please provide detailed comments on the following aspects of the programme after reference to the degree programme questionnaire, the programme material reviewed before and at the formal visit.

B.1 Programme context and objectives

Comment upon the high level objectives of the programme and upon any other aspects that will help to set the context for the accreditation.

B.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.

B.3 Summary of the programme content and structure

Verify the weightings of the programme structure against the defined categories. Use a basis of 60 ECTS credits per year of study (converting locally used metrics to this standard):

<table>
<thead>
<tr>
<th>Credit basis</th>
<th>Programme credit allocation</th>
<th>IChemE minimum credit guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underpinning mathematics and science</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Core chemical engineering</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Engineering practice</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Design practice</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Embedded Learning (SHE, sustainability, ethics)</td>
<td></td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Embedded Learning (transferable skills)</td>
<td></td>
<td>Sufficient demonstration</td>
</tr>
<tr>
<td>Advanced chemical engineering (depth)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering (breadth)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Advanced chemical engineering practice</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Including advanced chemical engineering design practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complementary Subjects</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Sub total of IChemE specified content (minimum)</strong></td>
<td><strong>125 - Bachelor</strong></td>
<td><strong>185 - Integrated Master 60 - MSc</strong></td>
</tr>
</tbody>
</table>

**Total programme content**

Advisory note: All credit counts are on an exclusive basis. Therefore total content of whole courses or modules cannot be accounted for twice nor appear under two categories of learning. If departments consider that it is appropriate for content of courses/modules be allocated across categories of learning, this is acceptable provided full explanation of rationale is provided to IChemE.
B.4 Learning outcomes

B.4.1 Achievement of learning outcomes

Comment upon how the Learning outcomes are achieved in the following specified categories:

B.4.1.1 Mathematics, underlying science and associated engineering disciplines

B.4.1.2 Core chemical engineering (include core process safety)

B.4.1.3 Engineering practice

B.4.1.4 Design practice

B.4.1.5 Embedded learning (sustainability, SHE, ethics)

B.4.1.6 Embedded learning (transferable skills)

For Master level accreditation:

B.4.1.7 Advanced chemical engineering (depth)

B.4.1.8 Advanced chemical engineering (breadth)

B.4.1.9 Advanced chemical engineering practice (including advanced design practice)

B.4.2 Study away from home university (academic/industry)

If the programme contains a period of study away from the home university, please comment on how the learning outcomes are defined, delivered, assessed and quality assured:

B.5 Innovative features

Are there any aspects of the programme that merit highlighting due to their novel or innovative nature?

B.5.1 Teaching practice

B.5.2 Programme design

B.6 Safety culture

Comment on the safety culture prevalent within the academic unit and the uniformity of adoption in practice:

B.7 Assessment and quality assurance

Comment upon pertinent details of the assessment strategy and the quality assurance in place to ensure outcome standards are consistently and fairly assessed:

B.7.1 Philosophy and methods of assessment

B.7.2 Quality assurance mechanisms

B.7.3 Compensation strategy (management of student progression)
B.8 Resources

Comment on the adequacy of resources to support delivery of the programme:

B.8.1 Academic staff

B.8.2 Technical and administrative support

B.8.3 Student facilities

B.8.4 Laboratory facilities

B.8.5 Information management facilities (IT, Library)

B.8.6 Any other resources not covered above

B.9 Observations arising from discussions

Summarise key concerns or issues arising from your time spent with the following groups during your visit:

B.9.1 Discussions with students

B.9.2 Discussions with staff

B.10 Developments

Summarise key changes made, or planned, which may impact upon the educational provision of this programme within the academic unit:

B.10.1 Recent developments

B.10.2 Future plans

B.11 Conclusions

Summarise key findings and conclusions from the materials assessed and the assessment visit:
Section C: Assessor panel recommendations
For internal IChemE purposes only – assessors and Accreditation Committee

C.1 Recommendations (for the sight of Accreditation Committee only)

– A degree programme can only have accredited or non-accredited status. (It is not possible to award provisional accreditation)
– A new programme can only be accredited for up to 3 years without condition.
– An existing accredited programme can be re-accredited for up to 5 years without condition.
– A condition is defined as work that the academic unit must implement if accreditation status is to be maintained. A time frame for implementation of any conditions must be proposed.

C.1.1 Highlight below specific areas of the report that the Accreditation Committee should discuss in detail, particularly raising any issues of concern that you have found as a result of your assessment.

