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Prepared by Nadarajah Sivakumaran

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EDEXCEL LEVEL 4 BTEC HIGHER NATIONALS IN AEROSPACE ENGINEERING

BTEC Higher National Certificate in Aerospace Engineering

BTEC Higher National Diploma in Aerospace Engineering
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Edexcel Level 4 BTEC Higher National Certificate in Aerospace Engineering
Edexcel Level 4 BTEC Higher National Diploma in Aerospace Engineering

These qualifications have been accredited to the National Qualifications Framework (NQF). The Qualification Accreditation Numbers (QANs) for these qualifications are listed in Annex A.

These qualification titles are as they will appear on the learner’s certificate. Learners need to be made aware of this when they are recruited by the centre and registered with Edexcel. Providing this happens, centres are able to describe the programme of study leading to the award of the qualification in different ways to suit the medium and the target audience.
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<td>Entry Level Certificate in Adult Numeracy, Literacy</td>
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Introduction

This document contains the units and associated guidance for the National Qualifications Framework (NQF) Edexcel Level 4 BTEC Higher Nationals in Aerospace Engineering. Each unit sets out the required outcomes and content and includes advice regarding appropriate delivery and assessment strategies. The guidance contains further details of the teaching, learning, assessment and quality assurance of these qualifications. It includes advice about Edexcel’s policy regarding access to its qualifications, the design of programmes of study and delivery modes.

Structure of the qualification

BTEC Higher National Certificate

The BTEC Higher National Certificate in Aerospace Engineering is a 10-unit qualification of which five are core units.

The BTEC Higher National Certificate programme must contain a minimum of five units designated at H2 level.

BTEC Higher National Diploma

The BTEC Higher National Diploma in Aerospace Engineering is a 16-unit qualification of which seven are core units.

The BTEC Higher National Diploma programme must contain a minimum of eight units designated at H2 level.
**Structure of Edexcel Level 4 BTEC Higher National Certificate in Aerospace Engineering**

<table>
<thead>
<tr>
<th>Unit No</th>
<th>Core units — all five units must be taken</th>
<th>Unit level H1 or H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Business Management Techniques</td>
<td>H1</td>
</tr>
<tr>
<td>2</td>
<td>Analytical Methods for Engineers</td>
<td>H1</td>
</tr>
<tr>
<td>3</td>
<td>Engineering Science</td>
<td>H1</td>
</tr>
<tr>
<td>4</td>
<td>Aircraft Systems Principles</td>
<td>H2</td>
</tr>
<tr>
<td>5</td>
<td>Project</td>
<td>H2</td>
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</tbody>
</table>

**Specialist units — choose five units**

<table>
<thead>
<tr>
<th>Unit No</th>
<th>Core units</th>
<th>Unit level H1 or H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Engineering Design</td>
<td>H2</td>
</tr>
<tr>
<td>7</td>
<td>Aerodynamics</td>
<td>H1</td>
</tr>
<tr>
<td>8</td>
<td>Further Aerodynamics</td>
<td>H2</td>
</tr>
<tr>
<td>9</td>
<td>Automatic Flight Control Systems</td>
<td>H1</td>
</tr>
<tr>
<td>10</td>
<td>Measurement and Testing</td>
<td>H1</td>
</tr>
<tr>
<td>11</td>
<td>Communication and Navigation</td>
<td>H1</td>
</tr>
<tr>
<td>12</td>
<td>Aircraft Fluid Systems</td>
<td>H1</td>
</tr>
<tr>
<td>13</td>
<td>Further Aircraft Fluid Systems</td>
<td>H2</td>
</tr>
<tr>
<td>14</td>
<td>Aircraft Structural Integrity</td>
<td>H2</td>
</tr>
<tr>
<td>15</td>
<td>Aircraft Propulsion Technology</td>
<td>H1</td>
</tr>
<tr>
<td>16</td>
<td>Integrated Flight Instrument Systems</td>
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</tr>
<tr>
<td>17</td>
<td>Gas Turbine Science</td>
<td>H2</td>
</tr>
<tr>
<td>18</td>
<td>Aviation Legislation and Human Factors</td>
<td>H1</td>
</tr>
<tr>
<td>19</td>
<td>Health and Safety and Risk Assessment</td>
<td>H1</td>
</tr>
<tr>
<td>20</td>
<td>Electrical, Electronic and Digital Principles</td>
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<td>21</td>
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<td>23</td>
<td>Materials Engineering</td>
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<td>24</td>
<td>Engineering Thermodynamics</td>
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<td>Quality Assurance and Management</td>
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<td>Further Analytical Methods for Engineers</td>
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<td>29</td>
<td>CAD/CAM</td>
<td>H2</td>
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The BTEC Higher National Certificate programme must contain a minimum of five units designated at H2 level.
### Structure of Edexcel Level 4 BTEC Higher National Diploma in Aerospace Engineering

<table>
<thead>
<tr>
<th>Unit No</th>
<th>Core units — all seven units must be taken</th>
<th>Unit level H1 or H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Business Management Techniques</td>
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</tr>
<tr>
<td>2</td>
<td>Analytical Methods for Engineers</td>
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<tr>
<td>3</td>
<td>Engineering Science</td>
<td>H1</td>
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<td>4</td>
<td>Aircraft Systems Principles</td>
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<tr>
<td>6</td>
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<td>7</td>
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**Specialist units — choose nine units**

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<th>Core units — all seven units must be taken</th>
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<td>8</td>
<td>Further Aerodynamics</td>
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<td>11</td>
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<td>13</td>
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<td>16</td>
<td>Integrated Flight Instrument Systems</td>
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<td>Gas Turbine Science</td>
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<tr>
<td>34</td>
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<td>H1</td>
</tr>
<tr>
<td>35</td>
<td>Quality and Business Improvement Techniques</td>
<td>H2</td>
</tr>
<tr>
<td>36</td>
<td>Further Business Improvement Techniques</td>
<td>H2</td>
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The BTEC Higher National Diploma programme must contain a minimum of eight units designated at H2 level.
Key features

BTEC Higher Nationals are designed to provide a specialist vocational programme, linked to professional body requirements and National Occupational Standards where appropriate, with a strong work related emphasis. The qualifications provide a thorough grounding in the key concepts and practical skills required in their sector and their national recognition by employers allows progression direct into employment. BTEC Higher Nationals offer a strong emphasis on practical skills development alongside the development of requisite knowledge and understanding in their sector. Learners are attracted to this strong vocational programme of study that meets their individual progression needs whether this is into employment or to further study on degree or professional courses.

A key progression path for BTEC Higher National Certificate and Diploma learners is to the second or third year of a degree or honours degree programme, depending on the match of the BTEC Higher National units to the degree programme in question. The BTEC Higher National Certificate and Diploma offer a progression route to the professional qualifications offered by Engineering Council UK and relevant Licensed Member organisations.

BTEC Higher Nationals in Aerospace Engineering have been developed to focus on:

- the education and training of aerospace engineers/technicians who are employed in a variety of types of technical work, such as aerospace systems design, manufacture, maintenance and technical services areas of the aerospace industry
- providing opportunities for aerospace engineers/technicians to achieve a nationally recognised level 4 vocationally specific qualification
- providing opportunities for full-time learners to enter employment as engineers/technicians or progress to a higher education vocational qualification such as a full-time degree in the aerospace engineering fields of electronics, mechanical, mechatronics or related areas
- providing opportunities for learners to focus on the development of higher level skills in a technological and management context
- providing opportunities for learners to develop a range of skills, techniques and attributes essential for successful performance in working life
- providing a significant basis for progression to Incorporated Engineer level, via further learning.

These qualifications meet the needs of the above rationale by:

- developing a range of skills and techniques, personal qualities and attributes essential for successful performance in working life and thereby enabling learners to make an immediate contribution to employment
- preparing learners for a range of technical and management careers in aerospace engineering
- equipping individuals with knowledge, understanding and skills for success in employment in the aerospace engineering industry
- providing specialist studies relevant to individual vocations and professions within aerospace engineering and its related industries, in which learners are working or intend to seek employment
- enabling progression to an undergraduate degree or further professional qualification in aerospace engineering or related area
giving opportunities for learners to develop and practise skills, knowledge and understanding required for category B staff under JAR-66 aircraft maintenance licence of the Civil Aviation Authorities (CAA) requirements.

Professional body recognition

The BTEC Higher Nationals in Aerospace Engineering have been developed with career progression and recognition by professional bodies in mind. Thus this development has been informed by discussions/relevant publications from the Engineering Council UK, the Occupational Standards Council for Engineering, the Engineering Professors’ Council and the Science, Engineering and Manufacturing Technologies Alliance (SEMTA).

The Royal Aeronautical Society recognise that when enhanced by successful further learning, this BTEC Higher National in Aerospace Engineering satisfies the educational requirement for registration as an Incorporated Engineer under Engineering Council (UK) UK Spec regulations.

Further details of professional body recognition and exemptions for BTEC Higher Nationals are given in the publication BTEC Professional Recognition which is available on Edexcel’s website (www.edexcel.org.uk).

National Occupational Standards

BTEC Higher Nationals in Aerospace Engineering are designed to relate to the Occupational Standards Council for Engineering (OSCEng) Higher Level Occupational Standards in the Engineering sector at Level 4, which in turn form the basis of the Engineering National Vocational Qualifications (NVQs). BTEC Higher Nationals do not purport to deliver occupational competence in the sector, which should be demonstrated in a work context. However, the qualifications provide underpinning knowledge for the National Occupational Standards, as well as developing practical skills in preparation for work and possible achievement of NVQs in due course.

Qualification Requirement

Edexcel has published Qualification Requirements as part of the revision of BTEC Higher Nationals. Qualification Requirements set out the aims and rationale of the qualifications and provide the framework of curriculum content. They also identify the higher-level skills associated with the qualifications and any recognition by relevant professional bodies. The Qualification Requirement for BTEC Higher Nationals in Aerospace Engineering is given in Annex E.

Edexcel standard specifications titles are developed from the Qualification Requirements. Licensed centres comply with Qualification Requirements when developing BTEC Higher Nationals under these standard titles.

Qualification Requirements provide consistent standards within the same vocational area and clearly identify the skills and knowledge that can be expected of any holder of an identical BTEC Higher National. This will allow higher education institutions, employers and professional bodies to confidently provide progression opportunities to successful learners.
Higher level skills

Learners studying for BTEC Higher Nationals in Aerospace Engineering will be expected to develop the following skills during the programme of study:

- analysing, synthesising and summarising information critically
- the ability to read and use appropriate literature with a full and critical understanding
- the ability to think independently and solve problems
- the ability to take responsibility for their own learning and recognise their own learning style
- obtaining and integrating several lines of subject-specific evidence to formulate and test hypotheses
- applying subject knowledge and understanding to address familiar and unfamiliar problems
- recognising the moral and ethical issues of scientific enquiry and experimentation and appreciating the need for ethical standards and professional codes of conduct
- designing, planning, conducting and reporting on investigations
- using their knowledge, understanding and skills to evaluate and formulate evidence-based arguments critically and identify solutions to clearly-defined problems of a general routine nature
- communicating the results of their study and other work accurately and reliably using a range of specialist techniques
- identifying and addressing their own major learning needs within defined contexts and undertaking guided further learning in new areas
- applying their subject-related and transferable skills in contexts where the scope of the task and the criteria for decisions are generally well defined but where some personal responsibility and initiative is required.

BTEC Higher National Certificate

The 10-unit BTEC Higher National Certificate in Aerospace Engineering provides a specialist work-related programme of study that covers the key knowledge, understanding and practical skills required in the aerospace sector and also offers particular specialist emphasis through the choice of specialist units.

BTEC Higher National Certificates provide a nationally recognised qualification offering career progression and professional development for those already in employment and opportunities to progress into higher education. The qualifications are mode free but they are primarily undertaken by part-time learners studying over two years. In some sectors there are opportunities for those wishing to complete an intensive programme of study in a shorter period of time.

This specification provides centres with a framework to develop engaging programmes for higher education learners who are clear about the area of employment that they wish to enter.

The BTEC Higher National Certificate in Aerospace Engineering mainly offers a progression route for learners who are employed in aerospace systems design, manufacture, maintenance and technical service areas of the aerospace engineering industry.
**BTEC Higher National Diploma**

BTEC Higher National Diploma provides greater breadth and specialisation than the BTEC Higher National Certificates. Higher National Diplomas are mode free but are followed predominately by full-time learners. They allow progression into or within employment in the aerospace engineering sector, either directly on achieving of the award or following further study to degree level.

The BTEC Higher National Diploma in Aerospace Engineering provides opportunities for learners to apply their knowledge and practical skills in the workplace. Full-time learners have the opportunity to do this through formal work placements or their part-time employment experience.

The qualification prepares learners for employment in the aerospace engineering sector and will be suitable for learners who have already decided that they wish to enter this area of work. Some adult learners may wish to make the commitment required by this qualification in order to enter a specialist area of employment in aerospace engineering or progress into higher education. Other learners may want to extend the specialism that they followed on the BTEC Higher National Certificate programme.

**Teaching, learning and assessment**

Learners must pass all 10 units on their programme of learning to be awarded a BTEC Higher National Certificate and all 16 units to be awarded a BTEC Higher National Diploma.

The assessment of BTEC Higher National qualifications is criterion-referenced and centres are required to assess learners’ evidence against published learning outcomes and assessment criteria. All units will be individually graded as ‘pass’, ‘merit’ or ‘distinction’. To achieve a pass grade for the unit learners must meet the assessment criteria set out in the specifications. This gives transparency to the assessment process and provides for the establishment of national standards for each qualification.

The units in BTEC Higher National qualifications all have a standard format which is designed to provide clear guidance on the requirements of the qualification for learners, assessors and those responsible for monitoring national standards.

**Unit format**

Each unit is set out in the following way.

*Unit title, learning hours and NQF level*

The unit title is accredited by QCA and this form of words will appear on the learner’s Notification of Performance. In BTEC Higher National qualifications each unit consists of 60 guided learning hours.

Each unit is assigned a notional level indicator of H1 or H2, indicating the relative intellectual demand, complexity and depth of study, and learner autonomy.

At **H1 level** the emphasis is on the application of knowledge, skills and understanding, use of conventions in the field of study, use of analytical skills and selection and organisation of information.

At **H2 level** the emphasis is on application and evaluation of contrasting ideas, principles, theories and practices, greater specialisation in the field of study, and an increasing independence in systematic enquiry and analysis.
Description of unit

A brief description of the overall purpose of the unit is given, together with the key areas of study associated with the unit.

Summary of learning outcomes

The outcomes of the unit identify what each learner must do in order to pass it. Learners must achieve all the outcomes in order to pass the unit.

Content

This section picks up highlighted words from the outcomes and amplifies the content coverage required when addressing the outcomes. The content section will often provide lists of topics. Please note all aspects of the listed topics should be covered, except those that begin with ‘eg’, where items listed are merely indicative.

Outcomes and assessment criteria

Each unit contains statements of the evidence that each learner should produce in order to receive a pass.

Guidance

This section is not prescriptive but provides additional guidance and amplification related to the unit to support teachers/deliverers and assessors. Its subsections are given below. Only those subsections which apply to the unit will appear.

• Delivery — offers guidance about possible approaches to delivery. The guidance is based on the more usual delivery modes and is not intended to rule out alternative approaches.

• Assessment — provides advice about the nature and type of evidence that learners are likely to need to produce. This subsection should be read in conjunction with the assessment criteria and the generic grade descriptors.

• Links — sets out the links between units. Provides opportunities for integration of learning, delivery and assessment. Any links to the National Occupational Standards will be highlighted here.

• Resources — identifies the specialist resources likely to be needed to allow learners to generate the evidence required by each unit. The centre will be asked to ensure that this resource requirement is in place when it seeks approval from Edexcel to offer the qualification.

• Support materials — identifies, where appropriate, textbooks, videos, magazines, journals, publications and websites that may support the delivery of the unit.

Learning and assessment

The purpose of assessment is to ensure that effective learning of the content of each unit has taken place. Evidence of this learning, or the application of the learning etc, is required for each unit. The assessment of the evidence relates directly to the assessment criteria for each unit, supported by the generic grade descriptors.

The process of assessment can aid effective learning by seeking and interpreting evidence to decide the stage that learners have reached in their learning, what further learning needs to take place and how best to do this. Therefore, the process of assessment should be part of the effective planning of teaching and learning by providing opportunities for both the learner and assessor to obtain information about progress towards learning goals. The assessor and learner must be actively engaged in promoting a common understanding of the assessment criteria and the grade descriptors (what it is they are trying to achieve and how well they achieve it) for further learning to take place. Therefore, learners need constructive feedback and guidance about how to improve, capitalising on strengths, with clear and constructive comments about weaknesses and how these might be addressed.
Assessment instruments are constructed by centres. Assessment instruments should collectively ensure coverage of all assessment criteria within each unit and should provide opportunities for the evidencing of all the grade descriptors. It is advised that assessment criteria and contextualised grade descriptors are clearly indicated on each assessment instrument to provide a focus for learners (for transparency and to ensure that feedback is specific to the criteria) and to assist with internal standardisation processes. Tasks/activities should enable learners to produce evidence that relates directly to the assessment criteria and grade descriptors.

When centres are designing assessment instruments, they need to ensure that the instruments are valid, reliable and fit for purpose, building on the application of the assessment criteria. Centres are encouraged to place emphasis on practical application of the assessment criteria, providing a realistic scenario for learners to adopt, making maximum use of work-related practical experience and reflecting typical practice in the sector concerned. The creation of assessment instruments that are fit for purpose is vital to achievement and their importance cannot be over-emphasised.

**Grading Higher National units**

The assessment of BTEC Higher National qualifications will be at unit level and there will be no overall grade for either the Certificate or the Diploma. This means that learners are able to access the qualification through a unitised approach.

Each unit will be graded as a pass, merit or distinction. A pass is awarded for the achievement of all outcomes against the specified assessment criteria. Merit and distinction grades are awarded for higher-level achievement.

The generic merit and distinction grade descriptors listed on pages 5–5 are for grading the total evidence produced for each unit and describe the learner’s performance over and above that for a pass grade.

The merit and distinction grade descriptors can be achieved in a flexible way, eg in a sequential or holistic mode, to reflect the nature of the sector concerned.

Each of the generic merit and distinction grade descriptors can be amplified by use of indicative characteristics. These give a guide to the expected learner performance, and support the generic grade descriptors. The indicative characteristics should reflect the nature of a unit and the context of the sector programme.

The indicative characteristics shown in the table for each of the generic grade descriptors are not exhaustive. Consequently, centres should select from the list or may construct other appropriate indicative characteristics for their sector programme which may be drawn from the appropriate higher-level skills. It is important to note that each assessment activity does not need to incorporate all the merit and/or distinction grade descriptors.

**Contextualising the generic grade descriptors**

The generic merit and distinction grade descriptors need to be viewed as a qualitative extension of the assessment criteria for pass within each individual unit. The relevant generic grade descriptors must be identified and specified within an assignment and the relevant indicative characteristics should be used to place the required evidence in context.
Grade descriptors

Pass grade

A pass grade is achieved by meeting all the requirements defined in the assessment criteria for pass for each unit.

Merit grade

<table>
<thead>
<tr>
<th>Merit descriptors</th>
<th>Indicative characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order to achieve a merit the learner must:</td>
<td>The learner’s evidence shows:</td>
</tr>
<tr>
<td>• identify and apply strategies to find appropriate solutions</td>
<td>• effective judgements have been made</td>
</tr>
<tr>
<td></td>
<td>• complex problems with more than one variable have been explored</td>
</tr>
<tr>
<td></td>
<td>• an effective approach to study and research has been applied</td>
</tr>
<tr>
<td>• select/design and apply appropriate methods/techniques</td>
<td>• relevant theories and techniques have been applied</td>
</tr>
<tr>
<td></td>
<td>• a range of methods and techniques have been applied</td>
</tr>
<tr>
<td></td>
<td>• a range of sources of information has been used</td>
</tr>
<tr>
<td></td>
<td>• the selection of methods and techniques/sources has been justified</td>
</tr>
<tr>
<td></td>
<td>• the design of methods/techniques has been justified</td>
</tr>
<tr>
<td></td>
<td>• complex information/data has been synthesised and processed</td>
</tr>
<tr>
<td></td>
<td>• appropriate learning methods/techniques have been applied</td>
</tr>
<tr>
<td>• present and communicate appropriate findings</td>
<td>• the appropriate structure and approach has been used</td>
</tr>
<tr>
<td></td>
<td>• coherent, logical development of principles/concepts for the intended audience</td>
</tr>
<tr>
<td></td>
<td>• a range of methods of presentation have been used and technical language has been accurately used</td>
</tr>
<tr>
<td></td>
<td>• communication has taken place in familiar and unfamiliar contexts</td>
</tr>
<tr>
<td></td>
<td>• the communication is appropriate for familiar and unfamiliar audiences and appropriate media have been used</td>
</tr>
</tbody>
</table>
### Distinction grade

<table>
<thead>
<tr>
<th>Distinction descriptors</th>
<th>Indicative characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order to achieve a <strong>distinction</strong> the learner must:</td>
<td>The learner’s evidence shows:</td>
</tr>
</tbody>
</table>
| • use critical reflection to evaluate own work and justify valid conclusions | • conclusions have been arrived at through synthesis of ideas and have been justified  
• the validity of results has been evaluated using defined criteria  
• self-criticism of approach has taken place  
• realistic improvements have been proposed against defined characteristics for success |
| • take responsibility for managing and organising activities | • autonomy/independence has been demonstrated  
• substantial activities, projects or investigations have been planned, managed and organised  
• activities have been managed  
• the unforeseen has been accommodated  
• the importance of interdependence has been recognised and achieved |
| • demonstrate convergent/lateral/creative thinking | • ideas have been generated and decisions taken  
• self-evaluation has taken place  
• convergent and lateral thinking have been applied  
• problems have been solved  
• innovation and creative thought have been applied  
• receptiveness to new ideas is evident  
• effective thinking has taken place in unfamiliar contexts |
Accreditation of Prior Learning (APL)

Edexcel encourages centres to recognise learners’ previous achievements and experience through APL. Learners may have evidence that has been generated during previous study, in their previous or current employment or whilst undertaking voluntary work that relates to one or more of the units in the qualification. Assessors should assess this evidence against the Higher National standards in the specifications in the normal way. As with all evidence, assessors should be satisfied about the authenticity and currency of the material when considering whether or not the outcomes of the unit have been met.

Full guidance about Edexcel’s policy on APL is provided on our website (www.edexcel.org.uk).

Quality assurance of BTEC Higher Nationals

The quality assurance system for BTEC Higher National qualifications, as higher level vocational qualifications at Level 4 on the NQF, will comprise three main components.

- **approval process** — a control measure to confirm that individual centres (and programme teams) are appropriately resourced and competent to deliver a BTEC Level 4 programme of study.

- **monitoring of centres** — a method of monitoring centres’ internal quality systems to ensure ongoing fulfilment of initial requirements and, where appropriate, enhancement of those requirements to accommodate new qualifications.

- **independent assessment** — a measure that provides independence within the assessment process, so that the certificated outcomes for each learner are not reliant on determinations by individuals or groups with a vested interest in the outcome. This measure should be consistent and reliable over time, and should not create unnecessary barriers.

Centre and programme approval

Approval to offer BTEC Higher National qualifications will vary depending on the status of the centre. Centres that have a recent history of delivering BTEC Higher National qualifications and have an acceptable quality profile in relation to their delivery will be able to gain approval through an accelerated process. Centres that are new to the delivery of BTEC Higher National qualifications will be required to submit evidence to demonstrate that they:

- have the human and physical resources required for effective delivery and assessment
- understand the implications for independent assessment and agree to abide by these
- have a robust internal assessment system supported by ‘fit for purpose’ assessment documentation
- have a system to internally verify assessment decisions to ensure standardised assessment decisions are made across all assessors and sites.

Such applications have to be supported by the head of the centre (principal, chief executive, etc).

We communicate all approvals in writing to the head of centre in the form of a qualification approval letter. The approval letter will also contain a programme definition for each qualification approved. The programme definition clearly states to the centre all units that comprise the qualification for which the centre is approved.
Monitoring centres’ internal quality systems

Centres will be expected to demonstrate ongoing fulfilment of approval criteria across all programme areas. This should include the consistent application of policies affecting learner registrations and appeals, together with the effectiveness of internal examination and standardisation processes.

Centres may opt for a review of their provision under the quality verifier/quality reviewer arrangements, which already apply to all further education centres. Alternatively, centres may present evidence of their operation within a recognised code of practice, such as that of the Quality Assurance Agency for Higher Education. Edexcel reserves the right to confirm independently that these arrangements are operating to our satisfaction.

Independent assessment: the role of the external examiner

Supporting consistency and appropriateness of centre assessor decisions

For all BTEC Higher Nationals accredited at Level 4 on the NQF, Edexcel will appoint appropriately qualified subject-specific external examiners to the programme in each centre. Edexcel will define the selection, appointment and training process, together with the roles and responsibilities of the external examiners and will communicate the details to centres in a centre handbook.

The function of the external examiner will be to review and evaluate objectively the assessment process and standards of learner attainment by independently reviewing, in the first year of the programme, a sample of learner work (including the centre-designed assignments on which the samples are based) selected by the external examiner, from across the programme.

When they visit centres, external examiners must be afforded reasonable access to the assessed parts of the programme, including evidence of learner performance on placement. They are required to:

- verify that standards are appropriate for the qualification and its elements
- assist institutions in the comparison of academic standards across similar awards nationally.

Should any disparity occur between the judgement of centre assessors and that of the external examiner, this will be reported to the centre and to Edexcel by the external examiner. The centre will be required to agree appropriate corrective action as a result of this report.

Independence in confirmation of certificated outcomes

In the final year of the programme, the external examiner will revisit the centre in order to independently assess learner work and to evaluate centre assessor decisions on final outcomes. This process of evaluation may focus upon work in units, selected by the external examiner, that present the most appropriate evidence for this exercise. The work of all learners not already sampled in the first year of the programme will be reviewed.

Resolution of assessments will normally be handled at the centre’s final programme review board. The external examiner will be expected to endorse the outcomes of assessment before certification can be authorised. Should the external examiner be unable to provide such endorsement, certification will be withheld until appropriate corrective action has taken place. (The senior subject examiner may become involved in such instances).

The external examiner will be required to prepare a written report after each visit. The report will include comments from the external examiner on:

- academic standards and programme specification
- academic standards and learner performance
- academic standards and assessment
• the assessment process
• assessment meetings
• physical resources
• comments of learners
• meetings with staff
• external examiner practice
• issues arising from previous reports
• details of sampling
• general points, areas of good practice and major issues
• action points.

The external examiner report provides the mechanism by which the external examiner independently verifies learner ability, endorses the validity of the assessment process and releases certification for a cohort.

The report is a confidential document between Edexcel, the appointed external examiner, and the centre to use for internal/external quality assurance processes. It provides the centre with feedback on the external examining process and on the judgements that determine the external examiner’s decisions on endorsement, or otherwise, of learner outcomes.

Programme design and delivery

The qualifications consist of core units (which are mandatory) and specialist units. These specialist units will be mostly optional and are designed to provide a specific focus to the qualification. Required combinations of specialist units are clearly set out in relation to each qualification in the defined qualification structures provided in this document.

In BTEC Higher National qualifications each unit consists of 60 guided learning hours. The definition of guided learning hours is ‘a notional measure of the substance of a qualification’. It includes an estimate of time that might be allocated to direct teaching, instruction and assessment, together with other structured learning time such as directed assignments or supported individual study. It excludes learner-initiated private study. Centres are advised to consider this definition when planning the programme of study associated with this specification.

Mode of delivery

Edexcel does not define the mode of study for BTEC Higher National qualifications. Centres are free to offer the qualifications using any mode of delivery that meets the needs of their learners. This may be through traditional classroom teaching, open learning, distance learning or a combination of these. Whatever mode of delivery is used, centres must ensure that learners have appropriate access to the resources identified in the specifications and to the subject specialists delivering the units. This is particularly important for learners studying for the qualification through open or distance learning.

Full guidance on Edexcel’s policies on ‘distance assessment’ and ‘electronic assessment’ are provided on our website.
Learners studying for the qualification on a part-time basis bring with them a wealth of experience that should be utilised to maximum effect by tutors and assessors. Assessment instruments based on learners’ work environments should be encouraged. Those planning the programme should aim to enhance the vocational nature of the BTEC Higher National qualification by:

- liaising with employers to ensure that the course is relevant to the specific needs of the learners
- accessing and using non-confidential data and documents from learners’ workplaces
- including sponsoring employers in the delivery of the programme and, where appropriate, in the assessment
- linking with company-based/workplace training programmes
- making full use of the variety of experiences of work and life that learners bring to the programme.

Resources

BTEC Higher National qualifications are designed to prepare learners for employment in specific sectors. Physical resources need to support the delivery of the programme and the proper assessment of the outcomes and, therefore, should normally be of industry standard. Staff delivering programmes and conducting the assessments should be fully familiar with current practice and standards in the sector concerned. Centres will need to meet any specialist resource requirements when they seek approval from Edexcel.

Please refer to the resource section in individual units for specialist resource requirements.

During their programme, learners should have experience of as many as possible of the following as required by their vocational area:

- appropriate laboratory facilities with technical support
- appropriate workshop facilities
- laboratory and workshop equipment and materials
- laboratory/workshop ICT resources, including access to the internet and data-logging facilities
- visits to relevant industry/service laboratories and appropriate plant facilities
- visits to health and safety training facilities
- visits to appropriate conferences and exhibitions
- visiting speakers from specialist professional bodies, mechanical and service industries
- work experience or work shadowing.

Delivery approach

It is important that centres develop an approach to teaching and learning that supports the specialist vocational nature of the BTEC Higher National qualifications. The specifications contain a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature. Tutors and assessors need to ensure that appropriate links are made between theory and practice and that the knowledge base is applied to the sector. This will require the development of relevant and up-to-date teaching materials that allow learners to apply their learning to actual events and activity within the sector. Maximum use should be made of the learner’s experience.
Meeting local needs

Centres should note the qualifications set out in these specifications have been developed in consultation with centres, employers and the Engineering Council UK, the professional body for the engineering sector, together with support from the Sector Skills Council for the engineering sector. The units are designed to meet the skill needs of the sector and the specialist units allow coverage of the full range of employment. Centres should make maximum use of the choice available to them within the specialist units in these specifications to meet the needs of their learners, as well as the local skills and training needs identified by organisations such as Regional Development Agencies and Local Learning and Skills Councils.

Centres may not always be able to meet local needs using the units in this specification. In this situation, centres may seek approval from Edexcel to make use of units from other standard NQF BTEC Higher National specifications. Centres will need to justify the need for importing units from other specifications and Edexcel will ensure that the vocational focus of the qualification has not been diluted.

Locally-devised specialist units

There may be exceptional circumstances where even the flexibility of importing units from other specifications does not meet a particular local need. In this case, centres can seek permission from Edexcel to develop a unit with us to meet this need. The cases where this will be allowable will be very limited. Edexcel will ensure that the integrity of the qualification is not reduced and that there is a minimum of overlap and duplication of content of existing units. Centres will need strong evidence of the local need and the reasons why the existing standard units are inappropriate. Edexcel will need to validate these units.

Limitations on variations from standard specifications

The flexibility to import standard units from other BTEC Higher National specifications and/or to develop unique locally-devised specialist units is limited to a maximum of four units in a BTEC Higher National Diploma qualification and a maximum of two units only in any BTEC Higher National Certificate qualification. The use of these units cannot be at the expense of the core units in any qualification.

