Pearson
Higher Nationals in
Aeronautical Engineering

Specification
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Issue 4
Edexcel, BTEC and LCCI qualifications

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## Summary of changes in Pearson BTEC Higher Nationals in Aeronautical Engineering Issue 4

### Meeting local needs and centre devised units:
Corrected language on 4th paragraph on mandatory units

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1. Introduction

BTEC is one of the world's most successful and best-loved applied learning brands, and it has been engaging students in practical, interpersonal and thinking skills for more than thirty years.

BTECs are work-related qualifications for students taking their first steps into employment, or for those already in employment and seeking career development opportunities. BTECs provide progression into the workplace either directly or via study at university and are also designed to meet employers' needs. Therefore, Pearson BTEC Higher National qualifications are widely recognised by industry and higher education as the principal vocational qualification at Levels 4 and 5.

When redeveloping the Pearson BTEC Higher National qualifications in Engineering, we collaborated with a wide range of students, employers, higher education providers, colleges and subject experts, to ensure that the new qualifications meet their needs and expectations. We also worked closely with the Engineering Council guidelines for Level 3 and Level 6 and the relevant Professional Bodies, to ensure alignment with recognised professional standards and the correct level of learning.

There is now a greater emphasis on employer engagement and work readiness. The new BTEC Higher National qualifications in Engineering are designed to reflect this increasing need for high quality professional and technical education pathways at Levels 4 and 5. These qualifications provide students with a clear pathway to employment, appropriate support during employment and a recognised progression route to gain the further learning required at Level 6 to achieve Incorporated Engineer (IEng) registration or to the final stages of a degree.

1.1 The Student Voice

Students are at the heart of what we do. That is why, from the outset, we consulted with students in the development of these qualifications. We involved them in writing groups, sought their feedback, and added their voices and views to those of other stakeholders.

The result, we believe, are qualifications that will meet the needs and expectations of students worldwide.

1.2 Why choose Pearson BTEC Higher Nationals?

Pearson BTEC Higher Nationals are designed to help students secure the knowledge skills and behaviours needed to succeed in the workplace. They represent the latest in professional standards and provide opportunities for students to develop behaviours for work, for example by undertaking a group project, or responding to a client brief. A student may even achieve exemption from professional or vendor qualifications, or student membership of selected professional bodies, to help them on their journey to professional competence.

At the same time the BTEC Higher Nationals are intended to keep doors open for future study should a student wish to progress further in their education after their level 5 study. They do this by allowing space for the development of higher education study skills, such as the ability to research. Clear alignment of level of demand with the Framework for Higher Education qualification descriptors at level 4 and 5 means that students wishing to progress to level 6 study should feel better prepared. The Pearson BTEC Higher Nationals address these various requirements by providing:
• A range of core, optional and specialist units, each with a clear purpose, so there is something to suit each student’s choice of programme and future progression plans.

• Fully revised content that is closely aligned with the needs of employers, professional bodies, vendors and higher education for a skilled future workforce.

• The opportunity to develop transferable skills useful for work and for higher education, including research skills, the ability to meet deadlines and communication skills.

• Learning Outcomes mapped against Professional Body standards and vendor accreditation requirements, where appropriate.

• Assessments and projects chosen to help students progress to the next stage (this means some are set by the centre to meet local needs, while others are set by Pearson). Students are required to apply their knowledge to a variety of assignments and activities, with a focus on the holistic development of practical, interpersonal and higher level thinking skills.

• An approach to demand at level 4 and 5 which is aligned with the Framework for Higher Education Qualifications (FHEQ).

• Support for student and tutors including Schemes of Work and Example Assessment Briefs.

1.3 HN Global

Pearson BTEC Higher Nationals are supported by a specially designed range of digital resources, to ensure that tutors and students have the best possible experience during their course. These are available from the HN Global website http://www.highernationals.com/.

With HN Global, tutors can access programme specifications which contain useful information on programme planning and quality assurance processes. Tutors can also view Schemes of Work and Example Assessment Briefs, helping them create meaningful courses and assessments. HN Global also allows tutors to create and annotate reading lists for their students and also keep up-to-date on the latest news regarding HN programmes.

1.4 Qualification titles

• Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering

• Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering

1.5 Qualification codes

Regulated Qualifications Framework (RQF) Qualification number:

• Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering: 603/0485/6

• Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering: 603/0484/4
1.6 Awarding organisation
Pearson Education Ltd

1.7 Key features
Pearson BTEC Higher National qualifications in Aeronautical Engineering offer:

- A stimulating and challenging programme of study that will be both engaging and memorable for students.
- The essential subject knowledge that students need to progress successfully within or into the world of work or onto further study.
- A simplified structure: students undertake a substantial core of learning, required by all engineers, with limited specialism in the Higher National Certificate, building on this in the Higher National Diploma, with further specialist and optional units linked to their specialist area of study.
- Refreshed content that is closely aligned with employer, professional body and higher education needs.
- Assessments that consider cognitive skills (what students know) along with affective and applied skills (respectively how they behave and what they can do).
- Unit-specific grading and Pearson-set assignments.
- A varied approach to assessment that supports progression to Level 6 and also allows centres to offer assessment relevant to the local economy, thereby accommodating and enhancing different learning styles.
- Quality assurance measures – as outlined in sections 6 and 7 of this Programme Specification – to ensure that all stakeholders (e.g. professional bodies, universities, businesses, colleges and students) can feel confident in the integrity and value of the qualifications.
- A qualification designed to meet the needs and expectations of students aspiring to work in an international setting.

Qualification frameworks
Pearson BTEC Higher National qualifications are designated higher education qualifications in the UK. They are aligned to the Framework for Higher Education Qualifications (FHEQ) in England, Wales and Northern Ireland, and Quality Assurance Agency (QAA) Subject Benchmark Statements. These qualifications are part of the UK Regulated Qualifications Framework (RQF).

1.8 Collaborative development
Students completing their BTEC Higher Nationals in Aeronautical Engineering will be aiming to go on to employment or progress to a final year at university. It was therefore essential that we developed these qualifications in close collaboration with experts from professional bodies, businesses and universities, and with the providers who will be delivering the qualifications.
We are very grateful to all the university and further education tutors, employers, Professional Body representatives and other individuals who have generously shared their time and expertise to help us develop these new qualifications. Employers and professional bodies involved have included:

- Alstom
- BMW
- Eaton
- GEN 2
- Jaguar Land Rover
- Railtrack
- Siemens
- UAE Military Logistics Support
- Engineering Council
- Royal Aeronautical Society
- Royal Academy of Engineering
- SEMTA
- Society of Operations Engineers
- The Institution of Engineering and Technology
- The Institute of the Motor Industry
- NFEC (National Forum of Engineering Centres)

Higher education providers that have collaborated with us include:

- Aston University
- Birmingham Metropolitan College
- Blackpool and Fylde College
- Bridgwater College
- Brunel University
- Coventry University College
- University of Derby
- St Helens College
- Teesside University
- UCL
- Warwickshire College.
1.9 Professional Body consultation and approval

Qualifications in engineering within the UK are referenced against the engineering council, UK specifications which sets standards at Levels 3, 6 and 8.

The Pearson BTEC Higher Nationals in Aeronautical Engineering are set at Level 4 and 5 and have been written with reference to the engineering council specification for Levels 3 and 6. The content and level has been written following advice from the professional bodies listed in section 1.7 above and is intended to exempt holders of this qualification from the Level 4 and 5 requirements of these bodies and articulate with the Level 6 in engineering degree courses.

Holders of a BTEC Higher National in Aeronautical Engineering meet the academic requirements for the Engineering Council Engineering Technician Standard (EngTech).
2. Programme purpose and objectives

2.1 Purpose of the BTEC Higher Nationals in Aeronautical Engineering

The purpose of BTEC Higher Nationals in Aeronautical Engineering is to develop students as professional, self-reflecting, individuals able to meet the demands of employers in the rapidly evolving aeronautical sector and adapt to a constantly changing world. The qualifications also aim to widen access to higher education and enhance the career prospects of those who undertake them.

2.2 Objectives of the BTEC Higher Nationals in Aeronautical Engineering

The objectives of the BTEC Higher Nationals in Aeronautical Engineering are as follows:

- To provide students with the core knowledge, skills and techniques that all engineers require, irrespective of future specialism, to achieve high performance in the engineering profession.
- To build a body of specialist knowledge, skills and techniques to be successful in a range of careers in aeronautical engineering at the Associate Engineer or Operational Engineer level.
- To develop the skills necessary to fault-find and problem solve in a timely, professional manner, reflecting on their work and contributing to the development of the process and environment they operate within.
- To understand the responsibilities of the engineer within society and work with integrity, regard for cost, sustainability and the rapid rate of change experienced in world class engineering.
- To provide opportunities for students to enter, or progress in employment within the aeronautical engineering sector, or progress to higher education qualifications such as degrees and honours degree in aeronautical engineering by balancing employability skills with academic attainment.
- To provide opportunities for students to make progress towards achieving internationally recognised registration with a Professional Body regulated by the Engineering Council.
- To allow flexibility of study and to meet local or specialist needs.
We aim to meet these objectives by:

- Providing a thorough grounding in general and aeronautical engineering principles at Level 4 that supports the student through a range of specialist progression options at Level 5 relating to individual professions within the aeronautical engineering sector.
- Equipping individuals with the essential qualities of an engineer, including integrity, regard for cost and sustainability, as they apply to a range of roles and responsibilities within the aeronautical sector.
- Enabling progression to a university degree by supporting the development of academic study skills and the selection of appropriate units for study at Level 5.
- Enabling progression to further professional qualifications in aeronautical engineering disciplines by mapping the units studied to the requirements of the professional bodies applicable to that discipline.
- Supporting a range of study modes and timeframes for completion of the qualifications.

Who is this qualification for?

The BTEC Higher National qualifications in Aeronautical Engineering are aimed at students wanting to continue their education through applied learning. Higher Nationals provide a wide-ranging study of the aeronautical sector and are designed for students who wish to pursue a career in aeronautical engineering. In addition to the skills, knowledge and techniques that underpin the study of the sector, Pearson BTEC Higher Nationals in Aeronautical Engineering give students experience of the breadth and depth of the sector that will prepare them for employment, progression within employment or further study.

2.3 Aims of the Level 4 Higher National Certificate in Aeronautical Engineering

The Level 4 Higher National Certificate in Aeronautical Engineering offers students a broad introduction to the subject area via a mandatory core of learning, while allowing for the acquisition of some sector-specific skills and experience through the specialist units, with the opportunity to pursue a particular interest through the appropriate selection of optional units. This effectively builds underpinning core skills while preparing the student for more intense subject specialisation at Level 5. Students will gain a wide range of sector knowledge tied to practical skills gained in research, self-study, directed study and workplace activities.

At Level 4 students develop a broad knowledge and awareness of key aspects of the engineering sector through four core units, including one unit assessed by a Pearson-set assignment. The core units are:

- Unit 1: Engineering Design
- Unit 2: Engineering Mathematics
- Unit 3: Engineering Science
- Unit 4: Managing a Professional Engineering Project*

*Unit 4: Managing a Professional Engineering Project is also the Pearson-set assignment unit.

Aeronautical engineering students study the four mandatory core units, one specialist units and an additional three optional units.
Graduates successfully completing the Higher National Certificate will be able to demonstrate a sound knowledge of the basic concepts of engineering and the nature of the underpinning concepts of aeronautical engineering. They will be able to communicate accurately and appropriately and they will have the qualities of personal responsibility needed for employment. They will have developed a range of transferable skills to ensure effective team working, independent working with growing fault-finding and problem-solving strategies, and organisational awareness. They will be adaptable and flexible in their approach to work, showing resilience under pressure and the ability to meet challenging targets within a reasonable, pre-set, timeframe. They will also demonstrate regard for the ethical responsibilities of the engineer, for cost and for the importance of protecting and sustaining the environment.

### 2.4 Aims of the Level 5 Higher National Diploma in Aeronautical Engineering

The Level 5 Higher National Diploma in Aeronautical Engineering offers students a pathway designed to support progression into relevant occupational areas or onto degree-level study. This pathway is linked to Professional Body standards (where appropriate) and can provide progression towards professional status or entry to the later stages of an appropriate degree.

Holders of the Level 5 Higher National Diploma will have developed a sound understanding of the principles in their field of study, and will have learned to apply those principles more widely. Through this they will have learned to evaluate the appropriateness of different approaches to solving problems. They will be able to perform effectively in their chosen field and will have the qualities necessary for employment in situations requiring the exercise of personal responsibility and decision-making.

At Level 5 students continue to build on the essential skills, knowledge and techniques necessary for all engineers whilst working through a larger number of subject-specific specialist and optional units. The two mandatory core units at Level 5 are:

- **34: Research Project**
- **35: Professional Engineering Management.** (Unit 35: Professional Engineering Management is also the Pearson-set assignment unit)

Aeronautical engineering students study the two mandatory core units, two specialist units and an additional three optional units.

(See section 4.2 for a full list of the mandatory core, specialist and optional units for each pathway.)

### 2.5 What could these qualifications lead to?

The Level 4 Higher National Certificate provides a solid grounding in engineering, which students can build on should they decide to continue their studies beyond the Certificate stage. The Level 5 Higher National Diploma allows students to specialise by committing to specific career paths and progression routes to degree-level study.
On successful completion of the Level 5 Higher National Diploma, students can develop their careers in the engineering sector through:

- Entering employment
- Continuing existing employment
- Linking with the appropriate Professional Body
- Linking with the appropriate vendor accredited certificates [if appropriate]
- Committing to Continuing Professional Development (CPD)
- Progressing to university.

The Level 5 Higher National Diploma is recognised by Higher Education providers as meeting admission requirements to many relevant aeronautical engineering degree programmes in subject specialisms such as aerospace engineering.

Students should always check the entry requirements for degree programmes at specific Higher Education providers. After completing a BTEC Higher National Certificate or Diploma, students can also progress directly into employment.

The skills offered as part of the Pearson BTEC Higher National Diploma can provide graduates with the opportunity to work in many different areas of the engineering. Overleaf are some examples of job roles each qualification could lead to.

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<th>Pathway</th>
<th>Typical Job Roles after HNC</th>
<th>Typical Job Roles after HND</th>
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</table>
| Aeronautical Engineering | Aerospace Engineering Technician  
                          | Aircraft Flight Control Systems Technician           | Aerospace Engineer  
                          | Flight Control Systems Engineer                      |

2.6 Use of maths and English within the curriculum

Those working within the engineering sector cannot just rely on their technical skills and must ensure they develop all relevant employability skills to increase employment opportunities. They will be required to communicate appropriately with stakeholders throughout their career and the ability to use maths and English in a professional context is an essential employability skill that must be developed at all levels of study.

Development of essential maths and English skills are embedded throughout these qualifications in accordance with industry requirements and below are some examples of how these skills are developed in the BTEC Higher Nationals Curriculum:

- Written reports
- Formal presentations
- Informal conversations
- Use of professional, sector specific language
- Algebraic, logarithmic and circular functions
● Use of analytical and computational methods to evaluate and solve engineering problems

● Use of integral calculus to solve practical problems relating to engineering.

Some aspects of engineering require high level maths skills and we strongly recommend all students complete diagnostic maths assessments, as well as having an A* to C grade and/or 9 to 4 in GCSE Maths prior to starting the course (see section 3.2 Entry requirements and admissions).

Throughout the programme, students will be using some level of maths within the curriculum. It is vital that all students taking a BTEC Higher National in Engineering are aware that these skills will be required throughout their studies, and as part of learning activities and assessments to ensure their skills are in line with current industry standards.

2.7 How Higher Nationals in Aeronautical Engineering provide both transferable employability skills and academic study skills

Students need both good qualifications and employability skills to enhance their career prospects and personal development. Pearson Higher National aeronautical engineering qualifications embed throughout the programme the development of key skills, attributes and strengths required by 21st century employers.

Where employability skills are referred to in this specification, this generally refers to skills in three main categories:

● **Cognitive and problem-solving skills**: critical thinking, approaching non-routine problems by applying expert and creative solutions, use of systems and digital technology, generating and communicating ideas creatively.

● **Intra-personal skills**: self-management, adaptability and resilience, self-monitoring and self-development, self-analysis and reflection, planning and prioritising.

● **Interpersonal skills**: effective communication and articulation of information, working collaboratively, negotiating and influencing and self-presentation.

Pearson Example Assessment Briefs make recommendations for a range of real or simulated assessment activities, for example group work where appropriate, to encourage development of collaborative and interpersonal skills or a solution focused case study to provide opportunity to develop cognitive skills. There are specific requirements for the assessment of these skills, as relevant, within the assessment grids for each unit. Example Assessment Briefs are for guidance and support only and must be customised and amended according to localised needs and requirements. All assignments must still be moderated as per the internal verification process.

Students can also benefit from opportunities for deeper learning, where they are able to make connections between units and select areas of interest for detailed study.
In this way, BTEC Higher Nationals provide a vocational context in which students can develop the knowledge and academic study skills required for particular degree courses and progression to university, including:

- Active research skills
- Effective writing skills
- Analytical skills
- Critical thinking
- Creative problem-solving
- Decision-making
- Team building
- Exam preparation skills
- Digital literacy
- Practical design and build skills
- Experimental and testing techniques
- Competence in assessment methods used in higher education.

To support you in developing these skills in your students, we have developed a map of higher education relevant transferable and academic study skills, available in Appendix 3.
3. Planning your programme

3.1 Delivering the Higher National Qualifications

You play a central role in helping your students to choose the right BTEC Higher National qualification

Assess your students very carefully to ensure that they take the right qualification and the right pathways or optional units, to allow them to progress to the next stage. You should check the qualification structures and unit combinations carefully when advising students.

You will need to ensure that your students have access to a full range of information, advice and guidance in order to support them in making the necessary qualification and unit choices. When students are recruited, you need to give them accurate information on the title and focus of the qualification for which they are studying.

3.2 Entry requirements and admissions

Although Pearson do not specify formal entry requirements, as a centre it is your responsibility to ensure that the students you recruit have a reasonable expectation of success on the programme.

For students who have recently been in education, the entry profile is likely to include one of the following:

- A* to C and/or 9 to 4 (or equivalent) grade in GCSE Maths is strongly recommended
- A BTEC Level 3 qualification in Engineering
- A GCE Advanced Level profile that demonstrates strong performance in a relevant subject or adequate performance in more than one GCE subject. This profile is likely to be supported by GCSE grades at A* to C and/or 9 to 4 (or equivalent)
- Other related Level 3 qualifications
- An Access to Higher Education Certificate awarded by an approved further education institution
- Related work experience
- An international equivalent of the above.

Centres may wish to consider applicants’ prior learning when considering their acceptance on a BTEC Higher Nationals, through Recognition of Prior Learning. (For further information please refer to section 8 of this document.)

English language requirements

Pearson's mission is to help people make more of their lives through learning. In order for students to be successful on Pearson BTEC Higher National qualifications which are both taught and assessed in English, it is critical that they have an appropriate level of English language skills.

The following clarifies the requirements for all centres when recruiting applicants on to new Pearson BTEC Higher National qualifications.
All centres delivering the new Pearson BTEC Higher National qualifications must ensure that all students who are non-native English speakers and who have not undertaken their final two years of schooling in English, can demonstrate capability in English at a standard equivalent to the levels identified below, before being recruited to the programme where the programme is both taught and assessed in English:

- Common European Framework of Reference (CEFR) level B2
- PTE 51
- IELTS 5.5; Reading and Writing must be at 5.5 or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

The following clarifies the requirements for all centres when recruiting applicants on to new Pearson BTEC Higher National qualifications which are taught in a language other than English, but are assessed in English.

All centres delivering the new Pearson BTEC Higher National qualifications wholly or partially in a language other than English, but who are assessed in English, must ensure that all students can demonstrate capability in English at a standard equivalent to the levels identified below, on completion of the programme:

- Common European Framework of Reference (CEFR) level B2
- PTE 51
- IELTS 5.5; Reading and Writing must be at 5.5 or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

**Centre approval**

To ensure that centres are ready to assess students and that we can provide the support that is needed all centres must be approved before they can offer these qualifications. For more information about becoming a centre and seeking approval to run our qualifications please visit the support section on our website (http://qualifications.pearson.com/).

**Level of sector knowledge required**

We do not set any requirements for tutors, but we do recommend that centres assess the overall skills and knowledge of the teaching team, which should be relevant, up to date and at the appropriate level.

**Resources required**

As part of your centre approval, you will need to show that the necessary material resources and work spaces are available to deliver BTEC Higher Nationals. For some units, specific resources are required, this is clearly indicated in the unit descriptors.

**HN Global support**

HN Global is an online resource that supports centre planning and delivery of BTEC Higher Nationals by providing appropriate teaching and learning resources. For further information see sections 5 and 6 of this Programme Specification.
Modes of delivery

Subject to approval by Pearson, centres are free to deliver BTEC Higher Nationals using modes of delivery that meet the needs of their students. We recommend making use of a wide variety of modes, including:

- Full-time
- Part-time
- Blended learning
- Distance learning.

Recommendations for employer engagement

BTEC Higher Nationals are vocational qualifications and as an approved centre you are encouraged to work with employers on the design, delivery and assessment of the course. This will ensure that students enjoy a programme of study that is engaging and relevant, and which equips them for progression. There are suggestions in section 5.2 about how employers could become involved in delivery and/or assessment, but these are not intended to be exhaustive and there will be other possibilities at a local level.

Support from Pearson

We provide a range of support materials, including Schemes of Work and Example Assessment Briefs, with supporting templates. You will be allocated an External Examiners early in the planning stage, to support you with planning your assessments, and there will be training events and support from our Subject Leads.

Student employability

All BTEC Higher Nationals have been designed and developed with consideration of National Occupational Standards, where relevant, and have been mapped to relevant Professional Body standards. Employability skills such as team working and entrepreneurialism as well as practical hands-on skills have been built into the design of the learning aims and content. This gives you the opportunity to use relevant contexts, scenarios and materials to enable students to develop a portfolio of evidence demonstrating the breadth of their skills and knowledge in a way that equips them for employment.

3.3 Access to study

This section focuses on the administrative requirements for delivering a BTEC Higher National qualification. It will be of value to Quality Nominees, Programme Leaders and Examinations Officers.

Our policy regarding access to our qualifications is that:

- They should be available to everyone who is capable of reaching the required standards.
- They should be free from any barriers that restrict access and progression.
- There should be equal opportunities for all those wishing to access the qualifications. We refer Centres to our Pearson Equality and Diversity Policy, which can be found in the support section of our website (http://qualifications.pearson.com/).
Centres are required to recruit students to Higher National programmes with integrity. They will need to make sure that applicants have relevant information and advice about the qualification, to make sure it meets their needs. Centres should review the applicant’s prior qualifications and/or experience to consider whether this profile shows that they have the potential to achieve the qualification. For students with disabilities and specific needs, this review will need to take account of the support available to the student during the teaching and assessment of the qualification. For further guidance and advice please refer to section 9 on reasonable adjustments.

3.4 Student registration and entry

All students should be registered for the qualification, and appropriate arrangements made for internal and external verification. For information on making registrations for the qualification, you will need to refer to the information manual available in the support section of our website (http://qualifications.pearson.com/).

Students can be formally assessed only for a qualification on which they are registered. If students’ intended qualifications change (for example, if a student decides to choose a different specialist pathway), then the centre must transfer the student to the chosen pathway appropriately. Please note that student work cannot be sampled if the student is not registered or is registered on an incorrect pathway.

3.5 Access to assessment

Assessments need to be administered carefully, to ensure that all students are treated fairly, and that results and certification are issued on time, to allow students to move on to chosen progression opportunities.

Our equality policy requires that all students should have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every student. We are committed to making sure that:

- Students with a protected characteristic (as defined in legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic.
- All students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Further information on access arrangements can be found on the Joint Council for Qualifications website (http://www.jcq.org.uk/).

3.6 Administrative arrangements for internal assessment

Records

You are required to retain records of assessment for each student. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information on quality and assessment can be found in our UK and international guides available in the support section on our website (http://qualifications.pearson.com/).
All student work must be retained for a **minimum of 12 weeks** after certification has taken place.

**Reasonable adjustments to assessment**

A reasonable adjustment is one that is made before a student takes an assessment, to ensure that he or she has fair access to demonstrate the requirements of the assessments.

You are able to make adjustments to internal assessments to take account of the needs of individual students. In most cases this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments, if necessary.

Further details on how to make adjustments for students with protected characteristics are available on the support section of our website (http://qualifications.pearson.com/).

**Special consideration**

Special consideration is given after an assessment has taken place for students who have been affected by adverse circumstances, such as illness, and require an adjustment of grade to reflect normal level of attainment. You must operate special consideration in line with Pearson policy (see previous paragraph). You can provide special consideration related to the period of time given for evidence to be provided or for the format of the assessment (if it is equally valid). You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can only consider applications for special consideration in line with the policy, which can be found in the document linked above.

Please note that your centre must have a policy for dealing with mitigating circumstances if students are affected by adverse circumstances, such as illness, which has resulted in non-submission or a late submission of assessment.