C.1.2 Do you recommend the degree programme(s) be accredited by IChemE? (Yes/No)

C.1.3 What level of accreditation do you recommend? (Master level, Further Learning to Master level, or Bachelor level)

C.1.4 For how long do you recommend accreditation?

C1.5 If you recommend that conditions should be imposed on any programme, please propose below and provide an indication of when it would be reasonable for changes to be implemented to the programme.

C1.6 Are there particular features of best practice/innovation that the academic unit would agree can be shared amongst the accredited IChemE community?

C.1.7 If you recommend the programme should not be accredited, please cite the key reasons for this recommendation.
## Section D: decisions of Accreditation Committee

For IChemE internal purposes only – Assessors and Accreditation Committee

Name of University:

Department:

<table>
<thead>
<tr>
<th>Programme Name</th>
<th>Decision</th>
<th>Level</th>
<th>Conditions</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>For example: MEng Chemical Engineering</td>
<td>Do not accredit</td>
<td>Bachelor</td>
<td>No</td>
<td>1 year</td>
</tr>
<tr>
<td></td>
<td>Accredit</td>
<td>Master</td>
<td>Yes</td>
<td>2 years</td>
</tr>
<tr>
<td></td>
<td>Re-accredit</td>
<td>FLML</td>
<td></td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEng</td>
<td></td>
<td>4 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Programme Name</th>
<th>Decision</th>
<th>Level</th>
<th>Conditions</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>For example: MEng chemical engineering with a year abroad</td>
<td>Do not accredit</td>
<td>Bachelor</td>
<td>No</td>
<td>1 year</td>
</tr>
<tr>
<td></td>
<td>Accredit</td>
<td>Master</td>
<td>Yes</td>
<td>2 years</td>
</tr>
<tr>
<td></td>
<td>Re-accredit</td>
<td>FLML</td>
<td></td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEng</td>
<td></td>
<td>4 years</td>
</tr>
</tbody>
</table>

**Conditions imposed (if any):**

D.6 Accreditation from student cohort entry date:

D.7 Re-accreditation visit due (date):

D.8 Additional actions (if any):

D.9 Signed by Chair Date:

**Distribution:**
- Accreditation Committee Chair
- Qualifications Director (for action)
- Assessor Panel members (for information)
Appendix D

Typical schedule for an assessment visit

Day 1

09:00  Welcome to the department
09:30  Private panel meeting, review of materials
11:00  Meet with head of department and programme directors to discuss course philosophy, future plans and the degree programme questionnaire
13:00  Working lunch with academic staff
14:00  Private panel meeting
14:30  Discuss degree programme curriculum and specific learning outcomes
15:30  Informal coffee break with all staff
16:00  Discuss design content of degree programme(s) and other major projects
17:00  Review day 1 with programme directors (an opportunity to guide the programme and materials required for day 2)

Day 2

09:00  Visit laboratories, computing facilities and library
10:30  Private panel discussion/break
11:00  Discuss achievement of embedded learning outcomes
11:30  Discuss industrial/professional training aspects
12:30  Lunch
13:30  Meet a representative group of students - including (if possible) some recent graduates – (no staff to be present)
14:30  Discuss assessment and quality assurance aspects
15:15  Private panel discussion
15:45  Final review and discussion with head of department and programme directors
16:30  Close
Getting help

IChemE specialist staff will be happy to advise the departments on any aspect of the accreditation process.

We recognise that each application is unique and will be pleased to help departments achieve ambitions for recognition of their degree programmes.

Departments can contact IChemE through a variety of channels:

In UK:
Tel: +44 (0)1788 578214
Fax: +44 (0)1788 560833
Email: accreditation@icheme.org
Mail: Accreditation administrator
Qualifications department
The Institution of Chemical Engineers
Davis Building, Railway Terrace
Rugby CV21 3HQ
UK

In Australia:
Tel: +61 (0) 3 9642 4494
Fax: +61 (0) 3 9642 4495
Mail: IChemE in Australia
Suite 11-2 / 488 Bourke Street
Melbourne, VIC 3000
Australia

In Malaysia:
Tel: +60 (0) 3 2166 0822
Fax: +60 (0) 3 2166 0922
Mail: IChemE in Malaysia
Suite 31-3, 31st Floor Wisma UOA II
21, Jalan Pinang, 50450 Kuala Lumpur
MALAYSIA