Access and recruitment

Edexcel’s policy regarding access to its qualifications is that:

- the qualifications should be available to everyone who is capable of reaching the required standards
- the qualifications should be free from any barriers that restrict access and progression
- there should be equal opportunities for all wishing to access the qualifications.

Centres are required to recruit learners to BTEC qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications and that the qualification will meet their needs. Centres should take appropriate steps to assess each applicant’s potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the learner within the centre during their programme of study and any specific support that might be necessary to allow the learner to access the assessment for the qualification. Centres should also show regard for Edexcel’s policy on learners with particular requirements.
Centres will need to review the profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a Level 4 qualification. For learners who have recently been in education, the entry profile is likely to include one of the following:

- a BTEC National Certificate or Diploma in an appropriate subject
- an AVCE/Advanced GNVQ in an appropriate vocational area
- a GCE Advanced level profile which demonstrates strong performance in a relevant subject or an adequate performance in more than one GCE subject. This profile is likely to be supported by GCSE grades at A* to C
- other related Level 3 qualifications
- an Access to Higher Education Certificate awarded by an approved further education institution
- related work experience.

Mature learners may present a more varied profile of achievement that is likely to include extensive work experience (paid and/or unpaid) and/or achievement of a range of professional qualifications in their work sector.

**Restrictions on learner entry**

The majority of BTEC Higher National qualifications are accredited on the NQF for learners aged 16 years and over. Learners aged 15 and under cannot be registered for a BTEC Higher National qualification.

**Learners with particular requirements**

Edexcel recognises that some learners, when studying vocationally-related qualifications, will have coped with the learning demands of a course but may find the standard arrangements for the assessment of their attainment presents an unfair barrier. This would apply to learners with known and long-standing learning problems and to learners who are affected at, or near to, the time of a time-constrained assessment.

Edexcel will seek to approve alternative arrangements that:

- meet the needs of learners with particular requirements
- do not confer advantage over other learners
- are commensurate with the proper outcomes from the qualification.

Details of the allowable arrangements for such learners are given in *Assessment of Vocationally Related Qualification: Regulations and Guidance relating to Learners with Special Requirements* (Edexcel, 2002).
The wider curriculum

The study of the BTEC Higher Nationals in Aerospace Engineering provides opportunities for learners to develop an understanding of spiritual, moral, ethical, social and cultural issues and an awareness of environmental issues, health and safety considerations, and European developments.

Moral, ethical, social and cultural issues

Moral and ethical issues are encountered throughout the BTEC Higher Nationals in Aerospace Engineering as dealing with people will always involve the learner engaging in moral and ethical issues. A more detailed analysis is given in certain units such as:

Unit 1: Business Management Techniques, Unit 5: Project, Unit 6: Engineering Design, Unit 18: Aviation Legislation and Human Factors, Unit 19: Health and Safety and Risk Assessment, Unit 33: Project Management, Unit 35: Quality and Business Improvement Techniques

Environmental issues

Learners are led to appreciate the importance of environmental issues as they engage in their study as well as through experience of the aerospace engineering industry, in:

Unit 5: Project, Unit 6: Engineering Design, Unit 19: Health and Safety and Risk Assessment, Unit 23: Materials Engineering, Unit 33: Project Management

European developments

Much of the content of the BTEC Higher Nationals in Aerospace Engineering is applicable throughout Europe owing to its international nature, even though the context of delivery is within the UK. The European dimensions of Aerospace engineering are specifically addressed in:

Unit 5: Project, Unit 6: Engineering Design, Unit 11: Communication and Navigation, Unit 12: Aircraft Fluid Systems, Unit 18: Aviation Legislation and Human Factors, Unit 19: Health and Safety and Risk Assessment, Unit 23: Materials Engineering, Unit 28: Computer-Aided Machining

Health and safety issues

The BTEC Higher Nationals in Aerospace Engineering are practically based and so health and safety issues are encountered throughout the courses. Learners will develop awareness of the safety of others as well as themselves in all practical activities. Learners will also explore health and safety issues across the industry, particularly in:


Equal opportunities issues

Equal opportunities issues are implicit throughout the BTEC Higher Nationals in Aerospace Engineering, particularly:

Unit 1: Business Management Techniques, Unit 5: Project, Unit 18: Aviation Legislation and Human Factors, Unit 19: Health and Safety and Risk Assessment, Unit 33: Project Management
Useful publications

Further copies of this document and related publications can be obtained from:

Edexcel Publications
Adamsway
Mansfield
Nottinghamshire NG18 4FN
Telephone: 01623 467 467
Fax: 01623 450 481
Email: publications@linneydirect.com

Related publications include:
- the current Edexcel publications catalogue and update catalogue
- Edexcel publications concerning the quality assurance system and the internal and external verification of vocationally-related programmes may be found on the Edexcel website and in the Edexcel publications catalogue.

NB: Most of our publications are priced. There is also a charge for postage and packing. Please check the cost when you order.

Professional body contact details

Engineering Council (UK)
10 Maltravers Street
London WC2R 3ER
Telephone: +44 (0)20 7240 7891
Fax: +44 (0)20 7240 7517
Email: staff@engc.org.uk
Website: www.engc.org.uk

Royal Aeronautical Society
4 Hamilton Place
London W1J 7BQ
Website: www.aerosociety.com

How to obtain National Occupational Standards

The Engineering Occupational Standards for Higher Levels can be obtained from:

The Occupational Standards Council for Engineering
Broadway House
Tothill Street
London SW1H 9NQ
Telephone: 0207 233 0935
Fax: 0207 233 0940
Website: www.osceng.co.uk
Professional development and training

Edexcel supports UK and international customers with training related to BTEC qualifications. This support is available through a choice of training options offered in our published training directory or through customised training at your centre.

The support we offer focuses on a range of issues including:

- planning for the delivery of a new programme
- planning for assessment and grading
- developing effective assignments
- building your team and teamwork skills
- developing student-centred learning and teaching approaches
- building key skills into your programme
- building in effective and efficient quality assurance systems.

The national programme of training we offer can be viewed on the Edexcel website (www.edexcel.org.uk). You can request customised training through the website or by contacting one of our advisers in the Professional Development and Training Team on telephone number 020 7758 5620 to discuss your training needs.

The training we provide:

- is active — ideas are developed and applied
- is designed to be supportive and thought provoking
- builds on best practice.

Our training will also underpin many areas of the Higher Education Staff Development Agency (HESDA)/FENTO standards for teachers and lecturers working towards them.

Further information

For further information please call Customer Services on 0870 240 9800, or visit our website at www.edexcel.org.uk.
Core units
Unit 1: Business Management Techniques

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

This unit develops the learner’s knowledge and understanding of the functions, structures and interrelationships of an engineering business. It then enables the learner to develop and apply the skills of costing, financial planning and control associated with engineered products or services. Finally, this is brought together with the development of the fundamental concepts of project planning and scheduling that can be applied within an engineering organisation.

Summary of learning outcomes

To achieve this unit a learner must:
1. Manage work activities to achieve organisational objectives
2. Select and apply costing systems and techniques
3. Analyse the key functions of financial planning and control
4. Apply project planning and scheduling methods to a specified project.
Content

1 Manage work activities

*Engineering business functions:* organisational, management and operational structures in general engineering settings (eg business planning, product/service development, design and production/delivery, quality assurance and control in relevant manufacturing, production, service or telecommunication industries, etc.)

*Processes and functions:* business planning (eg management, production/service planning, costing, financial planning) and organisation (eg mission, aims, objectives and culture, etc.)

*Manage work activities:* product and service specifications and standards; quality, time and cost objectives (eg just-in-time methods, value-added chains, statistical process control, etc.); working within organisational constraints and limitations

2 Costing systems and techniques

*Costing systems:* systems (eg job costing, process costing, contract costing, etc) and techniques (eg absorption, marginal, activity-based, etc.)

*Business performance:* measures and evaluation (eg break-even point, safety margin, profitability forecast, contribution analysis, ‘what if’ analysis, limiting factors, scarce resources, etc.)

3 Financial planning and control

*Financial planning process:* short, medium, and long-term plans; strategic plans; operational plans; financial objectives; organisational strategy

*Factors influencing decisions:* cash and working capital management (eg credit control, pricing, cost reduction, expansion and contraction, company valuation, capital investment); budgetary planning (eg fixed, flexible and zero-based systems, cost, allocation, revenue, capital, control, incremental budgeting)

*Deviations:* variance calculations for sales and costs (eg cash flow, causes of variance, budgetary slack, unrealistic target setting)

4 Project planning and scheduling

*Project resources and requirements:* human and physical resource planning techniques (eg time and resource scheduling techniques, Gantt charts, critical-path analysis, computer software packages, work breakdown structure, precedence diagrams)
Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
</tr>
<tr>
<td>1 Manage work activities to achieve organisational objectives</td>
<td>• identify and explain engineering business functions</td>
</tr>
<tr>
<td></td>
<td>• explain the inter-relationships between the different processes and functions of an engineering organisation</td>
</tr>
<tr>
<td></td>
<td>• manage work activities to meet specification and standards.</td>
</tr>
<tr>
<td>2 Select and apply costing systems and techniques</td>
<td>• identify and describe appropriate costing systems and techniques for specific engineering business functions</td>
</tr>
<tr>
<td></td>
<td>• measure and evaluate the impact of changing activity levels on engineering business performance.</td>
</tr>
<tr>
<td>3 Analyse the key functions of financial planning and control</td>
<td>• explain the financial planning process in an engineering business</td>
</tr>
<tr>
<td></td>
<td>• examine the factors influencing the decision-making process during financial planning</td>
</tr>
<tr>
<td></td>
<td>• apply standard costing techniques and analyse deviation from planned outcomes.</td>
</tr>
<tr>
<td>4 Apply project planning and scheduling methods to a specified project</td>
<td>• establish the project resources and requirements</td>
</tr>
<tr>
<td></td>
<td>• produce a plan with appropriate time-scales for completing the project</td>
</tr>
<tr>
<td></td>
<td>• identify human resource needs and costs associated with each stage of the project.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

This unit is intended to give learners an appreciation of business organisations and the application of standard costing techniques, as well as an insight into the key functions underpinning financial planning and control. It also aims to expand learners’ knowledge of managerial and supervisory techniques by introducing and applying the fundamental concepts of project planning and scheduling.

Learning and assessment can be across units, at unit level or at outcome level, but centres should be aware that study and assessment at outcome level could lead to assessment overload.

It may be beneficial to complete this unit through case studies that reflect a particular engineering business or specific engineering function (eg design function, plant installation and commissioning, etc.).

In estimating costs and approximating project completion times and human resource needs, it may be necessary to provide information from a ‘given data source’. However, learners should be encouraged to research their own data requirements, ideally from local industrial attachments, work-placement or employer.

Assessment

Evidence of outcomes may be in the form of assignments and projects. These may be undertaken individually or as part of a wide-ranging group assignment. However, if group work is used, care must be taken to ensure that the evidence produced by each of the individuals in the group fully meets the requirements of the assessment criteria. Wherever possible evidence should be provided at unit level, reflecting the links between the different outcomes.

Links

This unit can be linked with Unit 25: Quality Assurance and Management. Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed appropriate BTEC National units or equivalent.

Resources

Manual records and relevant computer software packages are needed to enable realistic project planning, resource allocation and costing assignments. Ideally, centres should establish a library of material that is capable of simulating a range of different applications of organisational structures and management techniques.
Support materials

Textbooks


Unit 2: Analytical Methods for Engineers

Learning hours:  60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The primary aim of this unit is to provide the fundamental analytical knowledge and techniques needed to successfully complete the core units of BTEC Higher National Engineering programmes. It is also intended as a base for the further study of analytical methods and mathematics needed for the more advanced option units. This unit has been designed to enable learners to use fundamental algebra, trigonometry, calculus, statistics and probability, for the analysis, modelling and solution of realistic engineering problems at BTEC Higher National level.

Summary of learning outcomes

To achieve this unit a learner must:

1. Analyse and model engineering situations and solve problems using **algebraic methods**
2. Analyse and model engineering situations and solve problems using **trigonometric methods**
3. Analyse and model engineering situations and solve problems using **the calculus**
4. Analyse and model engineering situations and solve problems using **statistics and probability**.
Content

1  Algebraic methods

Algebraic methods: polynomial division; quotients and remainders; use of factor and remainder theorem; rules of order for partial fractions (including linear, repeated and quadratic factors); reduction of algebraic fractions to partial fractions

Exponential, trigonometric and hyperbolic functions: the nature of algebraic functions; relationship between exponential and logarithmic functions; reduction of exponential laws to linear form; solution of equations involving exponential and logarithmic expressions; relationship between trigonometric and hyperbolic identities; solution of equations involving hyperbolic functions

Arithmetic and geometric: notation for sequences; arithmetic and geometric progressions; the limit of a sequence; sigma notation; the sum of a series; arithmetic and geometric series; Pascal’s triangle and the binomial theorem

Power series: expressing variables as power series functions and use series to find approximate values (eg exponential series, Maclaurin’s series, binomial series)

2  Trigonometric methods

Sinusoidal functions: review of the trigonometric ratios; Cartesian and polar co-ordinate systems; properties of the circle; radian measure; sinusoidal functions

Applications such as: angular velocity; angular acceleration; centripetal force; frequency; amplitude; phase; the production of complex waveforms using sinusoidal graphical synthesis; AC waveforms and phase shift

Trigonometric identities: relationship between trigonometric and hyperbolic identities; double angle and compound angle formulae and the conversion of products to sums and differences; use of trigonometric identities to solve trigonometric equations and simplify trigonometric expressions
3 The calculus

The calculus: the concept of the limit and continuity; definition of the derivative; derivatives of standard functions; notion of the derivative and rates of change; differentiation of functions using the product, quotient and function of a function rules; integral calculus as the calculation of area and the inverse of differentiation; the indefinite integral and the constant of integration; standard integrals and the application of algebraic and trigonometric functions for their solution; the definite integral and area under curves

Further differentiation: second order and higher derivatives; logarithmic differentiation; differentiation of inverse trigonometric functions; differential coefficients of inverse hyperbolic functions

Further integration: integration by parts; integration by substitution; integration using partial fractions

Applications of the calculus: eg maxima and minima; points of inflexion; rates of change of temperature; distance and time; electrical capacitance; rms values; electrical circuit analysis; ac theory; electromagnetic fields; velocity and acceleration problems; complex stress and strain; engineering structures; simple harmonic motion; centroids; volumes of solids of revolution; second moments of area; moments of inertia; rules of Pappus; radius of gyration; thermodynamic work and heat energy

Engineering problems: eg stress and strain; torsion; motion; dynamic systems; oscillating systems; force systems; heat energy and thermodynamic systems; fluid flow; ac theory; electrical signals; information systems; transmission systems; electrical machines; electronics

4 Statistics and probability

Tabular and graphical form: data collection methods; histograms; bar charts; line diagrams; cumulative frequency diagrams; scatter plots

Central tendency and dispersion: the concept of central tendency and variance measurement; mean; median; mode; standard deviation; variance and interquartile range; application to engineering production

Regression, linear correlation: determine linear correlation coefficients and regression lines and apply linear regression and product moment correlation to a variety of engineering situations

Probability: interpretation of probability; probabilistic models; empirical variability; events and sets; mutually exclusive events; independent events; conditional probability; sample space and probability; addition law; product law; Bayes’ theorem

Probability distributions: discrete and continuous distributions, introduction to the binomial, Poisson and normal distributions; use of the Normal distribution to estimate confidence intervals and use of these confidence intervals to estimate the reliability and quality of appropriate engineering components and systems.
### Outcomes and assessment criteria

To achieve each outcome a learner must demonstrate the ability to:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Analyse and model engineering situations and solve problems using</strong></td>
<td>• determine the quotient and remainder for algebraic fractions and reduce algebraic fractions to partial fractions&lt;br&gt;• solve engineering problems that involve the use and solution of exponential, trigonometric and hyperbolic functions and equations&lt;br&gt;• solve scientific problems that involve arithmetic and geometric series&lt;br&gt;• use power series methods to determine estimates of engineering variables, expressed in power series form.</td>
</tr>
<tr>
<td><strong>algebraic methods</strong></td>
<td></td>
</tr>
<tr>
<td><strong>2 Analyse and model engineering situations and solve problems using</strong></td>
<td>• use trigonometric functions to solve engineering problems&lt;br&gt;• use sinusoidal functions and radian measure to solve engineering problems&lt;br&gt;• use trigonometric and hyperbolic identities to solve trigonometric equations and to simplify trigonometric expressions.</td>
</tr>
<tr>
<td><strong>trigonometric methods</strong></td>
<td></td>
</tr>
<tr>
<td><strong>3 Analyse and model engineering situations and solve problems using</strong></td>
<td>• differentiate algebraic and trigonometric functions using the product, quotient and function of function rules&lt;br&gt;• determine higher order derivatives for algebraic, logarithmic, inverse trigonometric and inverse hyperbolic functions&lt;br&gt;• integrate functions using the rules, by parts, by substitution and partial fractions&lt;br&gt;• analyse engineering situations and solve engineering problems using the calculus.</td>
</tr>
<tr>
<td><strong>the calculus</strong></td>
<td></td>
</tr>
<tr>
<td><strong>4 Analyse and model engineering situations and solve problems using</strong></td>
<td>• represent engineering data in tabular and graphical form&lt;br&gt;• determine measures of central tendency and dispersion&lt;br&gt;• apply linear regression and product moment correlation to a variety of engineering situations&lt;br&gt;• use the normal distribution and confidence intervals for estimating reliability and quality of engineering components and systems.</td>
</tr>
<tr>
<td><strong>statistics and probability</strong></td>
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</tbody>
</table>
Guidance

Delivery

This unit may be delivered as a stand-alone unit, or integrated into other appropriate modules. If it is delivered with other units, care must be taken to provide tracking of evidence for the outcomes. In delivering the unit it is vital to ensure that the analytical methods are applied to the modelling and solution of realistic engineering problems.

The aim of this unit is to provide the minimum analytical knowledge, skills and understanding needed to successfully complete a BTEC Higher National in Engineering. For some programmes this unit will prove insufficient, and it will be necessary to select further units of mathematics to underpin specific areas of engineering.

This unit has been designed to give the lecturer choice in the delivery of the content. Providing the assessment criteria are met for each outcome, the content may be taught to reflect the chosen specialist pathway of the learner. For example, when delivering and assessing outcome 2, the trigonometry taught to cohorts of electrical, electronic or avionics learners would focus on the engineering applications of sinusoidal functions. Whereas the teaching and assessment for mechanical engineering learners would focus primarily on the applications concerned with angular motion and forces. This approach can be as equally well applied to the other outcomes in the unit, particularly with respect to the many applications given in outcome 3. In this outcome, the choice of applications for delivery and assessment are again easily separated into those required primarily by learners opting for the electrical/electronic or mechanical engineering pathways. The application of statistical techniques and probability may also be taught and assessed in a similar manner.

Prior to embarking on this unit all learners, as a minimum standard, should be able to demonstrate proficiency in the following mathematical fundamentals:

- **algebra**: laws of algebra, evaluation and transposition of formulae; algebraic operations; factorisation; linear, simultaneous and quadratic equations; laws of indices and logarithms; common and Naperian logarithms; indicial equations; direct and inverse proportion; inequalities; functional notation and manipulation of algebraic functions

- **trigonometry**: trigonometric ratios and their inverses; trigonometric ratios for the four quadrants; solution of triangles; calculation of areas and volumes of solids

- **numeracy**: notation and precedence rules; vulgar fractions; lowest common multiple and highest common factor; ratios and constant of proportionality; significant figures and estimation techniques

- **calculus**: familiarity with the concept of the differential and integral calculus; differentiate polynomial and trigonometric functions using the basic rules; integrate polynomial and trigonometric functions using the standard rules.

Learners not meeting the above standard need to be enrolled onto appropriate bridging studies.

Assessment

The results of tests and examinations are likely to form a significant part of the evidence of outcomes of this unit. However, it is also essential that evidence is gathered from assignments designed to apply the analytical methods to the modelling and solution of realistic engineering problems. The evidence gathered should, wherever possible, be deliberately biased to reflect the chosen engineering pathway.
Links

This unit is intended to underpin and link with those units which are analytical in nature.

Entry requirements for this unit are at the discretion of the centre. However, it is strongly advised that learners should have completed the BTEC National unit *Mathematics for Technicians* or equivalent. Learners who have not attained this standard will require appropriate bridging studies.

Resources

The use of mathematical software packages should be strongly encouraged to help learners understand and model scientific and engineering problems. Availability of mathematics and spreadsheet packages such as Autograph, MathCad and Excel would enable realistic assignments to be set and achieved by learners.

Support materials

Textbooks


Unit 3: Engineering Science

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to investigate a number of major scientific principles that underpin the design and operation of engineering systems. It is a broad-based unit, covering both mechanical and electrical principles. It is intended to give an overview that will provide the basis for further study in specialist areas of engineering.

Summary of learning outcomes

To achieve this unit a learner must:
1. Analyse static engineering systems
2. Analyse dynamic engineering systems
3. Apply DC and AC theory
4. Investigate information and energy control systems.
Content

1 Static engineering systems

Simply supported beams: determination of shear force; bending moment and stress due to bending; radius of curvature in simply supported beams subjected to concentrated and uniformly distributed loads; eccentric loading of columns; stress distribution; middle third rule

Beams and columns: elastic section modulus for beams; standard section tables for rolled steel beams; selection of standard sections (eg slenderness ratio for compression members, standard section and allowable stress tables for rolled steel columns, selection of standard sections)

Torsion in circular shafts: theory of torsion and its assumptions (eg determination of shear stress, shear strain, shear modulus); distribution of shear stress and angle of twist in solid and hollow circular section shafts

2 Dynamic engineering systems

Uniform acceleration: linear and angular acceleration; Newton’s laws of motion; mass moment of inertia and radius of gyration of rotating components; combined linear and angular motion; effects of friction

Energy transfer: gravitational potential energy; linear and angular kinetic energy; strain energy; principle of conservation of energy; work-energy transfer in systems with combine linear and angular motion; effects of impact loading

Oscillating mechanical systems: simple harmonic motion; linear and transverse systems; qualitative description of the effects of forcing and damping

3 DC and AC theory

DC electrical principles: Ohm’s and Kirchoff’s laws; voltage and current dividers; analogue and digital signals; review of motor and generator principles; fundamental relationships (eg resistance, inductance, capacitance; series C-R circuit, time constant, charge and discharge curves of capacitors, L-R circuits)

AC circuits: features of AC sinusoidal wave form for voltages and currents; explanation of how other more complex wave forms are produced from sinusoidal wave forms; R, L, C circuits (eg reactance of R, L and C components, equivalent impedance and admittance for R-L and R-C circuits); high or low pass filters; power factor; true and apparent power; resonance for circuits containing a coil and capacitor connected either in series or parallel; resonant frequency; Q-factor of resonant circuit

Transformers: high and low frequency; transformation ratio; current transformation; unloaded transformer; input impedance; maximum power transfer; transformer losses
4 Information and energy control systems

Information systems: block diagram representation of a typical information system (e.g., audio-communication, instrumentation, process monitoring); qualitative description of how electrical signals convey system information; function, operation and interfacing of information system components (e.g., transducers, transducer output and accuracy, amplifier types, typical gain, resolution of analogue to digital and digital to analogue converters, types of oscillators and operating frequencies); effect of noise on a system; determination of system output for a given input.

Energy flow control systems: block diagram representation of an energy flow control system (e.g., AC electric drives, DC electric drives, heating, lighting, air conditioning); qualitative description of how electrical signals control energy flow; function, operation and interfacing of energy flow control system components (e.g., transistor, thyristor, temperature-sensing devices, humidity sensing devices, speed control elements for DC and AC machines, dimmer devices and relays); determination of system output for a given input; selection and interfacing of appropriate energy flow control system components to perform a specified operation.

Interface system components: identification of appropriate information sources; select and interface information system components or select and interface energy flow control system components, to enable that system to perform desired operation.
## Outcomes and assessment criteria

<table>
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<tr>
<th>Outcomes</th>
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<tbody>
<tr>
<td></td>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
</tr>
</tbody>
</table>
| 1 Analyse static engineering systems | • determine distribution of shear force, bending moment and stress due to bending in simply supported beams  
• select standard rolled steel sections for beams and columns to satisfy given specifications  
• determine the distribution of shear stress and the angular deflection due to torsion in circular shafts. |
| 2 Analyse dynamic engineering systems | • determine the behaviour of dynamic mechanical systems in which uniform acceleration is present  
• determine the effects of energy transfer in mechanical systems  
• determine the behaviour of oscillating mechanical systems.                                           |
| 3 Apply DC and AC theory          | • solve problems using DC electrical principles  
• recognise a variety of complex wave forms and explain how they are produced from sinusoidal wave forms  
• apply AC theory to the solution of problems on single phase R, L, C circuits and components  
• apply AC theory to the solution of problems on transformers.                                           |
| 4 Investigate information and energy control systems | • describe the method by which electrical signals convey information  
• describe the methods by which electrical signals control energy flow  
• select and interface system components to enable chosen system to perform desired operation.           |
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated with other programme modules. If it is delivered in an integrated way, care must be taken in the tracking of evidence for the outcomes. Wherever possible, a practical approach should be adopted.

Since the unit outcomes have been designed to serve as a foundation for the mechanical or electrical principles that follow, this unit should be taught in the first year or first semester of a two-year programme. To support this unit the core BTEC Higher National unit Analytical Methods for Engineers may usefully be taught in tandem, drawing upon the mathematical principles in a staged manner, as required.

The AC principles content of outcome 3 does not require the use of complex numbers, merely the application of vector theory and trigonometry.

Assessment

Evidence of outcomes may be in the form of assignments, laboratory notes and/or solutions to applied problems or completed tests/examinations. Learning and assessment can be across units, at unit level or at outcome level. Evidence is likely to be at outcome level to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of activities or by tutor-led combination of tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit can be linked with the mathematics and other principles and applications units in the programme.

Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed the BTEC National unit Science for Technicians or equivalent. Knowledge of the BTEC National units Electrical and Electronic Principles and/or Mechanical Principles or equivalent would also be an advantage.

Resources

Access to appropriate mechanical and electrical laboratory equipment for the assignment and laboratory work is considered key to enhance learner learning. Suitable software packages should be used when possible to verify solutions to problems and system behaviour.
Support materials

Textbooks
Unit 4: Aircraft Systems Principles

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The primary aim of the unit is to apply the necessary mechanical, electrical and electronic principles to the examination of aircraft mechanical, fluid and avionic systems. In particular, these principles are applied to the construction, operation, component interfacing and performance monitoring of aircraft power supply and control systems.

Summary of learning outcomes

To achieve this unit a learner must:

1. Explain the underlying principles and examine the components used for the control and performance monitoring of aircraft systems
2. Explain the operation and performance of aircraft power systems
3. Apply control system fundamentals to the analysis of aircraft control systems.
Content

1 Control and performance monitoring

Aircraft systems: system definition; system state and operating environment; basic electro-mechanical system components (eg sensor/transducer, comparator (error detector), signal conditioner and actuation device); G notation; feedback signals; H notation; simple system transfer functions

Transducers: characteristics; operation and applications — optical (eg photoconductive cell, photovoltaic, photodiode, phototransistor); magnetic (eg induction, reluctance, hall-effect); heat (eg thermocouple, thermistor, radiation pyrometer); electro-mechanical (limit switches); other (eg potentiometers, strain gauges, differential transformers, tacho-generators, pressure sensors, gauges (flow meters), incremental and absolute encoders)

Signal conditioning and amplifiers: physical signals; digital and analogue signals; digital to analogue (DAC) and analogue to digital (ADC) converters; signal frequency and amplitude; error signal modification and amplification; open and closed loop control signal paths; introduction to feed-forward signals; mechanical amplifiers and signal conditioners; electrical amplifiers and comparators; active filters

2 Aircraft power systems

Power generation: comparison of aircraft pneumatic, hydraulic and electrical power generation (eg advantages and disadvantages, circuit operation, power distribution, alternative power supplies)

Safety of aircraft power distribution: primary and secondary systems; standby and emergency provision; circuit and system components; duplication and failsafe philosophy

Power actuation systems: principles; constructional detail; control and protection methods; comparison of fluid and electrical power actuation methods and systems (eg fluid motors and actuators (single, double acting, rotary, linear, reciprocating piston, spur gear), electric motors and actuators (eg alternating current (AC) and direct current (DC) motors, induction, synchronous, stepper motor, multi-phase cage motor), linear and rotary actuators)

Performance parameters: aircraft applications; high and fractional horsepower; fluid and electrically driven motors and actuators; parameters for DC applications (eg speed, torque, on and off load characteristics); parameters for AC applications (eg speed of rotation related to applied voltage, power available on constant rated applications)
3 **Aircraft control systems**

*Remote position control systems*: applications (e.g., guide vane control of missile, radar aerial movement, positioning of aircraft control surfaces, autopilot platform displacement, gyro compass platform positioning, inertial navigator platform stabilisation, nose wheel steering system, engine speed control, engine pressure ratio signalling and control, engine speed and temperature control, generator frequency and voltage control, hydraulic servo rate and positioning control, electric motor positioning and control, cabin temperature control, engine fuel control)

*Response of control systems*: step and ramp inputs; transient and steady state response; stability of response; overshoot and hunting

*Damping methods*: damping terms and definitions; Coulomb and viscous friction damping; electrical damping; velocity feedback damping; damping methods used in aircraft systems

*System control methods*: proportional and derivative control; proportional and integrative control; analogue/digital hybrid control; system response to control methods

*Servomechanism control systems*: control system definitions; open and closed loop control systems; servo-mechanism motion control; rate and position sensing and control synchros; remote positioning control (RPC) systems.
### Outcomes and assessment criteria

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<td></td>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
</tr>
</tbody>
</table>

1. **Explain the underlying principles and examine the components used for the control and performance monitoring of aircraft systems**
   - represent typical aircraft systems in block diagram form
   - identify and explain the use of transducers in aircraft systems
   - carry out block-diagram reduction exercises and so determine open and closed loop transfer functions, using G and H notation
   - identify and explain the operation of signal conditioning and amplifier circuits used in aircraft systems.

2. **Explain the operation and performance of aircraft power systems**
   - differentiate between mechanical, fluid and electrical methods of power generation for given aircraft usage
   - determine and explain the methods used to ensure the continuing integrity and safety of aircraft power distribution
   - identify and explain aircraft power actuation systems
   - evaluate the performance parameters of motors and actuators.

3. **Apply control system fundamentals to the analysis of aircraft control systems**
   - explain the operation of aircraft remote position control systems
   - determine the response of control systems to step, ramp and sinusoidal inputs
   - analyse the damping methods used to overcome control system overshoot and hunting
   - explain aircraft system control methods and apply them to the response of typical aircraft systems
   - select and analyse appropriate components and control methods for a given set of typical aircraft control system parameters
   - analyse selected aircraft servomechanism control systems.
Guidance

Delivery

This unit has been designed to provide a foundation for further work in aircraft systems engineering and therefore should be taught prior to or in tandem with those units that require a systems input. Emphasis should be placed on appropriate laboratory/practical work that will enhance the theory. Every effort should be made to link the system principles with current operational aircraft systems. Fundamental safety principles should be stressed whenever appropriate but in particular when relating the theory to aircraft applications.

Assessment

Evidence of outcomes may be generated through activities such as assignments, case studies, reports of practical activities and tests/examinations. Learning and assessment may be across units but is more likely to be at the unit and outcome level.