**Appeals against assessment**

Your centre must have a policy for dealing with appeals from students. These appeals may relate to assessment decisions being incorrect or assessment not being conducted fairly. The first step in such a policy could be a consideration of the evidence by a Programme Leader or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to students. If there is an appeal by a student, you must document the appeal and its resolution. Students have a final right of appeal to Pearson, but only if the procedures that you have put in place have been followed.

Further details of our policy on enquiries and appeals is available on the support section of our website (http://qualifications.pearson.com/).

If your centre is located in England or Wales and the student is still dissatisfied with the final outcome of their appeal s/he can make a further appeal to the Office of the Independent Adjudicator (OIA) by emailing: enquiries@oiahe.org.uk. In Northern Ireland a further appeal may be lodged with the Northern Ireland Public Service Ombudsman (NIPSO) by emailing: nipso@nipso.org.uk.
3.7 Dealing with malpractice in assessment

‘Malpractice’ means acts that undermine the integrity and validity of assessment, the certification of qualifications, and/or that may damage the authority of those responsible for delivering the assessment and certification. Malpractice may arise or be suspected in relation to any unit or type of assessment within the qualification.

Pearson does not tolerate actions (or attempted actions) of malpractice by students, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on students, centre staff or centres where incidents (or attempted incidents) of malpractice have been proven.

Further details regarding malpractice and advice on preventing malpractice by students, can be found in the support section of our website (http://qualifications.pearson.com/).

In the interests of students and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice. The procedures we ask you to adopt when tackling malpractice vary between units that are internally assessed and those that are externally assessed.

Internally assessed units

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Students must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. Full information on dealing with malpractice and the actions we expect you to take is available on the support section of our website (http://qualifications.pearson.com/).

Pearson may conduct investigations if it is believed that a centre is failing to conduct internal assessment according to Pearson policies. The above document gives further information, provides examples, and details the penalties and sanctions that may be imposed.

Student malpractice

Heads of centres are required to report incidents of any suspected student malpractice that occur during Pearson external assessments. We ask that centres do so by completing JCQ Form M1 from the Joint Council for Qualifications website (http://www.jcq.org.uk/) and emailing it, along with any accompanying documents, (signed statements from the student, invigilator, copies of evidence, etc.), to the Investigations Team at pqsmalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on students lies with Pearson.

Students must be informed at the earliest opportunity of the specific allegation and the centre’s malpractice policy, including the right of appeal. Students found guilty of malpractice may be disqualified from the qualification for which they have been entered with Pearson.
Tutor/centre malpractice

Heads of centres are required to inform Pearson’s Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of centres are requested to inform the Investigations Team by submitting a JCQ M2b form (downloadable from http://www.jcq.org.uk/) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example, Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist.

Incidents of maladministration (accidental errors in the delivery of Pearson qualifications that may affect the assessment of students) should also be reported to the Investigations Team, using the same method.

Heads of centres/Principals/Chief Executive Officers or their nominees are required to inform students and centre staff suspected of malpractice of their responsibilities and rights; see 6.15 of JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures.

Pearson reserves the right in cases of suspected malpractice to withhold the issue of results and/or certificates while an investigation is in progress. Depending on the outcome of the investigation, results and/or certificates may be released or withheld. We reserve the right to withhold certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties.

Where student malpractice is evidenced, penalties may be imposed such as:

- Disqualification from the qualification
- Being barred from registration for Pearson qualifications for a specified period of time.

If we are concerned about your centre’s quality procedures, we may impose sanctions such as:

- Working with you to create an improvement action plan
- Requiring staff members to receive further training
- Placing temporary blocks on your certificates
- Placing temporary blocks on registrations of students
- Debarring staff members or the centre from delivering Pearson qualifications
- Suspending or withdrawing centre approval status.

Your centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from heads of centres (on behalf of students and/or members or staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in our Enquiries and Appeals Policy available in the support section on our website (http://qualifications.pearson.com/).
In the initial stage of any aspect of malpractice, please notify the Investigations Team by email (pqsmalpractice@pearson.com), who will inform you of the next steps.
4. Programme structure

4.1 Units, Credits, Total Qualification Time (TQT) and Guided Learning (GL)

The Higher National Certificate (HNC) is a Level 4 qualification made up of 120 credits. It is usually studied full-time over one year, or part-time over two years.

The Higher National Diploma (HND) is a Level 4 and Level 5 qualification made up of 240 credits. It is usually studied full-time over two years, or part-time over four years.

Pearson would expect that an HND student would have achieved at least 90 credits at Level 4 before progressing to Level 5 units. This allows for the students to submit the remaining 30 credits at Level 4 while undertaking their Level 5 study.

Students undertaking an HND who fail to successfully complete the full qualification may be awarded an HNC, if their credit achievement permits.

BTEC Higher Nationals consist of core units, specialist units and optional units:

- Core units are mandatory
- Specialist units are designed to provide a specific occupational focus to the qualification and are aligned to Professional Body standards
- Required combinations of units are clearly set out in the tables below.

All units are usually 15 credits in value, or a multiple thereof. These units have been designed from a learning time perspective, and are expressed in terms of Total Qualification Time (TQT). TQT is an estimate of the total amount of time that could reasonably be expected to be required for a student to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification. TQT includes undertaking each of the activities of Guided Learning, Directed Learning and Invigilated Assessment. Each 15-credit unit approximates to a Total Unit Time of 150 hours and 60 hours of Guided Learning.

**Total Qualification Time (TQT)**
- Higher National Certificate (HNC) = 1,200 hours
- Higher National Diploma (HND) = 2,400 hours

Examples of activities which can contribute to Total Qualification Time include:

- Guided Learning
- Independent and unsupervised research/learning
- Unsupervised compilation of a portfolio of work experience
- Unsupervised e-learning
- Unsupervised e-assessment
- Unsupervised coursework
- Watching a pre-recorded podcast or webinar
- Unsupervised work-based learning.
**Guided Learning (GL)** is defined as the time when a tutor is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. Guided Learning includes any supervised assessment activity; this includes invigilated examination and observed assessment and observed work-based practice.

**Total Guided Learning (GL)** Higher National Certificate (HNC) = 480 hours

**Total Guided Learning (GL)** Higher National Diploma (HND) = 960 hours

Some examples of activities which can contribute to Guided Learning include:

- Classroom-based learning supervised by a tutor
- Work-based learning supervised by a tutor
- Live webinar or telephone tutorial with a tutor in real time
- E-learning supervised by a tutor in real time
- All forms of assessment which take place under the immediate guidance or supervision of a tutor or other appropriate provider of education or training, including where the assessment is competence-based and may be turned into a learning opportunity.

### 4.2 Programme structures

The programme structures specify:

- The total credit value of the qualification
- The minimum credit to be achieved at the level of the qualification
- The core units
- The specialist units
- The optional units
- The maximum credit value in units that can be centre commissioned.

When combining units for a Pearson Higher National qualification, it is the centre’s responsibility to make sure that the correct combinations are followed.

The aeronautical engineering pathway has been developed as part of the revision and updating of all engineering pathways. The pathway has a core of units, four at Level 4 and two at Level 5, which are mandatory and cannot be changed or substituted.

Aeronautical engineering has a single specialist unit at Level 4 and two at Level 5 which have been selected and recommended to provide an appropriate amount of common subject specific content for that level. The remaining optional units for aeronautical engineering may only be selected from the designated optional unit list and not from other engineering optional unit lists.
Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering

- Qualification credit value: a minimum of 120 credits. This is made up of eight units, each with a value of 15 credits.
- **Total Qualification Time (TQT)** Higher National Certificate (HNC) = 1,200 hours
- **Total Guided Learning Hours (GLH)** Higher National Certificate (HNC) = 480 hours
- There is a required mix of Core, Specialist and Optional units totalling 120 credits. All units are at Level 4.
- In some cases a maximum of 30 credits from a Higher National qualification may be from units designed by the centre and approved by Pearson. Core units may not be substituted and are mandatory. For more information please refer to Higher National Commissioned Qualifications.
- Please note that some specialist units are available as optional units and some optional units are available as specialist units.

The pathways and unit combinations are as follows; for the list of optional units for all pathways at Level 4, please see pages that follow.

<table>
<thead>
<tr>
<th>Level 4 Certificate in Aeronautical Engineering (120 credits)</th>
<th>Unit credit</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core unit <strong>Mandatory</strong></td>
<td>1 Engineering Design</td>
<td>15</td>
</tr>
<tr>
<td>Core unit <strong>Mandatory</strong></td>
<td>2 Engineering Maths</td>
<td>15</td>
</tr>
<tr>
<td>Core unit <strong>Mandatory</strong></td>
<td>3 Engineering Science</td>
<td>15</td>
</tr>
<tr>
<td>Core unit <strong>Mandatory</strong></td>
<td>4 Managing a Professional Engineering Project (Pearson-set)</td>
<td>15</td>
</tr>
<tr>
<td>Specialist unit <strong>Mandatory</strong></td>
<td>24 Aircraft Aerodynamics</td>
<td>15</td>
</tr>
<tr>
<td>Optional unit</td>
<td>Plus one optional unit from optional bank group A (see below)</td>
<td>15</td>
</tr>
<tr>
<td>Optional unit</td>
<td>Plus one optional unit from optional bank group A (see below)</td>
<td>15</td>
</tr>
<tr>
<td>Optional unit</td>
<td>Plus one optional unit from optional bank group A (see below)</td>
<td>15</td>
</tr>
<tr>
<td>Optional unit</td>
<td>Unit credit</td>
<td>Level</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>23 Computer Aided Design and Manufacture (CAD/CAM)</strong></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td><strong>25 Aircraft Electrical Power and Distribution Systems</strong></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td><strong>26 Airframe Mechanical Systems</strong></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td><strong>27 Composite Materials for Aerospace Applications</strong></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td><strong>28 Turbine Rotary Wing Mechanical and Flight Systems</strong></td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>
Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering

The Level 5 Higher National Diploma consists of the Level 4 Higher National Certificate (above) plus an additional 120 credits at Level 5.

- Qualification credit value: a minimum of 240 credits of which 120 credits are at Level 5, and 120 credits are at Level 4 and usually attained via the HNC.

- **Total Qualification Time (TQT)** Higher National Diploma (HND) = 2,400 hours.

- **Total Guided Learning Hours (GLH)** Higher National Diploma (HND) = 960 hours.

- There is a required mix of core, specialist and optional units for each pathway. The core units required for each Level 5 pathway (in addition to the specialist units) are 34 Research Project which is weighted at 30 credits, and 35 Professional Engineering Management, weighted at 15 credits.

- The requirements of the Higher National Certificate (or equivalent) have to be met. In some cases a maximum of 60 credits can be imported from another RQF Pearson BTEC Higher National qualification and/or from units designed by the centre and approved by Pearson. Core units and specialist units may **not** be substituted.

- Please note that some specialist units are available as optional units and some optional units are available as specialist units.

The pathways and unit combinations are as follows (for the list of optional units for all pathways at Level 5, please see pages that follow).

<table>
<thead>
<tr>
<th>Level 5 Diploma in Aeronautical Engineering (240 credits)</th>
<th>Unit credit</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 4 units:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core unit &lt;i&gt;Mandatory&lt;/i&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Engineering Design</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Core unit &lt;i&gt;Mandatory&lt;/i&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Engineering Maths</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Core unit &lt;i&gt;Mandatory&lt;/i&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Engineering Science</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Core unit &lt;i&gt;Mandatory&lt;/i&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Managing a Professional Engineering Project (Pearson-set)</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Specialist unit &lt;i&gt;Mandatory&lt;/i&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Aircraft Aerodynamics</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plus one optional unit from Level 4 Optional Unit Bank Group A (see below)</strong></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Optional unit</td>
<td>Plus one optional unit from Level 4 Optional Unit Bank Group A (see below)</td>
<td>15</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----</td>
</tr>
</tbody>
</table>

| Optional unit | Plus one optional unit from Level 4 Optional Unit Bank Group A (see below) | 15  | 4 |

### Level 5 units:

<table>
<thead>
<tr>
<th>Core unit</th>
<th>Mandatory</th>
<th>34 Research Project</th>
<th>30</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Core unit</th>
<th>Mandatory</th>
<th>35 Professional Engineering Management (Pearson-set)</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Specialist unit</th>
<th>Mandatory</th>
<th>39 Further Mathematics</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Specialist unit</th>
<th>Mandatory</th>
<th>55 Aircraft Flight Control Systems</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)</th>
<th>15</th>
<th>5</th>
</tr>
</thead>
</table>

### Level 4 Optional Unit Bank

<table>
<thead>
<tr>
<th>Unit credit</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>23 Computer Aided Design and Manufacture (CAD/CAM)</th>
<th>15</th>
<th>4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>25 Aircraft Electrical Power and Distribution Systems</th>
<th>15</th>
<th>4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Optional unit</th>
<th>26 Airframe Mechanical Systems</th>
<th>15</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional unit</td>
<td>27 Composite Materials for Aerospace Applications</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------------------------</td>
<td>----</td>
<td>---</td>
</tr>
<tr>
<td>Optional unit</td>
<td>28 Turbine Rotary Wing Mechanical and Flight Systems</td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 5 Optional Unit Bank</th>
<th>Unit credit</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group C:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56 Aircraft Propulsion Principles and Technology</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57 Aircraft Structural Integrity</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58 Avionic Systems</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59 Aircraft Gas Turbine Engine Design and Performance</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 Advanced Composite Materials for Aerospace Applications</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Optional unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61 Advanced Turbine Rotary Wing Mechanical and Flight Systems</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>
Meeting local needs and centre devised units

Centres should note that the qualifications set out in these specifications have been developed in consultation with centres, employers and relevant professional organisations.

The units are designed to meet the skill needs of the sector and the specialist units allow coverage of the full range of employment within the sector. Centres should make maximum use of the choice available to them within the specialist units to meet the needs of their students, as well as the local skills and training needs.

Where centres identify a specific need that cannot be addressed using the units in this specification, centres can seek approval from Pearson to use units from other BTEC Higher National qualifications on the RQF (refer to the website or your Pearson regional contact for application details). Centres will need to justify the need for importing units from other BTEC Higher National RQF specifications. **Meeting local need applications must be made in advance of delivery by 31 January in the year of registration.**

The flexibility to import standard units from other BTEC Higher National RQF specifications is **limited to a maximum of 30 credits in a BTEC HNC qualification and a maximum of 60 credits in any BTEC HND qualification.**

This is an overall maximum and centres should check the ‘Rules of Combination’ information for the specific qualification to confirm the actual requirements. These units cannot be used at the expense of the mandatory units in any qualification nor can the qualification’s rules of combination be compromised. The centre must ensure that approved units are used only in eligible combinations.

Alternatively centres can seek approval to use centre devised units up to the advised maximum amounts for an HNC or an HND in the rules of combination to meet a specific need. The centre must provide a clear rationale on the progression benefits to students of taking the unit(s) that they are seeking approval for. Pearson will review the application and confirm or deny the request. The centre devised units can be authored by the centre, subject to Pearson's scrutiny and approval process. Alternatively the centre may seek design and development of these units by Pearson. Applications for approval of centre devised unit(s) must be made one year in advance of the first year of centre devised unit(s) delivery. The centre must not deliver and assess centre devised units until they have been approved by Pearson.

For the **Pearson BTEC Higher National Certificate and Diploma in Aeronautical Engineering** the maximum number of credits that can be imported by pathway are as follows:

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Import at Level 4</th>
<th>Import at Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>HNC Aeronautical Engineering</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>HND Aeronautical Engineering</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
4.3 Pearson-Set Assignments

At both Level 4 and Level 5, as part of the Core units, there are Pearson-set assignments. Each year, Pearson will issue a Theme. Centres will develop an assignment, to be internally assessed, to engage students in work related to the Pearson-set Theme.

At Level 4, students will select a Topic to further define their approach to the Theme and assignment. At Level 5, it is expected that students will define their own Topic, in negotiation with tutors, based on the Pearson-set Theme.

For example, from the Higher Nationals in Business:

Theme: “Corporate Social Responsibility (CSR) and its importance for sustainability and competitive advantage”

Level 4 Topics:

- How to start up a socially responsible company
- The impact of CSR on a functional area (e.g. HR, Marketing, Finance) within an organisation to promote profitability and financial sustainability.
- Implementing CSR activities within organisations to meet sustainability objectives.

Centres can find relevant support in the Pearson-set Assignment Guidance for the units, and the Theme and Topic release documentation, which will be provided for each level.

The aim of the Pearson-set assignments is to provide a common framework for centres to develop work that will allow cross-sector benchmarking, through the standardisation of student work, and identification and sharing of ‘best practice’ in higher education teaching and learning. Pearson will share the ‘best practice’ results with all centres. For further information about Pearson-set assignments and assessment, see section 6.0 Assessment in this document.
4.4 Annotated unit descriptor

This is how we refer to the individual units of study that make up a Higher National qualification. Students will study and complete the units included in the programme offered at your centre.

The unit title tells your students what the unit is about is. At Level 4 they can expect to achieve a complete grounding in the subject and the knowledge and skills required to continue their studies in the subject at Level 5.

<table>
<thead>
<tr>
<th>Unit type</th>
<th>Optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit level</td>
<td>4</td>
</tr>
<tr>
<td>Credit value</td>
<td>15</td>
</tr>
<tr>
<td>TQT</td>
<td>150</td>
</tr>
</tbody>
</table>

There are three unit types: core units (which students have to complete to achieve either Level 4 Certificate or Level 5 Diploma; specialist units (which students have to compete when studying one of the specialist pathways) and optional units which can be chosen.

All Higher National Certificate units are at Level 4. All Higher National Diploma units are at Level 5.

The credit value related to the Total Qualification Time is simple to calculate: 1 credit equals 10 hours of TQT. So 150 hours of TQT equals 15 credits. To complete a Higher National Certificate or Diploma students are expected to achieve the appropriate number of credits.

Some notes on the unit, giving your students an idea of what they can expect to study, and why the unit is likely to be of interest to them.

TQT stands for Total Qualification Time. This means the total amount of time students can expect to spend completing the unit. It includes the time spent in class at lectures as well as the time spent studying and working on assignments. For more details of TQT see the relevant section in this Programme Specification.

There are usually four learning outcomes for each unit (and sometimes three). The learning outcomes are what students are able to do by the time they complete the unit.
This section covers the content that students can expect to study as they work towards achieving their learning outcomes.

**LO1** Analyse the design and operational characteristics of a PLC system.

- **System operational characteristics**
  - Modular, unitary and rack mounted systems
  - Characteristics, including: speed, memory, scan time, voltage and current limits
  - Input and output devices (digital, analogue)
  - Interface requirements
  - Communication standards (RS-232, RS-422, RS-485, Ethernet)
  - Internal architecture
  - Different types of programming languages (IEC 61131-3)

**LO2** Design a simple PLC program by considering PLC information, programming and communication techniques.

- **Programming language**
  - Signal types
  - Number systems (binary, octal, hexadecimal)
  - Allocation lists of inputs and outputs
  - Communication techniques
  - Network methods
  - Logic functions (AND, OR, XOR)
  - Associated elements (timers, counters, latches)

- **Test and debug methods**
  - Systematic testing and debugging methods
  - Proper application of appropriate testing and debugging methods

**LO3** Investigate the key elements of industrial robots and be able to program them with straightforward commands to perform a given task.

- **Element considerations**
  - Types of robots
  - Mobile robotics
  - Tools and end effectors
  - Programming methods
  - Robot manipulators (kinematics, design, dynamics and control, vision systems, user interfaces)

**LO4** Investigate the design and safe operation of a robot within an industrial application.

- **Safety**
  - Cell safety features
  - Operating envelope
  - Operational modes
  - User interfaces
When assignments are graded the tutor will refer to this table, which connects the units learning outcomes with the students work. The unit may be graded ‘Pass’, ‘Merit’ or ‘Distinction’ level depending on the quality of the students work.

<table>
<thead>
<tr>
<th>Learning Outcomes and Assessment Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass</strong></td>
</tr>
<tr>
<td>LO1 Analyse the design and operational characteristics of a PLC system.</td>
</tr>
<tr>
<td>P1 Describe the key differences of PLC construction styles and their typical applications.</td>
</tr>
<tr>
<td>LO2 Design a simple PLC program by considering PLC information, programming and communication techniques.</td>
</tr>
<tr>
<td>P4 Describe the design elements that have to be considered in the preparation of a PLC programme program</td>
</tr>
<tr>
<td>P6 Describe the types of industrial robots and their uses in industry.</td>
</tr>
<tr>
<td>P7 Describe the types of robot end effectors available and their applications.</td>
</tr>
<tr>
<td>P8 Describe the safety systems used within an industrial robotic cell.</td>
</tr>
</tbody>
</table>

**ALWAYS LEARNING**
Website-based resources – referencing:

Some units have website links as part of their recommended resources lists. Hyperlinking to these resources directly can be problematic as locations and addresses of resources can change over time. To combat this we have referenced website-based resources as follows:

1. A link to the main page of the website
2. The title of the site
3. The name of the section or element of the website where the resource can be found
4. The type of resource it is. This could be one of the following:
   - Research
   - General reference
   - Tutorials
   - Training
   - eBooks
   - Report
   - Wiki
   - Article
   - Datasets
   - Development tool
   - Discussion forum.
Some examples from computing units have been shown below:

**Websites**

1. www.thinkwatson.com
   - Critical Thinking
   - ‘Critical Thinking Correlation Studies’ (Research)
2. ipda.org.uk
   - International Professional Development Association
   - (General reference)
   - ‘Guidelines for managing projects – How to organise, plan and control projects.’ (Report)

### 4.5 Professional Body collaboration

In redeveloping the BTEC Higher National qualifications in Engineering, we have worked closely with the Engineering Council guidelines and the following Professional Bodies:

- Royal Aeronautical Society
- Royal Academy of Engineering
- Society of Operations Engineers
- The Institute of Engineering and Technology
- The Institute of the Motor Industry.
5. Teaching and learning

The aim of this section is to provide guidance to centres so they can engage students in a dynamic, interactive and reflective learning experience. This experience should effectively prepare students to successfully engage in the assessments, which will measure depth, as well as breadth, of knowledge. Teaching should stimulate academic engagement, develop challenging yet constructive discourse and encourage students to reflect on their own performance in preparation for a professional career. Additionally, centres are encouraged to expose students to autonomous and independent learning, which will facilitate the development of the academic skills, experiences and techniques required as they progress from one level of study to the next.

Centres are encouraged to develop programmes that have a distinctive focus on entry into work; delivering a curriculum that embeds employability, has a strong commitment to ethics and diversity, and introduces students to contemporary as well as seminal research. All teaching and learning should reflect the expectations of employers and society, and be informed and guided by external benchmarks such as professional and statutory bodies. In so doing students completing a Higher National in Engineering will have the attributes, skills, principles and behaviours that will enable them to make a valuable contribution to local, national and international engineering.

The contributions students make to their own experiences, alongside the experience of their peers, is invaluable. Student engagement and the student voice should form a significant aspect of a student's life. Centres are encouraged to counsel student opinions on a range of teaching and learning matters, which would be used to inform and enhance future practice within a programme of study and within a centre.

5.1 Delivering quality and depth

A high quality teaching and learning experience should include qualified and experienced tutors, an interactive and engaging curriculum, motivated and inspired students, and a support system that caters for the pastoral as well as academic interests of students.

In addition to delivering a quality learning experience, centres must also encourage students to have a deeper understanding of the subject where they are able to go beyond the fundamentals of explaining and describing. Students are expected to show they can analyse data and information, make sense of this and then reach evaluative judgements. At the higher levels of study there is an expectation that students will be able to apply a degree of criticality to their synthesis of knowledge. This criticality would come from exposure to appropriate and relevant theories, concepts and models.

One of the reasons for delivering a quality learning experience, which has depth as well as breadth, is the accreditation of the Higher Nationals in Engineering on Ofqual’s qualification framework (RQF) and benchmarking to the Framework for Higher Education Qualifications (FHEQ). The first stage of a Higher National in Engineering is the Higher National Certificate (HNC), which is aligned with Level 4 of both frameworks; with the Higher National Diploma (HND) aligned with Level 5. This means that the HNC has the same level of demand and expectations as the first year of a degree programme, with the HND having the same level of demand and expectations as the second year of a degree programme.
Centres are expected to provide a broadly similar experience for students to that which they would have if they had attended a similar programme at a university. This could mean:

- Providing access to a library which has, as a minimum, available copies (physically and/or electronically) of all required reading material
- Access to research papers and journals
- Utilising a virtual learning environment (VLE) to support teaching
- Working with local employers (see below) to present real-life case studies
- Creating schemes of work that embrace a range of teaching and learning techniques
- Listening to the student voice.

Irrespective of the type of programme on which a student is enrolled, it is highly advisable that students are inducted onto their Higher National programme. This induction should include an introduction to the learning and academic study skills that will be essential in supporting their research and studies, and therefore enhance the learning experience.

An induction programme should consist of the following:

- Course programme overview
- Preparing for lessons
- Effective engagement in lectures and seminars
- Making the most of their tutor
- Assignment requirements
- Referencing and plagiarism
- Centre policies
- Academic study skills.

Pearson offer Higher National Global Study Skills to all students – an online toolkit that supports the delivery, assessment and quality assurance of BTECs in centres. This is available on the HN Global website www.highernationals.com. HN Global provides a wealth of support to ensure that tutors and students have the best possible experience during their course.