Links

This is a core unit and as such provides a link with several of the BTEC Higher National programme units. These include Unit 3: Engineering Science, Unit 9: Automatic Flight Control Systems and Unit 12: Aircraft Fluid Systems.

Resources

A range of electro-mechanical laboratory equipment should be made available for the practical investigations that underpin the theory. This is likely to include the equipment necessary to analyse servo-systems, transducers, electrical, fluid and mechanical machines/mechanisms and equipment that allows for emphasis on the aerospace applications detailed in the unit.

Suggested reading

Textbooks


Unit 5: Project

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit develops learners’ ability to use the knowledge and skills they develop at work and/or on an engineering programme to complete a realistic work project. It also contributes, if appropriate, to the requirements of Engineering Applications theme 2.

The unit aims to integrate the skills and knowledge developed in other units of the course within a major piece of work that reflects the type of performance expected of a higher technician at work.

Summary of learning outcomes

To achieve this unit a learner must:

1. Select a project and agree specifications and procedures
2. Implement the project within agreed procedures and to specification
3. Evaluate the project
4. Present project outcome.
Content

1 Select a project

Process of project selection: formulate project plans, appraise the feasibility of the projects (eg comparison and decision-making methods and techniques for generating solutions from the selection of alternatives, brainstorming, mind mapping, etc.) and carry out an initial critical analysis of the outline specification; select chosen project option and agree roles and allocate responsibilities (individually with tutor/supervisor and within project group if appropriate); initiate a project log-book/diary; estimate costs and resource implications; identify goals and limitations

Project specifications: identify and record the technical and non-technical requirements relevant to the appropriate level of study and chosen project type (eg plant layout/ installation/ maintenance, product design, product manufacture or similar engineering-related topics); appropriate requirements may include costs, time scales, scale of operation, standards, legislation, quality, fitness-for-purpose, ergonomics, processing capability, business data, physical and human resource implications

Procedures: planning and monitoring methods; methods of working; lines of communication; structure of groups and collaborative working (eg learner groups or roles and responsibilities within a work-based project); targets and aims

2 Implement the project

Implement: proper use of resources (eg equipment, tools, materials, etc.); work within agreed time scale; use of appropriate techniques for generating solutions; maintaining and adapting project plan where appropriate; maintaining all records of development/progress

Record: maintain log-book/diary entries; prepare and collate developmental work (eg notes, sketches, drawings, meeting notes, research results, etc)

3 Evaluate

Evaluation techniques: appraisal of the feasibility/effectiveness of the project solution and a critical analysis against the project specification and planned procedures; use of graphs; statistics; Gantt charts; sequencing, scheduling; critical path methods; networking; application of Project Evaluation and Review Techniques (PERT); using computer software packages where appropriate

4 Present project outcome

Record of procedures and results: log-book/diary record of all events; record of developmental work (eg sketches, charts, graphs, drawings and associated notes); working records of planning and monitoring procedures; relevant data and results

Present: formal project report (eg written and/or oral presentation); use of appropriate media and methods (eg WP, CAD, DTP, PowerPoint, spreadsheets/databases, etc.); presentation to known audiences (peer groups, tutors) and unknown audience (actual or simulated, customer or client)
## Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
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</thead>
</table>
| **1 Select a project and agree specifications and procedures** | - establish and record possible project specifications  
- identify the factors that contribute to the process of project selection  
- identify and agree a project for an engineering application  
- prepare project specification and procedures |
| **2 Implement the project within agreed procedures and to specification** | - implement the chosen option to meet the agreed specification  
- record and collate relevant data. |
| **3 Evaluate the project** | - describe and use appropriate project evaluation techniques  
- interpret and justify the results in terms of the original project specification. |
| **4 Present project outcome** | - produce a record of all procedures and results  
- present the details of the project in a suitable format, using appropriate media. |
Guidance

Delivery

This unit is designed to bring small groups of learners together into a multi-disciplinary team, so that they can co-ordinate their individual skills and abilities. This allows them to develop the ability to work individually and with others, within a defined timescale and given constraints, to produce an acceptable and viable solution to an agreed brief. Learners may work individually or in small groups of three or four.

If the project is to be carried out as part of a team, it will be necessary to make sure that each member of the team has clear responsibilities and to ensure that everyone makes a contribution to the end result. It is important to be clear about who is responsible and accountable for each aspect of the work.

Once the initial brief for the project has been clarified, the tutor’s role is of a counselling rather than a directing nature. Groups might tackle different projects or several groups might elect to do similar projects. Part of the unit should be devoted to the presentation of findings, both at intermediate and final stages, so that all groups gain an insight into the thinking of others. After the final presentations, it could be useful to have feedback and/or debriefing to enable learners to benefit from comments on good and bad practice. Involving employers in all the stages of the project and at least in the presentation or plenary sessions, or both, is recommended.

Assessment

Evidence of outcomes may be in the form of a written or computer-based report supported by a fully documented log-book/diary and, where appropriate, an oral presentation.

Links

This unit may be linked with the BTEC Higher National Unit 6: Engineering Design.

The project unit is intended to integrate the skills and knowledge developed in many of the other units within the programme. Hence, the opportunity to apply the appropriate level of skills and knowledge defined by these BTEC Higher National units should be an important consideration in the selection of the project topic.

Entry requirements for this unit are at the discretion of the centre. However, it is strongly advised that learners should have completed appropriate BTEC National units or equivalent. Learners who have not attained this standard will require bridging studies.

Resources

Learners should have access to a wide variety of physical resources, depending on the specific project. Many of these are listed with the individual units associated and integrated with this one. Other data sources and reprographic facilities should also be readily accessible. Centres should try to work closely with industrial organisations in order to bring realism and relevance to the project.
Support materials

Due to the nature of the unit, learners should refer to the reading lists of other units in the programme which relate to the specific aspect they are investigating. However, the following references may be of general use.

Textbooks


Unit 6: Engineering Design

Learning hours: 60  
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to give learners an opportunity to experience the process of carrying out a design project. It will enable them to appreciate that design involves synthesising parameters that will affect the design solution.

Summary of learning outcomes

To achieve this unit a learner must:
1. Prepare a design specification
2. Prepare a design report
3. Use computer-based technology in the design process.
1 Design specification

*Customer requirements:* all relevant details of customer requirements (e.g., aesthetics, functions, performance, cost and production parameters) are identified and listed.

*Design parameters:* implications of specification parameters and resource requirements are identified and matched; the level of risk associated with each significant parameter is established.

*Design information:* all relevant information is extracted from appropriate reference sources; techniques and technologies used in similar products or processes are identified; use of new technologies are specified where appropriate; relevant standards and legislation are identified and applied throughout.

2 Design report

*Analysis of possible design solutions:* selection and use of appropriate analysis techniques to achieve a design solution (e.g., matrix analysis, brainstorming, mind mapping, forced decision making).

*Evaluation:* costs; future development potential; value engineering concepts.

*Compliance check:* using checklists; design review procedures.

*Report:* communicate rationale for adopting proposed solution; use of appropriate techniques and media in the presentation of the report (e.g., sketches, charts, graphs, drawings, spreadsheets/databases, CAD, DTP, word-processing).

3 Computer-based technology

*Key features of a computer-aided design system:* 2D design and 3D modelling systems (e.g., accessing standards, parts and material storage and retrieval, engineering calculations, PCB layouts, integrated circuit design, circuit and logic simulation — including AC, DC and transient analysis, schematic capture).

*Software:* accessing and using appropriate design software (e.g., parts assembly, pipework and ducting layouts, networks, planned maintenance, scheduling, planning, stress and strain, heat transfer, vibration analysis, resourcing, utilisation, plant layout, costing, circuit emulation, plant electrical services, for example, finite element analysis and printed-circuit board analysis software) Note: centres should select suitable examples from the applications listed.

*Evaluation:* consideration of costs, compatibility and function.
Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prepare a design specification</td>
<td>• establish customer requirements&lt;br&gt;• determine the major design parameters&lt;br&gt;• obtain design information from appropriate sources and prepare a design specification&lt;br&gt;• ensure that the design specification meets requirements.</td>
</tr>
<tr>
<td>2. Prepare a design report</td>
<td>• prepare an analysis of possible design solutions&lt;br&gt;• produce and evaluate conceptual designs&lt;br&gt;• select the optimum design solution&lt;br&gt;• carry out a compliance check&lt;br&gt;• prepare a final report.</td>
</tr>
<tr>
<td>3. Use computer-based technology in the design process</td>
<td>• identify the key features of a computer-aided design system&lt;br&gt;• use computer-aided design software to prepare a design drawing or scheme&lt;br&gt;• evaluate software that can assist the design process.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

This unit has been written in terms of general outcomes that examine products and services. It should be delivered in the context of the discipline that the learner is studying.

It can be delivered as a stand-alone unit but it is more appropriate to incorporate it into an integrated programme of study.

If it is delivered as part of an integrated programme of study, it must be possible to track evidence to show that learners have met the outcomes of the unit.

Assessment

Learners should prepare a design portfolio containing the information required to meet the outcomes. Preferably, this should be one design assignment, but it could be a series of discrete assignments.

Links

This unit would be suitable for delivery as part of an integrated assignment including other subject areas, covered by units such as Unit 3: Engineering Science and Unit 5: Project.

Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed an appropriate BTEC National unit such as Engineering Design or equivalent.

Resources

Suitable software packages should be used whenever possible. These could include packages for computer-aided design, assembly procedures, critical path, plant layout, planned maintenance, utilisation, material selection, standard component and matrix analysis.

Support materials

Textbooks


Unit 7: Aerodynamics

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

This unit enables learners to develop experimental and analytical skills together with an understanding of how aerodynamic principles influence aircraft design.

Summary of learning outcomes

To achieve this unit a learner must:

1. Investigate and describe the properties and behaviour of air
2. Investigate and analyse the forces on an aircraft in subsonic flight
3. Identify and explain the design features of high-speed aircraft
4. Describe how stability and control are achieved in conventional aircraft.
Content

1 Properties and behaviour of air

*Properties*: of International Standard Atmosphere; properties of air as a static gas only — discuss P, ρ and T variation in atmosphere; further properties (eg laminar and turbulent flow, lapse rate, P, ρ and T calculations link to ISA chart)

*Equations*: of state; speed of sound; continuity; Bernoulli for incompressible inviscid flow; shear forces and stresses; laminar flow; flow in boundary layer link to shear forces and viscosity — continuity equation

*Applications*: altitude and airspeed measurement; EAS; venturi; wind tunnels; flow in boundary layers; flow meters link to Bernoulli

2 Forces on an aircraft in subsonic flight

*Flight forces*: weight; lift; drag; thrust; line of action of forces

*Modes of flight*: steady level flight; steady balanced turn including bank angle; load factor, flight envelope, structural limits and rate of turn; glide; climb; stall

*Lift and drag*: aerofoil geometry; flow patterns; pressure distributions; air reaction; centre of pressure; coefficients of lift and drag; stall; pitching moments; aerodynamic centre; wing planform geometry; incidence; twist; stall; induced drag; lift augmentation; boundary layer control; drag of whole aeroplane; lift/drag ratio; adverse pressure gradients; vortex theory; ground effect; formation flying; downwash; camber chord; mean aerodynamic chord; angle of attack; wash in/out; fineness ratio; aspect ratio

3 Design features of high-speed aircraft

*Airflow*: compressibility; velocity; density; temperature; Mach number; Mach angle; shockwave types and development

*Effects of compressibility*: critical mach number; transonic, supersonic speeds and effects on flow, pressures, lift drag and pitching moments, coefficients and aerodynamic centre; shock stall

*Design features*: transonic and supersonic aerofoil sections; wing planforms; area ruling

4 Stability and control

*Motion*: aircraft axes; degrees of freedom; yaw; pitch; roll

*Stability*: static/dynamic stability; longitudinal, directional and lateral stick fixed stability; weight/cg envelope; static margin; horizontal stabiliser; longitudinal dihedral; vertical stabiliser; fuselage; lateral dihedral; wing sweep; simple stability equations; anhedral; active stability

*Control*: reversible/irreversible controls; rudder elevator; low-speed and high-speed ailerons; spoilers; speed brakes; variable incidence tail-planes; engine out/system failure design requirements; artificial feel; yaw dampers; Mach trim; gust lock systems; stall protection

*Types of aircraft*: hi-wing; mid-wing; modern examples of aircraft
## Outcomes and assessment criteria

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<tr>
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<tr>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
<td></td>
</tr>
</tbody>
</table>
| 1 Investigate and describe the properties and behaviour of air           | • describe the properties and behaviour of air  
• select and apply equations to solve problems for specified applications.                                                                                                                                                                    |
| 2 Investigate and analyse the forces on an aircraft in subsonic flight   | • identify and explain the origin of the four main flight forces  
• describe basic modes of flight  
• use and explain experimental techniques to investigate lift and drag production  
• select and apply equations for lift, drag and pitching movements  
• describe and explain the influence of aerofoil and wing geometry on force generation.                                                                                                                                               |
| 3 Identify and explain the design features of high-speed aircraft        | • describe qualitatively and numerically the effects of compressibility on airflow  
• relate the effects of compressibility to lift, drag and pitching movements  
• describe and explain design features of high-speed aircraft.                                                                                                                                                                           |
| 4 Describe how stability and control are achieved in conventional aircraft | • describe the motion of aircraft using standard terminology  
• distinguish between stability and control  
• describe the factors that influence the static stability of an aircraft and relate them to given types of aircraft  
• describe and compare control systems of given types of aircraft.                                                                                                                                                                     |
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated with other units. It should be related to the learners’ industrial experience and appropriate aircraft documentation. It may be possible for learners to research many of the outcomes in the workplace, however they should be given the opportunity to also undertake experimental work.

Assessment

Evidence of outcomes may be in the form of practical reports, solutions to problems, interpretation of aircraft data or evaluation of aircraft from drawings.

Links

This unit supports Unit 9: Automatic Flight Control Systems and Unit 14: Aircraft Structural Integrity.

Resources

Learners should have access to a subsonic wind tunnel with facilities for flow visualisation, lift, drag and pitching moment measurement and pressure distribution measurement.

Flight simulator software for PCs is also desirable. Access to full-size aircraft via colleges, aerospace companies, museums, etc. may also be beneficial. A wide range of textbooks and aircraft data sources should be available.

Support materials

Textbooks


Specialist units
Unit 8: Further Aerodynamics

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit follows on from Unit 7: Aerodynamics and it further develops learners’ practical skills and understanding of experimental aerodynamics. The unit also introduces the learner to the analysis of aircraft manoeuvres and evaluation of aircraft performance.

Summary of learning outcomes

To achieve this unit a learner must:
1 Investigate the applications and limitations of wind tunnel testing
2 Investigate and describe aircraft stability and control methods
3 Analyse the forces on aircraft in manoeuvres and evaluate their effects
4 Analyse aircraft performance.
Content

1 Wind tunnel testing

Model and tunnel parameters: scale effect; dynamic similarity; Reynolds number; Mach number; wind tunnel types (e.g., sizes, pressures, temperatures)

Wind tunnel investigation: flow visualisation; lift, drag and pitching moment measurement

Contribution of wind tunnel tests: limitations (e.g., size, inability to produce extremes of weather etc); aerodynamic development (e.g., Concorde wing, variable geometry wings, large aircraft configurations); aircraft performance (e.g., wing profiles, external equipment such as aerials and external loads, etc.)

2 Aircraft stability and control

Instability modes: long and short-period oscillations; spiral dive; Dutch roll

Common control systems: forces; hinge moments; stick forces; stick gearing; trim; trim curves; non-conventional controls; canard; elevons; tailerons; flaperons; active control; artificial stability; control response speed; control power; manoeuvrability; flight envelope protection; weight and drag savings

Less common control configurations: Vertical Take-Off and Landing (VTOL); Very Short Take-Off and Landing (VSTOL); helicopters; variable geometry winged aircraft

3 Forces on aircraft in manoeuvres

Forces on aircraft: gravitational forces due to aircraft manoeuvres; weight, thrust, drag and atmospheric conditions

Manoeuvres: instantaneous level co-ordinated turn and symmetrical pull-up/push-over; load factors; power/thrust for sustained turn and pull-up; spin; incipient; developed; recovery

Manoeuvre envelope: buffet limits; lg-stall; cruise; manoeuvre speeds; limit load factors; gust load lines

Aerodynamic effects: aeroelasticity; wing torsional divergence; control reversal; flutter of fixed surfaces and control surfaces; methods of alleviation

4 Aircraft performance

Aircraft Performance: aircraft drag and power required versus airspeed curves; minimum drag and power speeds; unpowered flight; glide angle; rate of descent; speed; range; endurance; stalling speed; powered flight; piston propeller and jet power/thrust available versus airspeed; minimum and maximum level flight speeds; rate of climb; airspeed for maximum rate of climb; absolute and service ceilings; take-off; ground roll; air distance; climb-out; $V_t$; $V_{TD}$; factors affecting take-off and landing; temperature; pressure altitude; ground effect; wind; runway surface; brakes; airworthiness performance regulations
Outcomes and assessment criteria

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<tr>
<td><strong>1 Investigate the applications and limitations of wind tunnel testing</strong></td>
<td>• specify appropriate model and tunnel parameters for a proposed wind tunnel test&lt;br&gt;• conduct an experimental investigation in a wind tunnel, record and comment on the validity of the results&lt;br&gt;• give examples of the contribution of wind tunnel tests in the development of aerodynamics and in individual aircraft performance.</td>
</tr>
<tr>
<td><strong>2 Investigate and describe aircraft stability and control methods</strong></td>
<td>• describe common instability modes, their effects and means of avoidance or mitigation&lt;br&gt;• analyse the size and balance of forces within a control system&lt;br&gt;• assess the merits and disadvantages of less common control configurations&lt;br&gt;• review current application of automatic/active control and discuss the implications of future developments.</td>
</tr>
<tr>
<td><strong>3 Analyse the forces on aircraft in manoeuvres and evaluate their effects</strong></td>
<td>• calculate the forces on an aircraft during manoeuvres&lt;br&gt;• identify and describe the potential hazards arising from manoeuvres&lt;br&gt;• explain and interpret manoeuvre envelopes&lt;br&gt;• describe aeroelastic effects and methods of alleviation.</td>
</tr>
<tr>
<td><strong>4 Analyse aircraft performance</strong></td>
<td>• evaluate aircraft performance in relation to airworthiness regulations and operators’ requirements&lt;br&gt;• use and explain the terminology required to describe aircraft performance&lt;br&gt;• draw conclusions from equations, graphs and tables of aircraft performance.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

This unit may be delivered as a stand-alone unit or could also be effectively integrated with other units. It should be related to industrial applications and appropriate aircraft documentation. It may be possible for learners to research many of the outcomes in the workplace, however they should also be given the opportunity to undertake experimental work.

Assessment

Evidence of outcomes may be in the form of practical reports, solutions to problems, interpretation of aircraft data, evaluation of aircraft from drawings etc.

Links

Unit 7: Aerodynamics provides the level of knowledge and understanding that is required before undertaking this unit. Additionally, this unit will support Unit 9: Automatic Flight Control Systems and Unit 14: Aircraft Structural Integrity.

Resources

Learners should have access to a subsonic wind tunnel with facilities for flow visualisation, lift, drag and pitching moment measurement and pressure distribution measurement.
Access to flight simulator software is desirable as is access to full-size aircraft via colleges, aerospace companies and museums.

Suggested reading

Unit 9: Automatic Flight Control Systems

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to develop learners’ understanding, through underpinning knowledge and skills, of the principles of automatic flight control systems. It will also enable learners to analyse the safety features built into multiplex systems.

Summary of learning outcomes

To achieve this unit a learner must:
1 Investigate and analyse aircraft servo mechanisms
2 Investigate and describe yaw damper systems
3 Investigate and analyse auto pilot and auto throttle systems
4 Investigate and evaluate auto land systems.
Content

1 Servo mechanisms

Aircraft servo-mechanisms: control and indication systems; remote position control (RPC) servomechanisms; digital and analogue control systems; integrated flight control systems; autopilots and autostabilisers

Block diagram analysis: closed and open loop systems; input signals (transient and steady state); position and velocity feedback; integral control; transfer functions

Nyquist diagrams and Bode plots: use of data to determine accuracy, stability and gain in servo systems

2 Yaw damper systems

Characteristics and operating parameters: use of system schematics to determine effect of aileron cross-feed, integration of yaw and aileron channels

System functions: band pass filters; rate gyro control

3 Auto pilot and auto throttle systems

Auto pilot inputs: radio including Instrument Landing System (ILS), Extended Twin-Engine Operations (ETOPS); collision avoidance such as Traffic alert and Collision Avoidance System (TCAS)

Auto pilot parameters: inner loop; series and parallel systems; synchronising; demand limiting evaluation; logic diagrams; detailed operation in various modes; fault diagnosis; built-in test equipment (BITE)

Auto throttle parameters: engine pressure ratio (EPR) control; mach hold; airspeed control; flap rate; pitch rate; long-term errors; auto land

4 Auto land systems

Characteristics: categories of landing; reliability requirements; auto land profile

Parameters: terrain clearance; landing profile; captive and track; attitude hold; exponential flare; kick-off drift; instinctive cut-off
Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
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</tr>
</thead>
</table>
| 1 Investigate and analyse aircraft servo mechanisms | • carry out a system analysis on an aircraft servo mechanism  
• prepare a block diagram for a servo mechanism and reduce to a transfer function  
• produce Nyquist diagrams and Bode plots from data obtained practically and theoretically. |
| 2 Investigate and describe yaw damper systems | • determine the function, operation and characteristics of a yaw damper system  
• examine yaw channel instability. |
| 3 Investigate and analyse auto pilot and auto throttle systems | • identify and describe the inputs to an auto pilot system  
• determine and describe the behaviour and parameters of an auto pilot system  
• determine and describe the behaviour and parameters of an auto throttle system  
• interpret typical auto pilot and auto throttle schematics. |
| 4 Investigate and evaluate auto land systems | • describe the characteristics and operating parameters of an auto land system  
• evaluate safety margins in multiplex systems  
• interpret auto land system schematics. |
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated with other units within the programme. It should be related to the learner’s industrial experience with appropriate aircraft documentation.

Assessment

Evidence of outcomes may be generated from activities such as assignments, solutions to applied problems, investigations using aircraft documentation, or completed tests/examinations. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Links

There are no specific links for this unit however it is advised that learners should have completed Unit 2: Analytical Methods for Engineers.

Resources

Basic avionic training rigs will assist with the investigative nature of this unit. Visits to modern aircraft operating facilities are considered to be an essential part of unit delivery.

Suggested reading

Unit 10: Measurement and Testing

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to develop learners’ understanding of the concepts of measurement and testing. In particular the unit is designed to develop the underpinning knowledge and skills required to perform complex measurement and test procedures.

Summary of learning outcomes

To achieve this unit a learner must:

1. Apply the concepts of measurement
2. Analyse the principles and techniques employed in measurement of data
3. Select and use test equipment to measure a range of signals
4. Apply the principles and techniques used in data acquisition.
Content

1  Concepts of measurement

   Measurement systems: transducers; transmission systems; instruments; response of the systems

   Definition of terms: transfer function; impulse response; frequency response and dynamic range

   Characteristics of signals: continuous signals; discrete signals; frequency and period; peak; average; effective value; phase shift; amplitude; peak to peak; time domain; frequency domain; Fourier series of signals

   Transmission systems: coaxial; twisted pairs; flat cable; fibre-optic; attenuation of the signal; frequency response of the lines; noise pick-up; block diagram of a typical system

2  Measurement of data

   Characteristics of data: error/accuracy/precision; significant digits; rounding numbers; types of errors; statistics

   Graphical techniques: linear graphs; polar graphs; logarithmic graphs; interpretation of graphs; finding the best-fit straight line; spreadsheets

3  Measure a range of signals

   Test equipment: specifications of equipment; operation of equipment; oscilloscopes; meters; signal generators; counters; logic analysers; spectrum analysers; block diagrams to explain the operation of selected test equipment

   Selection and use of test equipment: specify the correct equipment to measure a signal; practical use of equipment

4  Data acquisition

   Acquisition systems: compare types of system interfaces (analogue to analogue, analogue to digital, digital to digital); identify system elements (data acquisition, data analysis and data presentation)

   Application: overview of data acquisition systems, block diagram of typical system and explain its operation; input section (transducers, signal conditioning and multiplexer); sampling; output filtering and corrections (sin x/x); errors; A/D conversion; CPU and I/O; compare methods of recording data (eg graphic, magnetic); compare type of bus structures in use; block diagrams of typical structures; explain the operation of bus structures; control of data lines; analysis of results from a system
Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
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</tr>
</thead>
<tbody>
<tr>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
<td></td>
</tr>
<tr>
<td>1  Apply the <strong>concepts of measurement</strong></td>
<td>• analyse a measurement system&lt;br&gt;• solve problems relating to the characteristics of signals&lt;br&gt;• compare different types of transmission systems.</td>
</tr>
<tr>
<td>2  Analyse the principles and techniques employed in <strong>measurement of data</strong></td>
<td>• solve problems relating to data that has been measured&lt;br&gt;• solve problems using graphical techniques&lt;br&gt;• solve problems using spreadsheets.</td>
</tr>
<tr>
<td>3  Select and use test equipment to <strong>measure a range of signals</strong></td>
<td>• describe the operation of items of test equipment&lt;br&gt;• determine which items of equipment are required for a test and use items of test equipment to measure signals.</td>
</tr>
<tr>
<td>4  Apply the principles and techniques used in <strong>data acquisition</strong></td>
<td>• identify the hardware and software required to capture data from an item under test&lt;br&gt;• investigate the operation of a data acquisition system&lt;br&gt;• apply a data acquisition system to determine the performance of an item under test&lt;br&gt;• analyse the results obtained from the data acquisition.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

A practical hands-on approach to learning should be adopted wherever possible, with tutors providing relevant examples of the theory in practice. Visits to electronic test installations will be of value to learning.

Assessment

Evidence of outcomes may be in the form of an end-of-unit examination, assignments and reports of practical activities. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of practical activities or by a tutor-led combination of practical tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit is intended to stand alone, but may be linked with other units in the programme. Entry requirements for this unit are at the discretion of the centre. However, the unit assumes that learners have a prior knowledge of electrical/electronic principles at BTEC National level. Ideally, they should have completed BTEC National units in Science for Technicians and Mathematics for Technicians or equivalent.

Resources

A range of electronic test equipment should be available to support practical investigations. Appropriate software packages should be used wherever possible to solve problems.

Support materials

Textbooks

Unit 11: Communication and Navigation

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to develop learners’ understanding of the principles of operating aircraft communication and navigation systems. This includes the operation of radio transmitters, receivers and aircraft radio navigation systems. The unit enables the learner to examine aircraft inertial navigation systems and provides an opportunity to carry out calculations in addition to considering the operation of these systems. The unit also provides an opportunity for the learner to investigate the types, operation and operating parameters of continuous wave aircraft radar systems.

Summary of learning outcomes

To achieve this unit a learner must:
1. Analyse and explain the operation of a radio transmitter and receiver
2. Investigate and describe the operation of aircraft radio navigation systems
3. Analyse aircraft inertial navigation systems (INS)
4. Analyse pulsed and continuous wave aircraft radar systems.
Content

1 Radio transmitter and receiver

Legal requirements: licensing; regulatory authorities; frequency of operation; spurious emissions

Amplitude modulation (AM) transmitters: principles of transmission (eg electromagnetic radiation, electromagnetic spectrum and propagation of radio waves); types and principles of modulation; use of block/flow diagrams to aid explanation of the operation and stages within a transmitter system

Receivers: principles of radio reception (eg demodulation, Automatic Gain Control (AGC), Automatic Frequency Control (AFC)); types of receivers; use of block/flow diagrams of radio receiver systems; operation of stages within receivers; effects of noise and interfering signals on radio reception; signal to noise

Receiver performance: use of measurement and test equipment (eg signal generator, power meter, oscilloscope, noise test set, spectrum analyser); performance characteristic (eg sensitivity, signal to noise, adjacent channel, image channel rejection ratios)

2 Aircraft radio navigation system

Type of radio navigation systems: instrument landing system (ILS); very high frequency (VHF) omni-directional radio range (VOR); automatic direction finding (ADF); distance measuring equipment (DME); logan and omegal; global positioning systems (GPS)

Principles of operation: frequency bands; aerial pattern; system block diagrams; hyperbolic patterns; signal formats; GPS position determination

Aircraft systems: use of block diagrams to identify and explain a typical integrated aircraft radio navigation system; operation of the complete system

3 Inertial navigation system (INS)

Principle and operations: basic principles relating to Inertial navigation; Schuler tuning; block diagram of Schuler tuned INS; accelerometers; gyros; alignment and gyro compassing; errors; choice of platform axes; strap-down IN systems; aided IN systems; Kalman filters

Aircraft IN system: use of block diagram of complete IN system; applications of a typical align sequence; IN augmentation (eg using Doppler, GPS, Kalman Filter); operating principles of analogue computing systems as used in navigation systems

IN Problems: calculation on acceleration, velocity, distance; errors encountered in IN systems and how corrections are applied

4 Radar systems

Radar systems: pulsed; carrier wave (CW); primary; secondary; Doppler; applications of each system; use of block diagrams of typical radar systems

Parameters measured: range/bearing/height; radar equation; solve problems related to range/bearing/height
Outcomes and assessment criteria

<table>
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</thead>
<tbody>
<tr>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
<td></td>
</tr>
</tbody>
</table>
| 1  Analyse and explain the operation of a **radio transmitter and receiver** | • explain the legal requirements for transmitter operation  
• investigate an AM radio transmitter and explain the principles of operation  
• explain the principles of operation of a radio receiver  
• evaluate the performance of a radio receiver. |
| 2  Investigate and describe the operation of **aircraft radio navigation systems** | • compare the different types of radio navigation systems and identify the best fit for a particular aircraft  
• explain the principles of operation of a complete aircraft radio navigation system. |
| 3  Analyse aircraft **inertial navigation systems**                     | • explain the principles and operation of aircraft inertial navigation systems  
• analyse the effects on aircraft performance of IN problems  
• select and use equations of motion to solve inertial navigation problems. |
| 4  Analyse pulsed and continuous wave aircraft **radar systems**         | • explain the principles of operation of radar systems  
• analyse the factors affecting radar performance  
• solve problems relating to range, bearing and height of radar returns. |
Guidance

Delivery
A practical, hands-on approach to learning should be adopted wherever possible, with tutors providing relevant examples of the theory in practice. Visits to avionics installations will also be of value.

Assessment
Evidence of outcomes may be generated through tests/examination, assignments and reports of practical activities. Evidence may be gathered through a portfolio of practical activities or by a tutor-led combination of practical tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links
This unit may be effectively linked with other avionics units in the programme.

Resources
Appropriate laboratory experiments should be used where possible to verify the theory. Block and circuit diagrams for practical avionics systems should be used. Access to practical avionics systems is desirable but not essential.

Appropriate software packages should be used wherever possible to solve problems and simulate systems.

Suggested reading

Textbooks
Unit 12: Aircraft Fluid Systems

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

This unit provides an overview of the operation and control of aircraft hydraulic and pneumatic systems. It includes the constructional detail, operating principles and system function of a variety of aircraft hydraulic and pneumatic system components. The interpretation and analysis of hydraulic and pneumatic circuit drawings, using a variety of illustrative methods and conventions is included so that fluid system operational status may be determined.

Summary of learning outcomes

To achieve this unit a learner must:

1. Investigate the construction, operation and control of aircraft hydraulic systems and their system components
2. Investigate the construction, operation and control of aircraft pneumatic systems and their system components
3. Determine the fluid circuit operational status by reading and interpreting fluid circuit diagrams.
Content

1 Aircraft hydraulic systems

Hydraulic power: use; advantages/disadvantages of hydraulic actuation on aircraft; hydraulic system fluid principles

Aircraft hydraulic systems: power supplies; powered flying controls; landing gear; nose wheel steering; flaps; airbrakes; arrestor gear; braking and anti-skid; thrust reversers; emergency systems

Hydraulic system components: function and operation; oil types and properties; seals; pumps; linear actuators; rotary actuators (motors); pressure control valves; flow control valves; powered flying control units; accumulators; reservoirs; fluid conductors and plumbing; filters; pressure switches and gauges; fluid conditioning equipment; interface with other systems

2 Aircraft pneumatic systems

Air as a fluid power medium: use; advantages/disadvantages of pneumatic power on aircraft; pneumatic fluid power principles; properties of air including the special characteristics needed by a fluid when subject to extremes of environmental change; related safety precautions for air and oxygen

Aircraft pneumatic systems: pneumatic sources (eg engine bled, ram air, blowers, compressors, APU, bottles, oxygen generators, ground cart); air conditioning and pressurisation; wing and nacelle anti-icing; rain protection; reservoir/tank pressurisation; gyro instrument supply; engine starting; pneumatic landing gear/flaps/brakes; cabin/cargo heating and smoke detection; anti-g systems; oxygen systems; equipment cooling

Pneumatic system component: bottle; compressor; fan; turbine; blower; receiver; filter; dryer; humidifier; lubricator; pressure regulator; drainage points; oil separator; water separator; heat exchanger; cold air unit; cooling/refrigeration pack; duct; louvre; pipe; gauge; plenum chamber; check valve; mixing valve; sensor; switch; pressure controller; discharge valve; temperature controller; pneumatic actuator; air motor; relief valve; pressure control valve; directional control valve; non-return valve; flow control valve; solenoid valve; in/out flow valve; interface with other systems
3 Fluid circuit operational status

*Literature illustrating fluid power circuits*: CETOP RP 41 circuit diagrams and graphical representations (eg pictorial, schematic, diagrammatic, block diagram); standard symbols; fluid system publications (eg Air Transport Association (ATA) 100 system, air publications (APs), books, periodicals, manufacturers’ literature, maintenance manuals, operational manuals, wall charts and diagrams)

*ISO and BS circuit system diagrams*: ISO 1219/BS 2917 fluid power symbols; sketch and recognise symbols for fluid storage; power sources and other components (eg blowers, compressors, turbines, pumps and motors, drives, linear actuators, valve control mechanisms, directional control, servo and proportional control, pressure control, flow control, fluid plumbing and storage, fluid conditioning, fluid heating and cooling, refrigeration); associated electrical components

*Interpret aircraft system diagrams*: interpret fluid power circuit diagrams using all conventions (eg ATA 100, ISO 1219, BS 2917 etc); translate ISO 1219/BS 2917 into other conventions and vice-versa; use of aircraft fluid power circuit diagrams (eg to determine system operation, identify possible causes of system failure, suggest remedial action); identify required system functional tests and checks; prove integrity of fault diagnosis in practice and return system(s) to serviceable status
## Outcomes and assessment criteria

### Outcomes

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</table>
| 1 Investigate the construction, operation and control of **aircraft hydraulic systems** and their system components | • explain the reasons for using hydraulic power as a major source of energy for aircraft systems operation  
• determine the properties of aircraft hydraulic fluids and their behaviour when subject to pressure and to extreme operating environments  
• describe the function, operation and control of aircraft hydraulic systems and their associated status indicators  
• explain the operation and describe the constructional features of hydraulic system components  
• assemble, prime and bleed hydraulic systems and analyse system performance, using appropriate training rigs or aircraft systems. |
| 2 Investigate the construction, operation and control of **aircraft pneumatic systems** and their system components | • determine the properties of air as a fluid power medium for aircraft systems  
• explain the function and operation of aircraft pneumatic systems and their associated status indicators  
• investigate the function, nature and operation of selected aircraft pressurisation, air conditioning and refrigeration systems and their associated status indication systems  
• explain the operation and describe the constructional features of pneumatic system components  
• explain the operation and describe the constructional features of components used in aircraft pressurisation, cabin conditioning and refrigeration systems  
• dismantle, inspect and assemble selected aircraft pneumatic, pressurisation and conditioning systems/ components, using system mock-ups and/or aircraft. |
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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</table>
| 3  Determine the fluid circuit operational status by reading and interpreting fluid circuit diagrams | - identify and use appropriate sources of literature illustrating aircraft fluid power circuits  
- interpret ISO and BS circuit/system diagrams and translate these conventions into standard aircraft system schematic diagrams and vice-versa  
- produce circuit diagrams in standard and other conventions for given aircraft fluid system services  
- read and interpret aircraft system diagrams for selected hydraulic, pneumatic and environmental control systems  
- identify possible aircraft fluid system and component defects by interpreting circuit diagrams for given situations  
- carry out aircraft fluid system functional tests and checks, determine and prove defects and return system(s) to an airworthy condition. |
Guidance

Delivery

This unit has been designed to link with Unit 4: Aircraft Systems Principles and therefore they may be taught in tandem. Care should be taken in the tracking of evidence for the outcomes when integrating these units.

Emphasis should be placed, whenever possible, on a practical approach to the delivery of the unit outcomes. Effort should be made to identify operational principles and link them with aircraft systems and system component applications. Work placement and/or industrial visits to aircraft system manufacturers or airline operators would greatly enhance learning.

Safety must be emphasised at all times, particularly with respect to the dangers of hydraulic fluids, compressed gases, pressurised hydraulic and pneumatic systems, cryogenic substances, fluid replenishment, fluid toxicity and handling.

Assessment

Evidence of outcomes may be generated through assignments, practical activities, investigations and tests/examinations. Learning and assessment may be across units, at unit level or at outcome level to provide maximum flexibility of delivery.

Links

This unit may be effectively linked with Unit 4: Aircraft Systems Principles.

Resources

The unit requires access to aircraft hydraulic, pneumatic and environmental control systems and components (these may be in the form of system mock-ups). Appropriate sources of literature in the form of aircraft manuals, diagrams and charts will also be required.

Suggested reading

Textbooks


Other publications
Circuit Diagrams (CETOP RP41)
Air Transport Association ATA 100 System
Civil Aircraft Maintenance Manuals
Air Publications
Standards for Fluid Power Symbols (ISO 1219)
Manufacturers’ literature
Unit 13: Further Aircraft Fluid Systems

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit has been designed to build on the skills and knowledge gained from studying Unit 3: Engineering Science, Unit 4: Aircraft Systems Principles and Unit 12: Aircraft Fluid Systems, all of which are prerequisites. The unit is concerned with applying the basic principles of fluid mechanics, thermodynamics and heat transfer to the analysis of aircraft fluid systems and system components. The selection of components for a required system service is also considered, based on component performance characteristics.

Summary of learning outcomes

To achieve this unit a learner must:

1. Analyse and mathematically determine aircraft system performance characteristics
2. Apply the principles of fluid mechanics to analyse the performance of hydraulic system components
3. Apply the principles of fluid mechanics, thermodynamics and heat transfer to analyse the performance of pneumatic system components.
Content

1 Aircraft system performance

Fluid power systems: fluid properties; fluid work and power; continuity and energy equations; viscous force and flow; system loads and service requirements

Linear actuator circuits: sizing; Euler’s equation and piston buckling; flow control; velocity control; pressure control; dynamic braking; effects of load change; cavitation avoidance during overrun; emergency provision and accumulator sizing

Pump circuits and power packs: pump capacities; volumetric and mechanical efficiency; flow control; pressure control; flow; pressure and power matching

Fluid motor circuits: motor design; power requirements; motor system performance; pumps as motors; reversal control; speed control; torque control; motor sizing

Fluid conductors and fittings: laminar and turbulent flow; Reynold’s number; pressure losses in straight pipes; estimate of losses in fittings; Darcy formula; friction factor; Moody diagram

2 Hydraulic system components

Pressure control components: general theory and the orifice equation; flow and force considerations for pressure control; relief valve orifice characteristics; restrictor valve equation

Flow and velocity control: components; pressure compensated flow control; modulating and electrohydraulic flow control valves; directional control valves; speed control for fixed displacement pumps using metering systems

Aircraft system servo-valves: modulating and electrohydraulic flow control; servo-valve characteristics; land/port overlap characteristics; servo-flying control units — valve pressure drop and displacement characteristics; general servo valve equation

Component selection: aircraft hydraulic system service requirements; aircraft hydraulic component characteristics; selection of linear actuators; pressure; flow and directional control valves; pumps and motors
Fluid mechanics, thermodynamics and heat transfer

Fans, blowers, compressors and turbines: classification and types — propeller fans, duct fans, centrifugal fan and compressors, axial compressors, screw compressors, fluid flow through pneumatic components, compressed air flow and specific weight

Nozzles and flow measurement: nozzle — shape, critical pressure ratio, maximum mass flow, sonic velocity and adiabatic flow; variable head meters, turbine flow meter; mass flow measurement; pitot static head

Reciprocating machines: isothermal efficiency; volumetric efficiency; multi-stage compression

Air-conditioning heat exchangers: types of heat exchanger; constructional details; general equation for heat transfer across a surface; overall heat transfer coefficient; fouling factors; mean temperature difference; fluid properties through heat exchanger; boot strap systems

Refrigeration cycles: the reverse heat engine; properties of refrigerants; vapour-compression cycles; coefficient of performance; refrigerating load; pressure-enthalpy diagram; compressor displacement

Component selection: aircraft pneumatic system service requirements; aircraft pneumatic component characteristics; selection of nozzle valves, blowers, compressors, turbines, heat exchangers, evaporators and condensers
Outcomes and assessment criteria

<table>
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<tr>
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<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</tbody>
</table>
| **1 Analyse and mathematically determine aircraft system performance characteristics** | • mathematically determine work and power parameters, flow rates and velocities for system linear actuators and their associated circuits  
• determine fluid system accumulator size/capacity parameters, using graphical and analytical methods. |
| **2 Apply the principles of fluid mechanics to analyse the performance of hydraulic system components** | • explain the effects on valve performance when different valve elements are used, eg poppets, on/off slides, spools, flappers and proportional valve elements  
• determine flow and pressure values through the orifice of relief valves and restrictor valves, using the orifice equation and its variants  
• calculate flow and force parameters, through typical single stage valves  
• mathematically model mechanical lever and electro-mechanical servo-flying control units  
• investigate the service parameters needed for a variety of aircraft hydraulic system tasks, and use these parameters to select system components with appropriate performance characteristics. |
| **3 Apply the principles of fluid mechanics, thermodynamics and heat transfer to analyse the performance of pneumatic system components** | • calculate pneumatic system nozzle discharge rates for sub-sonic and sonic flow through a nozzle discharging to atmosphere  
• determine the volumetric, compressor and overall efficiencies for an aircraft pneumatic system reciprocating compressor functioning under known conditions  
• estimate the shell and tube dimensions for a heat exchanger required for a typical aircraft cabin-conditioning pack, given the heat exchanger operating parameters  
• calculate the power output from a typical aircraft turbo-compressor cold air unit, for assumed system conditions  
• investigate vapour-compression refrigeration cycles and determine the operating parameters of the refrigeration system components to meet a given refrigerating load  
• determine the service parameters needed for a variety of aircraft pneumatic system tasks, and use these parameters to select components which meet these system requirements. |
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated in part with Unit 17: Gas Turbine Science. If it is delivered in an integrated way, care must be taken in the tracking of evidence for the outcomes, and centres should be aware that study and assessment at outcome level could lead to an assessment overload. Wherever possible a practical approach should be adopted.

It is considered essential that the underpinning thermofluid dynamics and heat transfer principles are applied to aircraft system components. Learning will therefore be enhanced by ensuring that industrial visits to aircraft fluid system component manufacturers and airline operators are built in to the unit delivery.

Assessment

Evidence of outcomes may be in the form of assignments, laboratory notes, reports from investigations, group presentations, applied problems or completed tests/examinations. Learning and assessment can be across units, at unit level or at outcome level. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Links

This unit may be linked with Unit 17: Gas Turbine Science, since both units apply similar scientific principles.

Entry requirements for this unit are at the discretion of the centre. However, it is strongly advised that within the programme, learners should have completed Unit 3: Engineering Science, Unit 4: Aircraft Systems Principles and Unit 12: Aircraft Fluid Systems before embarking on this unit.

Resources

Learner access to aircraft hydraulic, pneumatic and environmental control components is essential. Access to laboratory equipment for the study of thermofluids mechanics and heat transfer is also considered necessary. For investigative work learner access to modern aircraft systems would be highly advantageous.
Support Materials


Other publications

Manufacturers’ Aircraft Fluid System, Hydraulic and Pneumatic Component Literature, Manuals and Publications
Unit 14: Aircraft Structural Integrity

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit aims to develop the underpinning knowledge, analytical skills and techniques necessary to ensure that aircraft are manufactured and maintained in such a manner that the integrity and continuing airworthiness of their structure is assured. Emphasis is placed on the analysis of structural failure and knowledge of bonded repair concepts, in addition to an understanding of fracture mechanics, in order to devise and produce manufacturing schedules and manage preventative maintenance programmes.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate failure mechanisms in aircraft structures
2. Design and analyse bonded repairs for both metal and composite structures
3. Devise and manage production schedules or preventative maintenance programmes.
Content

1  Failure mechanisms

Fracture strength: significance of fracture mechanics; strength; toughness; critical crack length; Griffith energy balance approach; Irwin’s theory; stress intensity approach; crack tip plasticity; fracture toughness; critical crack growth

Fatigue and creep: the nature of fatigue; fatigue effects; sources of fatigue (eg cyclic, thermal, acoustic, sonic, fretting and corrosion fatigue); fatigue strength; S-N curves; endurance limit; determination of fatigue life; fatigue testing; creep (eg characteristics, stages, creep rate and rupture times, kinetic heating and creep)

Design methods: design philosophy; safe-life and fail-safe structures

Crack growth: nature of fatigue crack growth and stress intensity factors; prediction of fatigue crack growth under constant amplitude loading; environmental effects

Fracture mechanisms: study of fracture surfaces; slip; plastic deformation and dislocations; ductile transgranular fracture by microvoid coalescence; brittle transgranular fracture (cleavage); transgranular and intergranular fracture by fatigue; the effects of fracture path and microstructure; material behaviour and mechanisms of fracture

2  Bonded repairs

Micromechanics and properties: mechanical properties of unidirectional composites (eg longitudinal stiffness and tensile strength, transverse stiffness and strength); fibre volume fraction and the equation of mixtures; off-axis stiffness and strength; properties of cross-ply and angle-ply laminates; discontinuous fibre laminates; the use of fibre composite materials in aircraft structures

Adhesion and surface treatments: analysis of bonded v rivet repairs; adhesives; adhesion and adhesive testing; surface preparation; surface treatments (eg structural aluminium alloys, titanium alloys, phosphoric acid anodising, chromic acid anodising)

Metal bonded repairs: thin sheet metal construction (eg sheet thickness criteria, overlap lengths, material specification, strength considerations); residual strength of flawed or damaged adhesive bonded joints; acceptable criteria for bond flaws and damage; life prediction for adhesively bonded joints

Composite bonded repairs: repair materials; composite repair concepts and methods (eg bolted repairs, bonded repair categorisation (non-structural, secondary structural and primary structural), non-patch repairs, bonded external patch, scarf and flush repairs); effects of moisture on bonded repair of composites; design of bonded repairs (eg general considerations, external patch design, laminate design)
3 Maintenance programmes

*Damage assessment:* structures and structural components (eg use of equipment to assess general damage, nature and identification of types of corrosion); non-destructive evaluation (NDE) of structures (eg using optical, penetrate dye, ultrasonic, radiographic, eddy current, acoustic emission and thermography techniques)

*Policy and procedures:* corrosion damage prevention methods (eg detail design, protective coatings, inhibitors, anodic protection, materials selection and treatment); repair policy (eg downtime considerations, costs, repair by replacement, repair and rectification organisation); quality assurance procedures; out sourcing; repair procedures for metal and polymer matrix composites (PMC) structures and components; repair materials handling, storage and procurement; field repair considerations (eg simple techniques, limited use of repair equipment, first-aid repair techniques, availability of cure facilities)

*Integrity of aircraft structures:* inspection procedures (eg nature and frequency of inspection, structural component access and component life considerations); condition monitored maintenance (eg hard-time, on-condition and condition monitoring and their relationship to aircraft structure); statistical information sources and corresponding reliability techniques; data collection and structural component history; maintenance reporting procedures; corrective action methodology and quality assurance procedures; SBAC, Civil Aviation Authority (CAA) and Military regulations for the manufacture and maintenance of aircraft structures and structural components; temporary repairs.
## Outcomes and assessment criteria

<table>
<thead>
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<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</tbody>
</table>
| **1 Investigate failure mechanisms in aircraft structures**              | • explain the significance and determine mathematically the fracture strength of aircraft structural materials  
• determine the nature and likely sources of fatigue and creep on aircraft  
• explain the significance of the operating environment on aircraft fatigue and the nature of the design methods used to minimise fatigue effects  
• determine the (CAA, FAA) structural damage tolerance requirements for aircraft  
• analyse the methods used to estimate fatigue crack growth and aircraft fatigue life  
• investigate the nature of fracture mechanisms for aircraft light alloys, subject to static and fatigue loading. |
| **2 Design and analyse bonded repairs for both metal and composite structures** | • analyse the nature and mathematically determine the micromechanical properties of aircraft carbon matrix composite (CMC) materials  
• describe the adhesion and surface treatments used for bonded metal structure repairs  
• mathematically determine the strength limits, dimensional requirements and curing times for metal and composite bonded repairs  
• design and prepare an adhesive joint using composite or light alloy adherends and analyse the results when the joint is subject to a non-destructive or destructive test. |
Outcomes | Assessment criteria for pass
--- | ---
To achieve each outcome a learner must demonstrate the ability to:

3 Devise and manage production schedules or preventative maintenance programmes
- carry out damage assessment and devise procedures to repair damage on aircraft structure or structural components
- evaluate the integrity of aircraft structures and/or structural components, subject to manufacture or repair using appropriate NDE techniques
- formulate organisational policy for base maintenance structural repairs or field repairs
- devise and produce simple manufacturing or maintenance inspection procedures for aircraft structures or structural components that comply with regulatory body legislation
- produce policy documents and associated procedural networks, for a quality system that ensures the integrity and safety of an aircraft structural component during manufacture or during its operational life.
Guidance

Delivery

Wherever possible the theoretical aspects of failure should be illustrated by analysing defects found on aircraft structures/structural components. Theoretical and practical design work forms an integral and essential part of the unit. Industrial visits to aerospace manufacturers or aircraft maintenance organisations would be beneficial.

Assessment

Evidence of outcomes may be generated through activities such as assignments, laboratory testing, practical activities, formal and informal reports, presentations, investigations and tests/examinations.

Links

This unit is intended to stand-alone but it has links with Unit 22: Mechanical Principles and Unit 23: Materials Engineering.

Resources

Aircraft-related structures/structural components and tools suitable for aircraft structural repairs need to be available for the delivery of this unit. Materials testing (e.g. destructive/non-destructive) facilities for metals and/or polymer matrix composites are also required.

Suggested reading

Textbooks


Unit 15: Aircraft Propulsion Technology

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to investigate the basic principles and laws of aircraft propulsion and their application to gas turbine systems and design. It is a broad-based unit, covering forces exerted by a fluid, gas turbine thermodynamics and their application to the engine modules.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate propulsion engine performance
2. Investigate aerodynamic and mechanical design of main engine modules and propellers
3. Investigate engine performance characteristics
4. Investigate aircraft piston engines.
Content

1  Propulsion engine performance

Gas turbine science: Newton’s laws; momentum; inertia; thrust; mechanics of reaction propulsion; nozzles and ducts; gas laws (eg Boyles Law)

Working cycles of gas turbine and piston engines: brayton cycle; velocity; temperature; pressure; propulsive efficiency; piston engine fundamentals and indication systems

Gas turbine and piston engine systems: turbo-prop; turbo-jet; high and low by-pass; 2 and 4 stroke engines

Performance data: power and thrust to weight ratio; engine dimensions; specific fuel consumption; engine rpm; effects of compressor bleed; nozzle areas; inlet temperatures; drag and ram pressure rise

Graphical methods: performance graphs and charts

2  Aerodynamic and mechanical design

Modules of a gas turbine engine: intakes (eg requirements for subsonic and supersonic intakes and intake design, effect of internal and external geometry on boundary layer and ram recovery, variable flight conditions, engine failure protection, high bypass engines, ice protection); compressors (eg centrifugal, axial, multi-spool, transonic, performance, stalling, surging, interaction between mechanical and aerodynamic design, in-service problems); combustion chambers (eg design criteria, typical combustion and ignition systems, types of burners); turbines (eg turbine geometry, blade cooling, design and aerodynamic performance of blades, nozzle guide vanes, related calculations, mechanical design of discs, blade attachment in relation to aerodynamic requirements, blade materials, vibration, root stresses, fatigue, creep); exhaust (eg function and design of jet pipe nozzle, control and direction, gas flow velocity, construction and operation of reverse thrust, after burners, noise reduction)

Maintenance activities: engine condition inspections; blade clearance checks; assessment of internal damage; fuel, lubricant and fluid system checks; pre-flight checks; controls inspections; ground running

Propeller aerodynamics: thrust; torque; lift and drag; blade angle; angle of attack; blade twisting; forces along blade; propeller efficiency; type (eg fixed, two pitch, constant speed and variable pitch propellers); windmilling; reverse pitch; aerodynamic and centrifugal turning moments

Propeller control: pitch change mechanism; control units (eg propeller governor, unfeathering accumulators, pitch control mechanism); operation; feathering system; pitch locks and beta control; synchronising
3 **Engine performance characteristics**

*Performance parameters:* design applications and performance parameters for turbo-prop, turbo-jet and turbo-fan; engine airflow graphs; choked nozzles; mechanical forces; thrust calculations and thrust load paths; dependent and independent accessories (gross, net, choked nozzle, thrust); thrust HP, ESHP

*Material limitations:* power rating; centripetal forces; temperatures

*Engine performance monitoring:* instrumentation (eg temperature and power output); thermocouple position; exhaust gas temperature (EGT) and jet pipe temperatures (JPT); thrust and rotational speed; engine pressure ratio and integrated engine pressure ratio; data analysis and performance trend monitoring

*Engine condition monitoring:* vibration; lubrication systems; FADEC systems

4 **Piston engines**

*Engine construction:* crankcase; crankshaft; sumps; accessory gearbox; cylinder and piston assemblies; valve mechanism and timing; propeller reduction gearboxes

*Fuel, lubrication and ignition systems:* carburettors; fuel injection; starting and ignition; exhaust and cooling; supercharging/turbo-charging; lubrication; operation; layout and components; FADEC

*Power plant installation:* configuration of firewalls; cowlings; acoustic panels; engine mounts; anti-vibration mounts; control systems

*Engine monitoring and ground operation:* starting and ground run-up; engine power output and parameters; engine inspection and maintenance
## Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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<tbody>
<tr>
<td>1 Investigate <strong>propulsion engine performance</strong></td>
<td>- apply Newton’s and gas laws to gas turbine and piston engine cycles</td>
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<tr>
<td></td>
<td>- explain the working cycles of gas turbine and piston engine systems</td>
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<tr>
<td></td>
<td>- calculate performance data for gas turbine and piston engines</td>
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<tr>
<td></td>
<td>- use graphical methods to present and evaluate engine performance data</td>
</tr>
<tr>
<td>2 Investigate <strong>aerodynamic and mechanical design</strong> of main engine modules and propellers</td>
<td>- describe the modules of a gas turbine engine</td>
</tr>
<tr>
<td></td>
<td>- determine and describe the maintenance activities associated with each module</td>
</tr>
<tr>
<td></td>
<td>- explain the aerodynamic and mechanical requirements of each module</td>
</tr>
<tr>
<td></td>
<td>- analyse propeller aerodynamics and control</td>
</tr>
<tr>
<td>3 Investigate <strong>engine performance characteristics</strong></td>
<td>- determine performance parameters of gas turbine engines</td>
</tr>
<tr>
<td></td>
<td>- describe the material limitations for each module in Outcome two</td>
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<tr>
<td></td>
<td>- investigate the information used to monitor engine performance and engine condition.</td>
</tr>
<tr>
<td>4 Investigate aircraft <strong>piston engines</strong></td>
<td>- explain engine construction</td>
</tr>
<tr>
<td></td>
<td>- identify and describe fuel, lubrication and ignition systems</td>
</tr>
<tr>
<td></td>
<td>- evaluate a power plant installation</td>
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<tr>
<td></td>
<td>- describe engine monitoring and ground operation procedures.</td>
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</tbody>
</table>
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated with other programme modules. If it is delivered in an integrated way, care must be taken in the tracking of evidence for the outcomes, and centres should be aware that study and assessment at outcome level could lead to an assessment overload. Wherever possible, a practical approach should be adopted. Effort should be made to identify the relevance of the principles covered to aircraft engineering applications, system control and design.

Assessment

Evidence of outcomes may be generated through such activities as assignments, laboratory work, solutions to applied problems or tests/examinations.

Links

This unit may be effectively linked with the mathematics, principles and applications units in the programme.

Resources

Appropriate laboratory equipment for the demonstration and determination of Boyle’s Law, Charles’ Law, Adiabatic index is required. It would be advantageous for learners to have access to equipment that demonstrates gas turbine and propeller control systems and simple gas turbine tests should be available to the learner.

Suggested reading


Unit 16: Integrated Flight Instrument Systems

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit
This unit is concerned with aircraft flight instruments and their integration into aircraft flight deck systems. It aims to develop and consolidate the learner’s understanding of the scientific and engineering principles that are exploited in the design and construction of aircraft flight instruments. It also considers the purpose, rationale and application of the major traditional groupings of flight data instruments and the ways in which traditional and newer forms of flight information are being integrated into current flight deck systems.

Summary of learning outcomes
To achieve this unit a learner must:
1. Investigate and describe the applications of gyroscopes in aircraft attitude indicators
2. Explain the application of directional references to aircraft systems
3. Investigate and describe the principles of operation and applications of air data systems
4. Investigate and describe integrated flight deck instrument systems.
Content

1 Aircraft attitude indicators

*Gyrosopes*: development of the gyroscope and its properties; drift and transport wander; practical gyroscopes; pneumatic, vacuum and electrically driven gyroscopes; errors and limitations

*Flight instrument applications*: direction indication (e.g., the horizontal axis gyroscope); artificial horizons (e.g., principle of the gyro horizon, use as standby attitude indicators); turn and bank indication (e.g., for turn rate detection and bank and slip indication); erection and levelling methods; error sources and control

2 Directional references

*Terrestrial magnetism*: nature of magnetism; variation; dip; direct reading compasses; compass construction; location considerations; errors and dynamic behaviour; analysis of deviation and compensation

*Remote indicating compass/magnetic heading reference system (MHRS)*: principles of synchronous data transmission and synchro types; flux valves; the directional gyro unit and its application as a directional reference; system operating modes; deviation compensation; integration with radio and inertial systems

3 Air data systems

*Features of the atmosphere*: layers of the atmosphere (e.g., ionosphere, troposphere) and their effects on pressure and temperature

*Air data measurement*: horizontal speed measurement (e.g., pitot systems and engineering considerations, direct and indirect systems, airspeed indication and terms, mach meters); altitude measurement (e.g., principle of the barometric altimeter, pressure settings); vertical speed measurement (e.g., principle of differential pressure measurement); air temperature measurement (e.g., total air temperature, static air temperature); construction; types of sensor; indicators; integration into other systems; error sources

*Air data computers*: advantages of integrating air data; analogue and digital methods of air data computation; utilisation of computed data; alerting and warning requirements; applications

4 Flight deck instrument systems

*Flight director systems*: use of the vertical gyro; systems inputs; computation; Attitude Director Indicators (ADI); Horizontal Situation Indicator (HSI); interface to other aircraft systems; typical aircraft control panels and mode selectors

*Electronic displays*: cathode ray tube displays; alphanumeric displays; Liquid Crystal Displays (LCDs); symbol generation; ambient light sensors

*Electronic flight instrument systems*: Electronic Attitude Director Indicator (EADI); Electronic Horizontal Situational Indicator (EHSI); system inputs; typical displays; failure and reliability considerations; aircraft case study
Outcomes and assessment criteria

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<td>To achieve each outcome a learner must demonstrate the ability to:</td>
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</table>
| 1  Investigate and describe the applications of gyroscopes in **aircraft attitude indicators** | • describe the development and construction of the gyroscope, its properties and limitations  
• identify and explain how gyroscopes are adapted for use in various flight instrument applications.                                                                                                                |
| 2  Explain the application of **directional references** to aircraft systems | • describe terrestrial magnetism and dependant effects  
• explain the principles and applications of the remote indicating compass/MHRS  
• evaluate and describe how MHRS are integrated into modern aircraft types.                                                                                     |
| 3  Investigate and describe the principles of operation and applications of **air data systems** | • explain the principal features of the atmosphere that are relevant to air data systems  
• describe air data measurement devices  
• describe typical analogue and digital air data computers.                                                                                                    |
| 4  Investigate and describe integrated **flight deck instrument systems** | • analyse representative flight director systems  
• draw and explain ADI and HSI presentations  
• explain the construction of electronic displays  
• analyse typical electronic flight instrument systems  
• draw and explain typical EADI and EHSI displays.                                                                                                        |
Guidance

Delivery

The delivery of this unit should be at the same time as or after Unit 4: Aircraft Systems Principles. When delivered with other units care must be taken in the tracking of evidence for the outcomes.

Assessment

Evidence of outcomes may be generated through activities such as, assignments, investigations, laboratory work, problem solving exercises, case studies or tests/examinations. Evidence may be accumulated, where appropriate, through aircraft case studies.

Links

The unit may be effectively linked with the aircraft systems units in the programme particularly Unit 9: Automatic Flight Control System, Unit 11: Communication and Navigation and Unit 20: Electrical, Electronic and Digital Principles.

Resources

Ideally, learners should have access to the flight deck of a contemporary civil transport aircraft or a simulator at some time during the course. Failing this, the availability of a representative detached flight instrument panel is highly desirable.