In addition, there is a wide range of free-to-access websites that can be used to support students in developing their learning and academic study skills.

### 5.2 Engaging with employers

Just as the student voice is important, so too is the employer’s. Employers play a significant role in the design and development of all regulated qualifications, including the Higher Nationals in Engineering. This input should extend into the learning experience, where engagement with employers will add value to students, particularly in transferring theory into practice.
Centres should consider a range of employer engagement activities. These could include:

- field trips to local engineering facilities
- inviting members of the local engineering community to present guest lectures
- using practising engineers to judge the quality of assessed presentations
- involving students in public events such as the Shell Mileage Marathon.

While detailed guidance on assessment has been provided in this specification (see section 6), it is worth considering the involvement of employers when determining assessment strategies and the use of different assessment methods. This would enable centres to design assessments that are more closely related to what students would be doing in the workplace. Employers would be able to comment on relevance and content, as well as the challenge presented by an assessment. Notwithstanding this, ultimately it is the centre’s responsibility to judge the extent to which any employer contributes to teaching and learning.

5.3 Engaging with students

Students are integral to teaching and learning. As such, it is important they are involved as much as possible with most aspects of the programme on to which they are enrolled. This input could include taking into account their views on how teaching and learning will take place, their role in helping to design a curriculum, or on the assessment strategy that will test their knowledge and understanding.

There are many ways in which to capture the student voice and student feedback, both formal and informal. Formal mechanisms include the nomination of student representatives to act as the collective student voice for each student cohort, student representation at course team meetings, and an elected higher education representative as part of the Student Union. Student forums should also take place periodically throughout the year with minutes and action plans updated and informing the overall annual course monitoring process. Unit specific feedback can also be collated by students completing unit feedback forms, end of year course evaluations, and scheduled performance review meetings with their tutor.

However, this should not be the only time when feedback from students is sought. Discourse with students should be constant, whereby tutors adopt a ‘reflection on action’ approach to adjust teaching, so that students are presented with an environment that is most supportive of their learning styles. Just as employers could have an input into assessment design, so too could students. This will support the development of assignments that are exciting and dynamic, and fully engage students in meaningful and informative assessment.

The biggest advantage of consulting students on their teaching, learning and assessment is securing their engagement in their own learning. Students are likely to feel empowered and develop a sense of ownership of all matters related to teaching, learning and assessment, not just their own experiences. Students could also view themselves as more accountable to their lecturers, ideally seeing themselves as partners in their own learning and not just part of a process.
5.4 Planning and structuring a programme

Learning should be challenging yet exciting; teaching should be motivating and inspirational. Consequently, both teaching and learning should form part of a programme structure that is active, flexible and progressive, and has an industry focus wherever possible.

It is important for a programme structure to be effectively planned, taking into account the nature of the student cohort, the primary mode of delivery (face-to-face or distance learning) and the level of study. It is also advisable to consider the student voice (whether that voice is heard through end of programme feedback, or through ongoing dialogue) when planning how and when students will be exposed to a particular subject. One other vital source of information that centres would do well to embrace is the feedback from tutors who have been and/or will be delivering learning.

It is recommended that centres establish a programme planning forum where various stakeholders are represented. This forum could consider different perspectives of teaching and learning and how these are planned into an effective programme structure. Consideration could be given to, for example, the holistic and consistent use of Virtual Learning Environments, a programme of field trips, a strategy for engaging with employers, and how and when to assess learning.

Consideration should be given to a number of factors when planning a programme structure. These include:

- The sequencing of units
- Whether to have condensed or expanded delivery
- Teaching and learning techniques.

5.4.1 Sequencing units

The level of demand embedded within a unit is benchmarked to recognised standards. This applies to all units within a level of study, and this means that all Level 4 units have similar demands, as do all Level 5 units. However, this does not mean that units can, or should, be delivered in any order. It is strongly advised that Level 4 units are delivered, and achieved, by students before progression to Level 5. However, students are able to progress to Level 5 with a minimum of 90 credits at Level 4.

Within each level it is advisable to sequence units so that those providing fundamental knowledge and understanding are scheduled early in the programme. It may also be advisable to schedule the assessment of units requiring the practice and application of more advanced skills later in the programme.

For example, at Level 4, Units 1 Engineering Design, 2 Engineering Mathematics and 3 Engineering Science could be the first three units that Higher National Certificate students study.
5.4.2 Condensed or expanded delivery

The next consideration is whether to deliver a unit in a condensed format alongside other units, or to deliver units over an expanded period. The following tables provide examples of this, based on four units being delivered in one teaching block.

Condensed version

<table>
<thead>
<tr>
<th>Weeks 1 to 6</th>
<th>Week 7</th>
<th>Weeks 8 to 13</th>
<th>Week 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Assessment</td>
<td>Unit 3</td>
<td>Assessment</td>
</tr>
<tr>
<td>Unit 2</td>
<td></td>
<td>Unit 4</td>
<td></td>
</tr>
</tbody>
</table>

Expanded version

<table>
<thead>
<tr>
<th>Weeks 1 to 12</th>
<th>Weeks 13 and 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Assessment</td>
</tr>
<tr>
<td>Unit 2</td>
<td></td>
</tr>
<tr>
<td>Unit 3</td>
<td></td>
</tr>
<tr>
<td>Unit 4</td>
<td></td>
</tr>
</tbody>
</table>

Mixed version:

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
<th>Week 9</th>
<th>Week 10</th>
<th>Week 11</th>
<th>Week 12</th>
<th>Week 13</th>
<th>Week 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit 2</td>
<td>Assessment</td>
<td>Unit 3</td>
<td>Assessment</td>
<td>Unit 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The decision to deliver a condensed, expanded or mixed programme would depend on a number of factors, including availability of resources, the subjects to be taught and the requirements of students. Each version has advantages: the condensed version would provide an opportunity for students to gain early success and achievement. This will enhance their self-efficacy, the sense of one’s belief in one’s ability to succeed, and self-confidence, with tutors being able to identify and respond to less able students early in the teaching and learning cycle.

The advantages of the expanded version include providing a longer timescale for students to absorb new knowledge and therefore, potentially, improve success, and giving tutors an opportunity to coach and support less able students over a longer period of time.
The mixed version, with some units spanning over the entire period and others lasting for shorter periods, provides opportunities for learning in some units to support development in others. This format may be particularly suited to a combination of practical and theoretical units. In all cases, the choice of which type of unit sequence must consider student opportunities as well as staff and physical resources of the centre.

As there are pros and cons to both approaches, the use of a planning forum would help to ensure the most appropriate approach is taken. For example, centres could choose to deliver the first teaching block using the expanded version, with the subsequent teaching block being delivered through a condensed approach.

It should be noted that the above consideration would apply equally to programmes that are being delivered face-to-face or through distance learning.

### 5.4.3 Drawing on a wide range of delivery techniques

As part of planning the range of delivery techniques that will be used to deliver the syllabus, centres should also consider an appropriate combination of techniques for the subject.

The table below lists, with explanation, some techniques that centres could introduce into a planned programme structure.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Face-to-face</th>
<th>Distance learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture and seminars</td>
<td>These are the most common techniques used by tutors. They offer an opportunity to engage with a large number of students, where the focus is on sharing knowledge through the use of presentations.</td>
<td>Delivery would be through video conferencing and/or pre-recorded audio and/or visual material, available through an online platform. Synchronous discussion forums could also be used.</td>
</tr>
<tr>
<td>Practical demonstrations</td>
<td>Demonstration by a qualified operator of the appropriate and safe operation of both production and testing equipment.</td>
<td>Delivery would normally occur when the students are physically present when the demonstration takes place, to allow interaction and questioning. In exceptional cases pre-recorded video material may be used.</td>
</tr>
<tr>
<td>Workshops</td>
<td>These are used to build on knowledge shared via tutors and seminars. Teaching can be more in-depth where knowledge is applied, for example to case studies or real-life examples. Workshops could be student-led, where students present, for example, findings from independent study.</td>
<td>While more challenging to organise than for face-to-face delivery, workshops should not be dismissed. Smaller groups of three or four students could access a forum simultaneously and engage in the same type of activity as for face-to-face.</td>
</tr>
<tr>
<td>Technique</td>
<td>Face-to-face</td>
<td>Distance learning</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Tutorials</td>
<td>These present an opportunity for focused one-to-one support, where teaching is led by an individual student’s requirements. These can be most effective in the run up to assessment, where tutors can provide more focused direction, perhaps based on a formative assessment.</td>
<td>Other than not necessarily being in the same room as a student, tutors could still provide effective tutorials. Video conferencing tools such as Google+ or Skype provide the means to see a student, which makes any conversation more personal.</td>
</tr>
<tr>
<td>Virtual Learning Environments (VLEs)</td>
<td>These are invaluable to students studying on a face-to-face programme. Used effectively, VLEs not only provide a repository for taught material such as presentation slides or handouts, but could be used to set formative tasks such as quizzes. Further reading could also be located on a VLE, along with a copy of the programme documents, such as the handbook and assessment timetable.</td>
<td>Where students are engaged with online delivery through distance or blended learning a VLE is a must, as this would be the primary or the key source of learning. Where distance learning is primarily delivered through hard copies of workbooks, etc., the same principle would apply as for face-to-face learning.</td>
</tr>
<tr>
<td>Blended learning</td>
<td>The combination of traditional face-to-face learning and online learning. This can enable the students to gain personalised support, instruction and guidance while completing assigned activities and tasks remotely.</td>
<td>Offline learning enables students to develop autonomy and self-discipline by completing set activities and tasks with limited direction and traditional classroom-based constraints.</td>
</tr>
<tr>
<td>Work-based learning</td>
<td>Any opportunity to integrate work-based learning into a curriculum should be taken. This adds realism and provides students with an opportunity to link theory to practice in a way in which case studies do not. Many full-time students are involved in some form of employment, either paid or voluntary, which could be used, where appropriate, as part of their learning (e.g. when assignments require students to contextualise a response to a real organisation).</td>
<td>It is likely that the majority of distance learning students would be employed and possibly classed as mature students. Bringing theory to life through a curriculum, which requires work-based application of knowledge, would make learning for these students more relevant and meaningful. Perhaps more importantly, assessment should be grounded in a student’s place of work, wherever possible.</td>
</tr>
<tr>
<td>Technique</td>
<td>Face-to-face</td>
<td>Distance learning</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Guest speakers</td>
<td>These could be experts from industry or visiting academics in the subject area that is being studied. They could be used to present a lecture/seminar, a workshop or to contribute to assessment. The key message here would be to make the most effective use of an expert’s knowledge and skill by adding value to the teaching and learning experience.</td>
<td>As long as the expert has access to the same platform as the students then the value added contribution would still be very high. Consideration would need to be given to timings and logistics, but with some innovative management this technique would still have a place in distance learning programmes.</td>
</tr>
<tr>
<td>Field trips</td>
<td>Effectively planned field trips, which have a direct relevance to the syllabus, will add value to the learning experience. Through these trips students can relate theory to practice, have an opportunity to experience organisations in action, and potentially open their minds to career routes.</td>
<td>The use of field trips can be included as part of a distance learning programme. They will add the same value and require the same planning. One additional benefit of field trips for distance learning is that they provide an opportunity for all students in a cohort to meet, which is a rare occurrence for distance learning students.</td>
</tr>
</tbody>
</table>

### 5.4.4 Assessment considerations

Centres should embrace the concept of assessment for learning. This is where an assessment strategy requires students to engage with a variety of assessment tools that are accessible, appropriately challenging, and support the development of student self-efficacy and self-confidence. To ensure that assignments are valid and reliable, centres must implement robust quality assurance measures and monitor the effectiveness of their implementation (see section 6 of this Programme Specification). This includes ensuring that all students engage in assessment positively and honestly.

Assessment also provides a learning opportunity for all stakeholders of the assessment to have access to feedback that is both individual to each student and holistic to the cohort. Feedback to students should be supportive and constructive. Student self-efficacy (and therefore self-confidence) can be significantly enhanced where feedback not only focuses on areas for improvement but recognises the strengths a student has. At the cohort level, similar trends could be identified that could inform future approaches to assessments and teaching. Assessment is an integral part of the overall learning process and assessment strategy must be developed to support effective, reflective, thinking engineering practitioners for the future. Assessment can be formative, summative, or both.
5.4.5 Formative assessment

Formative assessment is primarily developmental in nature and designed to give feedback to students on their performance and progress. Assessment designed formatively should develop and consolidate knowledge, understanding, skills and competencies. It is a key part of the learning process and can enhance learning and contribute to raising standards.

Through formative assessment tutors can identify students’ differing learning needs early on in the programme and so make timely corrective interventions. Tutors can also reflect on the results of formative assessment to measure how effective the planned teaching and learning is at delivering the syllabus. Each student should receive one set of written formative feedback, otherwise some students may feel that others are being given more than their share of verbal feedback.

5.4.6 Summative assessment

Summative assessment is where students are provided with the grades contributing towards the overall unit grade. For summative assessment to be effective it should also give students additional formative feedback to support ongoing development and improvement in subsequent assessments. All formative assessment feeds directly into summative assessment for each unit and lays the foundations from which students develop the necessary knowledge and skills required for the summative assessment.

5.4.7 Assessment feedback

Effective assessment feedback is part of continuous guided learning which promotes learning and enables improvement. It also allows students to reflect on their performance and helps them understand how to make effective use of feedback. Constructive and useful feedback should enable students to understand the strengths and limitations of their performance, providing positive comments where possible as well as explicit comments on how improvements can be made.

Feedback should reflect the learning outcomes and marking criteria to further help students understand how these inform the process of judging the overall grade.

The timing of the provision of feedback and of the returned assessed work also contribute to making feedback effective. Specific turnaround time for feedback should be agreed and communicated with both tutors and students. Timing should provide time for students to reflect on the feedback and consider how to make use of it in forthcoming assessments and take into account the tutor’s workload and ability to provide effective feedback.
5.4.8 Designing valid and reliable assessments

To help ensure valid and reliable assignments are designed and they are consistent across all units, centres could consider a number of actions.

Use of language

The first aspect of an assignment that a centre could focus on is language that makes tasks/questions more accessible to students.

Due consideration must be given to the command verbs used in the learning outcomes of a unit. Assignments must use appropriate command verbs that equate to the demand of the learning outcome. If the outcome requires analysis then evaluative tasks/questions within the assignment must not be set when testing that outcome. This would be viewed as over assessing. Similarly it is possible to under assess where analytical demands are tested using, for example, explanatory command verbs.

The following can be used as a guide to support assignment design:

- Ensure there is a holistic understanding (by tutors and students) and use of command verbs
- Set assignment brief that use a single command verb, focusing on the highest level of demand expected for the learning outcome(s) that is (are) being tested.
- Assignments should be supported by additional guidance that helps students to interpret the demand of the question or task
- Time-constrained assessments should utilise the full range of command verbs (or acceptable equivalents) appropriate to the academic level.

Consistency

This relates to consistency of presentation and structure, consistent use of appropriate assessment language, and the consistent application of grading criteria. Where assignments are consistent, reliability is enhanced. Where validity is present in assignments this will result in assignments that are fit for purpose and provide a fair and equitable opportunity for all students to engage with the assignment requirements.

Employing a range of assessment tools

Just as variety of teaching is important to the planning of a programme structure, so too is the use of a range of assessment tools appropriate to the unit and its content. Centres should consider taking a holistic view of assessment, ensuring a balanced assessment approach with consideration given to the subject being tested and what is in the best interests of students. As mentioned above, consultation with employers could add a sense of realism to an assessment strategy. (A comprehensive list of assessment tools is provided in section 6.2 Setting effective assessments.)
Some of the assessment tools that could be used are:

- work-based projects
- written assignments:
  - reports
  - briefing documents
  - planning documents
  - design documents
  - machine operating instructions in the form of a computer program
  - solutions to engineering problems through discourse and/or calculation
- presentations, vivas, role plays supported by an observer’s statement and/or video evidence
- portfolios
- reflective statements
- production of artefacts
- work log books
- witness statements.

No matter what tool is used, assignments should have a sector focus, whether this is in a workplace context or through a case study, and be explicitly clear in their instructions. In the absence of a case study a scenario should be used to provide some context. Finally, students should be clear on the purpose of the assignment and which elements of the unit it is targeting.
6. Assessment

BTEC Higher Nationals in Nuclear Engineering are assessed using a combination of internally assessed **centre-devised internal assignments** (which are set and marked by centres) and internally assessed **Pearson-set assignments** (which are set by Pearson and marked by centres). Pearson-set assignments are mandatory and target particular industry-specific skills. The number and value of these units are dependent on qualification size:

- For the HNC, one core, 15 credit, unit at Level 4 will be assessed by a mandatory Pearson-set assignment targeted at particular skills;
- For the HND, two core units: one core, 15 credit, unit at Level 4 and one core, 30 credit, unit at Level 5, will be assessed by a mandatory Pearson-set assignment targeted at particular skills;
- All other units are assessed by centre-devised assignments.

The purpose and rationale of having Pearson-set units on Higher Nationals is as follows:

- **Standardisation of student work** – Assessing the quality of student work, that it is meeting the level and the requirements of the unit across all centres, that grade decisions and assessor feedback are justified, and that internal verification and moderation processes are picking up any discrepancies and issues.
- **Sharing of good practice** – We will share good practice in relation to themes such as innovative approaches to delivery, the use of digital literacy, enhancement of student employability skills and employer engagement. **These themes will align to those for QAA Higher Education Reviews**.

An appointed External Examiner (EE) for the centre will ask to sample the Pearson-set assignment briefs in advance of the external examination visit. Although this is not a mandatory requirement for centres, we strongly advise that centres seek guidance and support from their EE on the Pearson-set assignments. The EE may also include the Pearson-set units in their sample of student work during their centre visit.

We have taken great care to ensure that the assessment method chosen is appropriate to the content of the unit and in line with requirements from professional bodies, employers and higher education.

In developing an overall plan for delivery and assessment for the programme, you will need to consider the order in which you deliver units, whether delivery will take place over short or long periods of time, and when assessment can take place.

**Example Assessment Briefs**

Each unit has supporting Example Assessment Briefs that are available to download from the course materials section on our website (http://qualifications.pearson.com/). The Example Assessment Briefs are there to give you an example of what the assessment will look like in terms of the content and level of demand of the assessment.

The Example Assessment Briefs, with the exception of the mandatory Pearson-set unit, provide tutors with suggested types of assignment and structure, which can be adopted and, if so, **must be** adapted accordingly.
6.1 Principles of internal assessment

This section gives an overview of the key features of internal assessment and how you, as an approved centre, can offer it effectively. The full requirements and operational information are given in the Pearson Quality Assurance Handbook available in the support section of our website (http://qualifications.pearson.com/). All of the assessment team will need to refer to this document.

For BTEC Higher Nationals it is important that you can meet the expectations of stakeholders and the needs of students by providing a programme that is practical and applied. Centres can tailor programmes to meet local needs and should use links with local employers and the wider engineering sector.

When internal assessment is operated effectively it is challenging, engaging, practical and up to date. It must also be fair to all students and meet national standards.

Assessment through assignments

For internally assessed units the format of assessment is an assignment taken after the content of the unit, or part of the unit if several assignments are used, has been fully delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity completed independently by students (either alone or in a team). An assignment is separate from teaching, practice, exploration and other activities that students complete with direction from and, formative assessment by, tutors.

An assignment is issued to students as an assignment brief with an issue date, a completion date and clear requirements for the evidence that students are expected to provide. There may be specific observed practical components during the assignment period. Assignments can be divided into separate parts and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome based on the assessment criteria.

Assessment decisions through applying unit-based criteria

Assessment decisions for BTEC Higher Nationals are based on the specific criteria given in each unit and set at each grade level. The criteria for each unit have been defined according to a framework to ensure that standards are consistent in the qualification and across the suite as a whole. The way in which individual units are written provides a balance of assessment of understanding, practical skills and vocational attributes appropriate to the purpose of the qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if an Merit criterion requires the student to show ‘analysis’ and the related Pass criterion requires the student to ‘explain’, then to satisfy the Merit criterion a student will need to cover both ‘explain’ and ‘analyse’. The unit assessment grid shows the relationships among the criteria so that assessors can apply all the criteria to the student’s evidence at the same time. In Appendix 5 we have set out a definition of terms that assessors need to understand.
Assessors must show how they have reached their decisions using the criteria in the assessment records. When a student has completed all the assessment for a unit then the assessment team will give a grade for the unit. This is given simply according to the highest level for which the student is judged to have met all the criteria. Therefore:

- to achieve a **Pass**, a student must have satisfied all the Pass criteria for the learning aims, showing coverage of the unit content and therefore attainment at Level 4 or 5 of the national framework
- to achieve a **Merit**, a student must have satisfied all the Merit criteria (and therefore the Pass criteria) through high performance in each learning outcome
- to achieve a **Distinction**, a student must have satisfied all the Distinction criteria (and therefore the Pass and Merit criteria), these define outstanding performance across the unit as a whole.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a student completing assignments. Students who do not satisfy the Pass criteria should be reported as Unclassified.

**The assessment team**

It is important that there is an effective team for internal assessment. There are three key roles involved in implementing assessment processes in your centre, each with different interrelated responsibilities, and these roles are listed below. Full information is given in the Pearson Quality Assurance Handbook available in the support section of our website (http://qualifications.pearson.com/).

- **The Programme Leader** has overall responsibility for the programme, its assessment and internal verification to meet our requirements, record keeping and liaison with the External Examiner. The Programme Leader registers with Pearson annually and acts as an assessor, supports the rest of the assessment team, makes sure they have the information they need about our assessment requirements, and organises training, making use of our guidance and support materials.
- **Internal Verifiers** (IVs) oversee all assessment activity in consultation with the Programme Leader. They check that assignments and assessment decisions are valid and that they meet our requirements. IVs will be standardised by working with the Programme Leader. Normally, IVs are also assessors, but they do not verify their own assessments.
- **Assessors** set or use assignments to assess students to national standards. Before taking any assessment decisions, assessors participate in standardisation activities led by the Programme Leader. They work with the Programme Leader and IVs to ensure that the assessment is planned and carried out in line with our requirements.
- Your **External Examiner** (EE) will sample student work across assessors. Your EE will also want to see evidence of internal verification of assignments and access decisions.

**Effective organisation**

Internal assessment needs to be well organised so student progress can be tracked and so that we can monitor that assessment is being carried out in line with national standards. We support you in this through, for example, providing training materials and sample documentation. Our online HN Global service can also help support you in planning and record keeping.
It is particularly important that you manage the overall assignment programme and deadlines to make sure that all your students are able to complete assignments on time.

**Student preparation**

To ensure that you provide effective assessment for your students, you need to make sure that they understand their responsibilities for assessment and the centre’s arrangements. From induction onwards you will want to ensure that students are motivated to work consistently and independently to achieve the requirements of the qualifications. They need to understand how assignments are used, the importance of meeting assignment deadlines, and that all the work submitted for assessment must be their own.

You will need to give your students a guide that explains:

- how assignments are used for assessment
- how assignments relate to the teaching programme
- how students should use and reference source materials, including what would constitute plagiarism.

The guide should also set out your approach to operating assessment, such as how students must submit work, the consequences of submitting late work and the procedure for requesting extensions for mitigating circumstances.

### 6.2 Setting effective assignments

**Setting the number and structure of assignments**

In setting your assignments you need to work with the structure of assignments shown in the relevant section of a unit. This shows the learning aims and outcomes and the criteria that you must follow.

Pearson provide Example Assessment Briefs for each unit to support you in developing and designing your own assessments, if you wish to do so you can find these materials with the specification on our website.

In designing your own assignment briefs you should bear in mind the following points:

- The number of assignments for a unit must not exceed the number of learning outcomes shown in the unit descriptor. However, you may choose to combine assignments (e.g. to create a single assignment for the whole unit).

- You may also choose to combine all or parts of different units into single assignments, provided that all units and all their associated learning aims are fully addressed in the programme overall. If you choose to take this approach you need to make sure that students are fully prepared, so that they can provide all the required evidence for assessment, and that you are able to track achievement in assessment records.

- A learning outcome must always be assessed as a whole and must not be split into two or more elements.

- The assignment must be targeted to the learning outcomes but the learning outcomes and their associated criteria are not tasks in themselves. Criteria are expressed in terms of the outcome shown in the evidence.
You do not have to follow the order of the learning outcomes of a unit in setting assignments, but later learning outcomes often require students to apply the content of earlier learning aims, and they may require students to draw their learning together.

Assignments must be structured to allow students to demonstrate the full range of achievement at all grade levels. Students need to be treated fairly by being given the opportunity to achieve a higher grade, if they have the ability.

As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning outcomes. The specified unit content must be taught/delivered. The evidence for assessment need not cover every aspect of the teaching content, as students will normally be given particular examples, case studies or contexts in their assignments. For example, if a student is carrying out one practical operation, or an investigation of one organisation, then they will address all the relevant range of content that applies in that instance.

Providing an assignment brief

A good assignment brief is one that, through providing challenging and authentic sector/work-related tasks, motivates students to provide appropriate evidence of what they have learnt.

An assignment brief should have:

- A vocational scenario: this could be a simple situation or a full, detailed set of vocational requirements that motivates the student to apply their learning through the assignment
- Clear instructions to the student about what they are required to do, normally set out through a series of tasks
- An audience or purpose for which the evidence is being provided
- An explanation of how the assignment relates to the unit(s) being assessed.