Suggested reading

Unit 17: Gas Turbine Science

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to investigate the basic principles of aircraft gas turbine technology and their application to the gas turbine engine modules and systems. It is a broad-based unit, covering thermodynamic principles and providing a basis for further study in aircraft thermo fluids.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate and describe the properties of aircraft gas turbine fluids and energy losses
2. Investigate thermodynamic properties and laws
3. Apply the thermodynamic principles to the design of gas turbine modules and control systems.
Content

1  Aircraft gas turbine fluids and energy losses

   Measurement of fluid flow: instrumentation (eg manometers, bourdon gauge, pressure transducers, micro-manometers); forces on curved surfaces; continuity equation; energy of a moving fluid; venturi meter; pitot tube

   Velocity diagrams and power: velocity and pressure distribution in nozzles; air velocity change through blade rows; forces acting on blades; power requirements for compressor and turbine stages

   Aerodynamic losses: losses in axial compressors and turbines; jet and propeller propulsion; flow-through turbines; fans; compressors; primary and secondary losses; operating characteristics and surge; losses due to sudden enlargement and contraction in turbulent flow

2  Thermodynamic properties and laws

   First law of thermodynamics: non-flow energy equation; reversibility; displacement work transfer; reversible non-flow processes; relationship of perfect gases; application of non-flow energy equation; steady flow energy equation; continuity equation; application of steady-flow energy equation

   Second law of thermodynamics: ideal heat engine and reversed heat engine; ideal heat engine cycle; entropy changes in adiabatic processes; isentropic efficiency; processes on T-S diagram; entropy changes for perfect gases

   Gas turbine cycle: gas turbine cycle with isentropic efficiency; velocity diagrams and power calculations
3 Thermodynamic principles to the design of gas turbine

Air intakes: design considerations of duct rating; types of intake; ideal airflow behaviour; shock waves; variable geometry intakes; supersonic intakes; flow through intake under static; climbing and high-speed conditions; asymmetrical intakes; area ratio; flow matching; loss characteristics; performance parameters; methods of diffusion; aerodynamic considerations for design of subsonic high-bypass fan; throat sizing; lip sizing; diffuser design; external cowl design

Compressors: degree of reaction and effects; blade design; compressor stage power requirements; work done factor; flow coefficient; stage temperature rise coefficient; surge at various operating conditions (mapping) and surge control; blade flutter; calculations for a stage

Combustion chambers: design features of combustion chambers; gas turbine combustion (eg diffusion, combustion, fuel injection, dilution); diffuser performance and stability loop; dilution zone performance; dilution zone mixing performance; losses due to dissociation; combustion system pressure losses; temperature distribution; combustion efficiency; derivation of pressure loss equation

Flame stabilisation: definition of stability performance; measurement of stability performance; experimental data on stability; factors controlling stability; fuel type; fuel-air-ratio; velocity; temperature; pressure; flame holder size and shape

Turbines: performance characteristics for a single stage; type of turbine stage; blade design; stage loading coefficient (eg flow coefficient characteristics); non-dimensional blade speed; non-dimensional temperature drop (eg flow velocity characteristics, reaction)

Pressure ratio: non-dimensional mass flow characteristics; pressure ratio; non-dimensional mass flow; reaction; design charts; metallurgical requirements; problems associated with turbines; forms and types of cooling; effects of reaction; blade loading; flow coefficient; stage loading coefficient; efficiency contours for single stage turbines; data for axial-flow gas turbine calculation
# Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
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</table>
| **1** Investigate and describe the properties of **aircraft gas turbine fluids and energy losses** | • describe the measurement of fluid flow  
• determine velocity change, forces and power for a single stage  
• describe aerodynamic losses in gas turbine modules |
| **2** Investigate **thermodynamic properties and laws** | • analyse concepts of phase change in energy conversion  
• determine and apply non-flow and steady-flow energy equations  
• analyse relationship between entropy and cycle efficiency and apply these concepts to thermodynamic processes  
• determine relationship between theoretical and real power plan cycles  
• determine module characteristics for a given thrust rating. |
| **3** Apply the **thermodynamic principles to the design of gas turbine modules and control systems** | • examine and explain the design criteria for a gas turbine intake  
• examine and describe the design criteria for a gas turbine compressor  
• examine and describe the design criteria for a gas turbine combustion chamber  
• examine and describe the design criteria for a turbine and analyse efficiency contours  
• analyse design charts, metallurgical and cooling requirements. |
Guidance

Delivery
This unit may be delivered as a stand-alone package or integrated into other units. If it is delivered in an integrated way, care must be taken in the tracking of evidence for the outcomes, and centres should be aware that study and assessment at outcome level could lead to an assessment overload. Wherever possible, a practical approach should be adopted and effort should be made to identify the relevance of the principles covered to engineering applications and system control and design.

Assessment
Evidence of outcomes may be generated through activities such as assignments, laboratory work, solutions to applied problems or tests/examinations.
Evidence may be accumulated by learners building a portfolio or by a tutor-led combination of tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links
This unit is intended to be linked with the mathematics and other principles and applications units in the programme.

Resources
Learners will require access to laboratory equipment for gas turbine testing or PC based simulations of gas turbine tests. Where such equipment is not available this testing could be carried out at an industrial gas turbine test house or through a local university, etc. Adequate gas turbine modules and associated control systems should be available for demonstration of design criteria.

Suggested reading
Unit 18: Aviation Legislation and Human Factors

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

This unit provides an overview of the regulatory framework and general issues that may affect human performance and limitations when working with aircraft. It includes the roles of regulatory bodies, understanding of the licensing and certification procedures which have a direct bearing upon maintenance and operation of aircraft. The general appreciation of work and non-work related events that contribute to factors affecting performance which may lead to human error, is designed to link all aspects of the unit together.

Summary of learning outcomes

To achieve this unit a learner must:

1. Investigate the regulatory framework of authorities and have a detailed knowledge of the aviation maintenance approvals required by them
2. Investigate the aircraft certification requirements and their associated documentation including JAR-OPS commercial air transport
3. Investigate the maintenance requirements of JAR-Maintenance, National and International Maintenance and JAR-OPS commercial air transport (subpart M)
4. Investigate the general, social and physical issues that are attributable to human factors/human error within the aircraft maintenance environment.
1 Regulatory framework and maintenance approvals

Regulatory bodies: role of International Civil Aviation Organisation (ICAO), Joint Aviation Authority (JAA); JAA full and candidate member authorities (NAA) relationship with other Aviation Authorities

Joint Airworthiness Requirements: relationship between JAR-OPS, JAR-145, JAR-66, JAR-147 and JAR-Maintenance

JAR 66 — Certifying Staff — Maintenance: detailed understanding of aircraft engineers maintenance licensing procedure, requirement, validity and privileges, category ‘A’ certifying mechanic, category ‘B1’ (mech/elect) and B2 (Avionics/elect), category C engineer (Maintenance Management)

JAR 145 – Approved Maintenance Organisations: detailed understanding of the maintenance of commercially operated aircraft and their components within the structure of an Approved JAR-145 company; accountable manager; company exposition; quality; line/hanger/workshop maintenance; Certificate of Release to Service (CRS); Certificate of Maintenance Review (CMR); approved stores, bonded and quarantine

2 Aircraft certification and documentation

General Certification Rules: JAR — 23/25/27/29; Type Certification/Supplemental Type Certification; JAR 21 — design/production organisation approvals

Documentation: certificate of airworthiness; certificate of registration; noise certificate; weight schedule; radio station licence and approvals

JAR-OPS Commercial Air Transport General: air operator’s certificate; operator’s responsibilities; documents to the carried; aircraft placarding (markings)

3 Maintenance

JAR Maintenance: when adopted by Regulatory Authorities (awaiting introduction by European Aviation Safety Agency (EASA))

National (UK) and international requirements: maintenance programmes; maintenance checks and inspections; master minimum equipment lists; minimum equipment lists; despatch deviation list; airworthiness directives; service bulletins; manufacturers’ service information; modification and repairs; maintenance documentation; maintenance manuals; structural repair manual; illustrated parts catalogue, etc; continuing airworthiness; test flights; series aircraft (A conditions), prototype/variant (B conditions); ETOPS maintenance and despatch requirements; all weather operations, category 2/3 operations and minimum equipment requirements

JAR-OPS — Commercial Air Transport (Subpart M): Maintenance responsibility; maintenance management; aircraft maintenance programme; aircraft technical log; maintenance records and log books; mandatory occurrence reporting scheme (MORS); Safety Data Analysis Unit (SDAU); Air Accident Investigation Branch (AAIB)
4 **General, social and physical issues**

*General*: the need to take human factors into account (eg the person both physically and mentally, the domestic and work environment); incidents attributable to human factors/human error; ‘Murphy’s law’

*Human performance and limitation*: vision; hearing; information processing; attention and perception; memory; claustrophobia and physical access

*Social psychology*: responsibility of individuals and group; motivation and de-motivation; peer pressure and culture issues; team working; management, supervision and leadership

*Factors affecting performance*: fitness/health; stress (work related and domestic); time pressures and deadlines; work load (overload and underload); fatigue; shiftwork; alcohol; medication; drug abuse

*Tasks*: physical work; repetitive tasks; visual inspection; complex systems (eg trade boundary interface, duties and responsibilities of a licensed member, Airworthiness Notice (AWN) 3, licensing categories under BCAR sect L and JAR 66)

*Aircraft working environments*: maintenance, overhaul, repair and manufacture; environmental conditions (eg noise, fumes, illumination, motion, vibration, climatic conditions such as temperature, wind, rain, etc)

*Communication*: within and between teams; work logging and recording; keeping up to date; currency; dissemination of information

*Human error*: error models and theories; types of error in maintenance tasks; implications of errors (ie accidents); avoiding and managing errors

*Hazards within the workplace*: recognising and avoiding hazards; dealing with emergencies.
## Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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<tbody>
<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</tbody>
</table>
| 1 Investigate the regulatory framework of authorities and have a detailed knowledge of the aviation maintenance approvals required by them | • explain the role of the ICAO, JAA, JAA full member Authorities, JAA candidate member Authorities and relationships with other aviation authorities  
• explain the Joint Airworthiness Requirements relationship between JAR-OPS, JAR-145, JAR-66, JAR-147 and JAR-Maintenance  
• explain the JAR-66 structure, procedures, requirements, validity and privileges  
• explain the JAR-145 structure for both large and small organisations. |
| 2 Investigate the aircraft certification requirements and their associated documentation including JAR-OPS commercial air transport | • explain certification rules such as JAR 21/23/25/27/29 taking into account Type and Supplementary Type certification  
• describe aircraft certification requirements taking into account both documentation and JAR-OPS commercial air transport (general). |
| 3 Investigate the maintenance requirements of JAR-Maintenance, National and International Maintenance and JAR-OPS commercial air transport (subpart M) | • explain JAR-Maintenance  
• describe National and International Requirements with regards to aircraft maintenance planning procedures and continuing airworthiness  
• explain the maintenance responsibilities for commercially operated aircraft in accordance with JAR-OPS (subpart M) |
| 4 Investigate the general, social and physical issues that are attributable to human factors/human error within the aircraft maintenance environment. | • explain the general issues of human factors, incidents attributable to human factors/human error and their link to human performance and limitations  
• explain the social psychology of the workplace and describe the factors that may effect performance and lead to hazards in the work place  
• describe typical tasks carried out within an aircraft working environment and how important the communication network is if human error and hazards are to be avoided. |
Guidance

Delivery

This unit has been designed to bring together all aspects of aviation legislation and factors affecting human performance that are a mandatory requirement under JAR 66 modules 9 and 10.

Due to the nature of the content contained within this unit it is imperative that tutors should be familiar with JAA and CAA requirements.

This unit may permit learners exemptions from part of the JAR 66 aircraft maintenance licence, however this will be at the discretion of the CAA. Delivering organisations must have an up to date in depth range of materials appropriate for this unit and appreciate that the British Civil Airworthiness Requirements (BCARs) still have to be covered even though we now abide by JAR rules.

The delivery should be varied and practical whenever possible in order to stimulate learner interest. However it must be realised that this is a specialist area that requires a comprehensive knowledge and certain sections do not permit a practical approach.

Assessment

Evidence of outcomes may be generated through research, assignment work, case studies, practical activities utilising JAA, CAA, ICAO and parliamentary documentation etc, and tests/examinations.

This unit may present opportunities for the assessment to be integrated with other units in the programme (ie various practical activities on aircraft supported by full paper-based case study prepared by learners to determine and explain the regulations, documentation and associated implications of the work carried out).

Links

This unit may be linked to any BTEC Higher National unit where a documentary trail is required.

Resources

This unit requires access to a substantial learning resource centre equipped with current manuals which are up to date and actively amended.
Support materials

The materials listed below are essential for this unit:

Other publications

Joint Aviation Requirements (JARs)
Air Transport Association 100 system (AMM, IPC, SRM, WD etc)
International Civil Aviation Organisation publications
Air Navigation Orders (ANOs)
British Civil Airworthiness Requirements (BCARs)
Air Worthiness Notices (AWNs)
Airworthiness Directives (ADs)
Service Bulletins (SBs)
Company documents (tech log etc)
Manufacturers’ literature

The following publications and legislation are recommended but not essential:

Statutory Instrument 1996 No 2798: The Civil Aviation (Investigation of air accidents and Incidents)
Statutory Instrument 1999 No 1452: The Aeroplane Noise Regulations
Statutory Instrument 1999 No 2253: The Aeroplane Noise (amendment) Regulations
Statutory Instrument 2002 No 798: The Air Navigation (Environmental Standards) Order
CAP 393: Air Navigation Order 22 April 2003
CAP 396: Registration, Certification and Maintenance of Aircraft
CAP 715: An introduction to aircraft maintenance engineering human factors JAR 66
CAP 716: Aviation maintenance human factors (JAA JAR 145)
CAP 718: Human factors in aircraft maintenance and inspection
CAP 719: Fundamental human factors concepts

Websites

www.caa.co.uk      Civil Aviation Authority
www.legislation.hmso.gov.uk  Her Majesty’s Stationary Office
Unit 19: Health and Safety and Risk Assessment

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

This unit develops learner awareness of the principles of health and safety planning and implementation in an industrial environment (eg manufacturing, service industries, telecommunications, etc.). The unit also considers current UK and EU health and safety legislation together with the concepts of risk assessment and its evaluation when applied to any potential hazard. This is followed by the applications of risk management techniques in the context of risks to life, property and general engineering activities.

Summary of learning outcomes

To achieve this unit a learner must:
1. Select and apply safe working procedures to industrial operations
2. Apply current health and safety legislation
3. Analyse systems for the assessment of risk
4. Apply risk management to life, property and activities.
Content

1 Safe working procedures

Permit-to-work: types; HSE Guidance Notes; hot cold entry; buddy and plant identification systems
Isolations: eg lock, multi-lock, blank off, removal, electrical, peg removal, linked valve key, isolation valves
Monitoring equipment: eg noise, dust, fumes, temperature, movement, radiation, costing
Protective clothing and equipment: eg chemical, temperature, crush resistance, noise protection, visor, goggle usage, electrical isolation, radioactive protection

2 Current health and safety legislation

Current regulations: relevant and current UK and EU regulations (eg COSHH, noise at work, pressure systems, manual handling, personal protective equipment, control of asbestos, Health and Safety at Work Act, management of health and safety at work, IEE wiring regulations, EMC directive) on typical engineering operations (eg engineering production and manufacture, engineering services, materials handling, telecommunications and transportation)
HSE inspectorate: role; span of authority; right of inspection; guidance notes and booklets
Safety audits: policies; record keeping; safety surveys; training; proformas; management commitment; planning
Codes of practice: use of Applying Technology for codes and regulations; awareness of relevant codes of practice (eg HSE guidance, Occupational Exposure Standards, etc.)

3 Assessment of risk

Hazard: eg fire, noise, temperature, field of vision, fumes, moving parts, lighting, access, pressure, falling bodies, airborne debris, radiation and chemical hazards, etc.
Risk rating: matrix production (eg low risk, moderate risk, substantial risk, high risk)
Frequency: rate of occurrence (eg improbable, possible, occasional, frequent, regular, common)
Severity: definitions of consequence; level of injury (eg graded: trivial, minor, major, multiple major, death, multiple death)
Record: systems; production of proforma for each hazard; types of recording systems; employee training; company awareness
4 Risk management

Evidence: to support the likelihood of or reoccurrence of a risk; statistical data (eg fatigue charts, working hours, temperature, lighting levels, noise, incorrect procedures, working practices, time of day, etc)

Implications: eg threat to life, injuries, property, environment, need to redesign, effect on company, effect on other companies; mandatory factory closure

Information: eg data sheets on substances, factory rules, codes of practice; safe working procedures, hazard identification (eg hard hat area); training in procedures for new staff and contractors

Minimising risk: eg control of known risks, guarding, covering, screening, encasing, design-out; disaster contingency planning, etc.

Implementation: eg management policy, lines of communication, responsibility, safety committees and trade union input

Compliance: knowledge of regulations and guidelines; mandatory compliance with current and relevant regulations (eg HASAWA and HSE; Deposit of Poisonous waste Act, EMC directive, etc.); working towards company risk assessment findings
## Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
</table>
| **1 Select and apply safe working procedures to industrial operations** | • evaluate a range of permit-to-work systems and identify isolation requirements for given applications  
• use monitoring equipment to ensure the promotion of a safe working environment  
• select and justify choice of protective clothing and equipment to ensure personal protection in a given environment.                                                                 |
| **2 Apply current health and safety legislation**                      | • identify industrial work areas where current regulations would apply and describe the role of the HSE inspectorate  
• implement a schedule for the setting up of a safety audit system  
• select the relevant codes of practice to enhance safety.                                                                                                                      |
| **3 Analyse systems for the assessment of risk**                       | • identify a hazard and produce a risk rating  
• evaluate frequency and severity of an identified hazard  
• produce a hazard proforma for a given application  
• analyse a recording system that tracks and highlights potential hazards.                                                                                                               |
| **4 Apply risk management to life, property and activities**           | • evaluate evidence that would specify the existence of a risk or risks  
• analyse the implications of the risk and the effect on life, property and activities  
• obtain and use accurate information on the risk for the protection of others  
• produce a report on how best to minimise the risk to people, property and activities and recommend effective methods of implementation and control  
• identify routes and methods of implementation within a company to ensure that compliance with codes of practice and regulations pertaining to the risk are fully understood. |
Guidance

Delivery

A practical approach to learning should be adopted wherever possible with tutors providing the means of sources for information. A series of co-ordinated assignments covering the outcomes should be produced by the tutor, which could be completed within the learner’s work place. Feedback, role-play and discussion groups should also be included in the delivery of this unit to allow group development.

Actual safety audits and risk assessments should be undertaken, under guidance, within the college/university workplace or in conjunction with local industry.

Practical work needs to be investigative and offer creative solutions for the reduction of risk.

Assessment

Evidence of outcome may be in the form of assignments and projects. These may be undertaken individually or in small groups (eg not exceeding three). Evidence should be the work of the individual and ideally at unit level, reflecting the strong links between the four outcomes.

Assessment should be of a continuous nature with grading and feedback given at regular intervals after each assignment. Grading criteria must be indicated on each assignment. Special care should be taken with group work assessments to ensure authentic evidence. Peer group grading could be offered under tight control. A final assessment drawing together two or more outcomes should be attempted.

Links

This unit may be linked with all other units in the qualification that have aspects of workplace practice and applications.

Resources

Publications are available from HSE and other regulating bodies relevant to the industry sector. Computer-based software packages for the recording of data and proforma generation. Ideally, centres should establish a library/learning resource centre of material capable of covering all current codes of practice and regulations together with case studies and relevant articles of interest.
Support materials

Textbooks


Health and Safety Executive — Health and Safety in Engineering Workshops (HSE, 1999) ISBN: 0717617173
Unit 20: Electrical, Electronic and Digital Principles

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to develop learners’ understanding of electrical and electronic principles necessary for further study in the specialist area of electro-mechanical systems (e.g. aircraft systems).

Summary of learning outcomes

To achieve this unit a learner must:
1. Apply complex notation in analysis of single phase circuits
2. Apply circuit theory to the solution of circuit problems
3. Evaluate the operation of electronic amplifier circuits used in electro-mechanical systems
4. Investigate digital electronic circuits used in electro-mechanical systems.
Content

1 Single phase circuits

*Series and parallel LCR circuits*: voltage, current and power with sinewave signals; conditions for resonance (eg frequency response, impedance, Q factor); complex notation

*Circuit performance*: Tolerancing; effect of changes in component values

2 Solution of circuit problems

*Circuit theorems*: Norton; Kirchhoff; Thévenin; superposition; Maxim power

*Circuit analysis*: mesh; nodal; maximum power transfer; impedance matching

3 Operation of electronic amplifier circuits

*Single- and two-stage transistor amplifiers*: analysis of bias; dc conditions; ac conditions; coupling; input impedance; output impedance; frequency response

*Design, test and evaluate*: a single-stage amplifier to a given specification; compare measured and theoretical results

4 Digital electronic circuits

*Digital electronic devices*: logic families (eg 74 series, 4000 series); comparison between families; circuits integration; identification of digital circuits in electro-mechanical systems

*Combinational circuits*: simplification methods; truth tables; single gate solutions; circuit simulation; testing

*Construct and test*: circuit designed should be bread-boarded or simulated using an appropriate computer software package
## Outcomes and assessment criteria

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<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</tbody>
</table>
| 1  Apply complex notation in analysis of single phase circuits           | • solve problems involving LCR circuits  
• evaluate the effects on circuit performance of changes in values of impedances.                                                                                   |
| 2  Apply circuit theory to the solution of circuit problems              | • solve problems using circuit theorems to calculate currents and voltage in circuits  
• analyse circuits including the value of circuit loads which produce maximum power.                                                                              |
| 3  Evaluate the operation of electronic amplifier circuits used in electro-mechanical systems | • analyse the operation of single- and two-stage amplifiers  
• evaluate the performance of single- and two-stage amplifiers  
• design and evaluate a single-stage transistor amplifier  
• compare measured results with theoretical calculations.                                                                                                           |
| 4  Investigate digital electronic circuits used in electro-mechanical systems | • evaluate digital electronic device families  
• design combinational and sequential digital electronic circuits  
• test digital circuits by construction, or by computer simulation.                                                                                               |
Guidance

Delivery
A practical, hands-on approach to learning should be adopted wherever possible, with tutors providing relevant examples of the theory in practice. Circuits should be those used in industrial electro-mechanical systems.

Assessment
Evidence of outcomes may be in the form of an end-of-unit examination, assignments and reports of practical activities. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of practical activities or by a tutor-led combination of practical tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links
This unit can be linked with Unit 21: Microprocessor Systems.

Entry requirements for this unit are at the discretion of the centre. However, the unit assumes that learners have a prior knowledge of electrical/electronics/digital principles at BTEC National level or equivalent.

Resources
Appropriate laboratory experiments should be used where possible to verify the theory.

Also available should be prototype board or digital circuit trainers and electronic circuit simulation.

Support materials

Textbooks


Maddock R J — Electronics for Engineers (Prentice Hall, 1994) ISBN: 0582215838
Unit 21: Microprocessor Systems

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to provide learners with an understanding of microprocessor-based systems and their use in instrumentation/control/communication systems. They will study the practical aspects of device selection and the interfacing of external peripheral devices. The development cycle of specify, design, build, program, test and evaluate will be covered.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate microprocessor-based systems
2. Produce software for a microprocessor-based system
3. Interface microprocessor-based systems.
Content

1 Microprocessor-based systems

Microprocessor device families: comparison based on speed, cost, i/o facilities, instruction set, physical size

Applications: control systems (e.g., car engine management, robotics, distributed control systems, coin-operated machines, printers); instrumentation systems (e.g., data acquisition and logging systems, indicator display systems, ‘intelligent’ panel instruments, test equipment); communication systems (e.g., facsimile machines, modems, radio transmitters, radar systems); commercial systems (e.g., electronic funds transfer at point of sale systems (EFTPOS), electronic bank teller machines, hand-held stock loggers, personal computers)

2 Software for a microprocessor-based system

Design software: algorithms in the form of a structure chart showing actions and conditions or in pseudo code (structured English)

Write programs: for applications requiring interfacing to external devices (e.g., lights, switches, motors, heaters, keypads, LCD and LED displays, printers, ADCs and DACs); use of assemblers and high-level language compilers (e.g., C, Pascal)

Test software: suitable test data (e.g., inputs and expected outputs) should be prepared prior to running programs and results of the tests should be documented; use of software debugging tools (e.g., Integrated Development Environment (IDE), In-Circuit Emulation (ICE), simulators)

3 Interface

Programmable interface devices: serial and parallel interfaces; UARTs; PPIs; I/O mapped devices; memory mapped devices; control signals; interrupts; polling; handshaking; port current rating

Design, build and test: a programmable interface; select and use devices; write and test suitable software in assembler or high-level language
Outcomes and assessment criteria

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<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
<td></td>
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</tbody>
</table>
| 1 Investigate microprocessor-based systems | • compare types of microprocessor device families  
• evaluate three typical applications of microprocessor-based systems. |
| 2 Produce software for a microprocessor-based system | • design software to a given specification using a structured design technique  
• write programs to implement designs using an appropriate computer language  
• test software to ensure it meets the given specification. |
| 3 Interface microprocessor-based systems | • evaluate and choose programmable interface devices for a particular situation  
• design, build program and test an interface for an external device to a microprocessor-based system. |
Guidance

Delivery

This unit is intended to be delivered as a stand-alone package, but could be integrated into a programme of study with other units. If it is delivered in an integrated way, care must be taken to provide tracking evidence of outcomes. Wherever possible, a practical approach should be adopted.

Assessment

Evidence may be generated from assignments, laboratory notes or reports of investigations.

Links

This unit may be linked with Unit 20: Electrical, Electronic and Digital Principles.

Entry requirements for this unit are at the discretion of the centre. However, it is recommended that learners should have completed the BTEC National Microelectronics or equivalent and should have some knowledge of digital electronics (tri-state devices and latches).

Resources

A microprocessor-based development system should be provided.

Learners will also need software development systems (personal computers/workstations/terminals capable of running program development software) and a software-editor, assembler/compiler debugging tools for target processor.

The software development system and the target microprocessor-based system may be the same (eg a personal computer).

Support materials

Textbooks


Unit 22: Mechanical Principles

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit covers an extended range of mechanical principles which underpin the design and operation of mechanical engineering systems. It includes strengths of materials and mechanics of machines. The aim of the unit is to provide a firm foundation for work in engineering design and a basis for more advanced study.

Summary of learning outcomes

To achieve this unit a learner must:

1. Analyse complex loading systems
2. Investigate the behaviour of loaded beams and cylinders
3. Analyse power transmission system elements
4. Investigate the dynamics of rotating systems.
1 Complex loading systems

Relationship: definition of Poisson’s Ratio; typical values of Poisson’s Ratio for common engineering materials

Two and three-dimensional loading: expressions for strain in the x, y and z-directions; calculation of changes in dimensions

Volumetric strain: expression for volumetric strain; calculation of volume change

Elastic constants: definition of Bulk Modulus; relationship between Modulus of Elasticity; Shear Modulus; Bulk Modulus and Poisson’s Ratio for an elastic material

2 Loaded beams and cylinders

Relationships: slope \( i = \frac{1}{E} \int Mdx \)

deflection \( y = \frac{1}{E} \int \int M dx \)

Loaded beams: slope and deflection for loaded beams (eg cantilever beams carrying a concentrated load at the free end or a uniformly distributed load over the entire length, simply supported beams carrying a central concentrated load or a uniformly distributed load over the entire length)

Stresses in thin-walled pressure vessels: circumferential hoop stress and longitudinal stress in cylindrical and spherical pressure vessels subjected to internal and external pressure (eg compressed-air receivers, boiler steam drums, submarine hulls, condenser casings); factor of safety; joint efficiency

Stresses in thick-walled cylinders: circumferential hoop stress, longitudinal stress and radial stress in thick-walled cylinders subjected to pressure (eg hydraulic cylinders, extrusion dies, gun barrels); Lame’s theory; use of boundary conditions and distribution of stress in the cylinder walls

3 Power transmission

Belt drives: flat and v-section belts; limiting coefficient friction; limiting slack and tight side tensions; initial tension requirements; maximum power transmitted

Friction clutches: flat single and multi-plate clutches; conical clutches; coefficient of friction; spring force requirements; maximum power transmitted by constant wear and constant pressure theories; validity of theories

Gear trains: simple, compound and epicycle gear trains; velocity ratios; torque, speed and power relationships; efficiency; fixing torques
4 Dynamics of rotating systems

*Balancing:* single plane and multi-plane rotating mass systems; Dalby’s method for determination of out-of-balance forces and couples and the required balancing masses

*Flywheels:* angular momentum; kinetic energy; coefficient of fluctuation of speed; coefficient of fluctuation of energy; calculation of flywheel mass/dimensions to give required operating conditions

*Effects of coupling:* conservation of angular momentum; energy loss due to coupling; final common rotational speed
Outcomes and assessment criteria

<table>
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<tbody>
<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1 Analyse complex loading systems</strong></td>
<td>• identify the relationship between longitudinal and transverse strain</td>
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<tr>
<td></td>
<td>• determine the effects of two-dimensional and three-dimensional loading on the dimensions of a given material</td>
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<tr>
<td></td>
<td>• determine volumetric strain and change in volume</td>
</tr>
<tr>
<td></td>
<td>• define Bulk Modulus and recognise the relationship between elastic constants.</td>
</tr>
<tr>
<td><strong>2 Investigate the behaviour of loaded beams and cylinders</strong></td>
<td>• recognise the relationship between bending moment, slope and deflection for a loaded beam</td>
</tr>
<tr>
<td></td>
<td>• determine slope and deflection along loaded beams</td>
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<tr>
<td></td>
<td>• determine the principal stresses that occur in a thin-walled pressure vessel</td>
</tr>
<tr>
<td></td>
<td>• determine the distribution of stress in a thick-walled cylinder when subjected to pressure.</td>
</tr>
<tr>
<td><strong>3 Analyse power transmission system elements</strong></td>
<td>• determine the maximum power which can be transmitted by means of a belt drive</td>
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<tr>
<td></td>
<td>• determine the maximum power which can be transmitted by a friction clutch</td>
</tr>
<tr>
<td></td>
<td>• determine the torque and power transmitted through gear trains.</td>
</tr>
<tr>
<td><strong>4 Investigate the dynamics of rotating systems</strong></td>
<td>• determine balancing masses required to obtain dynamic equilibrium in rotating systems</td>
</tr>
<tr>
<td></td>
<td>• determine the energy storage requirements of flywheels</td>
</tr>
<tr>
<td></td>
<td>• determine the effects of coupling freely rotating systems.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated into other programme units. If it is delivered in an integrated way, care must be taken in the tracking of evidence for the outcomes. Wherever possible, a practical approach should be adopted. Effort should be made to identify the relevance of the principles covered to engineering applications and system design.

Assessment

Evidence of outcomes may be in the form of assignments, laboratory notes, solutions to applied problems or the results of unseen, timed tests/examinations. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of activities or by a tutor-led combination of tests and assignments. In either case, the evidence must be authentic, relevant and sufficient to justify the grade awarded.

Links

This unit can be linked with the mathematics and mechanical applications units in the programme.

Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed the BTEC National unit in *Mechanical Principles* or equivalent.

Resources

Sufficient laboratory/test equipment should be available to support a range of practical investigations.

Appropriate software packages should also be used wherever possible to verify solutions to problems and system behaviour (for example, stress analysis).

Support materials

Textbooks


Unit 23: Materials Engineering

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to provide learners with the necessary background knowledge and understanding of the properties, selection, processing and use of materials.

Summary of learning outcomes

To achieve this unit a learner must:

1. Select suitable materials
2. Identify relationships between manufacturing processes and materials’ behaviour
3. Select materials and processing for a specified product
4. Diagnose causes of failure of materials.
Content

1 Suitable materials

Criteria for selection: definitions of material properties appropriate to the learner's programme of study (eg Aerospace, Mechanical, etc.); properties may include mechanical, physical, chemical, process characteristics and an appreciation of costs; range of materials to include metals, ceramics, polymers, and composites

Categorise materials: an appreciation of the properties of ceramics, metals and polymers; recognise the microstructural characteristic of the more commonly used engineering materials

Test data: measurement of electrical and general physical, mechanical, chemical and processing properties of materials (eg metals, ceramics, polymers and composites) appropriate to the learner's programme. For example, tests could include:

Electrical/magnetic: conductivity/resistivity, magnetic susceptibility
Mechanical: strength, hardness, toughness, fatigue, creep
Others: corrosion and reactivity, wear, optical, thermal, formability.

Attention should be paid to the reliability of results and the observation of trends in results by using appropriate statistical methods and the processing of test data.