Forms of evidence

BTEC Higher Nationals have always allowed for a variety of forms of assessment evidence to be used, provided they are suited to the type of learning aim being assessed. For many units, the practical demonstration of skills is necessary and, for others, students will need to carry out their own research and analysis, working independently or as part of a team.

The Example Assessment Briefs give you information on what would be suitable forms of evidence to give students the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms of evidence to those proposed. Overall, students should be assessed using varied forms of evidence.

These are some of the main types of assessment:

- Written reports
- Time constrained assessments
- Creation of design documents
- Projects
- Production of an artefact
- Solutions to engineering problems through discourse and/or calculation
• Academic posters, displays, leaflets
• PowerPoint (or similar) presentations
• Recordings of interviews/role plays
• Working logbooks, reflective journals
• Presentations with assessor questioning.

(Full definitions of types of assessment are given in Appendix 5.)

The form(s) of evidence selected must:
• Allow the student to provide all the evidence required for the learning aim(s) and the associated assessment criteria at all grade levels
• Allow the student to produce evidence that is their own independent work
• Allow a verifier to independently reassess the student to check the assessor’s decisions.

For example, when you are using performance evidence, you need to think about how supporting evidence can be captured through recordings, photographs or task sheets.

Centres need to take particular care that students are enabled to produce independent work. For example, if students are asked to use real examples, then best practice would be to encourage them to use examples of their own or to give the group a number of examples that can be used in varied combinations.

6.3 Making valid assessment decisions

Authenticity of student work

An assessor must assess only student work that is authentic (i.e. students’ own independent work). Students must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work. A student declaration must state that:
• Evidence submitted for that assignment is the students own.
• The student understands that false declaration is a form of malpractice.

Assessors must ensure that evidence is authentic to a student through setting valid assignments and supervising them during the assessment period. Assessors must also take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Centres may use Pearson templates or their own templates to document authentication.

During assessment an assessor may suspect that some or all of the evidence from a student is not authentic. The assessor must then take appropriate action using the centre’s policies for malpractice. (See section 3.7 in this Programme Specification for further information.)
Making assessment decisions using criteria

Assessors make judgements using the criteria. The evidence from a student can be judged using all the relevant criteria at the same time. The assessor needs to make a judgement against each criterion that evidence is present and sufficiently comprehensive. For example, the inclusion of a concluding section may be insufficient to satisfy a criterion requiring ‘evaluation’.

Assessors should use the following information and support in reaching assessment decisions:

- The explanation of key terms in Appendix 4 of this document
- Examples of moderated assessed work
- Your Programme Leader and assessment team’s collective experience.

Dealing with late completion of assignments

Students must have a clear understanding of the centre’s policy on completing assignments by the deadlines that you give them. Students may be given authorised extensions for legitimate reasons, such as illness, at the time of submission, in line with your centre policies (see also Section 3.6 “Administrative arrangements for internal assessment”).

For assessment to be fair, it is important that students are all assessed in the same way and that some students are not advantaged by having additional time or the opportunity to learn from others. Centres should develop and publish their own regulations on late submission; and, this should make clear the relationship between late submission and the centre’s mitigating circumstances policy.

Centres may apply a penalty to assignments that are submitted beyond the published deadline. However, if a late submission is accepted, then the assignment should be assessed normally, when it is submitted, using the relevant assessment criteria; with any penalty or cap applied after the assessment. Where the result of assessment may be capped, due to late submission of the assignment, the student should be given an indication of their uncapped mark; in order to recognise the learning that has been achieved, and assessment feedback should be provided in relation to the uncapped achievement.

As with all assessment results, both the uncapped and capped marks should be recorded and ratified by an appropriate assessment board; taking into account any mitigating circumstances that may have been submitted.

Issuing assessment decisions and feedback

Once the assessment team has completed the assessment process for an assignment, the outcome is a formal assessment decision. This is recorded and reported to students. The information given to the student:

- Must show the formal decision and how it has been reached, indicating how or where criteria have been met
- May show why attainment against criteria has not been demonstrated
- Must not provide feedback on how to improve evidence but how to improve in the future.
Resubmission opportunity

An assignment provides the final assessment for the relevant learning outcomes and is normally a final assessment decision. A student who, for the first assessment opportunity, has failed to achieve a Pass for that unit specification shall be expected to undertake a reassessment.

- Only one opportunity for reassessment of the unit will be permitted.
- Reassessment for coursework, project or portfolio-based assessments shall normally involve the reworking of the original task.
- For examinations, reassessment shall involve completion of a new task.
- A student who undertakes a reassessment will have their grade capped at a pass for that unit.
- A student will not be entitled to be reassessed in any component of assessment for which a Pass grade or higher has already been awarded.

Repeat units

A student who, for the first assessment opportunity and resubmission opportunity, still failed to achieve a Pass for that unit specification:

- At centre discretion and Assessment Board, decisions can be made to permit a repeat of a unit.
- The student must study the unit again with full attendance and payment of the unit fee.
- The overall unit grade for a successfully completed repeat unit is capped at a Pass for that unit.
- Units can only be repeated once.

Assessment Boards

Each centre is expected by Pearson to hold Assessment Boards for all of its BTEC Higher National programmes. The main purpose of an Assessment Board is to make recommendations on:

- The grades achieved by students on the individual units
- Extenuating circumstances
- Cases of cheating and plagiarism
- Progression of students on to the next stage of the programme
- The awards to be made to students
- Referrals and deferrals.

Assessment Boards may also monitor academic standards. The main boards are normally held at the end of the session, although if your centre operates on a semester system there may be (intermediate) boards at the end of the first semester. There may also be separate boards to deal with referrals.

Where a centre does not currently have such a process then the External Examiner (EE) should discuss this with the Quality Nominee and Programme Leader, stressing the requirement for Assessment Boards by both Pearson and QAA and that Assessment Board reports and minutes provide valuable evidence for QAA’s Review of College Higher Education process.
6.4 Planning and record keeping

For internal processes to be effective, an assessment team needs to be well organised and keep effective records. The centre will also work closely with us so that we can quality assure that national standards are being satisfied. This process gives stakeholders confidence in the assessment approach.

The Programme Leader must have an assessment plan, produced as a spreadsheet. When producing a plan the assessment team will wish to consider:

- The time required for training and standardisation of the assessment team.
- The time available to undertake teaching and carrying out of assessment, taking account of when students may complete external assessments and when quality assurance will take place.
- The completion dates for different assignments.
- Who is acting as Internal Verifier (IV) for each assignment and the date by which the assignment needs to be verified.
- Setting an approach to sampling assessor decisions though internal verification that covers all assignments, assessors and a range of students.
- How to manage the assessment and verification of students’ work so that they can be given formal decisions promptly.
- How resubmission opportunities can be scheduled.

The Programme Leader will also maintain records of assessment undertaken. The key records are:

- Verification of assignment briefs
- Student authentication declarations
- Assessor decisions on assignments, with feedback given to students
- Verification of assessment decisions.

Examples of records and further information are available in the Pearson Quality Assurance Handbook available in the support section of our website (http://qualifications.pearson.com).

6.5 Calculation of the final qualification grade

Conditions for the Award

Conditions for the Award of the HND

To achieve a Pearson BTEC Higher National Diploma qualification a student must have:

- completed units equivalent to 120 credits at level 5;
- achieved at least a pass in 105 credits at level 5;
- completed units equivalent to 120 credits at level 4;
- achieved at least a pass in 105 credits at level 4.
Conditions for the award of the HNC

To achieve a Pearson BTEC Higher National Certificate qualification a student must have:

- completed units equivalent to 120 credits at level 4;
- achieved at least a pass in 105 credits at level 4.

Compensation Provisions

Compensation Provisions for the HND

Students can still be awarded an HND if they have attempted but not achieved a Pass in one of the 15 credit units completed at level 4 and similarly if they have attempted but not achieved a Pass in one of the 15 credit units at level 5. However they must complete and pass the remaining units for an HNC or HND as per the unit rules of combination of the required qualification.

Compensation Provisions for the HNC

Students can still be awarded an HNC if they have not achieved a Pass in one of the 15 credit units completed, but have completed and passed the remaining units.

Calculation of the overall qualification grade

The calculation of the overall qualification grade is based on the student’s performance in all units. Students are awarded a Pass, Merit or Distinction qualification grade using the points gained through all 120 credits, at Level 4 for the HNC or Level 5 for the HND, based on unit achievement. The overall qualification grade is calculated in the same way for the HNC and for the HND.

All units in valid combination must have been attempted for each qualification. The conditions of award and the compensation provisions will apply as outlined above. All 120 credits count in calculating the grade (at each level, as applicable).

The overall qualification grade for the HND will be calculated based on student performance in Level 5 units only.

Units that have been attempted but not achieved, and subsequently granted compensation, will appear as ‘Unclassified’; i.e. a ‘U’ grade, on the student’s Notification of Performance, that is issued with the student certificate.

Points per credit

Pass: 4
Merit: 6
Distinction: 8

Point boundaries

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## Modelled Student Outcomes

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7. Quality assurance

Pearson’s quality assurance system for all Pearson BTEC Higher National programmes is benchmarked to Level 4 and Level 5 on the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications (FHEQ). This will ensure that centres have effective quality assurance processes to review programme delivery. It will also ensure that the outcomes of assessment are to national standards.

The quality assurance process for centres offering Pearson BTEC Higher National programmes comprise five key components:

1. The approval process
2. Monitoring of internal centre systems
3. Independent assessment review
4. Annual programme monitoring report
5. Annual student survey.

7.1 The approval process

Centres new to the delivery of Pearson programmes will be required to seek approval initially through the existing centre approval process and then through the programme approval process. Programme approval for new centres can be considered in one of two ways:

- Desk-based approval review
- Review and approval visit to the centre.

Prior to approval being given, centres 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.

Applications for approval must be supported by the head of the centre (Principal or Chief Executive, etc.) and include a declaration that the centre will operate the programmes strictly, as approved and in line with Pearson requirements.

Centres seeking to renew their programme approval upon expiry of their current approval period, may be eligible for the Automatic Approval process, subject to the centre meeting the eligibility criteria set out by Pearson.

Regardless of the type of centre, Pearson reserves the right to withdraw either qualification or centre approval when it deems there is an irreversible breakdown in the centre’s ability either to quality assure its programme delivery or its assessment standards.
7.2 Monitoring of internal centre systems

Centres will be required to demonstrate ongoing fulfilment of the centre approval criteria over time and across all Higher National programmes. The process that assures this is external examination, which is undertaken by External Examiners. Centres will be given the opportunity to present evidence of the ongoing suitability and deployment of their systems to carry out the required functions. This includes the consistent application of policies affecting student registrations, appeals, effective internal examination and standardisation processes. Where appropriate, centres may present evidence of their operation within a recognised code of practice, such as that of the Quality Assurance Agency for higher education. Pearson reserves the right to confirm independently that these arrangements are operating to Pearson’s standards.

Pearson will affirm, or not, the ongoing effectiveness of such systems. Where system failures are identified, sanctions (appropriate to the nature of the problem) will be applied, in order to assist the centre in correcting the problem.

7.3 Independent assessment review

The internal assessment outcomes reached for all Pearson BTEC Higher National programmes benchmarked to Level 4 and Level 5 of the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications (FHEQ), are subject to an independent assessment review by a Pearson appointed External Examiner. The outcomes of this process will be:

- To confirm that internal assessment is to national standards and allow certification, or
- To make recommendations to improve the quality of assessment outcomes before certification is released, or
- To make recommendations about the centre’s ability to continue to be approved for the Pearson BTEC Higher National qualifications in question.

7.4 Annual Programme Monitoring Report (APMR)

The APMR is a written annual review form that provides opportunity for centres to analyse and reflect on the most recent teaching year. By working in collaboration with centres, the information can be used by Pearson to further enhance the quality assurance of the Pearson BTEC Higher National programmes.

7.5 Annual student survey

Pearson will conduct an annual survey of Pearson BTEC Higher National students. The purpose of the survey is to enable Pearson to evaluate the student experience as part of quality assurance process, by engaging with students studying on these programmes.
7.6 Centre and qualification approval

As part of the approval process, your centre must make sure that the resource requirements listed below are in place before offering the qualification.

Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualifications.

- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by staff and students.
- Centres must deliver the qualification in accordance with current equality legislation.
- Centres should refer to the individual unit descriptors, to check for any specific resources required.

The result, we believe, are qualifications that will meet the needs and expectations of students worldwide.

7.7 Continuing quality assurance and standards verification

We produce annually the latest version of the Pearson Quality Assurance Handbook available in the support section of our website (http://qualifications.pearson.com). It contains detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- A centre delivering Pearson BTEC Higher National programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering.
- The centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; it must abide by these conditions throughout the period of delivery.
- Pearson makes available to approved centres a range of materials and opportunities, through the assessment checking service. This is intended to exemplify the processes required for effective assessment and provide examples of effective standards. Approved centres must use the materials and services to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment.
- An approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.
The approach of quality assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality assurance processes, where practicable. We work to support centres and seek to make sure that our quality assurance processes do not place undue bureaucratic processes on centres. We monitor and support centres in the effective operation of assessment and quality assurance.

The methods we use to do this for BTEC Higher Nationals include:

- Making sure that all centres complete appropriate declarations at the time of approval
- Undertaking approval visits to centres
- Making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- Assessment sampling and verification, through requested samples of assessments, completed assessed student work and associated documentation
- An overarching review and assessment of a centre’s strategy for assessing and quality assuring its BTEC programmes.

An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting. Centres that do not fully address and maintain rigorous approaches to quality assurance cannot seek certification for individual programmes or for all BTEC Higher National qualifications.

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.
8. Recognition of Prior Learning and attainment

Recognition of Prior Learning (RPL) is a method of assessment (leading to the award of credit) that considers whether students can demonstrate that they can meet the assessment requirements for a unit through knowledge, understanding or skills they already possess, and so do not need to develop through a course of learning.

Pearson encourages centres to recognise students’ previous achievements and experiences whether at work, home and at leisure, as well as in the classroom. RPL provides a route for the recognition of the achievements resulting from continuous learning. RPL enables recognition of achievement from a range of activities using any valid assessment methodology. Provided that the assessment requirements of a given unit or qualification have been met, the use of RPL is acceptable for accrediting a unit, units or a whole qualification. Evidence of learning must be valid and reliable.

For full guidance on RPL please refer to the Recognition of Prior Learning policy document available in the support section of our website (https://qualifications.pearson.com).
9. Equality and diversity

Equality and fairness are central to our work. The design of these qualifications embeds consideration of equality and diversity as set out in the Quality Assurance Agency – Quality Code and Ofqual’s General Conditions of Recognition. Promoting equality and diversity involves treating everyone with equal dignity and worth, while also raising aspirations and supporting achievement for people with diverse requirements, entitlements and backgrounds. An inclusive environment for learning anticipates the varied requirements of students, and aims to ensure that all students have equal access to educational opportunities. Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to learning. In addition, students with and without disabilities are offered learning opportunities that are equally accessible to them, by means of inclusive qualification design.

Pearson’s equality policy requires all students to have equal opportunity to access our qualifications and assessments. It also requires our qualifications to be designed and awarded in a way that is fair to every student. We are committed to making sure that:

- Students with a protected characteristic (as defined in legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic.
- All students achieve the recognition they deserve from undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

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

- Qualifications should be available to everyone who is capable of reaching the required standards.
- 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 students to Higher National 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 will need to review the entry profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a higher level qualification. 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 student within the centre during their programme of study and any specific support that might be necessary to allow the student to access the assessment for the qualification. Centres should consult our policy on students with particular requirements.
Access to qualifications for students with disabilities or specific needs:

Students taking a qualification may be assessed in a recognised regional sign language, where it is permitted for the purpose of reasonable adjustments. Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational qualifications. Details on how to make adjustments for students with protected characteristics are given in the document *Pearson Supplementary Guidance for Reasonable Adjustment and Special Consideration in Vocational Internally Assessed Units*. See the support section on our website for both documents (http://qualifications.pearson.com/).
10. Higher Nationals Aeronautical Engineering Units
Unit 1: Engineering Design

Unit code K/615/1475
Unit type Core
Unit level 4
Credit value 15

Introduction

The tremendous possibilities of the techniques and processes developed by engineers can only be realised by great design. Design turns an idea into a useful artefact, the problem into a solution or something ugly and inefficient into an elegant, desirable and cost effective everyday object. Without a sound understanding of the design process the engineer works in isolation without the links between theory and the needs of the end user.

The aim of this unit is to introduce students to the methodical steps that engineers use in creating functional products and processes; from a design brief to the work and stages involved in identifying and justifying a solution to a given engineering need.

Among the topics included in this unit are: Gantt charts and critical path analysis, stakeholder requirements, market analysis, design process management, modelling and prototyping, manufacturability, reliability life cycle, safety and risk, management, calculations, drawings and concepts and ergonomics.

On successful completion of this unit students will be able to prepare an engineering design specification that satisfies stakeholders' requirements, implements best practice when analysing and evaluating possible design solutions, prepare a written technical design report, and present their finalised design to a customer or audience.

Learning Outcomes

By the end of this unit a student will be able to:

1. Plan a design solution and prepare an engineering design specification in response to a stakeholder’s design brief and requirements.
2. Formulate possible technical solutions to address the student-prepared design specification.
3. Prepare an industry-standard engineering technical design report.
4. Present to an audience a design solution based on the design report and evaluate the solution/presentation.
Essential Content

LO1  **Plan a design solution and prepare an engineering design specification in response to a stakeholder’s design brief and requirements**

*Planning techniques used to prepare a design specification:*
- Definition of client’s/users objectives, needs and constraints
- Definition of design constraints, function, specification, milestones
- Planning the design task: Flow charts, Gantt charts, network and critical path analysis necessary in the design process
- Use of relevant technical/engineering/industry standards within the design process

*Design process:*
- Process development, steps to consider from start to finish
- The cycle from design to manufacture
- Three- and five-stage design process
- Vocabulary used in engineering design

*Stage of the design process which includes:*
- Analysing the situation, problem statement, define tasks and outputs, create the design concept, research the problem and write a specification
- Suggest possible solutions, select a preferred solution, prepare working drawings, construct a prototype, test and evaluate the design against objectives, design communication (write a report)

*Customer/stakeholder requirements:*
- Converting customer request to a list of objectives and constraints
- Interpretation of design requirements
- Market analysis of existing products and competitors
- Aspects of innovation and performance management in decision-making

LO2  **Formulate possible technical solutions to address the student-prepared design specification**

*Conceptual design and evaluating possible solutions:*
- Modelling, prototyping and simulation using industry standard software, (e.g. AutoCAD, Catia, SolidWorks, Creo) on high specification computers
- Use of evaluation and analytical tools (e.g. cause and effect diagrams, CAD, knowledge-based engineering)
LO3  **Prepare an industry-standard engineering technical design report**

*Managing the design process:*
Recognising limitations including cost, physical processes, availability of material/components and skills, timing and scheduling

*Working to specifications and standards, including:*
The role of compliance checking, feasibility assessment and commercial viability of product design through testing and validation

*Design for testing, including:*
Material selection to suit selected processes and technologies
Consideration of manufacturability, reliability, life cycle and environmental issues
The importance of safety, risk management and ergonomics

*Conceptual design and effective tools:*
Technologies and manufacturing processes used in order to transfer engineering designs into finished products

LO4  **Present to an audience a design solution based on the design report and evaluate the solution/presentation**

*Communication and post presentation review:*
Selection of presentation tools
Analysis of presentation feedback
Strategies for improvement based on feedback
<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td>LO1</td>
<td>P1</td>
<td>D1</td>
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<tr>
<td></td>
<td>Produce a design specification from a given design brief</td>
<td>Compare and contrast the completed design specification against the relevant industry standard specification</td>
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<td>P2</td>
<td>M1</td>
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<td></td>
<td>Explain the influence of the stakeholder's design brief and requirements in the preparation of the design specification</td>
<td>Evaluate potential planning techniques, presenting a case for the method chosen</td>
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<td>P3</td>
<td>M2</td>
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<td></td>
<td>Produce a design project schedule with a graphical illustration of the planned activities</td>
<td>Demonstrate critical path analysis techniques in design project scheduling/planning and explain its use</td>
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<tr>
<td>LO2</td>
<td>P4</td>
<td>D2</td>
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<tr>
<td></td>
<td>Explore industry standard evaluation and analytical tools in formulating possible technical solutions</td>
<td>Evaluate potential technical solutions, presenting a case for the final choice of solution</td>
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<td>P5</td>
<td>M3</td>
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<tr>
<td></td>
<td>Use appropriate design techniques to produce possible design solution</td>
<td>Apply the principles of modelling/simulation/prototyping, using appropriate software, to develop appropriate design solutions</td>
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<tr>
<td>LO3</td>
<td>P6</td>
<td>D3</td>
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<tr>
<td></td>
<td>Prepare an industry-standard engineering technical design report</td>
<td>Evaluate the effectiveness of the presented industry-standard engineering technical design report for producing a fully compliant finished product</td>
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<td>P7</td>
<td>M4</td>
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<td></td>
<td>Assess the presented technical design and identify any potential limitations it may have</td>
<td>Explain the role of design specifications and standards in producing a finished product</td>
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<td>M5</td>
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<td></td>
<td>Identify any compliance, safety and risk management issues present in the chosen solution</td>
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<td>Pass</td>
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<tr>
<td><strong>LO4</strong> Present to an audience a design solution based on the design report and evaluate the solution/presentation</td>
<td><strong>D4</strong> Justify potential improvements to the presented design solution, based on reflection and/or feedback obtained from the presentation</td>
<td></td>
</tr>
<tr>
<td><strong>P8</strong> Present the recommended design solution to the identified audience</td>
<td><strong>M6</strong> Reflect on effectiveness of communication strategy in presenting the solution</td>
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<tr>
<td><strong>P9</strong> Explain possible communication strategies and presentation methods that could be used to inform the stakeholders of the recommended solution</td>
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</tbody>
</table>
**Recommended Resources**

**Textbooks**


**Websites**

www.epsrc.ac.uk  Engineering and Physical Sciences Research Council  (General Reference)

www.imeche.org  Institution of Mechanical Engineers  (General Reference)

**Links**

This unit links to the following related units:

*Unit 23: Computer Aided Design and Manufacture (CAD/CAM)*

*Unit 35: Professional Engineering Management*
Unit 2: Engineering Maths

Unit code M/615/1476
Unit type Core
Unit level 4
Credit value 15

Introduction

The mathematics that is delivered in this unit is that which is directly applicable to the engineering industry, and it will help to increase students’ knowledge of the broad underlying principles within this discipline.

The aim of this unit is to develop students’ skills in the mathematical principles and theories that underpin the engineering curriculum. Students will be introduced to mathematical methods and statistical techniques in order to analyse and solve problems within an engineering context.

On successful completion of this unit students will be able to employ mathematical methods within a variety of contextualised examples, interpret data using statistical techniques, and use analytical and computational methods to evaluate and solve engineering problems.

Learning Outcomes

By the end of this unit students will be able to:

1. Identify the relevance of mathematical methods to a variety of conceptualised engineering examples.
2. Investigate applications of statistical techniques to interpret, organise and present data by using appropriate computer software packages.
3. Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application.
4. Examine how differential and integral calculus can be used to solve engineering problems.
Essential Content

LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples

Mathematical concepts:
Dimensional analysis
Arithmetic and geometric progressions

Functions:
Exponential, logarithmic, circular and hyperbolic functions

LO2 Investigate applications of statistical techniques to interpret, organise and present data, by using appropriate computer software packages

Summary of data:
Mean and standard deviation of grouped data. Pearson’s correlation coefficient. Linear regression

Probability theory:
Binomial and normal distribution
Hypothesis testing for significance

LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application

Sinusoidal waves:
Sine waves and their applications
Trigonometric and hyperbolic identities

Vector functions:
Vector notation and properties
Representing quantities in vector form
Vectors in three dimensions
LO4 Examine how differential and integral calculus can be used to solve engineering problems

_Differential calculus:_
Definitions and concepts
Definition of a function and of a derivative, graphical representation of a function, notation of derivatives, limits and continuity, derivatives; rates of change, increasing and decreasing functions and turning points
Differentiation of functions
Differentiation of functions including:
- standard functions/results,
- using the chain, product and quotient rules,
- second order and higher derivatives
Types of function: polynomial, logarithmic, exponential and trigonometric (sine, cosine and tangent), inverse trigonometric and hyperbolic functions

_Integral calculus:_
Definite and indefinite integration
Integrating to determine area
Integration of common/standard functions and by substitution and parts
Exponential growth and decay
Types of function: algebraic including partial fractions and trigonometric (sine, cosine and tangent) functions

_Engineering problems involving calculus:_
Including: 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
# Learning Outcomes and Assessment Criteria

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<tr>
<th>Pass</th>
<th>Merit</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Identify the relevance of mathematical methods to a variety of conceptualised engineering examples</td>
<td><strong>P1</strong> Apply dimensional analysis techniques to solve complex problems</td>
<td><strong>LO1 &amp; LO2 D1</strong> Present statistical data in a method that can be understood by a non-technical audience</td>
</tr>
<tr>
<td><strong>LO2</strong> Investigate applications of statistical techniques to interpret, organise and present data by using appropriate computer software packages</td>
<td><strong>M1</strong> Use dimensional analysis to derive equations</td>
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<td><strong>ลอ2</strong></td>
<td><strong>M2</strong> Interpret the results of a statistical hypothesis test conducted from a given scenario</td>
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<tr>
<td><strong>LO3</strong> Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application</td>
<td><strong>P6</strong> Solve engineering problems relating to sinusoidal functions</td>
<td><strong>D2</strong> Model the combination of sine waves graphically and analyse the variation in results between graphical and analytical methods</td>
</tr>
<tr>
<td><strong>P7</strong> Represent engineering quantities in vector form, and use appropriate methodology to determine engineering parameters</td>
<td><strong>M3</strong> Use compound angle identities to separate waves into distinct component waves</td>
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<tr>
<td><strong>LO4</strong> Examine how differential and integral calculus can be used to solve engineering problems</td>
<td><strong>D3</strong> Analyse maxima and minima of increasing and decreasing functions using higher order derivatives</td>
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</tr>
<tr>
<td><strong>P8</strong> Determine rates of change for algebraic, logarithmic and circular functions</td>
<td><strong>M4</strong> Formulate predictions of exponential growth and decay models using integration methods</td>
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<tr>
<td><strong>P9</strong> Use integral calculus to solve practical problems relating to engineering</td>
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</table>
Recommended Resources

Textbooks

Websites
https://www.khanacademy.org/ Khan Academy Physics (Tutorials)

Links
This unit links to the following related units:
Unit 39: Further Mathematics
Unit 3: Engineering Science

Unit code T/615/1477
Unit type Core
Unit level 4
Credit value 15

Introduction

Engineering is a discipline that uses scientific theory to design, develop or maintain structures, machines, systems, and processes. Engineers are therefore required to have a broad knowledge of the science that is applicable to the industry around them.

This unit introduces students to the fundamental laws and applications of the physical sciences within engineering and how to apply this knowledge to find solutions to a variety of engineering problems.

Among the topics included in this unit are: international system of units, interpreting data, static and dynamic forces, fluid mechanics and thermodynamics, material properties and failure and A.C./D.C. circuit theories.

On successful completion of this unit students will be able to interpret and present qualitative and quantitative data using computer software, calculate unknown parameters within mechanical systems, explain a variety of material properties and use electromagnetic theory in an applied context.

Learning Outcomes

By the end of this unit students will be able to:

1. Examine scientific data using both quantitative and computational methods.
2. Determine parameters within mechanical engineering systems.
3. Explore the characteristics and properties of engineering materials.
4. Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties.
Essential Content

LO1  Examine scientific data using both quantitative and computational methods

*International system of units:*  
The basic dimensions in the physical world and the corresponding SI base units  
SI derived units with special names and symbols  
SI prefixes and their representation with engineering notation

*Interpreting data:*  
Investigation using the scientific method to gather appropriate data  
Test procedures for physical (destructive and non-destructive) tests and statistical tests that might be used in gathering information  
Summarising quantitative and qualitative data with appropriate graphical representations  
Using presentation software to present data to an audience

LO2  Determine parameters within mechanical engineering systems

*Static and dynamic forces:*  
Representing loaded components with space and free body diagrams  
Calculating support reactions of objects subjected to concentrated and distributed loads  
Newton’s laws of motion, D’Alembert’s principle and the principle of conservation of energy

*Fluid mechanics and thermodynamics:*  
Archimedes’ principle and hydrostatics  
Continuity of volume and mass flow for an incompressible fluid  
Effects of sensible/latent heat of fluid  
Heat transfer due to temperature change and the thermodynamic process equations
LO3 **Explore the characteristics and properties of engineering materials**

*Material properties:*
Atomic structure of materials and the structure of metals, plastics and composites
Mechanical and electromagnetic properties of materials

*Material failure:*
Destructive and non-destructive testing of materials
The effects of gradual and impact loading on a material
Degradation of materials and hysteresis

LO4 **Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties**

*D.C. circuit theory:*
Voltage, current and resistance in D.C. networks
Exploring circuit theorems (Thevenin, Norton, Superposition), Ohm’s law and Kirchhoff’s voltage and current laws

*A.C. circuit theory:*
Waveform characteristics in a single-phase A.C. circuit
RLC circuits

*Magnetism:*
Characteristics of magnetic fields and electromagnetic force
The principles and applications of electromagnetic induction
## Learning Outcomes and Assessment Criteria

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<tr>
<th>Pass</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Examine scientific data using both quantitative and computational methods</td>
<td><strong>P1</strong> Describe SI units and prefix notation</td>
<td><strong>D1</strong> Present an analysis of scientific data using both computational and qualitative methods</td>
</tr>
<tr>
<td><strong>P2</strong> Examine quantitative and qualitative data with appropriate graphical representations</td>
<td><strong>M1</strong> Explain how the application of scientific method impacts upon different test procedures</td>
<td></td>
</tr>
<tr>
<td><strong>LO2</strong> Determine parameters within mechanical engineering systems</td>
<td><strong>P3</strong> Determine the support reactions of a beam carrying a concentrated load and a uniformly distributed load</td>
<td><strong>D2</strong> Critically compare how changes in the thermal efficiency of a heat transfer process can affect the behavioural characteristics of a mechanical systems</td>
</tr>
<tr>
<td><strong>P4</strong> Use Archimedes’ principle in contextual engineering applications</td>
<td><strong>M2</strong> Determine unknown forces by applying d’Alembert’s principle to a free body diagram</td>
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<tr>
<td><strong>P5</strong> Determine through practical examples the change within a solid material when exposed to temperature variations</td>
<td><strong>LO3</strong> Explore the characteristics and properties of engineering materials</td>
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</tr>
<tr>
<td><strong>P6</strong> Describe the structural properties of metals and non-metals with reference to their material properties</td>
<td><strong>M3</strong> Review elastic, electrical and magnetic hysteresis in different materials</td>
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</tr>
<tr>
<td><strong>P7</strong> Explain the types of degradation found in metals and non-metals</td>
<td><strong>D3</strong> Compare and contrast theoretical material properties of metal and non-metallic materials compared with values obtained through destructive and non-destructive test methods</td>
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<tr>
<td><strong>LO4</strong> Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties</td>
<td><strong>D4</strong> Critically evaluate different techniques used to solve problems on series-parallel R, L, C circuits using A.C. theory</td>
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<tr>
<td><strong>P8</strong> Calculate currents and voltages in circuits using circuit theorems</td>
<td><strong>M4</strong> Explain the principles and applications of electromagnetic induction</td>
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<tr>
<td><strong>P9</strong> Describe how complex waves are produced from sinusoidal waveforms</td>
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<tr>
<td><strong>P10</strong> Solve problems on series R, L, C circuits with A.C. theory</td>
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</tbody>
</table>
Recommended Resources

Textbooks

Journals

Websites
https://www.khanacademy.org/ Khan Academy
Physics
(Tutorials)

Links
This unit links to the following related units:
*Unit 3: Engineering Science*
*Unit 10: Materials, Properties and Testing*
Unit 4: Managing a Professional Engineering Project

Unit code A/615/1478
Unit level 4
Credit value 15

Introduction

The responsibilities of the engineer go far beyond completing the task in hand. Reflecting on their role in a wider ethical, environmental and sustainability context starts the process of becoming a professional engineer – a vital requirement for career progression.

Engineers seldom work in isolation and most tasks they undertake require a range of expertise, designing, developing, manufacturing, constructing, operating and maintaining the physical infrastructure and content of our world. The bringing together of these skills, expertise and experience is often managed through the creation of a project.

This unit introduces students to the techniques and best practices required to successfully create and manage an engineering project designed to identify a solution to an engineering need. While carrying out this project students will consider the role and function of engineering in our society, the professional duties and responsibilities expected of engineers together with the behaviours that accompany their actions.

Among the topics covered in this unit are: roles, responsibilities and behaviours of a professional engineer, planning a project, project management stages, devising solutions, theories and calculations, management using a Gantt chart, evaluation techniques, communication skills, and the creation and presentation of a project report.

On successful completion of this unit students will be able to conceive, plan, develop and execute a successful engineering project, and produce and present a project report outlining and reflecting on the outcomes of each of the project processes and stages. As a result, they will develop skills such as critical thinking, analysis, reasoning, interpretation, decision making, information literacy, and information and communication technology, and skills in professional and confident self-presentation.

This unit is assessed by a Pearson-set assignment. The project brief will be set by the centre, based on a theme provided by Pearson (this will change annually). The theme and chosen project within the theme will enable students to explore and examine a relevant and current topical aspect of professional engineering.

*Please refer to the accompanying Pearson-set Assignment Guide and the Theme Release document for further support and guidance on the delivery of the Pearson-set unit.
Learning Outcomes

By the end of this unit students will be able to:

1. Formulate and plan a project that will provide a solution to an identified engineering problem.
2. Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem.
3. Produce a project report analysing the outcomes of each of the project processes and stages.
4. Present the project report drawing conclusions on the outcomes of the project.
Essential Content

**LO1** Formulate and plan a project that will provide a solution to an identified engineering problem

*Examples of realistic engineering-based problems:*

- Crucial considerations for the project. How to identify the nature of the problem through vigorous research
- Feasibility study to identify constraints and produce an outline specification

*Develop an outline project brief and design specification:*

- Knowledge theories, calculations and other relevant information that can support the development of a potential solution

*Ethical frameworks:*

- The Engineering Council and Royal Academy of Engineering’s Statement of Ethical Principles
- The National Society for Professional Engineers’ Code of Ethics

*Regulatory bodies:*

- Global, European and national influences on engineering and the role of the engineer, in particular: The Royal Academy of Engineering and the UK Engineering Council
- The role and responsibilities of the of the UK Engineering Council and the Professional Engineering Institutions (PEIs)
- The content of the UK Standard for Professional Engineering Competence (UKSPEC)
- Chartered Engineer, Incorporated Engineer and Engineering Technician

*International regulatory regimes and agreements associated with professional engineering:*

- European Federation of International Engineering Institutions
- European Engineer (Eur Eng)
- European Network for Accreditation of Engineering Education
- European Society for Engineering Education
- Washington Accord
- Dublin Accord
- Sydney Accord
- International Engineers Alliance
- Asia Pacific Economic Cooperation (APEC) Engineers Agreement
LO2  **Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem**

*Project execution phase:*
- Continually monitoring development against the agreed project plan and adapt the project plan where appropriate
- Work plan and time management, using Gantt chart or similar
- Tracking costs and timescales
- Maintaining a project diary to monitor progress against milestones and timescales

*Engineering professional behaviour sources:*
- Professional responsibility for health and safety (UK-SPEC)
- Professional standards of behaviour (UK-SPEC)

*Ethical frameworks:*
- The Engineering Council and Royal Academy of Engineering’s Statement of Ethical Principles
- The National Society for Professional Engineers’ Code of Ethics

LO3  **Produce a project report analysing the outcomes of each of the project processes and stages**

*Convincing arguments:*
- All findings/outcomes should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the project process

*Critical analysis and evaluation techniques:*
- Most appropriate evaluation techniques to achieve a potential solution
- Secondary and primary data should be critiqued and considered with an objective mindset
- Objectivity results in more robust evaluations where an analysis justifies a judgement
LO4 **Present the project report drawing conclusions on the outcomes of the project**

*Presentation considerations:*
- Media selection, what to include in the presentation and what outcomes to expect from it. Audience expectations and contributions
- Presentation specifics. Who to invite; project supervisors, fellow students and employers. Time allocation and presentation structure
- Reflection on project outcomes and audience reactions. Conclusion to report, recommendations for future work, lessons learned, changes to own work patterns

*Reflection for learning and practice:*
- The difference between reflecting on performance and evaluating a project – the former considers the research process, information gathering and data collection, the latter the quality of the research argument and use of evidence

*The cycle of reflection:*
- To include reflection in action and reflection on action
- How to use reflection to inform future behaviour, particularly directed towards sustainable performance
- The importance of Continuing Professional Development (CPD) in refining ongoing professional practice

*Reflective writing:*
- Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way
### Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
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<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Formulate and plan a project that will provide a solution to an identified engineering problem</td>
<td><strong>P1</strong> Select an appropriate engineering based project, giving reasons for the selection</td>
<td><strong>D1</strong> Illustrate the effect of legislation and ethics in developing the project plan</td>
</tr>
<tr>
<td><strong>LO2</strong> Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem</td>
<td><strong>P2</strong> Create a project plan for the engineering project</td>
<td><strong>D2</strong> Critically evaluate the success of the project plan making recommendations for improvements</td>
</tr>
<tr>
<td><strong>LO3</strong> Produce a project report analysing the outcomes of each of the project processes and stages</td>
<td><strong>P3</strong> Conduct project activities, recording progress against original project plan</td>
<td><strong>LO3 &amp; LO4</strong></td>
</tr>
<tr>
<td><strong>LO4</strong> Present the project report drawing conclusions on the outcomes of the project</td>
<td><strong>P4</strong> Produce a project report covering each stage of the project and analysing project outcomes</td>
<td><strong>D3</strong> Critically analyse the project outcomes making recommendations for further development</td>
</tr>
<tr>
<td><strong>P5</strong> Present the project report using appropriate media to an audience</td>
<td><strong>M1</strong> Undertake a feasibility study to justify project selection</td>
<td><strong>M2</strong> Explore alternative methods to monitor and meet project milestones, justify selection of chosen method(s)</td>
</tr>
<tr>
<td><strong>M3</strong> Use appropriate critical analysis and evaluation techniques to analyse project findings</td>
<td><strong>M4</strong> Analyse own behaviours and performance during the project and suggest areas for improvement</td>
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</tbody>
</table>
Recommended Resources

Textbooks


Journals
Journal of Engineering Design.

Links
This unit links to the following related units:
Unit 34: Research Project
Unit 35: Professional Engineering Management
Unit 23: Computer Aided Design and Manufacture (CAD/CAM)

Unit code J/615/1497
Unit level 4
Credit value 15

Introduction

The capacity to quickly produce finished components from a software model is now essential in the competitive world of manufacturing. Businesses now invest heavily in Computer Aided Design (CAD) software, Computer Aided Manufacture (CAM) software and Computer Numerical Control (CNC) machines to facilitate this, thus reducing product lead times. CAD gives design engineers the platform to creatively model components that meet the specific needs of the consumer. When these models are combined with CAM software, manufacturing is made a reality.

This unit introduces students to all the stages of the CAD/CAM process and to the process of modelling components using CAD software specifically suitable for transferring to CAM software. Among the topics included in this unit are: programming methods, component set up, tooling, solid modelling, geometry manipulation, component drawing, importing solid model, manufacturing simulation, data transfer, CNC machine types and inspections.

On successful completion of this unit students will be able to illustrate the key principles of manufacturing using a CAD/CAM system; produce 3D Solid models of a component suitable for transfer into a CAM system; use CAM software to generate manufacturing simulations of a component and design a dimensionally accurate component on a CNC machine using a CAD/CAM system.

Learning Outcomes

By the end of this unit students will be able to:

1. Describe the key principles of manufacturing using a CAD/CAM system.
2. Produce 3D Solid models of a component suitable for transfer into a CAM system.
3. Use CAM software to generate manufacturing simulations of a component.
4. Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system.
Essential Content

LO1 Describe the key principles of manufacturing using a CAD/CAM system

*Hardware:*
CAD workstation, printers, USB flash drives and network cables

*Software:*
Operating systems, hard disk requirements, processor, CAD software (e.g. SolidWorks, Autodesk Inventor, CATIA, CAM software: e.g. Edgecam, Delcam, GibbsCAM, SolidCAM)

*Inputs:*
CAD model, material specifications, tooling data, spindle speeds and feed rate data calculations

*Outputs:*
CAM files, program code and coordinates, manufacturing sequences, tooling requirements, auxiliary data

*Programming methods:*
CAD/CAM, manual programming, conversational programming

*Component set up:*
Zero datum setting, tool set up and offsets, axis of movements

*Work holding:*
Machine vice, chuck, fixtures, clamping, jigs

*Tooling:*
Milling cutters, lathe tools, drills, specialist tooling, tool holders, tool turrets and carousels

LO2 Produce 3D Solid models of a component suitable for transfer into a CAM system

*Solid modelling:*
Extrude, cut, fillet, chamfer, holes, sweep, revolve, lines, arcs, insert planes, properties of solid models (e.g. mass, centre of gravity, surface area)
Geometry manipulation:
Mirror, rotate, copy, array, offset

Component drawing:
Set up template, orthographic and multi-view drawings, sections, scale, dimensions, drawing attributes (e.g. material, reference points, tolerances, finish)

LO3 Use CAM software to generate manufacturing simulations of a component

Import solid model:
Set up, model feature and geometry identification, stock size, material

Manufacturing simulation:
Operations (e.g. roughing and finishing, pockets, slots, profiling, holes, tool and work change positions, tool sizes and IDs, speeds and feeds, cutter path simulations, program editing)

LO4 Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system

CNC machine types:
Machining centres, turning centres, MCUs (e.g. Fanuc, Siemens and Heidenhain)

Data transfer:
Structured data between CAD and CAM software (e.g. datum position and model orientation), file types (e.g. SLDPRT, parasolid, STL, IGES, DXF) and transfer to CNC machine (e.g. network, USB, Ethernet)

Inspection:
Manual inspection (e.g. Using Vernier gauges, bore micrometres), automated inspection (e.g. coordinate measuring machine (CMM), stages of inspection throughout manufacturing process)
## Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
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<tr>
<td><strong>LO1</strong> Describe the key principles of manufacturing using a CAD/CAM system</td>
<td><strong>D1</strong> Critically evaluate using illustrative examples, the impact of different machining conditions and specifications on component manufacturing</td>
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</tr>
<tr>
<td><strong>P1</strong> Describe the hardware and software elements of a typical CAD/CAM system</td>
<td><strong>M1</strong> Analyse the suitability of different programming methods of CNC machines</td>
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</tr>
<tr>
<td><strong>P2</strong> Describe, with examples, the inputs and outputs of the CAD/CAM process</td>
<td><strong>P3</strong> Explain the different methods of component set up, work holding and tooling available on CNC machines</td>
<td></td>
</tr>
<tr>
<td><strong>P4</strong> Design and produce a CAD solid model of a component to be manufactured on a CNC machine</td>
<td><strong>M2</strong> Assess the importance of using different geometry manipulation methods for efficient model production</td>
<td></td>
</tr>
<tr>
<td><strong>P5</strong> Design a working drawing of a component containing specific manufacturing detail</td>
<td><strong>P6</strong> Use CAM software to generate a geometrically accurate CAD solid model of a component</td>
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</tr>
<tr>
<td><strong>LO2</strong> Produce 3D Solid models of a component suitable for transfer into a CAM system</td>
<td><strong>D2</strong> Critically evaluate the effectiveness of using a CAD/CAM system and solid modelling to manufacture components</td>
<td></td>
</tr>
<tr>
<td><strong>LO3</strong> Use CAM software to generate manufacturing simulations of a component</td>
<td><strong>D3</strong> Analyse the effect of applying different manufacturing techniques and modifications to achieve an optimised production time</td>
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<tr>
<td><strong>P6</strong> Use CAM software to generate cutter tool path simulations</td>
<td><strong>M3</strong> Using CAM software generate cutter tool path simulations</td>
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<tr>
<td><strong>LO4</strong> Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system</td>
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<td><strong>D4</strong> Critically analyse, giving illustrative examples the different methods of data transfer through a CAD/CAM system</td>
</tr>
<tr>
<td><strong>P7</strong> Detail a part program for a component using CAM software and transfer the part program to a CNC machine and manufacture a component</td>
<td><strong>M4</strong> Analyse different methods of component inspection used in manufacturing</td>
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<tr>
<td><strong>P8</strong> Describe the structural elements of a CNC machining centre</td>
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<tr>
<td><strong>P9</strong> Review a component manufactured on a CNC machine to verify its accuracy</td>
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Recommended Resources

Textbooks

Links
This unit links to the following related unit:

*Unit 1: Engineering Design*
Unit 24: Aircraft Aerodynamics

Unit code T/615/1527
Unit level 4
Credit value 15

Introduction

The thrill of designing and building heavier than air machines that mimic bird flight, has always been a source of inspiration to early aviation enthusiasts – their ultimate aim was to produce a heavier than air machine that would not only fly but could be controlled, manoeuvred and then landed safely. The aims of those early day enthusiasts are the same as those for latter day aeronautical engineers, where although far more complex, the study of aircraft aerodynamics is the essential science that underpins aircraft flight.

This unit introduces students to the atmosphere in which aircraft fly and the scientific principles that underpin flight theory; the aerodynamic forces that are generated throughout all phases of flight and the effect they have on the aircraft airframe; how a study of the nature of high speed air flows lead to the necessary design features for aircraft that fly at supersonic velocities and how aircraft are stabilised and controlled during flight.

Topics included in this unit are: the atmosphere, aerodynamic principles, flight forces and their effect, high speed airflows, design features of high speed aircraft, stability and control.

On successful completion of this unit students will be able to:

- Examine the properties of the atmosphere and aerodynamic principles and apply them to aircraft flight
- Examine the generation, nature and effects of aerodynamic forces during flight
- Examine the nature of high speed airflows and the need for high speed aircraft design features
- Investigate the nature and methods used to stabilise and control aircraft.

Learning Outcomes

By the end of this unit students will be able to:

1. Examine standard atmospheric properties and aerodynamic principles affecting flight.
2. Describe the nature and effect of forces that act on aircraft in flight.
3. Demonstrate the nature of high speed airflows and their effect on fixed wing aircraft design.
4. Investigate the nature and methods used to control and stabilise fixed-wing aircraft.
Essential Content

LO1  Examine standard atmospheric properties and aerodynamic principles affecting flight

*The standard atmosphere:*

The composition of the air and different layers of the real atmosphere

Nature of the International Standard Atmosphere (ISA): need, function, definitions of standard properties

Use tables and hydrostatic temperature lapse rate and state equations to determine the changing parameters (temperature, pressure, density, viscosity) of the air in the ISA, with changing altitude

*Aerodynamic principles:*

Airflow definitions; laminar, turbulent, compressible and incompressible flows

Nature of low speed airflow over aerofoil sections; aerofoil terminology, viscosity effects, boundary layer, aerodynamic shape, pressure and flow changes with differing angle of attack (AOA) and airspeeds

Determine experimentally and analytically lift \( L = C_L \rho V^2 S \) and drag \( D = C_D \rho V^2 S \) forces over aerofoil sections subject to low speed airflows and how lift and drag forces interact over aircraft wings and the significance of the lift/drag ratio as a measure of performance

Define and use the continuity, energy, Bernoulli, isentropic and Reynolds number fluid flow equations to determine low speed airflow parameters

LO2  Describe the nature and effect of forces that act on aircraft in flight

*Factors effecting flight forces:*

Wing plan form geometry and its effects on lift and drag production

Boundary layer effects on lift and drag and its control

Atmospheric events: severe air turbulence, frost and ice accretion

Aero-elastic effects: wing torsional divergence, controls reversal and flutter

*Nature of flight forces:*

Lift/weight, drag/thrust, forces and couples, line of action, airspeed

Determine gravitational and aerodynamic forces during, straight and level flight, steady coordinated turn, climbing and diving flight, glide, pull-up, push-over manoeuvres

Manoeuvre envelope and structural limits, interpretation and consequences of exceeding limits
LO3 **Demonstrate the nature of high speed airflows and their effect on fixed wing aircraft design**

*Nature of high speed airflows:*

Speed of sound definition and relationship for a perfect gas \(a=\sqrt{\gamma RT}\), relationship between speed of sound and Mach number \((M=V/a)\)

Nature of transonic and supersonic airflows over aerofoil sections, compressibility effects, shockwave formation, the shock stall, airflow parameters across the shockwave, Mach cone

*Effects on fixed-wing aircraft design:*

Problems with flight in the transonic range, shock stall effects, pitching and buffeting, transonic drag rise at constant lift, effect on flow rate, pressure, lift, drag, pitching moment and aerodynamic centre

Transonic flow and aircraft design: conventional, thin and supercritical wing sections, swept wings, load distribution, wing tip flow and design, transonic airflow over fuselage/wing and use of area ruling

Supersonic flow and aircraft wing plan form design, un-swept and swept wings, leading and trailing edge sweep back, swing-wing, swept forward wings

LO4 **Investigate the nature and methods used to control and stabilise fixed-wing aircraft**

*Flight control:*

Control requirements, aircraft axes, roll, yaw, pitch, six degrees of freedom

Primary conventional control surfaces: aileron, elevator and rudder, servo-tabs, balance-tabs, trim-tabs and q-feel control

Secondary controls: slab, all-moving tailplanes, canard surfaces, vee-tail, spoilers, high speed ailerons, flaperons, elevons

Lift augmentation and drag inducing devices: flaps, slats, slots, vortex generators, wing fences, winglets, spoilers and airbrakes

*Aircraft stability:*

Nature of static and dynamic stability: reaction to a disturbance for stable, neutrally stable and unstable bodies

Longitudinal static stability: trim, use of tailplane, pitching moments and significance of centre of pressure movement and centre of gravity limits, lateral static stability, yawing, rolling, stability methods and use of an hedral for inherent instability

Longitudinal dynamic stability: nature and damping methods for short period pitching oscillations and phugoid motion, lateral dynamic stability, nature and damping methods for spiral mode and Dutch roll
## Learning Outcomes and Assessment Criteria

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<tr>
<td><strong>LO1</strong> Examine standard atmospheric properties and aerodynamic principles affecting flight</td>
<td><strong>D1</strong> Analyse the properties of the air in the ISA, with changing altitude and the relationship between fluid flow equations and the generation of lift and drag affecting flight</td>
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<tr>
<td><strong>P1</strong> Describe the nature of the ISA and the changes that take place to the properties of the air with changing altitude</td>
<td><strong>M1</strong> Explore quantitatively, how the properties of the air in the ISA change with altitude and the differences between the lift and drag forces found from theoretical calculations and from experimental results</td>
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<tr>
<td><strong>P2</strong> Assess, using theoretical calculations and experimental results how lift and drag forces are generated from low speed airflows over aerofoil sections</td>
<td><strong>P3</strong> Describe how wing planform, the boundary layer, atmospheric events and aero-elasticity, effect the generation and distribution of lift and drag</td>
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<tr>
<td><strong>M2</strong> Explore, using theoretical calculations the nature of flight forces during manoeuvres, how these forces are effected by geometrical and external factors and the significance of the manoeuvre envelope in protecting the aircraft structure</td>
<td><strong>P4</strong> Calculate the forces that act on aircraft in straight and level flight and during manoeuvres</td>
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<tr>
<td><strong>D2</strong> Evaluate the effect and nature of flight forces on the aircraft airframe, throughout all phases and conditions of flight, including the nature and significance of the load limits, within the manoeuvre envelope that protect the aircraft structure</td>
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<td><strong>LO3</strong> Demonstrate the nature of high speed airflows and their effect on fixed wing aircraft design</td>
<td><strong>D3</strong> Analyse transonic and supersonic airflows over aerofoil surfaces and the resulting problems, design features and their interrelationship, for aircraft that fly at transonic and supersonic speeds</td>
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<tr>
<td><strong>P5</strong> Discuss the relationship between the speed of sound and Mach number and the nature of transonic and supersonic airflows over aerofoil surfaces</td>
<td><strong>M3</strong> Explain transonic and supersonic airflows over aerofoil surfaces and the resulting problems and design features for aircraft that fly at transonic and supersonic speeds</td>
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<tr>
<td><strong>P6</strong> Describe the problems with aircraft flight in the transonic range and the resulting design features for aircraft that fly at transonic and supersonic speeds</td>
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<tr>
<td><strong>LO4</strong> Investigate the nature and methods used to control and stabilise fixed-wing aircraft</td>
<td><strong>D4</strong> Analyse aircraft control and stabilisation devices and methods and their interaction, for aircraft that fly in the transonic and supersonic speed range</td>
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</tr>
<tr>
<td><strong>P7</strong> Explore the nature and operation of aircraft primary controls and secondary controls, lift augmentation and drag inducing devices</td>
<td><strong>M4</strong> Illustrate aircraft control and stabilisation devices and methods and their interaction</td>
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<tr>
<td><strong>P8</strong> Describe the nature of static and dynamic stability and how aircraft are stabilised about their axes of rotation</td>
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Recommended Resources

Textbooks

Journals
*Aerospace* (the magazine of the Royal Aeronautical Society), with articles on all areas of aerospace including innovation and design for flight.