Sources: suitable data (eg British Standards, ISO, product data sheets, IT sources, standard published data sources, manufacturers’ literature, job-specific information such as specifications, test data and engineering drawings as appropriate to the learner's programme); assessment of data reliability

2 Relationships

Manufacturing processes: a selection of processes depending on the learner’s programme (eg Aerospace, Mechanical, etc.) which may include some of the following:

Heat treatment: for example Martensitic decomposition; complex heat treatments (eg involving conjoint mechanical/thermal treatments); glass transitions; coated materials; CVD/vacuum coating processes; chip technology; surface treatments/surface engineering; polymer treatments; composites/powder produced materials, matrix/reinforcement relationships, dispersion strengthening

Liquid processing: eg metal casing and injection moulding/extrusion of polymers; porosity

Mechanical processing: eg effect on structure and properties illustrated by a range of processes such as mechanical working of metals, powder processing, metals and ceramics, extrusion and forming of polymer sheet, residual stresses, joining, welding, effect on structure and properties, adhesives

Composition and structure: alloying; co-polymerisation; additives; cross-linking — effects on structure and properties; crystallinity

Structure/property relationships: the effects of the processing method on the resulting properties (eg cast structures, work hardening)
3 **Materials and processing**

*Functional analysis*: in terms of the design constraints (eg working conditions such as applied forces (stress, strain, etc), environment, electrical/magnetic requirements, etc) and the shape, form and function of the product

*Materials, properties and processing*: recognising the inter-relationship between product design, material selection and processing methods; merit index/index of suitability

*Processing limitations*: effects of the manufacturing processing on the structure of materials preventing or facilitating product design

4 **Causes of failure**

*Causes of failure*: including failure of metals, ceramics, polymers and composites; applications should cover a range appropriate to the learners’ background and needs (eg may include creep, fatigue, impact, overstressing, corrosion, temperature, thermal cycling, residual stresses, stress relaxation, degradation (composition change), radiation, electrical breakdown, or combinations of these)

*Service life*: considerations should include the response of various materials to such effects as inappropriate maintenance, inappropriate use, faults (in manufacture, materials, selection and design) and changes in service conditions such as, environment, stress and temperature

*Estimation*: methods of investigating failure should be known in outline; estimates of product service life that requires the use of calculations (eg creep or fatigue failure)

*Improving service life*: remedial and/or preventative measures, for example, changes to material, product design, protective systems (eg for corrosion), service conditions (eg stress, type of loading, temperature)
### Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</table>
| **1 Select suitable materials** | - identify criteria for selection of materials  
- categorise materials and describe the range of properties available from similar materials  
- generate and process test data to assess material properties  
- look up, identify and assess the quality of suitable data in a range of sources. |
| **2 Identify relationships between manufacturing processes and materials’ behaviour** | - identify and discuss a range of manufacturing processes appropriate to the programme of study  
- recognise the influence of composition and structure on the processing of materials  
- recognise structure/property relationships, including their influence on processing and usage. |
| **3 Select materials and processing for a specified product** | - analyse the function of a product in terms of the materials’ constraints on its design  
- identify appropriate materials, properties and processes for the product  
- identify possible limitations on the product imposed by the processing. |
| **4 Diagnose causes of failure of materials** | - identify potential causes of failure in service  
- identify factors affecting service life  
- identify service failures  
- carry out estimations of service life  
- suggest ways of improving service life. |
Guidance

Delivery

This unit may be delivered as a stand-alone package or integrated into other appropriate programme units. If it is delivered in an integrated way, care must be taken to provide tracking evidence for the outcomes, and centres should be aware that study and assessment at an individual outcome level could lead to an assessment overload. Wherever possible, a practical approach should be adopted. Learning and assessment can be across units, at unit level or at individual outcome level. Effort should be made to identify the relevance of the principles covered to engineering applications and system design.

Assessment

Evidence of outcomes may be in the form of assignments, reports of practical activities, computer printouts, solutions to applied problems or the results of previously unseen tests/examinations. Evidence is likely to be at individual outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of activities or by a tutor-led combination of tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit may be linked with Unit 6: Engineering Design. Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed appropriate BTEC National units or equivalent.

Resources

Access to suitable laboratory equipment and test instrumentation is required. A supply of relevant materials is necessary. The range of tests chosen will depend on the learner’s working environment and particular needs. It is advised that metals, ceramics, polymers and composites should be selected as samples for appropriate tests so that an appreciation of the variation in procedures for different materials is developed.

Support materials

Textbooks

ISBN: 0130408719
Unit 24: Engineering Thermodynamics

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to introduce learners to the principles and laws of thermodynamics and their application to engineering thermodynamic systems. The unit covers system definition, the first and second laws of thermodynamics, heat engine cycles, the measurement of engine performance and the layout and performance of steam plant.

Summary of learning outcomes

To achieve this unit a learner must:
1. Analyse thermodynamic systems
2. Investigate internal combustion engine performance
3. Investigate reciprocating air compressors
4. Investigate steam and gas turbine power plant.
Content

1 Thermodynamic systems

Polytropic processes: general equation $p^nv^n=c$, relationships between index ‘$n$’ and heat transfer during a process; constant pressure and reversible isothermal and adiabatic processes; expressions for work flow

Thermodynamic systems and their properties: closed systems; open systems; application of first law to derive system energy equations; properties; intensive; extensive; two-property rule

Relationships: $R = c_p - c_v$ and $\gamma = c_p/c_v$

2 Internal combustion engine performance

Second law of thermodynamics: statement of law; schematic representation of a heat engine to show heat and work flow

Heat engine cycles: Carnot cycle; Otto cycle; Diesel cycle; dual combustion cycle; Joule cycle; property diagrams; Carnot efficiency; air-standard efficiency

Performance characteristics: engine trials; indicated and brake mean effective pressure; indicated and brake power; indicated and brake thermal efficiency; mechanical efficiency; relative efficiency; specific fuel consumption; heat balance

Improvements: turbocharging; turbocharging and intercooling; cooling system and exhaust gas heat recovery systems

3 Air compressors

Property diagrams: theoretical pressure-volume diagrams for single and multi-stage compressors; actual indicator diagrams; actual, isothermal and adiabatic compression curves; induction and delivery lines; effects of clearance volume

Performance characteristics: free air delivery; volumetric efficiency; actual and isothermal work done per cycle; isothermal efficiency

First law of thermodynamics: input power; air power; heat transfer to intercooler and aftercooler; energy balance

Faults and hazards: effects of water in compressed air; causes of compressor fires and explosions
4 Steam and gas turbine

*Principles of operation:* impulse and reaction turbines; condensing; pass-out and back pressure steam turbines; single and double shaft gas turbines; regeneration and re-heat in gas turbines; combined heat and power plants

*Circuit and property diagrams:* circuit diagrams to show boiler/heat exchanger; superheater; turbine; condenser; condenser cooling water circuit; hot well; economiser/feedwater heater; condensate extraction and boiler feed pumps; temperature-entropy diagram of Rankine cycle

*Performance characteristics:* Carnot, Rankine and actual cycle efficiencies; turbine isentropic efficiency; power output; use of property tables and enthalpy-entropy diagram for steam
### Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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</thead>
</table>
| **1 Analyse thermodynamic systems** | • investigate polytropic processes  
• define thermodynamic systems and their properties  
• apply the first law of thermodynamics to thermodynamic systems  
• determine the relationships between system constants for an ideal gas. |
| **2 Investigate internal combustion engine performance** | • relate the second law of thermodynamics to the operation of heat engines  
• investigate theoretical heat engine cycles  
• determine the performance characteristics of gas-based heat engines  
• recognise how improvements may be made to the efficiencies of IC power units. |
| **3 Investigate reciprocating air compressors** | • draw property diagrams for compressor cycles  
• determine the performance characteristics of compressors  
• apply the first law of thermodynamics to compressors  
• recognise compressor faults and hazards. |
| **4 Investigate steam and gas turbine power plant** | • describe the principles of operation of steam and gas turbines  
• draw circuit and property diagrams to show the functioning of steam power plant  
• determine the performance characteristics of steam power plant. |
Guidance

Delivery

A practical approach to learning should be adopted wherever possible, with tutors providing relevant examples of the application of theory in practice. Practical work needs to be investigative, to give learners opportunities to provide evidence for distinctive performance. Visits to industrial installations will be of value for the achievement of outcomes 2, 3 and 4 if college facilities are not available.

Assessment

Evidence of outcomes may be in the form of assignments, laboratory notes, solutions to applied problems or completed tests/examinations. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of activities or by a tutor-led combination of tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit has links with Unit 2: Analytical Methods for Engineers and Unit 3: Engineering Science. Entry requirements for this unit are at the discretion of the centre. However, learners should have achieved learning equivalent to the BTEC National units in Science for Technicians and Mathematics for Technicians.

Resources

If possible, laboratory facilities should be available for the investigation of the properties of working fluids, internal combustion engines and compressor performance, but they are not essential.

Support materials

Textbooks


Unit 25: Quality Assurance and Management

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to raise awareness and familiarise learners with the principles and applications of quality management. The learner will examine the basic principles of Total Quality Management (TQM) and develop an understanding of the key factors that underpin Quality Assurance (QA) techniques. The unit also introduces the learner to the application of Quality Control (QC) techniques.

Summary of learning outcomes

To achieve this unit a learner must:

1. Investigate total quality management (TQM)
2. Examine the key factors of quality assurance (QA) techniques
3. Apply quality control (QC) techniques.
Content

1 Total quality management (TQM)

Principles of TQM: continuous improvement; total company commitment; quality strategy; management of change; focus (eg internal and external customers, products/services, processes and people, fit-for-purpose); leadership; motivation and training; applicable supporting theories (eg Deming, Juran, Crosby, Ishikawa, etc.)

Management structures: organisational structures and responsibilities; quality improvement methods (eg quality improvement teams and teamwork, quality circles/Kaizen teams, etc.); operational theory (eg organisational culture, strategy, vision, mission, values and key issues); barriers to TQM (eg lack of commitment, fear of change/responsibility, immediacy of pay-off, cost of TQM, etc)

TQM techniques: use of tools (eg process flow charts, tally charts, Pareto analysis, cause and effect analysis, hazard analysis-critical control points, statistical process control SPC, benchmarking) and methods (eg brainstorming, team building, appraisal, training and development, mentoring, etc.); compliance to standards; procedures and manuals; impact of organisational factors (eg leadership, communications, performance indicators and objectives)

2 Quality assurance (QA)

Key factors: procedures; quality manuals; parameters (eg fitness-for-purpose, customer satisfaction, cost effectiveness, compliance with standards); standards organisation and documentation charts; communication; feedback; legislation

Control purposes: internal and external quality audits (eg trace ability, compliance, statistical methods, planned maintenance, condition monitoring, etc.)

Costing: quality vs. productivity; cost centres; allocation of overheads; maintenance and downtime cost

3 Quality control (QC)

Quality control techniques: inventory control (eg JIT, MRP, KANBAN, etc.); statistical process control (eg frequency distribution, mean range, standard deviation, control charts, calculation of warning and action limits); acceptance sampling (eg producer’s and consumer’s risk, sampling plans, plotting and interpretation of an operating characteristic curve)

Process capability: relationship between specification limits and control chart limits; modified limits; relative precision index

Software packages: eg quality audit procedures, vendor rating, cause and effect analysis, Pareto analysis.
## Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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<tr>
<td></td>
<td>To achieve each outcome a learner must demonstrate the ability to:</td>
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<tr>
<td>1 Investigate <strong>Total Quality Management (TQM)</strong></td>
<td>- identify and explain the principles of TQM in relation to a specific application</td>
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<td>- identify and evaluate management structures that can lead to an effective quality organisation</td>
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<td>- analyse the application of TQM techniques in an organisation.</td>
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<td>2 Examine the key factors of <strong>Quality Assurance (QA) techniques</strong></td>
<td>- identify the key factors necessary for the implementation of a QA system within a given process</td>
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<td>- interpret a given internal and external quality audit for control purposes</td>
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<td></td>
<td>- describe and evaluate factors affecting costing.</td>
</tr>
<tr>
<td>3 Apply <strong>Quality Control (QC) techniques</strong></td>
<td>- describe the applications of quality control techniques</td>
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<tr>
<td></td>
<td>- apply quality control techniques to determine process capability</td>
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<td></td>
<td>- identify and use software packages for data collection and analysis.</td>
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</table>
Guidance

Delivery

This unit has been written in terms of general outcomes and should be delivered in the context of the discipline being studied. It may be used as a free-standing unit or integrated with general business management units. The use of pre-prepared examples is to be encouraged with groups of learners participating in a case study workshop approach based on actual or simulated data.

The concept of Total Quality Management to all aspects of a company’s organisation should be stressed throughout the delivery of this unit.

Assessment

Evidence of outcomes may be presented in the form of assignment or project reports, accounts of practical activities, notes on industrial visits or, where applicable, the results of applied examples. Evidence should be accumulated in a portfolio containing a mix of assessment material. Where group work is undertaken, assessment evidence must be produced at an individual level to sufficiently meet all the requirements of the outcomes and assessment criteria.

Links

This unit has links with Unit 1: Business Management Techniques and Unit 5: Project.

Resources

Centres should aim to provide simulated or actual examples for the application of methods used to install, monitor and control the quality of both products/services and their associated processes. The use of appropriate software packages should be encouraged in the processing of data.

Industrial visits, work placements or employment could provide access to additional resource facilities and reinforce relevance.

Support materials

Textbooks
Unit 26: Further Analytical Methods for Engineers

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit
This unit provides the underpinning analytical knowledge and techniques necessary to successfully complete many of the more advanced analytical option units within the programme. It complements and broadens the subject knowledge contained in Analytical Methods for Engineers. This unit has been designed to enable learners to use number systems, graphical and numerical methods, vectors, matrices and ordinary differential equations to analyse, model and solve realistic engineering problems.

Summary of learning outcomes
To achieve this unit a learner must:
1 Analyse and model engineering situations and solve problems using number systems
2 Analyse and model engineering situations and solve problems using graphical and numerical methods
3 Analyse and model engineering situations and solve problems using vector geometry and matrix methods
4 Analyse and model engineering situations and solve problems using ordinary differential equations.
Content

1 Number systems

*Error arithmetic*: significant figures and estimation techniques; error arithmetic operations; systematic and random errors; application to experimentation and general laboratory work

*Number systems*: natural, integer, rational, reals, dinary, binary, octal and hexadecimal number systems; conversion from dinary to numbers of other bases and vice versa; two-state logic systems, binary numbers and logic gates, logic gate tables, application to logic circuits

*Complex numbers*: real and imaginary parts of complex numbers, complex number notation; Cartesian and polar forms; modulus, argument and complex conjugate; addition, subtraction, multiplication and division of Cartesian and polar forms; use of Argand diagrams; powers and roots and the use of de Moivre’s theorem

*Engineering applications*: eg electric circuit analysis, phasors, transmission lines, information and energy control systems

2 Graphical and numerical methods

*Graphical techniques*: Cartesian and polar co-ordinate systems and representation of complex number operations; vector representation; standard curves; asymptotes; systematic curve sketching; curve fitting; irregular areas and mean values of wave forms; use of phasor and Argand diagrams; application to engineering situations

*Numerical integral*: determine the integral of functions using mid-ordinate; trapezoidal and Simpson’s rules

*Numerical estimation methods*: method of bisection; Newton-Raphson iteration method; estimates of scientific functions

3 Vector geometry and matrix methods

*Vector notation and operations*: Cartesian co-ordinates and unit vectors; types of vector and vector representation; addition and subtraction; multiplication by a scalar; graphical methods

*Matrix operations and vectors*: carry out a range of matrix operations eg vectors in matrix form, square and rectangular matrices, row and column vectors, significance of the determinant, determinant for 2x2 matrix, the inverse of a 2x2 matrix; use Gaussian elimination to solve systems of linear equations (up to 3x3)

*Vector geometry*: determine scalar product, vector product, angle between two vectors, equation of a line, norm of a vector, dot and cross products; apply vector geometry to the solution of engineering problems (eg velocity vector and mechanisms, acceleration vector and mechanisms, forces in static frameworks and structures, evaluation of static joint structures using dot product, phasors)
4 Ordinary differential equations

First order differential equations: engineering use; separation of variables; integrating factor method, complementary function and particular integral

Numerical methods for first order differential equations: need for numerical solution; Euler’s method; improved Euler method; Taylor series method

Application of first order differential equations: eg RC and RL electric circuits, time constants, motion with constant and variable acceleration, Fourier equation for heat transfer, Newton’s laws of cooling, charge and discharge of electrical capacitors, complex stress and strain, metrology problems

Second order differential equations: engineering use; arbitrary constants; homogeneous and non-homogeneous linear second order equations

Application of second order differential equations: eg RLC series and parallel circuits, undamped and damped mechanical oscillations, fluid systems, flight control laws, mass-spring-damper systems, translational and rotational motion systems, thermodynamic systems, information and energy control systems, heat transfer, automatic control systems, stress and strain, torsion, shells, beam theory

Engineering situations: applications (eg heat transfer, Newton’s laws, growth and decay, mechanical systems, electrical systems, electronics, design, fluid systems, thermodynamics, control, statics, dynamics, energy systems, aerodynamics, vehicle systems, transmission and communication systems)
### Outcomes and assessment criteria

To achieve each outcome a learner must demonstrate the ability to:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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</thead>
</table>
| 1 Analyse and model engineering situations and solve problems using **number systems** | • use estimation techniques and error arithmetic to establish realistic results from experiment  
• convert number systems from one base to another, and apply the binary number system to logic circuits  
• perform arithmetic operations using complex numbers in Cartesian and polar form  
• determine the powers and roots of complex numbers using de Moivre’s theorem  
• apply complex number theory to the solution of engineering problems when appropriate. |
| 2 Analyse and model engineering situations and solve problems using **graphical and numerical methods** | • draw graphs involving algebraic, trigonometric and logarithmic data from a variety of scientific and engineering sources, and determine realistic estimates for variables using graphical estimation techniques  
• make estimates and determine engineering parameters from graphs, diagrams, charts and data tables  
• determine the numerical integral of scientific and engineering functions  
• estimate values for scientific and engineering functions using iterative techniques. |
| 3 Analyse and model engineering situations and solve problems using **vector geometry and matrix methods** | • represent force systems, motion parameters and wave forms as vectors and determine required engineering parameters using analytical and graphical methods  
• represent linear vector equations in matrix form and solve the system of linear equations using Gaussian elimination  
• use vector geometry to model and solve appropriate engineering problems. |
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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</thead>
</table>
| 4 Analyse and model engineering situations and solve problems using *ordinary differential equations* | • analyse engineering problems and formulate mathematical models using first order differential equations  
• solve first order differential equations using analytical and numerical methods  
• analyse engineering problems and formulate mathematical models using second order differential equations  
• solve second order homogeneous and non-homogenous differential equations  
• apply first and second order differential equations to the solution of engineering situations. |
Guidance

Delivery

This unit may be delivered as a stand-alone unit, or integrated into other appropriate programme modules. If it is delivered in an integrated way, care must be taken to provide tracking of evidence for the outcomes.

The core unit *Analytical Methods for Engineers* is considered to be the pre-requisite for this unit. It is envisaged that this unit would be taught, as an option, in the second year or second semester of a BTEC Higher National Engineering programme. This will provide learners with an extended knowledge of all the analytical tools they may need for their Higher National studies and have the necessary preparation for studying further mathematics at Degree level.

This unit, like its prerequisite Analytical Methods, has been designed to afford the lecturer choice in the delivery of the content. Providing that the assessment criteria are met for each of the outcomes, the content may be taught and assessed to reflect the chosen pathway of the learner. For example, complex numbers may be taught to mechanical engineering learners but there is no need for this group to apply complex numbers to electrical theory. All other outcomes in this unit allow a choice of applications that are most relevant to the learners chosen pathway. Adopting this method of delivery and assessment should enable the learner to cover the entire essential mathematical principles and techniques and apply this theory to relevant engineering applications.

The amount of time the tutor wishes to apportion to each outcome will very much depend on the learner cohort being taught. For this reason no order should be inferred from either the layout of content or from the order of the outcomes and grading criteria table.

Assessment

The results of tests and examinations are likely to form a significant part of the evidence of attainment for the outcomes of this unit. However, it is also considered essential that evidence is gathered from assignments designed to apply the analytical methods to the modelling and solution of realistic engineering problems. The use of computer programmes is likely to form a significant part of testing or modifying possible solutions to such problems. The evidence gathered should, wherever possible, be deliberately biased to reflect the chosen engineering pathway.

Links

This unit is intended to link with the more analytical programme units and extend the knowledge gained from studying *Unit 2: Analytical Methods for Engineers*. The unit serves as a necessary foundation for *Unit 32: Engineering Mathematics*, for those wishing to pursue their studies at degree level.

Entry requirements are at the discretion of the centre. However, it is strongly advised that within the programme learners should have studied *Unit 2: Analytical Methods for Engineers*, or its academic equivalent, before embarking on this unit.
Resources

The use of mathematical software packages should be strongly encouraged, wherever appropriate, to help learners understand the model scientific and engineering problems. Availability of mathematical and spreadsheet packages such as Autograph, MathCad and Excel would enable realistic assignments to be set and achieved by learners.

Support materials

Textbooks

Unit 27: Manufacturing Process

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to provide learners with a broad and in-depth knowledge of manufacturing processes and techniques that can be applied to a range of materials for a variety of manufacturing applications.

Summary of learning outcomes

To achieve this unit a learner must:

1. Select suitable conventional machining processes and techniques for generating geometrical forms for a given component specification
2. Select suitable moulding and shaping processes for a given component specification
3. Select suitable non-conventional machining techniques for a given component specification.
Content

1 Conventional machining

Component manufacture: specify components for manufacture (eg criteria-tolerances, types of material, machining technique, surface texture, material removal rates, speeds and feeds, cutting times, cutter offsets, table angles)

Machining techniques: production of flat and cylindrical geometry (eg milling, surface grinding, lapping, planing, turning, cylindrical grinding, centreless grinding, honing, super-finishing, thread milling techniques, jig boring, horizontal boring, vertical boring, transfer machines)

Tooling requirements: multi-tooth cutting (eg milling, grinding, hobbing, drilling, reaming, and broaching); single-point cutting (eg turning, planing and slotting); appropriate cutting angles for given materials; types, advantages and disadvantages of coolants and cutting fluids used for various materials and processes (eg advantages — prolonging tool life, increased material removal rate, improved surface finish; disadvantages — fumes and possible irritations to operators)

Work-holding techniques: selection of appropriate work-holding devices (eg three and four jaw chucks, vices, jigs, fixtures, clamping arrangements, vee blocks, angle plates and magnetic chucks); health and safety issues and limitations of devices

2 Moulding and shaping

Component manufacture: specify components for moulding and shaping (eg criteria-tolerances, type of moulding/shaping technique to be used, limitations of size, shape and production volume, properties of materials being moulded/shaped, surface texture, cost factors, post-moulding operations required — machining, clipping, welding, finishing, etc.)

Moulding processes: casting (eg sand, die, investment and continuous casting); powder metallurgy; sintering

Shaping processes: extrusion (eg direct, indirect and impact); forging (eg drop, pressure and upset); rolling; hot and cold presswork (eg forming, bending and deep drawing); metal spinning

Ceramic materials: range applicable to component (eg metallic carbides, nitrides and oxides)

Material properties: changes to the molecular structure and hence the material properties that may arise from a moulding or shaping operation (eg grain growth, work hardening, cracking, orientation of grain flow)

Tooling requirements: appropriate tooling and equipment required to produce given components by moulding and shaping techniques (eg re-usable moulds and non-permanent moulds, suitable casting materials for a particular casting process); press tools, punches, dies, press capacity and calculations in terms of tonnage
3 Non-conventional machining

*Component manufacture*: principle of operation of the non-conventional machining techniques (eg electro-discharge machining (EDM), wire erosion, ultrasonic machining, etching of electronic printed circuit boards (PCBs), laser-beam machining, plasma-jet machining); specification of components for non-conventional machining techniques (eg criteria-tolerances, types of material, suitable technique, surface texture, material removal rate, cost factors)

*Tooling requirements*: tooling and ancillary equipment needed to perform non-conventional machining techniques; work-holding techniques; health and safety issues
## Outcomes and assessment criteria

### Outcomes

<table>
<thead>
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<tbody>
<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| 1 Select suitable **conventional machining** processes and techniques for generating geometrical forms for a given component specification | • identify and select suitable data and processes for component manufacture using a range of conventional machining techniques  
• identify and describe tooling requirements and work-holding techniques. |
| 2 Select suitable **moulding and shaping** processes for a given component specification | • identify and select suitable data and processes for component manufacture using moulding and shaping techniques for metals and ceramics  
• identify changes to material properties due to the moulding and shaping processes  
• identify and describe tooling requirements. |
| 3 Select suitable **non-conventional machining** techniques for a given component specification | • identify and select suitable data and processes for component manufacture using a non-conventional machining process  
• identify and describe the tooling and ancillary equipment required to manufacture the component. |
Guidance

Delivery

The unit may be delivered as a stand-alone package, or integrated into other appropriate programmes. If it is delivered in an integrated way, care must be taken to provide tracking evidence for the outcomes. Centres should also be aware that study and assessment at an individual outcome level throughout the programme could lead to assessment overload. Wherever possible a practical approach should be adopted. Learning and assessment can be across units, at unit level or at individual outcome level. Effort should be made to identify the relevance of the principles covered.

Assessment

Evidence of outcomes could be in the form of reports of practical activities. This evidence may be generated in a learner’s place of work.

Evidence for this unit is likely to be at individual outcome level to provide maximum flexibility of delivery. However, centres may wish to consider assemblies that include components manufactured using the four processes — machining, moulding, shaping and non-conventional methods. This approach would provide a central theme and may lead to a more coherent use of the outcomes and assessment criteria.

Evidence may be accumulated by learners building a portfolio record of the activities carried out in their place of work, or by tutor-led assignments.

Links

This unit is intended to be linked with Unit 23: Materials Engineering.

Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed appropriate BTEC National units or equivalent. Learners who have not attained this standard may require an element of bridging studies built into their programme.

Resources

Access to suitable instructional material in the form of books or digital means, whereby the learner can research various manufacturing processes is desirable. Access to conventional machine tools and as wide a range of processes, as identified in the content, would also be desirable.
Support materials

Textbooks
Kalpakjian S — *Manufacturing Engineering and Technology* (Addison-Wesley, 2000)
ISBN: 0201361310

ISBN: 0130408719

ISBN: 0071169113
Unit 28: Computer-Aided Machining

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H1

Description of unit

The aim of this unit is to provide a practical understanding of computer-aided machining (CAM) systems. Outcome 1 focuses on the hardware and software of CAM systems. Outcomes 2 and 3 deal with manual and computer-assisted part programming, giving learners the opportunity to derive and prove part programs for engineered components. Outcome 4 is concerned with quality control in CAM systems, particularly the various levels of inspection and the capture, transmission and analysis of quality control data.

Summary of learning outcomes

To achieve this unit a learner must:

1. Investigate the design and operational characteristics of CAM systems
2. Produce and prove manual part programs
3. Produce and prove computer-assisted part programs
4. Investigate inspection and quality control in CAM systems.
Content

1 Design and operational characteristics of CAM

*Hardware elements:* computer (eg mainframe, mini, micro); computer power and memory; printer; mouse; digitiser; digital and screen data displays; disc drives; axes of CNC machines; parametric settings (eg zero datum setting and transfer, manual modes, program overrides)

*Software elements:* operating system; CAM software; CAM database management systems; program editing facilities; diagnostic testing techniques

*Inputs:* geometry data; material specifications; CAD data

*Outputs:* manufacturing data; tool data; cutter path; component profile; CAM file

*Component location, work-piece clamping and tool holding:* eg jigging devices, holding techniques, punch tooling, formers for bending

2 Manual part programs

*Elements and structures:* system initialisation; tooling information and data; positional control and sequence

*ISO standards:* block, word and letter addresses; system management; positional data and coded data transfer

*Programming techniques:* macro routines; sub-routines; rotation; zero shifts; scaling and minor imaging

3 Computer-assisted part programs

*Functions:* generation of graphics and component profile definition; geometry manipulation; tooling and machinery sequences; cutter path simulation; post-processing

*Databases:* CAD profile and attribute data; material files; tool data; cutter location files

*Macro routines:* eg continuous operations, automatic tooling sequences, standard components

4 Inspection and quality control

*Levels of inspection:* tooling verification; datum and location checks; in-process measurement; post-process inspection; qualitative data and attributes; statistical analysis; technical and management information

*Data capture:* tactile sensing; non-tactile sensing; data transmission features
Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
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</table>
| 1 Investigate the **design and operational characteristics of CAM systems** | • describe the hardware and software elements of a CAM system  
• identify the inputs and outputs of a CAM system  
• describe the methods of component location, clamping and tool holding in CNC machines.                                                                 |
| 2 Produce and prove **manual part programs**                             | • identify the elements and structure of a CNC part program  
• investigate the use of ISO standards with respect to codes and program format  
• investigate programming techniques that promote enhanced system performance  
• produce manually written part programs for engineered components  
• input manually written part programs to a CNC machine and prove their accuracy.                                                                                           |
| 3 Produce and prove **computer-assisted part programs**                  | • identify the functions of computer-assisted part programs  
• investigate the use of databases in support of computer-assisted part programming  
• use macro routines in support of computer-assisted part programming  
• produce computer-assisted part programs for engineered components  
• pass computer-assisted part programs to a CNC machine and prove their accuracy.                                                                                       |
| 4 Investigate **inspection and quality control in CAM systems**          | • identify the various levels of inspection in CAM systems  
• describe the techniques used for data capture in automated inspection systems  
• explain the significance of adaptive control methods in CAM systems.                                                                                                    |
Guidance

Delivery

A practical, hands-on approach to learning should be adopted wherever possible, with tutors providing relevant examples of the application of theory in practice. Practical work needs to be investigative, to give learners the opportunities to provide evidence for distinctive performance. Visits to industrial installations will be of value to supplement learning activities.

Assessment

Evidence of outcomes may be in the form of assignments, solutions to applied problems or completed tests/examinations. Evidence may be accumulated by learners building a portfolio of work or by a tutor-led combination of written tests and assignments. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit is designed to stand-alone, but it may be linked with Unit 29: CAD/CAM.

Entry requirements for this unit are at the discretion of the centre. However, it is advised that learners should have completed appropriate BTEC National units or equivalent.

Resources

Centres delivering this unit should be equipped with, or have access to, industrial-standard NC machining centres and programming hardware and software.

Support materials

Textbooks


Unit 29: CAD/CAM

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit will integrate the two subject areas of computer-aided design and computer aided-manufacture (CAD/CAM). It will enable the learner to acquire a broader and deeper understanding of the practical applications of a CAD/CAM system.