Websites
http://www.av8n.com/ AV8N
See How It Flies
(E-Book)

Links
This unit links to the following related units:
*Unit 28: Turbine Rotary Wing Mechanical and Flight Systems*
*Unit 56: Aircraft Propulsion Principles and Technology*
Unit 25: Aircraft Electrical Power and Distribution Systems

Unit code  A/615/1528
Unit level  4
Credit value  15

Introduction

All modern aircraft make extensive use of electrical power and the systems that generate and distribute this power are becoming increasingly more complex. Aircraft electrical power can be derived from a variety of different sources but it must then be distributed to the aircraft services that rely on that power, including engine starting, lighting, air conditioning, de-icing, galley services and a wide variety of essential avionic systems.

Primary sources of aircraft electrical power include batteries, DC and AC generators, and transformer rectifier units (TRU). In addition to these internal sources of power, aircraft also have the ability to be connected to external ground power units (GPU). For large transport aircraft, the use of ground power is essential during maintenance and whilst an aircraft is being loaded or fuelled. Larger aircraft may also have the benefit of an auxiliary power unit (APU), which can be used for starting the aircraft’s main engines as well as providing power for essential systems.

This unit will provide the student with a comprehensive introduction to the generation and distribution of electrical power in an aircraft. Different methods of generating, supplying, distributing and managing the electrical power required by typical modern aircraft will also be investigated, together with the purpose and operation of related components and sub-systems such as contactors, regulators, protection circuits and bus power control units (BPCU).

On successful completion of this unit students will be able to interpret electrical power schematic diagrams, identify the function of components and sub-systems, and understand the rationale and technology used for distributing power to system-critical components.

Learning Outcomes

By the end of this unit students will be able to:

1. Identify internal and external sources of aircraft power and their application in modern civil and military aircraft.
2. Explain the principles and application of aircraft DC power sources.
3. Explain the principles and application of aircraft AC power sources.
4. Illustrate the function and operation of the components and sub-systems used in aircraft electrical power distribution systems.
**Essential Content**

**LO1** Identify internal and external sources of aircraft power and their application in modern civil and military aircraft

*Primary and secondary sources of aircraft power:*
- Batteries
- DC generators
- AC generators (engine driven)
- APU driven generators
- Ram air turbine (RAT)

*External sources of aircraft power:*
- External DC and AC supplies
- Ground power units (GPU)

*Aircraft applications of electrical power:*
- Services needed for flight
- Essential services
- Non-essential services
- Engine starting
- Lighting. Air conditioning
- Avionic systems (radio communication, navigation, weather radar, anti-collision)
- Galley services

**LO2** Explain the principles and application of aircraft DC power sources

* Batteries:*
- Battery types and characteristics (lead-acid, nickel-cadmium, nickel-metal hydride, lithium)
- Battery charging and venting

*DC generators:*
- DC generator principles
- Series, shunt and compound wound generators
- Voltage regulation (vibrating contact, carbon pile, solid-state)
LO3 Explain the principles and application of aircraft AC power sources

AC generators:
Three-phase AC principles
Star and delta connected sources and loads
Power and power factor
Three-phase AC generators
Integrated drive generators (IDG)
Frequency wild generating systems
Constant frequency generating systems

LO4 Illustrate the function and operation of the components and sub-systems used in aircraft electrical power distribution systems

Components and sub-systems:
Transformers
Transformer/rectifier units (TRU)
Inverters
Relays and contactors
Current transformers (CT)
Protection (over-voltage and over-current)
Power factor correction
Harmonic suppression

Power distribution:
Aircraft electrical bus systems
Load sharing techniques (split bus, bus transfer, parallel load distribution)
Bus-tie breakers (BTB)
Essential services bus
Phase protection
Differential current protection
Load shedding
External GPU connection
Power monitoring
# Learning Outcomes and Assessment Criteria

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<tr>
<td><strong>LO1</strong> Identify internal and external sources of aircraft power and their application in modern civil and military aircraft</td>
<td><strong>M1</strong> Explain the need for multiple sources of aircraft power</td>
<td><strong>D1</strong> Assess a typical transport aircraft (civil or military) in terms of its electrical supply requirements and the available power sources</td>
</tr>
<tr>
<td><strong>P1</strong> Categorise aircraft systems as essential, needed for flight, and non-essential</td>
<td><strong>M2</strong> Explain the need for an auxiliary power unit (APU) in a large aircraft</td>
<td></td>
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<tr>
<td><strong>P2</strong> Outline available sources of power as batteries, DC generators, AC generators (engine driven), AC generators (APU driven) and external ground power</td>
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<tr>
<td><strong>P3</strong> Distinguish between different types of aircraft load in terms of supply voltage, current demand and duty cycle</td>
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<tr>
<td><strong>LO2</strong> Explain the principles and application of aircraft DC power sources</td>
<td><strong>M3</strong> Explain the principle of operation of an aircraft DC generator</td>
<td><strong>D2</strong> Evaluate the performance of an aircraft DC voltage regulator over a range of different drive shaft speeds and load currents</td>
</tr>
<tr>
<td><strong>P4</strong> Identify and describe the characteristics of lead-acid, nickel-cadmium, nickel-metal hydride and lithium batteries for use in aircraft</td>
<td><strong>M4</strong> Illustrate the characteristics of series, shunt and compound wound aircraft DC generators</td>
<td></td>
</tr>
<tr>
<td><strong>P5</strong> Outline and describe the construction of an aircraft DC generator</td>
<td><strong>M5</strong> Explain the need to regulate the DC output from an aircraft generator</td>
<td></td>
</tr>
<tr>
<td><strong>P6</strong> Outline different types of DC voltage regulator, including vibrating contact, carbon pile and solid-state</td>
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<tr>
<td>Pass</td>
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</tr>
<tr>
<td><strong>LO3</strong> Explain the principles and application of aircraft AC power sources</td>
<td><strong>D3</strong> Evaluate the performance of a three-phase AC generating system over a range of different load currents and load power factors</td>
<td></td>
</tr>
<tr>
<td><strong>P7</strong> Identify and describe the construction of an aircraft AC generator</td>
<td><strong>M6</strong> Explain the advantages of three-phase AC power when compared with single-phase AC systems</td>
<td></td>
</tr>
<tr>
<td><strong>P8</strong> Describe, with the aid of labelled circuit diagrams, star and delta connected three-phase AC sources and loads</td>
<td><strong>M7</strong> Illustrate the advantages and disadvantages of frequency wild and constant frequency AC generating systems</td>
<td></td>
</tr>
<tr>
<td><strong>P9</strong> Describe, with the aid of a labelled diagram, the construction and electrical arrangement of an integrated drive generator (IDG)</td>
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<tr>
<td><strong>LO4</strong> Illustrate the function and operation of the components and sub-systems used in aircraft electrical power distribution systems</td>
<td><strong>D4</strong> Evaluate the performance of an aircraft electrical bus distribution system under varying conditions, including loss or failure of one or more primary or secondary power sources</td>
<td></td>
</tr>
<tr>
<td><strong>P10</strong> Outline the need for, and function of, a DC to DC inverter</td>
<td><strong>M8</strong> Justify the arrangement of an aircraft electrical bus distribution system</td>
<td></td>
</tr>
<tr>
<td><strong>P11</strong> Outline the need for, and function of, a power factor corrector</td>
<td><strong>M9</strong> Explain, with the aid of a labelled diagram, the principle of the current transformer</td>
<td></td>
</tr>
<tr>
<td><strong>P12</strong> Outline the need for, and function of, a harmonic suppressor</td>
<td><strong>M10</strong> Illustrate, with the aid of a labelled diagram, the principle of power factor correction</td>
<td></td>
</tr>
<tr>
<td><strong>P13</strong> Outline the need for, and function of, a transformer/rectifier unit (TRU)</td>
<td><strong>M11</strong> Explain the function of a bus power control unit (BPCU)</td>
<td></td>
</tr>
<tr>
<td><strong>P14</strong> Outline the need for, and function of, an essential services bus</td>
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</tbody>
</table>
Recommended Resources

Textbooks


Websites
https://www.faa.gov/ Aircraft Electrical Systems (FAA)
AMT Airframe Handbook: Ch 9 Aircraft electrical Systems
(E-Book)

http://www.mathworks.com MathWorks
Aircraft Electrical Power Generation and Distribution (Simulation)
(Development Tool)

http://www.maritime.org San Francisco Maritime National Park Association
Aviation Electricity and Electronics—Power Generation and Distribution
(E-Book)

http://cdn.intechopen.com/ INTECH
Power Generation and Distribution System for a More Electric Aircraft (MEA) – A Review
(E-Book)

https://core.ac.uk CORE
Dynamic Power Distribution Management for All Electric Aircraft
(E-Book)

Links
This unit links to the following units:

Unit 17: Instrumentation and Control Systems

Unit 19 Electrical and Electronic Principles
Unit 26: **Airframe Mechanical Systems**

**Unit code**  
F/615/1529  
**Unit level**  
4  
**Credit value**  
15

**Introduction**

When aircraft take off and land they require an undercarriage, wheels and brakes to allow them to accelerate and decelerate along the runway. During flight, aircraft are manoeuvred using flight controls, fuel is continuously supplied to the engines for propulsive power, personnel are kept safe and comfortable in a pressurised air-conditioned environment and emergency protection systems ensure the safety of the aircraft and personnel, no matter what the weather or the emergency situation.

This unit introduces students to the design and operation of airframe mechanical systems (hydraulic power, landing gear, flight control systems, environmental control systems, protection systems and airframe fuel systems) and how these systems contribute to the safety of personnel, the aircraft airframe and its engines.

On successful completion of this unit, students will be able to examine how the design and operation of hydraulic systems and services and environmental control systems contribute towards safe aircraft flight and passenger and crew comfort and safety. They will also be able to determine how the layout and operation of protection and airframe fuel systems contribute to the safety of the aircraft, personnel and engine operation.

**Learning Outcomes**

By the end of this unit students will be able to:

1. Explore how the design and operation of hydraulic systems contribute to safe flight.
2. Examine how the design and operation of cabin environmental control systems contribute to the safety of the airframe and personnel.
3. Investigate how the layout and operation of protection systems contribute to safe flight.
4. Explain how the layout and operation of airframe fuel systems ensures a continuous safe supply to the aircraft engines.
Essential Content

LO1  Explore how the design and operation of hydraulic systems contribute to safe flight

Hydraulic power supply systems:

Hydraulic fluids: characteristics, types, mineral and phosphate ester-based oils, identification, sources and consequences of contamination

System design requirements: power source, fluid storage, actuation, conditioning, filtration, directional, flow and temperature control, distribution, emergency/alternative provision system operation under normal and emergency conditions

Design and operation of power supply systems and components: function and operation of reservoirs, pumps, actuators, fluid pressure, flow and direction control valves, heat exchangers and fluid plumbing, hydraulic panel indications and warnings, under normal and emergency supply conditions

Landing gear systems:

Design and operation of landing gear and retardation components: single and multi-bogies, undercarriage bay layout, shock absorbers, wheels, tyres, brake units, steering mechanisms

Design and operation of extension/retraction and retardation systems: hydraulic directional control and sequencing, braking, anti-skid, cockpit/cabin indications and warnings, emergency provision

Hydraulically powered flight control systems:

Design and operation of: primary flight control systems, powered flight control units (PFCU), leading and trailing edge lift augmentation systems and lift reduction systems, under normal and emergency conditions

Introduction to fault finding in hydraulic power supply systems

LO2  Examine how the design and operation of cabin environmental control systems contribute to the safety of the airframe and personnel

Pneumatic supplies:

Requirements: air supply source, storage, conditioning, directional, flow and temperature control and distribution

Services: air-conditioning, pressurisation, thermal anti-icing, engine starting, door sealing and pitot-static system

Air supply sources and control: gas turbine engine and auxiliary power unit (APU) bled air, piston engine compressor, blower and receiver air supplies, ram air, ground cart air, control via ducts, louvres, trunking, check valves flow and pressure control valves
Cabin air-conditioning and pressurisation systems:
Requirements for conditioned and pressurised cabin air
Function and system operation of cabin/cockpit air-conditioning components: air mixing plenum chambers, recirculation fans, temperature control valves and duct stats, filters, humidifiers, water separators, air-conditioning pack, cold air unit (CAU)
Design and operation of air-conditioning system: mixing, temperature and humidity control and recirculation of conditioned air, under normal and emergency conditions
Function and operation of cabin pressurisation system components: pressure controllers, discharge valves, relief valves, warning and indicating devices
Design and operation of cabin pressurisation system: cabin pressure control cycles, discharge methods, emergency provision, warnings and indications

Oxygen systems:
Need, design and operation of aircraft oxygen systems and components under normal and emergency conditions: crew and cabin therapeutic walk-round bottles, oxygen generators chemical and molecular sieve, cabin and crew oxygen storage, distribution and regulation, emergency drop-down masks

LO3 Investigate how the layout and operation of protection systems contribute to safe flight

Aircraft ice protection systems:
Nature of ice formation and its effect on aircraft safety and operation
Ice detection devices function and activation: probes, vanes, electronic and mass activation
Layout and operation of pre-emptive anti-icing systems: electrical, hot air, chemical, ground anti-icing
Layout and operation of reactive de-icing systems: pneumatic, electromagnetic-impulse, chemical

Fire detection and extinguishing systems:
Layout and operation of fire detection components and circuitry: unit detectors and detector alarm and test circuits, continuous loop detectors, resistance and pneumatic detectors and control unit
Operation of smoke and fire detectors
Type and meaning of flight-deck and cabin warnings: fire warning panel, location indicators, lights, claxons, overheat indicators
Classes of fire A, B, C and D and type of extinguishing agent/s to be used on each
Layout and operation of plumbed extinguisher systems, components and handheld appliances: extinguisher bottles, discharge valves, cartridges, plumbing, check valves, bottle pressure and discharge indicators, pilot and automatic operation of extinguishant actuation system
LO4 Explain how the layout and operation of airframe fuel systems ensures a continuous safe supply to the aircraft engines

Aircraft engine fuels and fuel system components:
Properties, use and handling of aircraft fuels: aviation gasoline (AVGAS), aviation jet turbine kerosene JETA1 (AVTUR) and wide cut jet turbine fuel JET B (AVTAG), type and function of fuel additives, handling precautions
Fuel system component description and function: fuel tanks, fuel booster and transfer pumps, transfer valves, non-return and vent valves, plumbing, fuel quantity sensors, gauges, warning and indicating sensors, heat exchangers, built-in component redundancy

Layout and operation of airframe fuel systems:
Fuel tank layout, balance and trim tanks, cross-feed and alternative provision
Fuel system operating modes: fuel feed, pressurisation, inerting and transfer; fuel jettison, venting, refuelling and de-fuelling
## Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Explore how the design and operation of hydraulic systems contribute to safe flight</td>
<td><strong>D1</strong> Analyse the design and operation of hydraulic, power supply, landing gear and flying control systems and their major components operating under normal and emergency conditions</td>
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</tr>
<tr>
<td><strong>P1</strong> Explain the system requirements, fluid properties, design and operation of aircraft hydraulic power supply systems and the function of their components, operating under normal and emergency conditions</td>
<td><strong>M1</strong> Illustrate the design features and operation of hydraulic, power supply, landing gear and flying control systems and their major components, operating under normal and emergency conditions</td>
<td></td>
</tr>
<tr>
<td><strong>P2</strong> Describe the design and operation of aircraft landing gear and hydraulically powered flying control systems and the function of their components, operating under normal and emergency conditions</td>
<td><strong>P3</strong> Describe pneumatic system requirements and the control and distribution of air supplies to the aircraft services</td>
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</tr>
<tr>
<td><strong>LO2</strong> Examine how the design and operation of cabin environmental control systems contribute to the safety of the airframe and personnel</td>
<td><strong>M2</strong> Explain the design and operation of oxygen, pneumatic air supply, air-conditioning and pressurisation systems and components under normal and emergency operating conditions</td>
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<tr>
<td><strong>P4</strong> Discuss the design and operation of oxygen, air-conditioning and pressurisation systems and the function of their components under normal and emergency operating conditions</td>
<td><strong>D2</strong> Analyse the design and operation of oxygen, pneumatic air supply, air-conditioning and pressurisation systems and components under normal and emergency operating conditions, assessing the contribution made by each system to the safety of the airframe and personnel</td>
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<td>Pass</td>
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<tr>
<td><strong>LO3</strong> Investigate how the layout and operation of protection systems contribute to safe flight</td>
<td><strong>D3</strong> Analyse the layout and operation of ice protection and fire detection and extinguishing systems and associated components under normal and emergency operating conditions, assessing the contribution made by each system to safe flight</td>
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<tr>
<td><strong>P5</strong> Discuss the layout and operation of aircraft ice protection systems and function of system components, under normal and emergency operating conditions</td>
<td><strong>M3</strong> Illustrate the layout and operation of ice protection and fire detection and extinguishing systems and associated components under normal and emergency operating conditions</td>
<td></td>
</tr>
<tr>
<td><strong>P6</strong> Describe the layout and operation of aircraft fire detection and extinguishing systems and function of their components under normal and emergency operating conditions</td>
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</tr>
<tr>
<td><strong>LO4</strong> Explain how the layout and operation of airframe fuel systems ensures a continuous safe supply to the aircraft engines</td>
<td><strong>D4</strong> Analyse the layout and operation of airframe fuel systems and their components for all operating modes, assessing the contribution made by the system and its components to the continuous safe supply of fuel to the engines</td>
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<tr>
<td><strong>P7</strong> Discuss the properties, use and safe handling of aircraft fuels and the nature and function of airframe fuel system components</td>
<td><strong>M4</strong> Illustrate the layout and operation of airframe fuel systems and their components for all operating modes, identifying the contribution made by the system to the continuous safe supply of fuel to the engines</td>
<td></td>
</tr>
<tr>
<td><strong>P8</strong> Describe the layout and operation of airframe fuel systems for all operating modes</td>
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</tr>
</tbody>
</table>


Recommended Resources

Textbooks

Journals
Aerospace (the magazine of the Royal Aeronautical Society), with articles on all areas of aerospace including airframe systems design and innovation.

Websites

https://www.faa.gov Federal Aviation Administration
AMT Airframe Handbook
(E-Book)

https://ocw.mit.edu MIT Open Courseware
hydro-mechanical aircraft systems design and flight control systems engineering
(Tutorials)

Links
This unit links to the following related units:
Unit 57: Aircraft Propulsion Principles and Technology
Unit 60: Advanced Composite Materials for Aerospace Applications
**Unit 27: Composite Materials for Aerospace Applications**

**Unit code** T/615/1530  
**Unit level** 4  
**Credit value** 15

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**Introduction**

The aerospace market combines both the civil and the military sectors. The civil market is highly competitive and cost driven, whilst cuts in military funding have changed the drivers from purely performance to cost and performance. Composite materials are now key in the manufacture of modern aircraft structures and components, combining exceptional fatigue properties with the ability to form complex shapes, whilst reducing weight, which offers such benefits as increased fuel efficiency and additional payload. It is no wonder that the aerospace market is the lead user of composites.

This unit explores what makes up a composite material and how the properties can be tailored to achieve the required performance. Students will appreciate the different manufacturing techniques used in aerospace and what influences the choices made by designers and manufacturers. A key part of composites in service is how damage is identified, assessed and rectified. This unit looks at common causes of defects, methods of assessment of defects and common repairs of composite structures used in aerospace.

The unit is a mix of theoretical and practical work and is designed to give learners a holistic understanding of composites used in aerospace. Previous knowledge of composites is not assumed, but a background in engineering would be advantageous. On successful completion of this unit, learners will be able to describe in detail how composites are produced, maintained and repaired in aerospace applications.

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**Learning Outcomes**

By the end of this unit a student will be able to:

1. Distinguish between the different constituents of composite materials used in aerospace engineering.
2. Compare key manufacturing processes used in aerospace composite production.
3. Correlate defects, their identification and evaluation.
4. Review repair methods and techniques stated in Structural Repair Manuals (SRM) from Original Equipment Manufacturer (OEM) or Design Authority (DA).
Essential content

LO1  **Distinguish between the different constituents of composite materials used in aerospace engineering**

*Fibres:*
Types of fibres used, the benefits of the available sub-types of fibres, sizing treatments and interface

*Reinforcement:*
How the fibres are put together to form a fabric and the benefits of the different weave styles available
How the reinforcements are used to tailor the strength of the component

*Matrix:*
Role of the matrix, difference between thermoset and thermoplastic and how to select
 Advantages and disadvantages of the four main aeronautical thermoset matrices used (epoxy, phenolic, bismaleimide, cyanate ester), as well as metal and ceramic matrices. Fibre volume fraction, glass transition temperature, post curing

*Core materials:*
Types of core materials used in aeronautical structures and their benefits
Complexities of manufacturing with core materials, limitations of core materials (galvanic corrosion)

*Non-structural materials:*
Lightning strike protection, paints, coatings

LO2  **Compare key manufacturing processes used in aerospace composite production**

*Pre-preg lay up:*
Processing limitations, nomenclature, laminate theory (balanced and symmetrical plies), tooling and tooling features, release agent and consumables

*Automated systems:*
Automated Fibre (Placement) (AFP), Automated Tape Laying (ATL), preforms, 3D weaving, filament winding. Benefits, associated costs, current applications
Liquid resin processes:

Resin Transfer Moulding (RTM), Resin Film Infusion (RFI), SPRINT (Trade name surface coating), Relative Temperature Index (RTI), Liquid Resin Infusion (LRI), Vacuum Assisted Resin Transfer Moulding (VARTM)

Advantages and disadvantages, tool design, material selection, flow media
Computational analysis of large structures

LO3 Correlate defects, their identification and evaluation

Defects:
Manufacturing and in-service defects may occur in a composite component
Identify the causes of these defects and their implications. Barely Visible Impact Damage (BVID), impact, compression after impact, ballistic, birdstrike, lightning strike

Evaluation of defects:
What analysis and testing is carried out at OEM to define acceptable defects

Testing methods:
Testing methods available for checking for defects: visual, acoustic, shearography, thermography, ultrasonic and X-ray

LO4 Review repair methods and techniques stated in Structural Repair Manuals (SRM) or Aircraft Repair Manual (ARM) from the Design Authority (DA)

Bonding:
Mechanical and chemical surface preparation, bond joint types, mechanical joints, bonding composites and metals, adhesive selection, mechanical testing of joints

Repair:
Common repair techniques, allowable repairs, calculating repair limits, scarf repairs, stepped repairs, core repairs

Structural integrity
How repairs affect structural integrity, what additional checks are required
### Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Distinguish between the different constituents of composite materials used in aerospace engineering</td>
<td></td>
<td><strong>D1</strong> Explain how coatings and surface materials are used to protect composite structures from environmental factors, including lightning strike</td>
</tr>
<tr>
<td><strong>P1</strong> Describe the function of the fibre and subsequent reinforcement in a composite material and numerically demonstrate its contribution to laminate strength. Describe how this is changed with post-curing</td>
<td><strong>M1</strong> Summarise the benefits of different core materials and numerically show the benefits of sandwich panels</td>
<td></td>
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<tr>
<td><strong>P2</strong> Compare matrices used in aerospace engineering, including thermoset, thermoplastic, metal and ceramic, and examine their benefits and typical applications</td>
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<tr>
<td><strong>LO2</strong> Compare key manufacturing processes used in aerospace composite production</td>
<td></td>
<td><strong>D2</strong> Appraise how liquid resin systems are being introduced into aerospace composite manufacture and discuss their advantages and disadvantages</td>
</tr>
<tr>
<td><strong>P3</strong> Describe why balanced and symmetrical laminates are important in composite design and explain where an unbalanced layup may be beneficial</td>
<td><strong>M2</strong> Compare three automated manufacturing methods and describe their benefits, limitations, applications and associated costs</td>
<td></td>
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<tr>
<td><strong>P4</strong> Compare the various types of tooling materials used in aeronautical composite manufacture and highlight a tooling feature specific to each manufacturing method</td>
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<tr>
<td><strong>LO3</strong> Correlate defects, their identification and evaluation</td>
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<td>D3 Compare six NDT methods and describe their advantages, disadvantages, applications and associated costs</td>
</tr>
<tr>
<td><strong>P5</strong> List and describe manufacturing and in-service defects and attribute a possible effect of the defects</td>
<td>M3 Describe the testing carried out at OEM/DA to define allowable defect limits on flight critical components</td>
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<tr>
<td>P6 Describe BVID and explain how this would present itself in both a solid composite structure and a sandwich panel</td>
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<tr>
<td><strong>LO4</strong> Review repair methods and techniques stated in Structural Repair Manuals (SRM) or Aircraft Repair Manual (ARM) from the Design Authority (DA)</td>
<td></td>
<td>D4 Explain how repairs affect the structural integrity of a flight component and what testing has been carried out at OEM/DA to allow that repair to be carried out</td>
</tr>
<tr>
<td><strong>P7</strong> Describe both the mechanical and chemical preparation required for bonding of metallic and composite parts</td>
<td>M4 Mechanically compare bonded and bolted composite joints and explain the benefits of four different bonded joint designs</td>
<td></td>
</tr>
<tr>
<td><strong>P8</strong> Using a structural repair manual, summarise the different allowable repair types and their restrictions</td>
<td></td>
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</tr>
</tbody>
</table>
Recommended Resources

Textbooks


Websites
http://www.gurit.com/ GURIT
Guide to Composites
(E-Books)

http://www.hexcel.com/ HEXCEL
Hexply Prepreg Technology
(E-Book)
Unit 28: Turbine Rotary Wing Mechanical and Flight Systems

Unit code A/615/1531
Unit level 4
Credit value 15

Introduction

Leonardo da Vinci produced the first conceptual helicopter design in 1493. However, due to a lack of technological knowledge, helicopter production did not occur until the 1940s. These technologically complex machines require engineers to utilise skills in both mechanical and electrical engineering in order to ensure they function safely in all environments.

This unit explores the roles of individual mechanical and electrical rotary wing flight systems and explains their interrelationships in modern integrated flight controls. Finally, students will be exposed to the need for Health and Usage Monitoring Systems (HUMS) and systems methods to overcome airframe fatigue failure.

On successful completion of this unit students will be able to describe the mechanical airframe control systems associated with rotary wing flight and explain the interrelationships between flight systems in modern integrated flight controls, describe the operation of rotary wing transmission systems and determine the efficiency of transmission system components, explain the requirements and system operation of typical rotary wing hydraulic systems and design a hydraulic system to solve a given application, and identify the need for Health Usage Monitoring Systems and the methods used to combat airframe fatigue failure.

Learning Outcomes

By the end of this unit students will be able to:

1. Describe the mechanical airframe control systems associated with rotary wing flight and explain the interrelationships between flight systems in modern integrated flight controls.
2. Explain the operation of rotary wing transmission systems and determine the efficiency of transmission system components.
3. Identify the requirements and system operation of typical rotary wing hydraulic systems and design a hydraulic system to solve a given application.
4. Justify the need for Health and Usage Monitoring Systems and the methods used to combat airframe fatigue failure.
Essential Content

LO1  Describe the mechanical airframe control systems associated with rotary wing flight and explain the interrelationships between flight systems in modern integrated flight controls

Cyclic control:
Collective control, swashplate, yaw control: anti-torque control, tail rotor, bleed air, No Tail Rotar (NOTAR)

Main rotor head:
Design and operation features, blade dampers: function and construction, rotor blades

Main and tail rotor blade:
Construction and attachment; trim control, fixed and adjustable stabilisers

System operation:
Manual, hydraulic, electrical and fly-by-wire, artificial feel, Integrated Modular Avionics, auto flight

LO2  Explain the operation of rotary wing transmission systems and determine the efficiency of transmission system components

Gearboxes and clutches:
Main and tail rotors, clutches, free wheel units and rotor brake

Tail rotor drive shafts:
Flexible couplings, bearings, vibration dampers and bearing hangers
Gearbox and transmission system calculations

LO3  Identify the requirements and system operation of typical rotary wing hydraulic systems and design a hydraulic system to solve a given application

System layout:
Schematic diagrams, BS ISO 1219-1:2012+A1:2016 circuit symbols

Hydraulic fluids:
Hydraulic reservoirs and accumulators
Pressure generation: electric, mechanical, pneumatic. Emergency pressure generation, filters, pressure control, power distribution, indication and warning systems, interface with other systems
LO4 Justify the need for Health and Usage Monitoring Systems (HUMS) and the methods used to combat airframe fatigue failure

*HUMS: vibration:*

Sources and effects, balancing and rigging, vibration monitoring, Active Vibration Reduction
<table>
<thead>
<tr>
<th>Learning Outcomes and Assessment Criteria</th>
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<tbody>
<tr>
<td><strong>Pass</strong></td>
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<tr>
<td><strong>LO1</strong> Describe the mechanical airframe</td>
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<tr>
<td>control systems associated with</td>
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<tr>
<td>rotary wing flight and explain the</td>
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<tr>
<td>interrelationships between flight</td>
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<td>systems in modern integrated flight</td>
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<tr>
<td>controls</td>
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<tr>
<td><strong>P1</strong> Describe the function and</td>
</tr>
<tr>
<td>characteristics of the mechanical</td>
</tr>
<tr>
<td>flight controls fitted to rotary wing</td>
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<tr>
<td>aircraft</td>
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<tr>
<td><strong>P2</strong> Identify the different types of</td>
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<td>operating systems that can be utilised</td>
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<tr>
<td>to operate the mechanical flight</td>
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<tr>
<td>control systems</td>
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<tr>
<td><strong>LO2</strong> Explain the operation of rotary</td>
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<tr>
<td>wing transmission systems and</td>
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<tr>
<td>determine the efficiency of</td>
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<tr>
<td>system components</td>
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<tr>
<td><strong>P3</strong> Describe the layout, component</td>
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<tr>
<td>function and operation of the</td>
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<tr>
<td>transmission systems fitted to a</td>
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<td>turbine-powered helicopter</td>
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<td><strong>P4</strong> Explain the principles of</td>
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<tr>
<td>operation of both NOTAR and Fenestron</td>
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<tr>
<td>tail rotors</td>
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<tr>
<td><strong>LO3</strong> Identify the requirements and</td>
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<tr>
<td>system operation of typical rotary wing</td>
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<tr>
<td>hydraulic systems and design a</td>
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<tr>
<td>hydraulic system to solve a given</td>
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<tr>
<td>application</td>
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<td><strong>P5</strong> Using standard hydraulic symbols,</td>
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<tr>
<td>design a helicopter hydraulic schematic</td>
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<td>that incorporates at least two</td>
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<tr>
<td>independent hydraulic systems</td>
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<tr>
<td><strong>P6</strong> Explain the operation of a</td>
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<tr>
<td>typical hydraulic system in normal</td>
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<tr>
<td>operation</td>
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</tr>
<tr>
<td><strong>LO4</strong> Justify the need for Health and Usage Monitoring Systems (HUMS) and the methods used to combat airframe fatigue failure</td>
</tr>
<tr>
<td><strong>P8</strong> Explain the techniques used by engineers to adjust flying controls and rotors for optimal performance</td>
</tr>
<tr>
<td><strong>M4</strong> Explain the reasons why Health Usage Monitoring is an integral part of modern helicopter operations and how it is used to combat fatigue failure</td>
</tr>
</tbody>
</table>
Recommended Resources

Textbooks

Link
This unit links to the following related unit:

*Unit 62: Advanced Turbine Rotary Wing Mechanical and Flight Systems*
Unit 34: Research Project

Unit code J/615/1502
Unit type Core
Unit level 5
Credit value 30

Introduction
Completing a piece of research is an opportunity to showcase your intellect and talents. It integrates knowledge with different skills and abilities that may not have been assessed previously. These may include seeking out and reviewing original research papers, designing your own experimental work, solving problems as they arise, managing your time, finding new ways of analysing and presenting data, and writing an extensive report. Research can always be a challenge but one that can be immensely fulfilling, an experience that goes beyond a mark or a grade, but extends into long-lasting areas of personal and professional development.

This unit introduces students to the skills necessary to deliver a complex, independently conducted research project that fits within an engineering context.

On successful completion of this unit students will be able to deliver a complex and independent research project in line with the original objectives, explain the critical thinking skills associated with solving engineering problems, consider multiple perspectives in reaching a balanced and justifiable conclusion, and communicate effectively a research project’s outcome. Therefore, developing skills such as critical thinking, analysis, reasoning, interpretation, decision making, information literacy, information and communication technology literacy, innovation, conflict resolution, creativity, collaboration, adaptability, and written and oral communication, which are crucial skills for gaining employment and developing academic competence for degree progression.

Learning Outcomes
By the end of this unit students will be able to:
1. Conduct the preliminary stages involved in the creation of an engineering research project.
2. Examine the analytical techniques used to work on all stages of the project and strategies required to overcome the challenges involved in a research project.
3. Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context.
4. Explore the communication approach used for the preparation and presentation of the research project’s outcomes.
Essential Content

LO1  **Conduct the preliminary stages involved in the creation of an engineering research project**

*Setting up the research preliminaries:*
- Project proposal.
- Developing a research question(s).
- Selection of project approach.
- Identification of project supervisor.
- Estimation of resource requirements, including possible sources of funding.
- Identification of project key objectives, goals and rational.
- Development of project specification.

LO2  **Examine the analytical strategies and techniques used to work on the literature review and data analysis and collection stages of the research project**

*Investigative skills and project strategies:*
- Selecting the method(s) of collecting data.
- Data analysis and interpreting findings.
- Literature review.
- Engaging with technical literature.
- Technical depth.
- Multi-perspectives analysis.
- Independent thinking.
- Statement of resources required for project completion.
- Potential risk issues, including health and safety, environmental and commercial.
- Project management and key milestones.

LO3  **Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context**

*Research purpose:*
- Detailed statement of project aims.
- Relevance of the research.
- Benefits and beneficiaries of the research.
LO4  Explore the communication approach used for the preparation and presentation of the research project’s outcomes

*Reporting the research:*

Project written presentation.
Preparation of a final project report.
Writing research report.
Project oral presentation, such as using a short presentation to discuss the work and conclusions.
<table>
<thead>
<tr>
<th>Learning Outcomes and Assessment Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass</strong></td>
</tr>
<tr>
<td><strong>LO1</strong> Conduct the preliminary stages involved in the creation of an engineering research project</td>
</tr>
<tr>
<td><strong>P1</strong> Produce a research project proposal that clearly defines a research question or hypothesis</td>
</tr>
<tr>
<td><strong>P2</strong> Discuss the key project objectives, the resulting goals and rationale</td>
</tr>
<tr>
<td><strong>LO2</strong> Examine the analytical strategies and techniques used to work on the literature review and data analysis and collection stages of the research project</td>
</tr>
<tr>
<td><strong>P3</strong> Conduct a literature review of published material, either in hard copy or electronically, that is relevant to your research project</td>
</tr>
<tr>
<td><strong>P4</strong> Examine appropriate research methods and approaches to primary and secondary research</td>
</tr>
<tr>
<td><strong>LO3</strong> Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context</td>
</tr>
<tr>
<td><strong>P5</strong> Reflect on the effectiveness and the impact the experience has had upon enhancing personal or group performance</td>
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<tr>
<td>Pass</td>
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</tr>
<tr>
<td><strong>LO4</strong> Explore the communication approach used for the preparation and presentation of the research project’s outcomes</td>
</tr>
<tr>
<td><strong>P7</strong> Communicate research outcomes in an appropriate manner for the intended audience</td>
</tr>
</tbody>
</table>


Recommended Resources

Textbooks


Website
https://www.apm.org.uk/ Association for Project Management (General Reference)

Links
This unit links to the following related unit:
*Unit 4: Managing a Professional Engineering Project*
**Unit 35: Professional Engineering Management**

**Unit code**  L/615/1503  
**Unit type**  Core  
**Unit level**  5  
**Credit value**  15

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**Introduction**

Engineers are professionals who can design, develop, manufacture, construct, operate and maintain the physical infrastructure and content of the world we live in. They do this by using their academic knowledge and practical experience in a safe, effective and sustainable manner, even when faced with a high degree of technical complexity.

The aim of this unit is to continue building upon the knowledge gained in Unit 4. It provides students with the professional standards for engineers, and guides them on how to develop the range of employability skills needed by professional engineers.

Among the topics included in this unit are: engineering strategy and services delivery planning, the role of sustainability, the total quality management, engineering management tools, managing people and becoming a professional engineer.

On successful completion of this unit students will be able to construct a coherent engineering services delivery plan to meet the requirements of a sector-specific organisational or business. They will display personal commitment to professional standards and obligations to society, the engineering profession and the environment.

This unit is assessed by a Pearson-set assignment. The project brief will be set by the centre, based on a theme provided by Pearson (this will change annually). The theme and chosen project within the theme will enable students to explore and examine a relevant and current topical aspect of professional engineering.

*Please refer to the accompanying Pearson-set Assignment Guide and the Theme Release document for further support and guidance on the delivery of the Pearson-set unit.*
Learning Outcomes

By the end of this unit students will be able to:

1. Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology.

2. Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation.

3. Develop effective leadership skills, and individual and group communication skills.

4. Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment.
Essential Content

LO1 Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology

The engineering business environment:
Organisational structures and functional elements
Strategic planning and deployment
Engineering strategy and services delivery planning
The role of sustainability
Total quality management
Logistics and supply chain management
New product development strategies
Legal obligations and corporate responsibility

Engineering relationships:
The relationship between engineering and financial management, marketing, purchasing, quality assurance and public relations

LO2 Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation

Engineering management tools:
Problem analysis and decision making, risk management, change management, performance management, product and process improvement, project management and earned value analysis

LO3 Develop effective leadership skills, and individual and group communication skills

Managing people:
Describe the most effective leadership styles
Techniques for effectively managing teams
Steps to follow for delivering effective presentations
Meeting management skills
Communication and listening skills
Negotiating skills
Human error evaluation
Coaching and mentoring
LO4 Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment

Becoming a professional engineer:

Engineering social responsibility

Importance of being active and up to date with the engineering profession, new developments and discoveries

Methods of continuing professional development
<table>
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<tr>
<th>Learning Outcomes and Assessment Criteria</th>
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<tbody>
<tr>
<td><strong>Pass</strong></td>
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<tr>
<td><strong>Merit</strong></td>
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<tr>
<td><strong>Distinction</strong></td>
</tr>
<tr>
<td><strong>LO1</strong> Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology</td>
</tr>
<tr>
<td><strong>P1</strong> Evaluate the risk evaluation theories and practices associated with the management of engineering projects</td>
</tr>
<tr>
<td><strong>P2</strong> Assess elements and issues that impact the successful management of engineering activities</td>
</tr>
<tr>
<td><strong>LO2</strong> Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation</td>
</tr>
<tr>
<td><strong>P4</strong> Determine the engineering management tools needed for designing an engineering services delivery plan</td>
</tr>
<tr>
<td><strong>LO3</strong> Develop effective leadership skills, and individual and group communication skills</td>
</tr>
<tr>
<td><strong>P5</strong> Describe the steps for effective persuasion and negotiation</td>
</tr>
<tr>
<td><strong>P6</strong> Explain the steps for managing effective group meetings</td>
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<td>Pass</td>
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<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>LO4</strong> Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment</td>
</tr>
<tr>
<td><strong>P8</strong> Discuss the context of social responsibility for scientists and engineers</td>
</tr>
<tr>
<td><strong>P9</strong> Explore the ways in which an engineer can engage in continuing professional development</td>
</tr>
</tbody>
</table>
Recommended Resources

Textbooks

Websites
http://www.engc.org.uk/ Engineering Council
  UK-SPEC UK Standard for Professional Engineering Competence
  (E-Books)
http://www.ewb-uk.org/ Engineering without Borders
  (General Reference)

Links
This unit links to the following related units:
  Unit 4: Managing a Professional Engineering Project
Unit 39: Further Mathematics

Unit code: H/615/1507
Unit level: 5
Credit value: 15

Introduction

The understanding of more advanced mathematics is important within an engineering curriculum to support and broaden abilities within the applied subjects at the core of all engineering programmes. Students are introduced to additional topics that will be relevant to them as they progress to the next level of their studies and advances their knowledge of the underpinning mathematics gained in the Level 4 unit, Engineering Maths, Unit 2.

The unit will prepare students to analyse and model engineering situations using mathematical techniques. Among the topics included in this unit are: number theory, complex numbers, matrix theory, linear equations, numerical integration, numerical differentiation, and graphical representations of curves for estimation within an engineering context. Finally, students will expand their knowledge of calculus to discover how to model and solve engineering problems using first and second order differential equations.

On successful completion of this unit students will be able to use applications of number theory in practical engineering situations, solve systems of linear equations relevant to engineering applications using matrix methods, approximate solutions of contextualised examples with graphical and numerical methods and review models of engineering systems using ordinary differential equations.

Learning Outcomes

By the end of this unit students will be able to:

1. Use applications of number theory in practical engineering situations.
2. Solve systems of linear equations relevant to engineering applications using matrix methods.
3. Approximate solutions of contextualised examples with graphical and numerical methods.
Essential Content

LO1  Use applications of number theory in practical engineering situations

Number theory:
- Bases of a number (Denary, Binary, Octal, Duodecimal, Hexadecimal) and converting between bases
- Types of numbers (Natural, Integer, Rational, Real, Complex)
- The modulus, argument and conjugate of complex numbers
- Polar and exponential forms of complex numbers
- The use of de Moivre’s Theorem in engineering
- Complex number applications e.g. electric circuit analysis, information and energy control systems

LO2  Solve systems of linear equations relevant to engineering applications using matrix methods

Matrix methods:
- Introduction to matrices and matrix notation
- The process for addition, subtraction and multiplication of matrices
- Introducing the determinant of a matrix and calculating the determinant for a 2x2 matrix
- Using the inverse of a square matrix to solve linear equations
- Gaussian elimination to solve systems of linear equations (up to 3x3)

LO3  Approximate solutions of contextualised examples with graphical and numerical methods

Graphical and numerical methods:
- Standard curves of common functions, including quadratic, cubic, logarithm and exponential curves
- Systematic curve sketching knowing the equation of the curve
- Using sketches to approximate solutions of equations
- Numerical analysis using the bisection method and the Newton–Raphson method
- Numerical integration using the mid-ordinate rule, the trapezium rule and Simpson’s rule
LO4 Review models of engineering systems using ordinary differential equations

Differential equations:
Formation and solutions of first-order differential equations
Applications of first-order differential equations e.g. RC and RL electric circuits, Newton’s laws of cooling, charge and discharge of electrical capacitors and complex stresses and strains
Formation and solutions of second-order differential equations
Applications of second-order differential equations e.g. mass-spring-damper systems, information and energy control systems, heat transfer, automatic control systems and beam theory and RLC circuits
Introduction to Laplace transforms for solving linear ordinary differential equations
Applications involving Laplace transforms such as electric circuit theory, load frequency control, harmonic vibrations of beams and engine governors
## Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Use applications of number theory in practical engineering situations</td>
<td><strong>P1</strong> Apply addition and multiplication methods to numbers that are expressed in different base systems</td>
<td><strong>D1</strong> Test the correctness of a trigonometric identity using de Moivre’s Theorem</td>
</tr>
<tr>
<td><strong>P2</strong> Solve engineering problems using complex number theory</td>
<td><strong>P3</strong> Perform arithmetic operations using the polar and exponential form of complex numbers</td>
<td><strong>M1</strong> Deduce solutions of problems using de Moivre’s Theorem</td>
</tr>
<tr>
<td><strong>LO2</strong> Solve systems of linear equations relevant to engineering applications using matrix methods</td>
<td><strong>P4</strong> Ascertain the determinant of a given 3x3 matrix</td>
<td><strong>D2</strong> Evaluate and validate all analytical matrix solutions using appropriate computer software</td>
</tr>
<tr>
<td><strong>P5</strong> Solve a system of three linear equations using Gaussian elimination</td>
<td><strong>M2</strong> Determine solutions to a set of linear equations using the inverse Matrix method</td>
<td><strong>LO3</strong> Approximate solutions of contextualised examples with graphical and numerical methods</td>
</tr>
<tr>
<td><strong>P6</strong> Estimate solutions of sketched functions using a graphical estimation method</td>
<td><strong>P7</strong> Calculate the roots of an equation using two different iterative techniques</td>
<td><strong>D3</strong> Critique the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods</td>
</tr>
<tr>
<td><strong>P8</strong> Determine the numerical integral of engineering functions using two different methods</td>
<td><strong>M3</strong> Solve engineering problems and formulate mathematical models using graphical and numerical integration</td>
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<tr>
<td>Pass</td>
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<tr>
<td><strong>LO4</strong> Review models of engineering systems using ordinary differential equations</td>
<td><strong>D4</strong> Critically evaluate first- and second-order differential equations when generating the solutions to engineering situations using models of engineering systems</td>
<td></td>
</tr>
<tr>
<td><strong>P9</strong> Determine first-order differential equations and their application to engineering systems using analytical methods</td>
<td><strong>M4</strong> Evaluate how different models of engineering systems using first-order differential equations solve engineering problems</td>
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<tr>
<td><strong>P10</strong> Determine second-order homogeneous and non-homogenous differential equations and their application to engineering systems using analytical methods</td>
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<tr>
<td><strong>P11</strong> Calculate solutions to linear ordinary differential equations using Laplace transforms</td>
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</tbody>
</table>
Recommended Resources

Textbooks

Journals
Communications on Pure and Applied Mathematics. Wiley.
*Journal of Mathematical Physics*. American Institute of Physics.

Websites
http://www.mathcentre.ac.uk/ Maths Centre (Tutorials)
http://www.mathtutor.ac.uk/ Maths Tutor (Tutorials)

Links
This unit links to the following related unit:
*Unit 2: Engineering Maths*
Unit 55: Aircraft Flight Control Systems

Unit code F/615/1532
Unit level 5
Credit value 15

Introduction

The need to control aircraft during all phases of flight has become ever more sophisticated as the complexity, size and flight speed of aircraft have increased. This has led to developments that increase the functionality, power output, fault tolerance and integration of the systems that provide flight control. With each aircraft generation, flight control system design has developed from simple manual and power-assisted mechanical systems, through to hydraulically and/or electrically powered and on to the advanced computer-controlled fly-by-wire and automatic flight control systems that we see today.

This unit will cover the design, development and operation of flight control systems for fixed wing aircraft through the generations and introduces students to the design, development and operation of mechanical, hydraulic power and fly-by-wire systems, and automatic flight control in the form of autopilot and autoland systems.

On successful completion of this unit students will be able to determine the construction, layout and operation of mechanical flight control systems and control surfaces, examine the design and operation of fly-by-wire flight control systems, determine the functions and operation of autopilot and autoland flight control systems and determine the contribution made to safe flight control by each system.