Summary of learning outcomes

To achieve this unit a learner must:

1. Produce a component drawing suitable for transfer onto a CAM system and produce a simple 3D surface
2. Transfer data generated in CAD to a CAM system for subsequent machining
3. Simulate the cutter paths on a CAM system to optimise the machining sequences
4. Transfer a generated tape file to a CNC machine and produce the component.
Content

1 Component drawing 3D surface

Component drawing: configure the hardware contained within a typical CAD workstation; produce CAD profiles using the more common types of editing facilities; geometry manipulation (eg mirror, rotate, copy, array, offset); drawing attributes and structure with specific reference to associated profile data and parts listing

3D surface: use of world axis to produce geometry suitable for transfer to a CAM system; 3D surfaces generated for visualisation and subsequent machining

2 Transfer data

Transfer data: structured CAD data with reference to suitable datum and direction of lines; methods of transfer DYF and IGES; CAD layers used to help tooling sequences with consideration to tool changes

3 Cutter paths

Cutting and tooling: tooling sequences optimised by using simulated cutting times generated within the CAM system; tooling data files containing calculated speeds and feeds to suit component material; cutting directions and offsets determined with due consideration for component accuracy and finish; clamping and general workholding safety considered with reference to clamping methods including program controlled clamping

CAM software: simulation of a range of cutter paths; component profiles; generation of cutter paths

4 Generated tape file

Generated tape file: offsets checked and setting values determined using MDI (manual data input) facilities to modify program where required; consider using buffer stores when applied to large amounts of program data; canned and repetitive cycles analysed and incorporated into the program when appropriate; sub-routines may be used for pockets, profiles and managed by the main program
## Outcomes and assessment criteria

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</table>
| 1 Produce a **component drawing** suitable for transfer onto a CAM system and produce a simple **3D surface** | • use suitable CAD software to produce a working drawing for subsequent manufacture, using drawing techniques available within the package  
• identify the hardware in a typical CAD/CAM configuration  
• describe the values of geometry manipulating functions that are available in a typical CAD system such as mirror, rotate, copy, array and offset  
• explain the significance of drawing attributes for CAD/CAM with specific reference to profile data and parts listing.  
• use a CAD system to produce a variety of geometrical shapes from datum in 3 dimensional space. |
| 2 **Transfer data** generated in CAD to a CAM system for subsequent machining | • describe the significance of structured data within a CAD/CAM system  
• produce a DXF (data exchange file) from a standard drawing file  
• use a DXF file to produce geometry within a CAM system. |
| 3 Simulate the **cutter paths** on a CAM system to optimise the machining sequences | • use suitable CAM software to simulate a range of cutter paths on a component profile  
• modify generated paths to obtain optimum cutting performances. |
| 4 Transfer a **generated tape file** to a CNC machine and produce the component | • identify the more common methods of data transfer  
• input a program processed from CAM simulation  
• produce a component on a suitable CNC machine. |
Guidance

Delivery

A practical, hands-on approach to learning should be adopted wherever possible, with tutors providing relevant examples of the application of theory in practice. Practical work needs to be investigative, to give learners the opportunities to provide evidence for distinctive performance. Learners should develop an awareness of alternative CAD/CAM systems and machining methods.

Assessment

Evidence of outcomes may be in the form of assignments. Evidence is likely to be at outcome level in order to provide maximum flexibility of delivery.

Evidence may be accumulated by learners building a portfolio of activities, tutor-led assignments or tests. In either case, the evidence must be both relevant and sufficient to justify the grade awarded.

Links

This unit is designed to stand-alone, but it links with Unit 6: Engineering Design and Unit 28: Computer-Aided Machining.

Resources

Centres delivering this unit must be equipped with industrial standard CAD/CAM software and hardware.

The CAM software would be similar to SMARTCAM, MASTERCAM, APS or equivalent. Whereas CAD software similar to ACAD, Release 13 and above would be considered adequate.

Suitable machining centres with FANUC or HEIDENHAIN controllers or equivalent would be affected.

Support materials

Textbooks


Unit 30:  Application of Machine Tools

Learning hours:  60
NQF level 4:  BTEC Higher Nationals — H1

Description of unit

This unit introduces learners to the types of manually operated machine tools commonly used in industry and typical applications of such equipment. It introduces the theory of cutting tools, the practice of tool and work setting for production on manual machine tools and the checking of critical features and dimensions against specifications. Safe use of equipment will be a constant theme throughout the unit.

The unit aims to provide the learner with the skills necessary for the safe and efficient production of components on manual machine tools. It also provides the learner with a broad knowledge base upon which suitable types of machine tool and appropriate tooling may be chosen for specific sorts of work.

Summary of learning outcomes

To achieve this unit a learner must:

1. Describe the characteristics of a range of machine tools
2. Investigate machining operations
3. Investigate material cutting and forming processes
4. Produce components to specification using safe working practices.
1 Machine tools

*Machine tools:* a range of machine tools and their applications (eg centre lathes, vertical and horizontal milling machines, cylindrical and surface grinders, centreless grinders, lapping, honing, planing and shaping machines, internal and external broaching machines, sawing machines, presses, sheet and tube bending machines); types of drives (eg for lathes, milling machines and presses); relative motion between cutting tool and workpiece

*Work holding techniques:* the six degrees of freedom of a rigid body with respect to work holding and jig and fixture design (eg the need for rigidity in design and build of machine tools, three and four-jaw chucks, use of centres, machine vices, worktable clamps, magnetic tables, etc.)

*Tool holding:* toolposts; morse taper shanks; Jacobs chucks; milling machine arbors; mounting and dressing of grinding wheels

2 Machining operations

*Components and geometries:* component features typically associated with lathe work, milling, sheet metal forming and broaching. For example:

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**Lathe work:** rotational operations — diameters and face turning, taper turning, chamfers, radii, drilled holes and internal bores, deep holes, internal and external threads, grooving, knurling, parting off, roughing and finishing cuts, the purpose and use of cutting fluids

**Milling:** prismatic operations — face milling, slab milling, profiles, pockets and slots, drilling, reaming, thread tapping, thread milling, counterboring, countersinking, roughing and finishing cuts

**Press work:** sheet metal forming operations — blanking, piercing, drawing, bending, notching, cropping, use of progression tooling; finishing operations

**Broaching:** internal and external — square and round holes, splines, gear teeth, keyways, rifling and flat, round and irregular external surfaces

3 Material cutting and forming processes

*Tooling:* choice and effects of tool geometries; choice of tool material; permissible depth of cut; types and consequences of tool wear; importance of clearance in pressworking operations; calculation of expected tool life

*Forces:* theory of metal cutting; mechanics of chip formation; shearing mechanisms in press work; calculation of forces exerted on cutting/forming tool and workpiece during various operations; calculation of power required to perform specific operations; use of dynamometers and other condition monitoring/measuring equipment

*Speeds and feeds:* calculation of speeds and feeds for turning and milling operations on a variety of workpiece features, sizes and materials (eg aluminium alloys, mild steel, tool steels, cast metals and alloys); relationship between cutting speed and tool life — economics of metal removal
4 Produce components

*Health and safety:* issues related to machine tools, workshops and the production environment in general; responsibilities of the employer and employee under the Health and Safety at Work Act and other legislation; correct and approved use and operation of systems and equipment; potential hazards for given machine tools

*Principles of production:* tool and work setting techniques; interpretation of specifications and engineering/production drawings; feature measurement (eg depths, diameters, screw threads, etc)
## Outcomes and assessment criteria

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<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
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</table>
| **1** Describe the characteristics of a range of machine tools | - identify the typical axis conventions of given machine tools  
- identify the types of drive and the axis control systems, such as hand-wheels and servo-motors, for given machine tools  
- describe the six degrees of freedom of a rigid body and how they relate to work holding techniques  
- describe work and tool holding devices for given machine tools. |
| **2** Investigate machining operations | - identify the types of machine tool suitable for the production of specific components and geometries  
- develop the sequence of operations required to produce specific components  
- describe the machining and forming processes involved in the production of specific features. |
| **3** Investigate material cutting and forming processes | - select appropriate tooling for the production of specific features on specific materials  
- determine the forces acting on the tool face and work piece during ideal orthogonal cutting  
- calculate speeds and feeds for turning and milling operations for a variety of tool and work piece materials  
- describe the mechanisms and effects of different types of tool wear and catastrophic failure  
- estimate the life of given tools for specific applications. |
| **4** Produce components to specification using safe working practices | - demonstrate awareness of health and safety issues related to the specific machine tools used and the workshop in general  
- apply the principles of production  
- produce given components in accordance with specifications. |
Guidance

Delivery

Learners should work individually. Delivery may be achieved by formal lectures, supported by tutorial sessions focusing upon the theoretical aspects of the syllabus, and practical workshop sessions.

Assessment

Evidence of outcomes may be in the form of a written report supported by a fully documented log book, production of an assembly or component produced with available machine tool resources and written tests based on theoretical principles.

Links

This unit may be effectively linked with Unit 27: Manufacturing Process.

Entry requirements for this unit are at the discretion of the centre. However, it is strongly advised that learners should have completed an appropriate BTEC National unit or equivalent.

Resources

Learners should have access to appropriate machine tools and properly trained support staff. Institutions should try to work closely with industrial organisations in order to bring realism and relevance to the unit.

Support materials

Textbooks

Kalpakjian S — Manufacturing Engineering and Technology (Addison-Wesley, 2000)
ISBN: 0201361310

Unit 31: Advanced Machine Tools

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

This unit introduces learners to the types of numerical control (NC) and computer numeric control (CNC) machine tools commonly used in industry and typical applications of such equipment. The design and build of advanced machine tools and the economics of production on CNC plant are addressed. The concept of cellular manufacture is introduced and is supported by the programming of programmable logic controllers (PLCs). Workholding and tooling issues for CNC are covered and reference is made to the special needs of high-speed machining. The application of probes for work and tool setting is discussed. Safe use of equipment will be a constant theme throughout the unit.

The unit aims to provide the learner with the theory behind the safe and efficient production of components on NC and CNC machine tools. It also provides the learner with a broad knowledge base upon which the ideas of cellular manufacture can be discussed.

Summary of learning outcomes

To achieve this unit a learner must:
1. Determine the cost of producing simple components on CNC equipment
2. Investigate the design and construction of CNC machine tools
3. Investigate the use of tool management in automated environments
4. Describe the requirements of a flexible manufacturing cell (FMC) and the uses of programmable logic controllers (PLCs).
Content

1 Cost of producing simple components

Economics of production on CNC equipment: advantages and disadvantages of CNC; comparison of CNC and manual machine tools (eg impacts on productivity, quality and flexibility); comparison of costs of simple components produced manually and by CNC; determination of cost of producing specific components on CNC machine tools based on machine utilisation; hourly machine rates, labour rates and other overheads

2 Design and construction

Design and construction of CNC machine tools: history of machine tools; axis conventions; horizontal and vertical lathes; horizontal and vertical milling machines multi-axis machine tools — 4, 5, and 6 axis milling machines and machining centres, 3 and 4 axis turning centres and millturn centres; special considerations for high speed machining; special purpose machine tools; cast versus fabricated bases; modular designs; typical configurations; requirement of machine tools — rigidity, power requirements, cost of construction

Control systems: relationship between CNC controller and machine control unit (MCU); closed-loop control and feedback systems; types of positional encoders

3 Automated environments

Tool management in automated environments: tool libraries; data requirements; geometry and offsets; feeds and speeds; control of maximum depth of cut; updating; linking tool libraries with bill of materials (BOM)

Tool life management: sister tooling; adaptive control for tool wear monitoring; probing systems for tool setting and tool wear detection; tool wear compensation by workpiece probing

Tool delivery: tool pre-setting and storage; automated tool stores; automated tool delivery and loading

4 Flexible manufacturing cell (FMC) and the uses of programmable logic controllers (PLCs)

Flexible manufacturing: overview of requirements of FMCs — introduction to group technology (GT) and just-in-time (JIT) manufacturing; typical cell configurations

Automated materials handling: use of robots for machine loading/unloading; multi-pallet systems for milling; bar feeding systems for turning

Applications of PLCs: PLC programming using ladder logic; handshaking and communication between key elements of the cell
Outcomes and assessment criteria

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<td></td>
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</tbody>
</table>
| 1 Determine the cost of producing simple components on CNC equipment | - describe the relative merits of manual and CNC machine tools  
- determine the economics of producing a simple component on CNC equipment. |
| 2 Investigate the design and construction of CNC machine tools | - describe typical configurations of CNC machine tools and relevant axis conventions  
- describe the relationships between the main design features of CNC machine tools  
- describe the use of control systems applied to CNC equipment. |
| 3 Investigate the use of tool management in automated environments | - describe the requirements of an automated tool management system  
- report on the uses of adaptive control and sister tooling for tool life management and the use of probing systems for tool setting and tool wear compensation  
- analyse the requirements of an automated tool delivery system. |
| 4 Describe the requirements of a flexible manufacturing cell (FMC) and the uses of Programmable Logic Controllers (PLCs) | - describe the main physical features of a flexible manufacturing cell  
- report on the uses of automated material handling systems within the FMC environment  
- prepare simple programs for applications of PLC cell control. |
Guidance

Delivery

Learners may work individually or in small groups. Delivery may be achieved by formal lectures supported by tutorial sessions focusing on the theoretical aspects of the syllabus and practical workshop sessions.

Assessment

Evidence may be generated from a written report based on case studies or tests based on theoretical principles.

Links

This unit may be linked with Unit 30: Application of Machine Tools.
The unit is intended to lead the learner towards an understanding of machine tool technology and its utilisation through the study of theory and practical application.

Resources

Learners should ideally have access to appropriate machine tools and properly trained support staff. Centres should try to work closely with industrial organisations in order to bring realism and relevance to the unit.

Support Material

Textbooks


Unit 32: Engineering Mathematics

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The primary aim of this unit is to provide the analytical knowledge and techniques necessary for studying engineering to Degree level. It also aims to provide some of the more advanced knowledge required for those wishing to pursue careers in mechanical engineering, aeronautical engineering, electronics, communications engineering, systems engineering and all variants of control engineering.

The unit leads on from *Further Analytical Methods for Engineers*, extending some of the outcomes and introducing more analytical techniques.

This unit has been designed to enable learners to develop further techniques for the modelling and solution of engineering problems, including series and numerical methods for ordinary differential equations, Laplace transforms, Fourier series and an introduction to partial differential equations.

Summary of learning outcomes

To achieve this unit a learner must:

1. Analyse and model engineering situations and solve engineering problems using series and numerical methods for the **solution of ordinary differential equations**
2. Analyse and model engineering situations and solve engineering problems using **Laplace transforms**
3. Analyse and model engineering situations and solve engineering problems using **Fourier series**
4. Analyse and model engineering situations and solve engineering problems using **partial differential equations**.
Content

1 Solution of ordinary differential equations

*Power series*: review of methods for standard series, Maclaurin’s series and Taylor’s series

*Power series methods*: eg higher differential coefficients and Leibnitz’ theorem, recurrence relations, Leibnitz — Maclaurin method, Frobenius method, engineering use of Bessel’s equation and Legendre equation, Bessel functions of the first and second kind, Legendre’s equation and polynomials

*Numerical methods*: restrictions on the analytical solution of differential equations, typical methods (eg Taylor’s series, solution of first order differential equations, Euler’s method, improved Euler method, Runge — Kutta method)

*Engineering situations*: model engineering situations and solve problems using ordinary differential equations (eg vibration, thermofluids and heat transfer, mechanics of solids, electrical systems, information systems)

2 Laplace transforms

*Laplace transform*: its use; transforms of standard functions; first shift theorem; inverse transforms and tables of inverse transforms; transforms using partial fractions; poles and zeros; solution of first and second order differential equations using Laplace transforms; solution of simultaneous differential equations; initial and final value problems

*Engineering problems*: eg electrical circuits in the s-domain, modelling and analysis of closed loop control systems, response of first and second order systems, servomechanisms, systems engineering, systems stability analysis, automatic flight control systems, design of feedback systems: root locus plots, Nyquist and Bode plots, Nichols charts

3 Fourier series

*The Fourier series*: sinusoidal and non-sinusoidal waveforms; periodic functions; harmonics; the Fourier series; Fourier coefficients; series for common wave-forms; odd and even functions and their products; half-range series; non-periodic functions and their half-range series

*The exponential form*: complex notation; symmetry relationship; frequency spectrum and phasors

*Engineering applications*: eg electric circuit analysis, root mean square values, power and power factors, numerical integration and numerical harmonic analysis
4 Partial differential equations

**Partial differentiation**: review of partial differentiation techniques; partial differentiation and rates of change problems; change of variables; stationary values and saddle points

**Partial differential equations**: definition of partial differential equations; partial integration; solution by direct partial integration; initial conditions and boundary conditions; solution by separation of variables

**Engineering situations**: eg the wave equation and its application to vibration, the heat conduction equation, the Laplace equation and its application to temperature and potential
### Outcomes and assessment criteria

<table>
<thead>
<tr>
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</table>
| **1 Analyse and model engineering situations and solve engineering problems using series and numerical methods for the solution of ordinary differential equations** | • determine power series values for common scientific and engineering functions  
• solve ordinary differential equations using power series methods  
• solve ordinary differential equations using numerical methods  
• model engineering situations, formulate differential equations and determine solutions to these equations using power series and numerical methods. |
| **2 Analyse and model engineering situations and solve engineering problems using Laplace transforms** | • determine Laplace transforms and their inverse using tables and partial fractions  
• solve first and second order differential equations using Laplace transforms  
• model and analyse engineering systems and determine system behaviour using Laplace transforms. |
| **3 Analyse and model engineering situations and solve engineering problems using Fourier series** | • determine Fourier coefficients and represent periodic functions as infinite series  
• apply the Fourier series approach to the exponential form and model phasor behaviour  
• apply Fourier series to the analysis of engineering problems  
• use numerical integration methods to determine Fourier coefficients from tabulated data and solve engineering problems using numerical harmonic analysis. |
| **4 Analyse and model engineering situations and solve engineering problems using partial differential equations** | • solve rates of change problems and problems involving stationary values using partial differentiation  
• solve partial differential equations using direct partial integration and separation of variables methods  
• model and analyse engineering situations using partial differential equations. |
Guidance

Delivery

This unit may be delivered as a stand-alone unit, or integrated into other appropriate units. If it is delivered in an integrated way, care must be taken to provide tracking of evidence for the outcomes. In delivering the unit every effort should be made to ensure that the outcomes are applied to the modelling and solution of realistic engineering problems, applicable to the chosen engineering pathway. Cross-unit assignments, requiring a considerable element of self-directed learning, are an appropriate medium for practising the engineering modelling skills required by this unit. The analysis and research required is likely to be enhanced by appropriate use of mathematical software packages. Team design exercises and presentations are also an appropriate method for assessing the engineering applications in the outcomes.

Assessment

The results of tests and examinations are likely to form a significant part of the evidence of attainment for the outcomes of this unit. It is also considered important that evidence is gathered from assignments designed to apply the analytical methods to the modelling and solution of realistic engineering problems. The use of computer programmes is likely to form a significant part of testing or modifying possible solutions to such problems. The evidence gathered should, wherever possible, be deliberately biased to reflect the chosen engineering pathway.

Links

This unit is intended to link with the more analytical programme units required in some BTEC Higher National engineering programmes and to extend the knowledge gained from studying Unit 26: Further Analytical Methods for Engineers. This unit is particularly relevant to learners following the mechanical, electrical, aeronautical, telecommunications and system engineering pathways. This unit is also intended to prepare learners for entry into Degree level programmes.

Entry requirements are at the discretion of the centre. However, it is unlikely that learners will have the required entry level knowledge unless they have successfully completed both Unit 2: Analytical Methods for Engineers and Unit 26: Further Analytical Methods for Engineers or equivalent.

Resources

The use of mathematical software packages should be strongly encouraged, particularly when solving or modifying differential equations for a particular engineering application.
Support materials

Textbooks

ISBN: 075064110X

Croft/Davis and Hargreaves — Introduction to Engineering Mathematics (Prentice Hall, 1995)
ISBN: 020162447


Unit 33: Project Management

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to provide a knowledge of project management principles, methodologies, tools and techniques that may be used in any industry, the professions and the public sector. Organisational and human resource factors are also included.

Learners will develop an understanding of what constitutes a project and the role of a project manager. They will be able to analyse and plan the activities needed to carry out the project, including how to set up a project, how to control and execute a project, and how to carry out project reviews. They will also understand how the project fits into the company or other organisational environment.

It is intended that this unit will support the knowledge and understanding requirements for the NVQ in Project Management at level 4.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate project management principles
2. Examine project organisation and people
3. Examine project processes and procedures.
Content

1 Project management principles

Project management: definition of projects; project management and the role of the project manager (eg management of change, understanding of project management system elements and their integration, management of multiple projects, project environment and the impact of external influences on projects); identification of the major project phases and why they are required; an understanding of the work in each phase; the nature of work in the lifecycles of projects in various industries

Success/failure criteria: the need to meet operational, time and cost criteria, and to define and measure success (eg develop the project scope, product breakdown structure (PBS), work breakdown structure (WBS), project execution strategy and the role of the project team); consideration of investment appraisal (eg use of discount cash flow (DCF) and net present value (NPV), benefit analysis and viability of projects); determine success/failure criteria; preparation of project definition report; acceptance tests

Project management systems: procedures and processes; knowledge of project information support (IS) systems; how to integrate human and material resources to achieve successful projects

Terminating the project: audit trails; punch lists; close-out reports and post-project appraisals; comparison of project outcome with business objectives

2 Organisation and people

Organisational structure: functional, project and matrix organisational structures (eg consideration of cultural and environmental influences, organisational evolution during the project lifecycle); job descriptions and key roles (eg the project sponsor, champion, manager, integrators); other participants (eg the project owner, user, supporters, stakeholders)

Control and co-ordination: the need for monitoring and control (eg preparation of project plans, planning, scheduling and resourcing techniques, use of work breakdown structure to develop monitoring and control systems, monitoring performance and progress measurement against established targets and plans, project reporting, change control procedures)

Leadership requirements: stages of team development (eg Belbin’s team roles, motivation and the need for team building, project leadership styles and attributes); delegation of work and responsibility; techniques for dealing with conflict; negotiation skills

Human resources and requirements: calculation, specification and optimisation of human resource requirements; job descriptions
3 Processes and procedures

*Project management plans:* the why, what, how, when, where and by whom of project management (e.g., contract terms, document distribution schedules, procurement, establishing the baseline for the project)

*Project organisation:* the product breakdown structure (PBS) and the work breakdown structure (WBS); project execution strategy and the organisation breakdown structure (OBS) (e.g., preparation of organisation charts, task responsibility matrix, statement of work (SOW) for project tasks)

*Scheduling techniques:* relationship between schedules, OBS and WBS; bar charts; milestone schedules; network techniques; resourcing techniques; computer-based scheduling and resourcing packages; project progress measurement and reporting techniques; staff-hours earned value and progress ‘S’ curves; critical path analysis and reporting; milestone trending

*Cost control:* cost breakdown structure (e.g., types of project estimate, resources needed, estimating techniques, estimating accuracy, contingency and estimation, bid estimates, whole-life cost estimates, sources of information, cost information sensitivity, computer-based estimating)

*Techniques:* allocation of budgets to packages of work; committed costs; actual costs; cash flow; contingency management

*Performance:* cost performance analysis (e.g., budgeted cost for work scheduled (BCWS) budgeted cost for work performed (BCWP)); concept of earned value; actual cost of work performed (ACWP); cost performance indicators

*Change control:* the need for formal control of changes (e.g., project impact of changes, principles of change control and configuration management, changes to scope, specification, cost or schedule); change reviews and authorisation; the formation of project teams; project initiation and start-up procedures
# Outcomes and assessment criteria

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1. Investigate **project management principles**
   - describe the background and principles of project management
   - appraise the viability of projects and develop success/failure criteria
   - understand the principles behind project management systems and procedures
   - identify the key elements involved in terminating projects and conducting post-project appraisals.

2. Examine project **organisation and people**
   - identify the most appropriate organisational structure, roles and responsibilities of participants within a project
   - control and co-ordinate a project
   - identify project leadership requirements and qualities
   - plan and specify human resources and requirements for a project.

3. Examine project **processes and procedures**
   - prepare project plans and establish the project organisation
   - apply project scheduling, estimating and cost control techniques
   - describe the methods used to measure project performance
   - describe project change control procedures.
Guidance

Delivery

This unit is largely free-standing without reference to other units, although it could be integrated with general business management units or with operations management courses.

A practical approach should be adopted where possible. However, it is important that learners do not spend too much time doing numerical work, preparing or analysing large quantities of data. The analysis of data is an inevitable aspect of project management life, which is best learned using pre-prepared examples in electronic form that enable the principles to be quickly demonstrated without oversimplifying the complexity of everyday project operations.

A case study workshop approach with groups of learners would provide an excellent learning medium. Note that outcome 2 of this unit should be started only after the completion of outcome 1.

Assessment

Evidence of outcomes may be in the form of assignments, analysis of case studies, completed tests or examinations. Evidence should be provided at unit level in order to ensure proper integration of all the outcomes within the unit.

Links

This unit could be studied in parallel with, and complement, Unit 5: Project, which could provide many of the skills necessary for the successful completion of this unit. This unit is also supported by Unit 1: Business Management Techniques, that will provide an initial foundation of understanding in the techniques of costing, financial planning and control, project planning and scheduling methods.

Entry requirements for this unit are at the discretion of the centre.

Resources

Appropriate software packages should be used to demonstrate project control and reporting techniques. Packages might include:

- time and cost scheduling packages
- documentation and procurement control packages
- spreadsheet packages
- graphic presentation packages.

Other packages for items such as risk analysis, project accounting and procurement control could be used to illustrate particular techniques in specific industries.

Access to real project data in electronic spreadsheet form would be an advantage.
For the operation of complex proprietary computer software systems, project managers should know what to expect from such facilities, but are not necessarily expected to be able to operate them.

The project management principles and techniques are all important, together with an appreciation of how the various operations within the project integrate with one another.

**Support materials**

**Textbooks**


Unit 34: Work-based Assignment

Learning hours: 60
NQF Level 4: BTEC Higher Nationals — H1

Description of unit

This unit is intended for part-time learners. It is designed to allow flexibility of study, to enable employed learners to gain credit for work-based activities, and to contribute to the development of transferable skills.

Summary of learning outcomes

To achieve this unit a learner must:
1. Negotiate a work-based topic
2. Keep a detailed work log book
3. Undertake an extended work-based practical investigation
4. Report the investigation in the form of an engineering technical report
5. Make an oral presentation.
Content

1 Work-based topic

Both a work-based supervisor and academic supervisor should be appointed. The proposed topic should involve of the order of 60 hours work and its relationship to aspects of the Higher National curriculum should be identified.

2 Work log book

Log book entries should be dated and completed either during or immediately after each period spent on the topic. Entries should include details of activities carried out, resources used, costs involved, observations, safety measures taken, advice sought etc.

3 Work-based practical investigation

Practical work should be of the order of 40 hours duration and where possible cover a range of techniques. Team work is acceptable but clear documentation must be kept to distinguish the work of the candidate from that of other members of the team.

4 Report

Abstract: a summary of the purpose of the engineering activity, methods used, results obtained and any conclusions that can be drawn.

Introduction and objectives: a discussion of the relevant background theory making reference to any appropriate data, reports or previous work carried out which relates to the engineering activity. From this a list of objectives should be produced.

Results: record results in their fully processed form, (raw data, test data, questionnaire survey results etc may be included as an appendix). Where possible results should be tabulated with units and displayed in an appropriate form eg graphs, bar chart etc.

Engineering activity: a record of the detailed conditions excluding information relating to routine equipment.

Discussion: the purpose and outcomes of engineering activities and results together with the interpretation of test results should be included. Where appropriate suggestions for improvements and modifications should be included.

Appendices: should include important test data that is relevant to the engineering activity but which would make the results section too cumbersome.

Bibliography: a list of references recorded in the manner agreed with the academic supervisor.

5 Oral presentation

An oral presentation should be given to a group of five or more peers and should demonstrate the ability to produce and use a variety of methods eg overhead transparencies, PowerPoint projection, flipcharts, computer simulation; providing clear explanations and summarising results.
# Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To achieve each outcome a learners must demonstrate an ability to:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **1 Negotiate a work-based topic** | • propose a suitable work-based topic which relates to chosen area of study  
• document a proposed schedule for the agreed topic  
• discuss the topic and schedule with work and academic supervisors and amend as appropriate  
• identify resources required and necessary support procedures. |
| **2 Keep a detailed work log book** | • record work undertaken in a systematic manner  
• record and, where appropriate, tabulate observations and test results  
• list materials and other resources used and, where appropriate, procedures and conditions. |
| **3 Undertake an extended work-based practical investigation** | • work safely conforming to codes of practice and complete and record all health and safety requirements  
• complete an engineering activity involving substantial independent work  
• make suggestions for amendments to practices and/or procedures in the light of recorded observations and discuss with appropriate supervisor  
• agree and execute shared work as appropriate. |
| **4 Report the investigation in the form of an engineering technical report** | • present an engineering technical report of the investigation and activity of approximately 5000 words  
• use accepted formats for engineering technical reports  
• report the work undertaken completely and concisely  
• draw clear and coherent conclusions from the results obtained. |
| **5 Make an oral presentation** | • deliver an oral presentation of approximately 15 to 20 minutes in duration  
• give an overview of the topic investigated  
• summarise the results obtained  
• analyse the relevance and limitations of the results  
• relate the results obtained to the objectives of the engineering activity. |
Guidance

Delivery

Learners and industrial supervisors will need to be briefed precisely on the nature of the unit and of
the evidence required to achieve the outcomes. The planning stage is crucial, and should be carried
out jointly by the learners and academic and industrial supervisors.

The programme team may wish to define common formats for reports and presentations, or allow
them to be tailored to the nature of the engineering activities undertaken by the learners.

Assessment

The work used for this unit may be part of the learners’ normal workload or some activity designed
specially to deliver the required evidence. In either case, the negotiation and planning required by
outcome 1 should be completed and agreed before commencement of the detailed practical work. The
identity of the Higher National level of demand should be clearly identified at this stage.

The process of the work and its recording for outcomes two and three should follow normal
engineering practices as closely as possible.

The format of the final report for outcome four should be determined at the planning stage.

The oral presentation will normally be made to college tutors and fellow learners. For assessment
purposes, but input from industrial supervisors and fellow employees at this stage should be
couraged.

Links

This unit may be linked with all units in the programme.

Resources

The work will normally be planned to be achievable within the resource constraints of the employer.
Additional use of resources at the college may be appropriate in specific cases. These may involve
workshop facilities, or resources to develop the report and/or presentation.

Support materials

No general advice on reading is possible. The identification of appropriate sources, both textual and
electronic, is an important part of the demand on the learners. However, general texts on industrial
organisation and practices may be helpful.
Unit 35: Quality and Business Improvement

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to raise awareness and familiarise learners with the principles and applications of quality and business improvement. It examines the basic principles of continuous improvement and is intended to develop and understanding of the key factors which underpin the application of six sigma methodology. It also aims to introduce the application of failure modes and effect analysis techniques, measurement systems analysis and give opportunities of practical experience to support a basic understanding in mistake/error proofing.

Summary of learning outcomes

To achieve this unit a learner must:
1. Investigate continuous improvement techniques
2. Examine the key factors of six sigma methodology
3. Understand the use of potential failure modes and effects analysis (FMEA)
4. Investigate the use of a worksheet of a mistake/error proofing activity
Content

1 Continuous improvement techniques

*Principles of continuous improvement*: continuous improvement; total company commitment; quality strategy; standard operating procedures; organisational policy and procedures

*Continuous improvement techniques*: quality improvement terms; quality circles; Kaizen; key performance indicators

2 Six sigma methodology

*Key factors*: procedures; five phases of six sigma; metric charts; critical to control characteristics

3 Potential failure modes and effects analysis (FMEA)

*Areas for analysis*: eg concept, product, design, process, system, machine

*Activities to be analysed*: failure modes; effects from failure modes; causes of failure modes

4 Mistake/error proofing activity

*Benefits*: improved quality; reduced costs; delivery

*Content of worksheet*: description of the mistake/error identified; containment action plan; root cause of the mistake/error; corrective action to be taken

*Suitable solutions*: effectiveness; cost; complexity
## Outcomes and assessment criteria

To achieve each outcome a learner must demonstrate the ability to:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment criteria for pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Investigate continuous improvement techniques</td>
<td>• identify potential areas for improvements within a working area or activity&lt;br&gt;• produce standard operating procedures for a working area or activity.&lt;br&gt;• identify and calculate key performance indicators.</td>
</tr>
<tr>
<td>2 Examine the key factors of six sigma methodology</td>
<td>• explain the key factors of six sigma methodology&lt;br&gt;• produce a metric chart for a six sigma project&lt;br&gt;• identify the critical to quality characteristic of a six sigma project.</td>
</tr>
<tr>
<td>3 Understand the use of potential failure modes and effects analysis (FMEA)</td>
<td>• carry out a potential failure modes and effects analysis&lt;br&gt;• describe activities to be analysed.</td>
</tr>
<tr>
<td>4 Investigate the use of a worksheet of a mistake/error proofing activity</td>
<td>• create a worksheet of a mistake/error proofing activity&lt;br&gt;• identify suitable solutions and describe how benefits are gained.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

This unit has been written in terms of general outcomes and should be delivered in the context of the discipline being studied. It may be used as a free-standing unit or integrated with general business management units. The use of pre-prepared examples is to be encouraged with groups of learners participating in a case study workshop approach based on actual or simulated data.

The concept of quality and business improvement management techniques to all aspects of a company’s organisation should be stressed throughout the delivery of this unit.

Assessment

Evidence may be generated from assignments or projects, accounts of practical activities, industrial visits or, where applicable, applied examples. Evidence should be accumulated in a portfolio containing a mix of assessment material.

Links

This unit has links with Unit 1: Business Management Techniques, Unit 5: Project and Unit 25: Quality Assurance and Management.

Resources

Centres should aim to provide simulated or actual examples for the application of methods used to install, monitor and improve the quality of both products and their associated processes. The use of appropriate software packages should be encouraged in the processing of data.

Industrial liaison could provide access to an alternative resource facility.

Support materials

Textbooks


Wild R — Essentials of Production and Operation Management (Continuum, 1998)
ISBN: 0304704032
Unit 36: Further Business Improvement Techniques

Learning hours: 60
NQF level 4: BTEC Higher Nationals — H2

Description of unit

The aim of this unit is to provide knowledge of some of the principles, methodologies and techniques that are used in a range of business improvement activities. Those covered by this unit can be applied in a variety of manufacturing situations.

The learner will be able to apply the principles of lead-time analysis by using a range of processes associated with this. They will also be able to use techniques to reduce set-up times for a particular application and present this improvement as a standard operating procedure. Learners will be able to describe the techniques employed in Total Productive Maintenance (TPM) and explain the benefits. They will also be able to investigate and discover where the use of Optimised Production Technology (OPT) is useful to make whole factory or whole unit improvements.

Summary of learning outcomes

To achieve this unit a learner must:

1. Apply the principles and processes of Lead Time Analysis
2. Investigate the techniques used in Set up Reduction and prepare an improved standard operating procedure
3. Describe the use of Total Productive Maintenance (TPM) techniques
4. Investigate the use of Optimised Production Technology (OPT).
Content

1 Principles and processes of Lead Time Analysis

Lead time analysis: lead-time profiles; representative parts or processes; improvements to profiles; planning improvements; problem solving and route cause analysis (eg Ishikawa diagram, fishbone diagram, cause and effect diagram with addition of cards (CEDAC))

Principles and processes: objectives and targets for reduction in lead-time; identifying lead-time profiles with problems; improvement opportunities (eg supply or delivery of parts, improved work flow, improved quality, flexibility of people, launch of material, inventory balance); determination of waste; frequency diagrams; identifying bottlenecks or constraints within lead-time profiles

2 Techniques used in Set up Reduction and standard operating procedure

Techniques: evaluating improvement ideas; distinguishing between internal and external activities with reference set-up; route cause analysis; principles and application of the 5 whys

Standard operating procedure: all of the new steps and time required for each step; differentiation between internal and external steps; standard equipment and it’s location (eg cutting tools, clamps, inspection equipment); information required for a quick set-up and it’s location (eg CNC programmes, drawings, manufacturing instructions)

3 Total Productive Maintenance (TPM) techniques

Techniques: obtaining information; how to select a resource (eg plant, equipment, machines, office equipment, services equipment, utilities); seven steps of autonomous and planned maintenance; overall equipment effectiveness; standard operating procedures

Scope of TPM: resources (eg plant, equipment, machines, office equipment, services equipment, utilities); chronic and sporadic loss; benefits of TPM

4 Optimised Production Technology (OPT)

Aims of Optimised Production Technology (OPT): increasing plant throughput; decreasing inventory; decreasing operating expenses

Principles of Optimised Production Technology (OPT): balancing flow (not capacity); determination of non-bottleneck utilisation; critical and non-critical resources; activation of resources; throughput and inventory governed by bottlenecks; transfer batch

Supporting tools: throughput accounting

Supporting tools measures: contribution per factory or unit hour; total factory or unit cost per hour; return per factory or unit hour
## Outcomes and assessment criteria

### Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>To achieve each outcome a learner must demonstrate the ability to:</strong></td>
<td></td>
</tr>
<tr>
<td>1  Apply the principles and processes of Lead Time Analysis</td>
<td>• gather information and create lead-time profiles</td>
</tr>
<tr>
<td></td>
<td>• produce a frequency diagram listing the major bottlenecks or constraints as identified by lead-time profiles</td>
</tr>
<tr>
<td></td>
<td>• use a cause and effect diagram to identify improvement opportunities and determine waste.</td>
</tr>
<tr>
<td>2  Investigate the techniques used in Set up Reduction and prepare an improved standard operating procedure</td>
<td>• carry out a set-up reduction activity on a chosen machine, or process using the appropriate techniques</td>
</tr>
<tr>
<td></td>
<td>• produce Standard Operating Procedures for a new set-up.</td>
</tr>
<tr>
<td>3  Describe the use of Total Productive Maintenance (TPM) techniques</td>
<td>• describe a range of techniques used in TPM</td>
</tr>
<tr>
<td></td>
<td>• identify the countermeasures for chronic and sporadic loss and explain the benefits of TPM.</td>
</tr>
<tr>
<td>4  Investigate the use of Optimised Production Technology (OPT)</td>
<td>• describe the importance of the principles of OPT to the aims of OPT</td>
</tr>
<tr>
<td></td>
<td>• use throughput accounting to measure the performance of a factory or unit</td>
</tr>
<tr>
<td></td>
<td>• make recommendations for improvements to meet the aims of OPT.</td>
</tr>
</tbody>
</table>
Guidance

Delivery

Learning and assessment can be at unit level or at outcome level, but centres should be aware that study and assessment at outcome level can lead to an assessment overload.

A practical approach to learning should be adopted throughout, with tutors providing relevant industrial examples of the application of theory in practice. An investigative approach should be applied in order to give learners opportunities to provide evidence for distinctive performance.

Visits to industrial installations will be of value to supplement learning activities.

Assessment

Evidence of outcomes may be in the form of assignments, solutions to applied problems or completed tests. Assignments may be undertaken individually or as part of a wide-ranging group exercise although individual evidence against the assessment criteria is required. Evidence should be provided at unit level in order to reflect the links between the respective outcomes.

Links

This unit is designed to stand alone but has links with Unit 35: Quality and Business Improvement.

Resources

Ideally, centres should establish a library of material which will simulate a range of different applications associated with lead-time analysis and set-up reduction techniques. Case study material would be very useful for investigating the use of Optimised Production Technology (OPT). To enable the accounting measures to be calculated and used financial and other performance data is required for a range of applications. Both manual records and relevant computer software of industrial standards should be available to enable realistic project and assignment work to be undertaken. Computer software is particularly useful when dealing with Optimised Production Technology (OPT).

Liaison with industry should be encouraged in order to develop a valuable, relevant and alternative resource facility.

Support materials

Textbooks


Journals

Journal of the Institution of Electrical Engineers (IEE) — Manufacturing Engineer
Annex A

Qualification codes

Each qualification title, or suite of qualification titles with endorsements, is allocated two codes, as are the individual units within a qualification.

QCA codes

The QCA National Qualifications Framework (NQF) code is known as a Qualification Accreditation Number (QAN). Each unit within a qualification will also have a QCA NQF unit code.

The QCA qualification and unit codes will appear on the learner’s final certification documentation.

The QANs for qualifications in this publication are:

100/3584/9 Edexcel Level 4 BTEC Higher National Certificate in Aerospace Engineering
100/3583/7 Edexcel Level 4 BTEC Higher National Diploma in Aerospace Engineering

Edexcel codes

The Edexcel codes enable approval, registration, assessment and certification, they will appear on documentation such as the Student Report Form (SRF) and the programme definition. The Edexcel codes are not provided in this publication. The Edexcel codes will link automatically to the QCA codes for certification purposes.

QCA and Edexcel codes

All QCA and Edexcel qualification and unit codes will be published in a booklet, which will be made available on the Edexcel website. It will provide a comprehensive catalogue of all the qualifications and units available to centres. It will be useful for centres when making future decisions about centre choice units.
Annex B

Engineering Council (UK) – Extract from New Standards for Registration

A Draft Specification for Standards for Registration as a Professional Engineer

1 The document sets out the proposed basis for standards of competence and commitment to be demonstrated by anyone who wishes to be registered by the Engineering Council (UK) as a professional engineer. A separate document sets out the proposed standards for registration as a professional Engineering Technician. The documents also briefly describe the process of education, training and development (known collectively as formation) likely to be required to attain the necessary standards.

Registration irrespective of route

2 Registration as a professional engineer or technician is open to everyone who can demonstrate the competence to perform professional work to the necessary standards, and a commitment to:
   a maintain that competence;
   b work within professional codes, and;
   c participate actively within the profession.

Two categories of Professional Engineer

3 Careful consideration has been given to the number of registration categories, their nomenclature, and the relationship between them. The present categories, and titles, of Chartered Engineer (CEng) and Incorporated Engineer (IEng) will be retained. Although there have been some difficulties in securing for Incorporated Engineer the same degree of recognition which the Chartered Engineer title has secured, there is good evidence that, in the majority of industries, the two categories are recognised and the differences between them are understood. They will also continue to be described by competence statements associated with mature professionals. While it is important that everything is done to ensure that those who are competent to be registered at an early age are able to register, this is best secured by other means than a manipulation of registration categories. Incorporated Engineer registration will not therefore be defined in terms which make it a staging post en route to Chartered Engineer. It is important, however, that there are clear means for those who wish to do so to move from one registration category to another, and these will be developed.

4 The role of the Chartered Engineer may be stated as:

Chartered engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change. They may develop and apply new technologies, promote advanced designs and design methods, introduce new and more efficient production techniques and marketing and construction concepts, and pioneer new engineering services and management methods.
The role of the Incorporated Engineer may be stated as:

**Incorporated engineers** act as exponents of today’s technology and, to this end, they maintain and manage applications of current and developing technology. They require a detailed understanding of a recognised field of technology so they can exercise independent professional technical judgement and management in that field.

The present detailed generic competence standards for Chartered Engineer and Incorporated Engineer registration are set out at the end of this document. These have widespread support and it is proposed that they are used as the basis for future standards, but are reviewed fully, including against the latest occupational standards, to determine whether any change is necessary. Although the standards cover the whole engineering profession, the professional engineering institutions that are licensed by the Engineering Council (UK) to assess candidates for registration will contextualise them to their own disciplines or sectors of professional activity. In doing so they may make use for example of the generic Occupational Standards for Engineering maintained by the Occupational Standards Council for Engineering, and of National Occupational Standards and National or Scottish Vocational Qualifications derived from these and developed by a number of Sector Skills Councils and other relevant bodies.

Competence includes the knowledge, understanding and skills that underpin performance. It is attained through a mixture of education, training and professional development, traditionally known as the formation process for engineers. The different elements of this process are described below. Competence is ultimately assessed through a Professional Review, against specified standards.

**Educational requirements**

Educational qualifications are an indicator that the holder possesses the required level of underpinning knowledge and understanding (but other means of demonstrating this are not precluded). This document describes the exemplifying educational qualifications proposed for the two categories of registration, CEng and IEng. Candidates possessing these exemplifying qualifications will automatically be deemed to have met the educational requirements.

Where a candidate does not hold the benchmark academic qualification for CEng or IEng there will be a unified approach to assessment based on a career appraisal and technical report. The same methodology could also be used as a bridge from IEng to CEng. Work has been undertaken in Engineering Council (UK)’s Registration Standards Committee to develop this approach from a methodology which has been trialled with some success over the last 12 months. Candidates will have to submit a technical report or dissertation, based upon work done as part of their employment. They will be interviewed on this report, and the interview will provide a rigorous assessment of the candidate’s knowledge and understanding against the required output standard.

For Chartered Engineers and Incorporated Engineers respectively, part or all of the academic base will be exemplified by successful completion of a Bachelors degree programme in engineering or technology, accredited by one of the professional engineering institutions licensed by the Engineering Council (UK). One of the criteria for accreditation will be that the programme meets defined output standards. Engineering Council (UK) intends to work with the Quality Assurance Agency (QAA) and the Engineering Professors Council on the revision of the QAA’s generic benchmark statements for engineering degrees to ensure that the revised generic benchmarks can be used by the profession. These generic standards will then be developed into discipline-based outcomes by Institutions in such a way as to indicate minimally constraining core content for accredited programmes, so that accreditation does not constrain innovation and diversity.
11 For Chartered Engineers, the second part of the academic base will be exemplified by an appropriate Masters degree, undertaken either on a full- or part-time basis, which accords with the Quality Assurance Agency’s descriptor for a Masters degree. Appropriate degrees will have been accredited or approved by a licensed professional engineering institution. For Incorporated Engineers, part of the academic base may be exemplified by an appropriate BTEC HND or Foundation degree. This would need to be enhanced by further learning, for example an Edexcel Professional Development Award. The Engineering Council examinations will also offer a means for candidates for CEng and it is hoped IEng to demonstrate the required knowledge and understanding.

12 MEng degree programmes, which meet the Quality Assurance Agency’s descriptor for Masters degrees and have been accredited by a professional engineering institution, will continue to provide a fast-track route for high ability candidates to satisfy the academic requirements for Chartered Engineer. There will be defined output standards for these programmes, developed through the review of benchmarks referred to above. It will no longer be a condition of accreditation for either Bachelors or MEng programmes that a specified proportion of each entry cohort meets defined entry standard requirements. However accrediting Institutions will continue to have regard to entry standards when accrediting courses, and Engineering Council (UK) will work with Institutions and Universities to monitor entry standards nationally, and issue indicative guidance when appropriate.

13 Graduates in cognate disciplines such as physics, or geology, may satisfy the academic requirements for Chartered Engineer, either by completing an appropriate Masters degree as described in paragraph 11, or through the technical report process outlined in paragraph 9. For registration as an Incorporated Engineer, they may also need to submit a technical report.

14 The following diagram illustrates the formation process.

<table>
<thead>
<tr>
<th>Registration</th>
<th>Formation</th>
<th>Professional Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEng</td>
<td>Education</td>
<td>Professional Review</td>
</tr>
<tr>
<td></td>
<td>- MEng</td>
<td>Demonstration of competence, knowledge and understanding. For those without exemplifying qualifications, may require submission of technical report</td>
</tr>
<tr>
<td></td>
<td>- B(Hons) degree plus masters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- B(Hons) Degree plus further learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professional development</td>
<td></td>
</tr>
<tr>
<td>IEng</td>
<td>Education</td>
<td>Professional development</td>
</tr>
<tr>
<td></td>
<td>- HNC/HND/FD plus further learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Bachelors degree</td>
<td></td>
</tr>
</tbody>
</table>

15 Although some of the educational base for practice is likely to be laid before beginning full-time work as an engineer, the two elements of formation may also be undertaken concurrently, as the above diagram indicates.
Professional development

16 Professional development builds upon, and in some cases contributes to, the educational process. Initial Professional Development is necessary to acquire the competence, and demonstrate the professional commitment, necessary for registration. Continuing Professional Development ensures the development of this profile of competence in new job roles.

17 The variety of patterns of employment now prevalent mean that it is not at all appropriate to prescribe a particular model for the professional development element of formation. While many large companies do maintain graduate training schemes that are likely to provide the necessary further training and experience, many future registrants will not be working in such organisations. They will need to develop profiles of competence and professional activity to help them prepare for registration. In some cases employers will make use of occupational standards in determining job descriptions and for general staff development, even without a formal training programme, and these will assist. More generally, individuals will need access to advice and guidance. Professional institutions and Sector Skills Councils will be sources for this.

Revalidation

18 It is not proposed to introduce a requirement for regular revalidation of competence and registration. Professional commitment brings obligations to maintain competence, which in a changing world means developing and renewing knowledge, understanding and skills. There is also a commitment not to undertake work for which one is not competent. The obligation to undertake continuing professional development will therefore remain material to maintenance of registration. The guidance that has been given to the profession on this issue remains valid and will be updated as appropriate. Independently of the development of these standards, consideration will be given to introducing a voluntary system of revalidation of competence and re-registration for those desiring it.
Annex C

Engineering Applications

All engineering higher education being submitted for accreditation for IEng registration, must be provided in the context of Engineering Applications (EA). The term ‘Engineering Applications' originated in the Finniston Report *Engineering Our Future* in 1980. These are intended for integration into higher education courses to give structure and definition to the application of engineering. They aim to achieve some of the benefits of integrated sandwich courses where such courses are not available.

There are two components: Engineering Applications 1 (EA1) and Engineering Applications 2 (EA2).

EA1 — an introduction to the fabrication and use of materials, designed to raise learners’ awareness of the realities of present-day industrial processes. This focuses on practical engineering in the context of design, manufacture, construction, assembly, commissioning, operation, maintenance, reliability and quality of products and systems.

EA2 — the application of engineering principles to the solution of practical problems-based upon engineering systems and processes. This should ideally be a learning theme which runs through all aspects of the course. However, it will be particularly evident in projects relating to real engineering problems, undertaken both individually and in groups, which integrate practical, theoretical, business and personal development skills and knowledge.

The extent to which a cohort of learners needs to be formally introduced to EA will vary with their educational, personal and industrial background. Part-time and integrated sandwich course learners, and those with other accredited work-based learning, will have opportunities to develop EA at work. Nevertheless, all learners should be aware of the broader educational potential of their own experiences and skills.

There is no clear boundary between EA1 and EA2 and, because many aspects of both can be integrated in the content of programmes, there is every reason not to introduce one.

As new technologies and materials are introduced, engineers need multidisciplinary skills, and the way you implement EA1 and EA2 should reflect this. You should, wherever possible, choose engineering applications that relate to each learner’s chosen discipline: for example, for ‘electronic’ technician engineers, workshop methods involving hand tools and materials processing should probably be related to the electronics industry’s manufacturing methods.

EA1 can be done at work or in the centre. In full-time and sandwich (ie HND) programmes, activity for EA1 should take about 300 hours. In a well-designed and implemented course, up to 200 hours of this could be identifiable within programme units. In part-time (HNC and HND) programmes, learners can provide evidence of objectives that they have met at work and through a log book signed by a responsible supervisor.
Guidance for Interpretation of Engineering Applications

EA1

To achieve EA1 the learner should:

1 Use safe working practices, and understand the reason for them.
   Safety in line with good industrial practice and current legislation and regulations, must be a theme throughout the course.

2 Appreciate multidisciplinary practical skills through the use of industrial equipment and processes.
   As manufacturing systems and products become more complex, technician engineers will need a wide range of technological skills. An increasingly necessary requirement is for the integration of skills from mechanical engineering, electronic engineering and computing. Activities must therefore reflect the general convergence of traditionally separate disciplines.

   The following should be covered, though the depth of cover and the illustrative material required will vary according to the needs of learners and industry:
   - hand tools
   - material removal
   - material forming
   - measurement
   - installation, maintenance and fault-finding
   - electrical installation and wiring
   - electrical circuitry and printed circuits and components
   - pneumatic and hydraulic circuitry and components.

3 Select and use appropriate computer software packages.

   Learners should develop the ability to operate a computer keyboard and use a range of software packages. They should have an awareness of:
   - obligations under the Data Protection Act
   - the need for system security
   - use of software documentation
   - understanding basic software tools
   - interconnection of appropriate microcomputer and peripheral devices.

4 Interpret engineering drawings and circuit diagrams.

   Activities should be designed according to the needs and aims of the learner. Some exercises should also make use of the knowledge and skills in paragraph 2, above, that relate to interpreting engineering drawings and circuit diagrams.

5 Be aware of developing technologies and appropriate techniques in areas such as:
   - microprocessors
   - programmable logic controllers
   - computer-aided design
   - numerical robotics
   - systems approach to manufacture.
EA2

To achieve EA2 the learner should:

1. Appreciate the uses and limitations of engineering materials and components
2. Appreciate the cost factors relating to the design, manufacture and servicing of a product
3. Appreciate the importance of a logical approach to engineering activities
4. Work in a team.

Some EA2 objectives can be met through assignments and other studies in appropriate design, manufacturing technology, materials and industrial management units or subjects. Others can be met through integrative assignments or projects.

An appropriate approach might be to use case studies involving the design and manufacture of engineering components and systems. This would enable learners to consider design, selection of materials and components, manufacturing methods, and cost factors in the manufacturing and servicing of products. The case studies would also develop learners’ awareness of problems associated with a logical approach to efficient production, and awareness of the importance of effective maintenance schedules. In addition case studies could help develop learners’ abilities to work as part of a team.
Annex D

Overall structure of OSCEng Higher Level Standards: Functional Map (V 2)

1. Develop engineering products and processes
   1.1 Establish requirements for engineering products and processes
   1.2 Initiate and specify research into engineering products or processes
   1.3 Implement research into engineering products or processes
   1.4 Design engineering products or processes
   2. Produce engineering products or processes
      2.1 Specify the production requirements of engineering products or processes
      2.2 Implement the production of engineering products or processes
      2.3 Evaluate the production of engineering products or processes
   3. Install engineering products and processes
      3.1 Specify the installation requirements of engineering products or processes
      3.2 Implement the installation of engineering products or processes
      3.3 Evaluate the installation of engineering products or processes
      3.4 Commission engineering products or processes after installation
   4. Operate engineering products and processes
      4.1 Specify the operational requirements for engineering products or processes
      4.2 Implement the operation of engineering products or processes
      4.3 Evaluate the operation of engineering products or processes
      4.4 Decommission engineering products or processes
   5. Maintain engineering products and processes
      5.1 Specify the maintenance requirements for engineering products or processes
      5.2 Implement the maintenance of engineering products or processes
      5.3 Evaluate the maintenance of engineering products or processes
   6. Improve the safety and quality of engineering products and processes
      6.1 Assess and minimise risks from engineering products or processes
      6.2 Improve the quality of engineering products or processes
   7. Plan, implement and manage engineering projects
      7.1 Plan engineering projects
      7.2 Implement and manage engineering projects
   8. Develop own engineering competence
      8.1 Improve own ability to undertake engineering activities

Key purpose: To develop and deliver engineering products and processes
## Illustration of possible links between HN Aerospace Engineering units and Higher Level OSCEng standards (Version 2)

<p>| BTEC Higher National unit                  | OSCEng Standards | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 3.4 | 4.1 | 4.2 | 4.3 | 4.4 | 5.1 | 5.2 | 5.3 | 6.1 | 6.2 | 7.1 | 7.2 | 8.1 |
|--------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Business Management Techniques            |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Analytical Methods for Engineers           |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Engineering Science                        |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Aircraft Systems Principles                |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Project                                    |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Engineering Design                         |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Measurement and Testing                    |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Health and Safety and Risk                 |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Electrical, Electronic and Digital Principles |              |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Microprocessor Systems                      |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Mechanical Principles                      |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Materials Engineering                       |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Engineering Thermodynamics                 |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Quality Assurance and Management            |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Further Analytical Methods for Engineers    |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Manufacturing Process                      |                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |</p>
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Annex E

Qualification Requirement

Edexcel Level 4 BTEC Higher Nationals in Aerospace Engineering

This qualification requirement will be read in conjunction with overarching guidance from Edexcel.

Rationale

BTEC Higher Nationals using the title Aerospace Engineering should be developed to focus on:

- the education and training of aerospace engineers/technicians who are employed in a variety of types of technical work, such as aerospace systems design, manufacture, maintenance and technical services areas of the aerospace industry
- providing opportunities for aerospace engineers/technicians to achieve a nationally recognised level four vocationally specific qualification
- providing opportunities for full-time learners to enter employment as an engineer/technician or progress to higher education vocational qualifications such as a full-time degree in aerospace engineering fields of electronics, mechanical, mechatronics or related area
- providing opportunities for learners to focus on the development of the higher level skills in a technological and management context
- providing opportunities for learners to develop a range of skills, techniques and attributes essential for successful performance in working life.

Aims of the qualification

Qualifications in Aerospace Engineering meet the needs of the above rationale by:

- developing a range of skills and techniques, personal qualities and attributes essential for successful performance in working life and thereby enabling learners to make an immediate contribution to employment
- preparing learners for a range of technical and management careers in aerospace engineering
- equipping individuals with knowledge, understanding and skills for success in employment in the aerospace engineering industry
- providing specialist studies relevant to individual vocations and professions in which learners are working or intend to seek employment in aerospace engineering and its related industries
- enabling progression to an undergraduate degree or further professional qualification in aerospace engineering or related area
- giving opportunities for learners to develop and practice skills, knowledge and understanding required for category B staff under JAR-66 aircraft maintenance licence of the Civil Aviation Authorities (CAA) requirements
Mandatory curriculum

The mandatory curriculum will give learners the opportunity to build on previous attainment while allowing them to progress and study a selection of optional curriculum. It will display the following features:

- a knowledge and use of essential scientific principles to produce routine solutions to familiar aerospace engineering problems and using this knowledge to model and analyse routine aerospace engineering systems, processes and products
- major scientific principles which underpin the design and operation of static and dynamic engineering systems and provide an overview as the basis for further study in specialist areas of aerospace engineering
- an extended range of principles for more advanced study and which underpin the design and operation of aerospace engineering systems in planning and scheduling
- use of skills and knowledge developed during the course to select a project and agree specifications, implement and evaluate the project and present the project evaluation
- obtaining accurate information on the requirements for an individual or group engineering project
- project work that is of a technical nature and supportive of engineering orientation of the Aerospace Engineering Higher National programme, in particular integrated exercises involving a technical investigation, which incorporates a financial appreciation
- knowledge of the calculation of costs associated with engineered products and services
- fundamental analytical knowledge and techniques used for analysis, modelling and solution of realistic engineering problems within aerospace engineering
- a knowledge of routine mathematical methods essential to aerospace engineering including an awareness of the functionality of standard methods
- opportunity to experience a design project through appreciation of synthesising parameters affecting design solutions
- the application of engineering principles to the design and manufacture of products, systems and services
- the experience of design modification for an existing system, component or process to meet a specified requirement
- undertaking routine practical or simulation tests of a design solution, report and comment on results
- searching for information related to aerospace engineering design solution and present it for discussion
- in producing solutions an integration of knowledge of mathematics, science, information technology, design, business context and aerospace engineering practice, to solve routine problems.
Optional curriculum

The optional curriculum will give learners the opportunity to select relevant specialism while allowing them to build on learning within the mandatory curriculum. It will display the following features:

- the experimental and analytical skills which underpin the application of aerospace principles with particular emphasis on aerodynamics and aircraft performance
- a knowledge of the principles underpinning automatic flight control systems and the principles of operating communication and navigation aircraft systems
- an overview of the operation and control of aircraft hydraulic and pneumatic systems with particular emphasis on applications of fluid mechanics, thermodynamics and heat transfer
- an understanding and use of analytical skills when ensuring continuing airworthiness of aircraft structures, analysis of failures and repair
- the basic principles of gas turbine technology when applied to aerospace engineering
- an understanding of aircraft flight instrumentation and its integration into aircraft flight deck systems
- the properties, selection, processing and use of materials
- an awareness of the principles of health and safety planning and implementation in an aerospace engineering environment
- using number systems, graphical and numerical methods, vectors, matrices and ordinary differential equations to analyse, model and solve realistic engineering problems
- the engineering principles which underpin the application of manufacturing processes applicable to the aerospace engineering industry
- a broad and in depth knowledge of a range of aerospace processes and techniques including NC/CNC and CAM which can be applied across a variety of materials and applications considering function, purpose and economic evaluation of different aerospace technologies and strategies
- application of relevant measurement, testing, quality assurance and management principles
- an extended range of electrical/electronic principles for more advanced study and which underpin the design and operation of aircraft mechatronic engineering systems
- an understanding of microprocessor-based systems and their use in instrumentation/control/communication systems
- an extended range of mechanical principles which underpin the design and operation of mechanical engineering systems including strengths of materials and mechanics of machines.
Professional Body Recognition

The Higher National qualifications in Aerospace Engineering have been developed with career progression and recognition by professional bodies in mind. Thus this development has been informed by discussions/relevant publications from the Engineering Council (UK), the Occupational Standards Council for Engineering, the Engineering Professors’ Council and the Sector Skills Council, the Science, Engineering and Manufacturing Technologies Alliance (SEMTA).

The Royal Aeronautical Society recognise that when enhanced by successful further learning, this BTEC Higher National in Aerospace Engineering satisfies the educational requirement for registration as an Incorporated Engineer under Engineering Council (UK) UK Spec regulations. Further details of professional body recognition and exemptions are available on our website.

Links to National Standards

Through the study of the core and relevant option unit’s learners will cover much of the underpinning knowledge, skills and understanding for the relevant NVQ level 4 units in Aerospace Engineering.

Entry prerequisites

The fundamental principles of Edexcel’s policy are:

- qualifications should be available to everyone who is capable of reaching the required standards
- qualifications should be free from barriers which restrict access and progression
- equal opportunities exist for all.

Nevertheless it is the responsibility of the centre to recruit with integrity. Centres should therefore:

- provide applicants with appropriate information and advice
- identify applicants’ needs
- select on the basis of each applicant’s previous qualifications and experience.

Edexcel BTEC Higher National programmes are intended primarily for those who are in, or plan to enter, employment and who have reached the minimum age of 18. Learners who enter with at least one of the following qualifications are likely to benefit more readily from the programme:

- a BTEC National Certificate or Diploma in an engineering discipline
- an Edexcel Advanced GNVQ or Vocational Certificate of Education VCE in Engineering
- a GCE Advanced level profile which demonstrates strong performance in a relevant subject or an adequate performance in more than one GCE subject. This profile is likely to be supported by GCSE grades at A* to C
Higher Level skills and abilities

Learners will be expected to develop the following skills during the programme of study:

• analysing, synthesising and summarising information critically
• the ability to read and use appropriate literature with a full and critical understanding
• the ability to think independently and solve problems
• the ability to take responsibility for their own learning and recognise their own learning style
• obtaining and integrating several lines of subject-specific evidence to formulate and test hypotheses
• applying subject knowledge and understanding to address familiar and unfamiliar problems
• recognising the moral and ethical issues of scientific enquiry and experimentation and appreciating the need for ethical standards and professional codes of conduct
• designing, planning, conducting and reporting on investigations
• use their knowledge, understanding and skills to evaluate and formulate evidence-based arguments critically and identify solutions to clearly defined problems of a general routine nature
• communicate the results of their study and other work accurately and reliably using a range of specialist techniques
• identify and address their own major learning needs within defined contexts and to undertake guided further learning in new areas
• apply their subject-related and transferable skills in contexts where the scope of the task and the criteria for decisions are generally well defined but where some personal responsibility and initiative is required.