Learning Outcomes

By the end of this unit students will be able to:

1. Determine how the construction, layout and operation of mechanical flight control systems contribute to safe flight control
2. Investigate how the design and operation of hydraulic powered flight control systems contribute to safe flight control
3. Investigate how the development and operation of fly-by-wire flight control systems contribute to safe flight control
4. Show how the functions and operation of autopilot and autoland flight control systems contribute to safe flight control.
Essential Content

LO1  **Determine how the construction, layout and operation of mechanical flight control systems contribute to safe flight control**

*Flight control:*

Control requirements; control about aircraft axes, roll, yaw and pitch control, six degrees of freedom, control loads, feel and trim

Flight control surfaces, construction and aerodynamic operation: primary control surfaces, aileron, elevator, rudder; servo-tab, balance tab, trim tab; secondary control surfaces and devices, flap, slat, slot, flaperon, elevon, spoiler, vee-tail ruddervator, gust lock

*Mechanical flight control systems and their components:*

Construction, function and layout of mechanical control system components: control column, wheels and levers, chains and sprockets, push/pull rods, bell crank levers, torque tubes, spring feel units, control cables, pulleys, cable tensioner, turnbuckles, fairleads

Pilot input and system response, push/pull control rod and cable and pulley systems

LO2  **Investigate how the design and operation of hydraulic powered flight control systems contribute to safe flight control**

*Hydraulically powered flight control system component design and operation:*

System requirements: sufficient power for control actuation, control surface rigidity, need for trim actuation, artificial (Q) feel, stall warning, redundancy provision

Constructional design, function and operation of system major components: (Q) feel unit, trim actuator, hydraulic stick shaker; servo operated powered flying control unit (PFCU), hydro-mechanical power assisted and fully power operated PFCU, mechanically signalled hydraulic motor driven screw jack, electro-hydraulic PFCU

*Design architecture and operation of hydraulically powered flight control systems:*

Hydro-mechanical and electro-hydraulic powered flying control systems: pilot inputs and system response; PFCU servo actions, inputs, outputs, closed loop feedback; system redundancy provision for primary and secondary control surface operation
LO3 Investigate how the development and operation of fly-by-wire flight control systems contribute to safe flight control

*Fly-by-wire (FBW) control system development:*

Introduction of electronically controlled, hydraulically and electrically powered actuators

Solid state electronics for actuator control, pre-programmed computers for the control and integration of primary and secondary flight controls functions

Benefits resulting from FBW control: improved flight handling, reduction in airframe weight and control size, integration of flight control functions, flight envelope protection and alerting

Present and future benefits of fly-by-light (FBL) system signalling and control: further weight reduction from use of fibre-optic cabling and reduced component size, improved redundancy provision through system multiplexing

*Operation of FBW systems and components:*

FBW powered flight control unit (PFCU) operation: electro-hydraulic and electro-mechanical actuators, pilot side stick and conventional controls inputs, hydraulic servo operation, hydraulic and electrical feedback, redundancy provision

FBW system control and operation: operating modes, pilot and autopilot signal conditioning, closed-loop control, transducers and feedback circuitry; computer function, architecture, inputs and outputs for FBW controls integration

LO4 Show how the functions and operation of autopilot and autoland flight control systems contribute to safe flight control

*Autopilot functions and operation:*

Autopilot functions: maintenance of desired flight path and flight direction, pitch roll and yaw control

Autopilot servo-system operation: principles; error sensing inputs, correction, feedback and commanded outputs; circuitry signalling and actuation; input signals via transducers, error signal detection using electrical amplifiers, control surface actuation via servo-motor, position feedback signals to error detector amplifier

Autopilot operation for pitch, roll and yaw control; pitch damping and altitude hold, vertical speed and level change commands; roll heading and navigation modes; yaw damper signalling, rudder servo motor action
Automatic landing system functions and operation:

Instrument landing systems (ILS): function of aircraft and airfield navigation aids, automatic direction finder (ADF), distance measuring equipment (DMS), VHF omnidirectional range (VOR), during final approach, localiser and glideslope modes

Fully automatic landing system enhanced functionality and operation: functionality; radio altimeter, auto-throttle, enhanced ILS beam control laws, crosswind correction, continuation of runway flight guidance, go-round facility, continuous instrument display and monitoring; operation, during the approach, glideslope and landing phases of flight
## Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Determine how the construction, layout and operation of mechanical flight control systems contribute to safe flight control</td>
<td><strong>D1</strong> Analyse the function, layout and operation of mechanical flight control systems and components, assessing the contribution made by the system to safe flight control</td>
<td></td>
</tr>
<tr>
<td><strong>P1</strong> Discuss the control of fixed wing aircraft about their axes of rotation</td>
<td><strong>M1</strong> Explore the function, layout and operation of mechanical flight control systems and components, identifying the contribution made by the system to safe flight control</td>
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</tr>
<tr>
<td><strong>P2</strong> Investigate the function, layout and operation of mechanical flight control systems and components</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LO2</strong> Investigate how the design and operation of hydraulic powered flight control systems contribute to safe flight control</td>
<td><strong>D2</strong> Analyse the function, layout and operation of hydro-mechanical and hydro-electric powered flight control systems and their components, assessing the contribution made by each system to safe flight control</td>
<td></td>
</tr>
<tr>
<td><strong>P3</strong> Discuss the design and operation of hydraulically power flight control system components</td>
<td><strong>M2</strong> Explore the design and operation of hydro-mechanical and hydro-electric powered flight control systems and their components, identifying the contribution made by each system to safe flight control</td>
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<tr>
<td><strong>P4</strong> Illustrate the design and operation of hydro-mechanical and electro-hydraulic powered flight control systems</td>
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</tr>
<tr>
<td><strong>LO3</strong> Investigate how the development and operation of fly-by-wire flight control systems contribute to safe flight control</td>
<td><strong>D3</strong> Show how the development and operation of fly-by-wire control systems and components has contributed to safe flight control</td>
<td></td>
</tr>
<tr>
<td><strong>P5</strong> Discuss the development and benefits of fly-by-wire control systems and components</td>
<td><strong>M3</strong> Justify the development and operation of fly-by-wire control systems and components, identifying the contribution made by these systems to safe flight control</td>
<td></td>
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<tr>
<td><strong>P6</strong> Illustrate the operation of fly-by-wire control systems and components</td>
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</tr>
<tr>
<td>Pass</td>
<td>Merit</td>
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<tr>
<td><strong>LO4</strong> Show how the functions and operation of autopilot and autoland flight control systems contribute to safe flight control</td>
<td><strong>D4</strong> Assess how the functions and operation of modern autopilot, instrument and fully automated landing systems and components, assessing the enhanced functions that contribute to safe flight and landing control</td>
<td></td>
</tr>
<tr>
<td><strong>P7</strong> Discuss the functions and operation of a modern autopilot system and components</td>
<td><strong>M4</strong> Explore the functions and operation of modern autopilot, instrument and fully automated landing systems and components, identifying the enhanced functions that contribute to safe flight and landing control</td>
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</tr>
<tr>
<td><strong>P8</strong> Illustrate the functions and operation of modern instrument and fully automated landing systems and components</td>
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</tbody>
</table>
Recommended Resources

Textbooks

Journals
Aerospace (the magazine of the Royal Aeronautical Society), with articles on all areas of aerospace including the latest innovations on the design of fly-by-wire and fly-by-light flight control systems.

Websites
https://www.faa.gov Federal Aviation Administration
Advanced Avionics Handbook
(E-Book)

Links
This unit links to the following related units:
Unit 24: Aircraft Aerodynamics
Unit 59: Aircraft Gas Turbine Engine Design and Performance
Unit 56: Aircraft Propulsion Principles and Technology

Unit code J/615/1533
Unit level 5
Credit value 15

Introduction

No matter what method of propulsion is used to propel aircraft through the air, they all rely on the principle laid down in Newton’s third law, which states in its simplest form that to every action there is an equal and opposite reaction. The action force which we know as thrust may be provided by aircraft propellers or by the fluid stream from a jet engine exhaust, or by a combination of both.

This unit introduces students to the thermodynamic and mechanical principles that underpin aircraft propulsion and to gas turbine engine and piston engine construction, function and operation, as well as to the layout and operation of their associated components and support systems.

On successful completion of this unit students will be able to determine how thermodynamic and mechanical properties are applied to aircraft propulsion, and examine the construction, function and operation of gas turbine engines, their fluid, control and monitoring systems and piston engines and systems.

Learning Outcomes

By the end of this unit students will be able to:

1. Determine how thermodynamic and mechanical principles are applied to aircraft propulsion.
2. Examine the construction, function and operation of gas turbine engines and components.
3. Examine the layout, function and operation of the fluid control and monitoring systems of gas turbine engines.
4. Describe the construction, function and operation of piston engines and systems.
**Essential Content**

**LO1**  Determine how thermodynamic and mechanical principles are applied to aircraft propulsion

*Thermodynamic principles applied to combustion engines:*

The gas laws and the expansion and compression of perfect gases, constant volume, constant pressure, isothermal, adiabatic and polytropic processes

First law of thermodynamics applied to closed and open systems, non-flow (NFEE) and steady flow (SFEE) energy equations, concept of enthalpy in open systems, second law of thermodynamics applied to heat engines, measure of thermal efficiency

Thermal cycles and the concept of entropy, use of pressure-volume and temperature-entropy diagrams, the Otto cycle for spark ignition piston engines, the Joule constant pressure cycle for gas turbine engines

The practical four-stroke cycle for piston engines, performance indicators, indicated and brake power, engine thermal efficiency

The practical closed and open gas turbine cycle, losses compared with the ideal Joule cycle; thermal and propulsive efficiencies and measure of specific fuel consumption in aircraft gas turbine engines

*Mechanical principles applied to fluid flow and propulsive thrust:*

Newton’s laws of motion applied to fluid flow; momentum and kinetic energy of fluid flow, use of continuity, Bernoulli equation and SFEE for incompressible gas flows; compressible sonic flows, Mach number and airflow velocities, static and stagnation conditions, jet nozzle flow, chocked nozzles

Newton’s laws and aircraft thrust from gas stream; gross thrust, intake drag force, net thrust, net thrust with pressure thrust, thrust power; propeller aerodynamics and thrust production

Appropriate calculations to support principles detailed above

**LO2**  Examine the construction, function and operation of gas turbine engines and components

*Types, construction and operation of gas turbine engines:*

Turbojet engine: construction, arrangement and location of engine components and associated gearing and connections; operation, changes to the working fluid and the production of thrust as air/gas flows into the intake and through the compressor, combustor, turbine, propelling nozzle and exhaust components of the engine; operational limitations of the pure jet engine, noise pollution, reduced propulsive efficiency

Turbofan engine: construction, arrangement and operational differences between multi-shaft high bypass turbofan engines and the single shaft turbojet; relative advantages of turbofan engines over turbojets, fuel and propulsive efficiency, cooling and noise reduction
Turboprop engine: construction, arrangement and component location, addition of low-pressure turbine, main gearbox and propeller; operational differences in the production of thrust via a propeller; relative advantages/disadvantages over turbofan engines

Turboshaft engine: construction, arrangement and component location, introduction of larger diameter drive shaft and more robust compressors and turbines; operation for the production of torque to drive helicopter rotors; relative advantages in the use of this type of engine

*Function and operation of gas turbine engine components:*

Function and operation of compressors: axial flow compressors, stage rotors and stators, working fluid temperature and pressure rises and governing factors, inlet guide vanes, variable stator vanes; centrifugal compressors, inlet duct and vanes, the impeller, rotating guide vanes and radial diffuser vanes, airflow pressure rise and centrifugal action

Function and operation of fans: compression of bypass air, supercharged air feed into core, need for multi-stage fans and form of fan blade, disc, attachments and casing

Combustors: types, multiple combustion chamber, tubo-annular and annular; requirements, high combustion efficiency, reliable ignition, restart facility, low-pressure losses and emissions, high durability; function and operation, control of combustible gases, fuel injectors, vaporisers, spray nozzles, ignitors and combustion chamber cooling

Function and operation of turbines: single and multi-stage, impulse and reaction turbines, energy transfer from the working fluid, turbine casing, discs, shafts and nozzle guide vanes, turbine cooling and constructional materials limitations

Function and operation of intakes and exhausts: intakes, bell-mouth, circular, variable geometry, drag minimisation at cruise speeds, integration with engine cowlings; exhausts, gas exhaust propelling nozzles, reverse thrusters, thrust vectoring nozzles, after burners

Appropriate calculations to support principles detailed above

**LO3** Examine the layout, function and operation of the fluid control and monitoring systems of gas turbine engines

*Layout and operation of turbine engine fluid systems:*

Engine fuel systems: airframe and engine fuel system interaction requirements, avoidance of fuel contamination and suction operation, priming, re-priming and relight facilities; component identification, function and layout; function and operation of typical engine fuel system including operation of hydro-mechanical fuel meeting unit

Engine lubrication systems: lubricant types, properties, identification and use of additives; oil system functions; function and layout of lubrication system components; operation of recirculatory lubrication systems, pressure relief and full flow systems and pressure feed and distribution, scavenger and vent sub-systems
Internal air systems: functions cooling, sealing and bearing load control; function and operation of air cooling system; identification, functions and nature of air system seals and sealing methods

Function and operation of engine control and monitoring systems:
Engine electro mechanical control systems: function and operation of mechanical cables, rods and pilot control levers, electrically actuated valves and switches; function and operation of auto-throttle, regulation and switching, flight/ground idle control

Electronic engine control systems: identification and function of typical electronic control system components, electronic controller, demand and feedback sensors, fuel pumps and fuel metering controller; function and operation of FADEC system, electronic engine controller (EEC), fuel metering unit (FMU) and fuel control monitoring

Engine performance and condition monitoring systems: instrumentation and measurement of engine temperature, pressure ratio, rotational speed and thrust performance parameters; vibration and lubrication condition monitoring, use of magnetic chip detectors

LO4 Describe the construction, function and operation of piston engines and systems

Piston engine construction, operation and installation:
Engine construction and operation: crankcase, crankshaft, cylinder and piston assemblies, valve mechanism and timing, accessory and propeller reduction gearboxes, two and four stroke cycle operation, power and efficiency parameters and their monitoring and measurement

Power plant installation: configuration and function of firewalls, cowlings, acoustic panels, engine mounts, anti-vibration mounts

Function and operation of piston engine fluid, ignition and control systems:
Engine fuel and fuel metering systems: fuel system requirements, fuel metering devices; carburation principles, float and pressure injection carburettors, automatic mixture control; fuel-injection systems, fuel injectors and pumps, airflow/fuel regulation and metering; supercharged induction systems, turbochargers and their control

Lubrication systems: functions, types and characteristics of engine oil lubricants; lubrication system requirements; combined splash and pressure lubrication; dry and wet sump lubrication system components and operation

Engine ignition, control and starter systems: magneto-ignition principles, circuit operation and components; full authority electronic digital control (FADEC) system operation and function of electronic control unit (ECU), booster coil, impulse coupling and retard breaker vibrators; inertia starters, direct cranking electric starter system operation and monitoring
### Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Determine how thermodynamic and mechanical principles are applied to aircraft propulsion</td>
<td><strong>D1</strong> Analyse the thermodynamic and mechanical principles applied to the operating cycles and production of propulsive thrust by piston-propeller and gas turbine engine driven aircraft, assessing the relative merits of each method of propulsion</td>
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</tr>
<tr>
<td><strong>P1</strong> Describe the thermodynamic principles applied to reciprocating piston engine and aircraft gas turbine engine operating cycles</td>
<td><strong>M1</strong> Explain, with the use of calculations, the thermodynamic and mechanical principles applied to the operating cycles and production of propulsive thrust by piston-propeller and gas turbine engine driven aircraft, identifying the relative merits of each method of propulsion</td>
<td></td>
</tr>
<tr>
<td><strong>P2</strong> Describe the mechanical principles applied to the production of propulsive thrust by piston-propeller and gas turbine engine driven aircraft</td>
<td><strong>D2</strong> Analyse the constructional features, function and operation of turbojet, turbofan, turboshaft and turboprop gas turbine engines and their components, assessing the relative performance of each engine and component arrangement</td>
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</tr>
<tr>
<td><strong>LO2</strong> Examine the construction, function and operation of gas turbine engines and components</td>
<td><strong>P3</strong> Illustrate the construction and operation of turbojet, turbofan, turboshaft and turboprop gas turbine engines</td>
<td></td>
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<tr>
<td><strong>P4</strong> Describe the function and operation of gas turbine engine, intake, compressor, combustor, turbine and exhaust components</td>
<td><strong>M2</strong> Explore the construction, function and operation of turbojet, turbofan, turboshaft and turboprop gas turbine engines and their components, identifying, with calculations, the relative performance of each engine type</td>
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<tr>
<td><strong>LO3</strong></td>
<td>Examine the layout, function and operation of the fluid control and monitoring systems of gas turbine engines</td>
<td></td>
</tr>
<tr>
<td><strong>P5</strong></td>
<td>Illustrate the layout and operation of engine fuel, lubrication and internal air fluid systems</td>
<td>M3 Explain the layout and operation of engine, fluid, control and monitoring systems and the function and operation of the major components for each system</td>
</tr>
<tr>
<td><strong>P6</strong></td>
<td>Describe the function and operation of engine electro-mechanical, electronic and FADEC control systems and engine monitoring systems</td>
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<tr>
<td><strong>LO4</strong></td>
<td>Describe the construction, function and operation of piston engines and systems</td>
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</tr>
<tr>
<td><strong>P7</strong></td>
<td>Describe the construction, operation and installation of aircraft reciprocating piston engines</td>
<td>M4 Explore the construction and operation of aircraft reciprocating piston engines and their supporting systems, identifying the function and layout of the major components, for each supporting system</td>
</tr>
<tr>
<td><strong>P8</strong></td>
<td>Illustrate the function and operation of engine fuel, lubrication, ignition, control and starter systems</td>
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</tbody>
</table>
Recommended Resources

Textbooks

Journals

Links
This unit links to the following related units:
Unit 13: Fundamentals of Thermodynamics and Heat Engines
Unit 38: Further Thermodynamics
Unit 60: Advanced Composite Materials for Aerospace Applications
Unit 57: Aircraft Structural Integrity

Unit code L/615/1534
Unit level 5
Credit value 15

Introduction

To ensure the integrity of aircraft structures and structural components, the designer must consider the properties, failure characteristics and selection of aircraft materials used for the construction, repair and maintenance of the airframe, in conjunction with the loading criteria, in-service role and operation of the aircraft. This unit introduces you to the materials, science, failure analysis, repair techniques, design, policies and procedures that collectively ensure the integrity and continued airworthiness of the aircraft’s structure.

This unit introduces students to the properties and selection of materials used for the construction and repair of the airframe, the prediction of structural damage and design against failure, the methods and design of adhesively bonded repairs, as well as to the policies, procedures and regulation used to ensure the integrity of aircraft structures during service.

On successful completion of this unit students will be able to examine the design criteria, properties and selection of aircraft metallic and composite structural materials, examine aircraft structural fatigue, damage prediction and design against failure, examine fibre composite adhesively bonded repairs to aircraft metallic and composite structures, and investigate how policies, procedures and regulations are used to ensure the integrity of aircraft structures.

Learning Outcomes

By the end of this unit students will be able to:

1. Evaluate the design criteria, properties and selection of aircraft metallic and composite structural materials.
2. Investigate aircraft structural fatigue, damage prediction and design against failure.
3. Examine fibre composite adhesively bonded repairs to aircraft metallic and composite structures.
4. Demonstrate how policies, procedures and regulations are used to ensure the integrity of aircraft structures.
Essential Content

LO1 Evaluate the design criteria, properties and selection of metallic and composite aircraft structural materials

Design criteria for aircraft structural materials:
General: purchase, maintenance and repair costs, availability, ease of manufacture and fabrication
Environmental durability: corrosion, moisture absorption, wear and erosion resistance
Mechanical properties: density ($\rho$), stiffness (elastic modulus $E$), strength (yield stress $\sigma_y$), shear strength ($\tau$), structural efficiency measured by, specific stiffness ($E/\rho$) and specific strength ($\sigma/\rho$), fatigue resistance, fatigue stress ($\sigma_{fs}$) fracture toughness ($K_c$), impact resistance, strength and stiffness parameter calculations
Thermal and electrical properties: high temperature resistance, creep resistance, electrical conductivity, radar transparency

Common aircraft structural materials and their properties:
Metallic-alloys
Aluminium lithium (8090), copper (2014, 2024) and magnesium (7075) alloys; high temperature titanium alloys (e.g. Ti-6Al-4V); high strength steels, nickel-based super alloys
Composites
Polymer matrix composites (PMC) (e.g. epoxy, PEEK), metal matrix composites (MMC), fibre-metal laminates (FML), ceramic matrix composites (CMCs), glass reinforced aluminium (GLARE) property parameters including: tensile, compressive and shear strength, elastic and shear modulus, specific strength and stiffness, hardness, fracture toughness, crack growth resistance and corrosion resistance for metallic alloy and composite materials

Materials selection:
Using design criteria select appropriate metallic and composite materials for: wing, fuselage and empennage skins, leading edges, fuselage frames and stringers, undercarriage struts, engine turbines, jet pipes and exhausts, for both modern military fighter and commercial aircraft and make comparisons between the choice of materials
LO2  Investigate aircraft structural fatigue, damage prediction and design against failure

Nature of fatigue:
Sources: alternating, fluctuating and repeating cyclic stressing, corrosion, fretting, thermal and acoustic
Fatigue parameters: representation on S-N curves, fatigue strength, fatigue limit, endurance limit, fatigue behaviour in ferrous and non-ferrous light alloy and composite structures

Fatigue damage prediction:
Fatigue life prediction methods: structural fatigue testing; use of empirical stress relationships, Goodman equation, Gerber parabolic equation, Soderberg equation, Miner’s law of cumulative damage; use of ground-air-ground and gust load cycles and fatigue meters
Use of linear elastic fracture mechanics (LEFM): fracture mechanisms, slip, plastic deformation and dislocations, ductile transgranular fracture, brittle fracture (cleavage); the Griffith energy balance and Irwin’s stress intensity approach to predict fatigue crack behaviour including, stress concentration and intensity factors, crack tip plasticity, fracture toughness, critical crack growth, propagation rates and time to failure predictions
Creep failure prediction; characteristics, stages creep rate and rupture times, kinetic heating effects

Aircraft structure design prevention methods:
Correct materials selection based on design criteria
Use of jointing compounds, surface hardening and finish, doublers and butt straps
Avoidance of sudden changes in cross-section and bend designs that trap moisture and dirt
Use of aircraft structural failure categorisation methods: primary, secondary and tertiary structures; structurally significant items (SSIs); fail safe, damage tolerant and safe life design

LO3  Examine fibre composite adhesively bonded repairs to aircraft metallic and composite structures

Properties of fibre composite materials:
Unidirectional composites; longitudinal stiffness and strength, transverse stiffness and strength
Fibre volume fraction and use of the equation of mixtures (σc = σfVf + σmVm and Ec = EfVf + EmVm)
Off-axis stiffness and strength in tension normal and parallel to fibres (σ1 = σfcos²θ and σ2 = σfsin²θ) and shear stress parallel to fibres (τ12 = 1/2 σf sin2θ)
Matrix materials and properties for (PMCs) including, epoxies, bismaleimide resins, thermoplastic polymers

Properties of cross-ply and angle-ply laminates

*Adhesion and surface treatments:*

Adhesives; thermo-plastic, thermos-setting, solvent activated, impact activated; adhesion and adhesive testing

Surface preparation treatments for aluminium alloys, titanium alloys e.g. phosphoric acid anodising, chromic acid anodising; preparation for bonding composite surfaces e.g. grit blasting, sanding and solvent degrease

*Adhesively bonded repairs:*

Types and requirements

Repair types: non-patch; resin injection, potting; patch; external patch and scarf joints; consideration of type used to effect repair

Repair requirements: dependence on structural classification primary, secondary and tertiary and criticality of repair; restoration of structural capability, ability to withstand design loads, maintenance of aerodynamic shape, restoration of thermal and electrical properties; minimisation of downtime, repair materials and weight gain

Bonded repair joint design

Joint classification: primary lap joints; secondary reinforcement patch repair and laminate repair joints

Design criteria: metallic and composite material thickness and specification, strength considerations, residual strength of flawed or damaged adhesive bonded joints, acceptable criteria for bond flaws and damage, moisture ingress limits, life prediction for adhesively bonded joints

Repair design calculations for patch repairs including; the load carrying capacity of the joint and the adherand, joint and overlap lengths and peel stress

**LO4** Demonstrate how policies, procedures and regulations are used to ensure the integrity of aircraft structures

*Damage assessment methods:*

General damage assessment including; visual inspection of metallic and composite structure for corrosion and impact damage, surface damage, cracking, water ingress aided by moisture meter and delamination aided by ‘tap test’

Non-destructive evaluation (NDE) of structural damage using e.g.: optical, penetrant dye, ultrasonic, radiographic, eddy current and thermography techniques
Repair policies and procedures:

Repair policies: repair and maintenance organisation considerations; damage assessment methods, repair categorisation, downtime, costs, repair by replacement, physical and human resource requirements; structural integrity policies for e.g. aging aircraft, fighter aircraft

Procedures: quality assurance procedures for repair integrity and airworthiness; procedures and manuals for the damage assessment and repair of metallic and polymer-matrix composite structures and structural components

Field repair considerations e.g. simple techniques, limited use of repair equipment, first-aid and temporary repair techniques, availability of cure facilities

Aircraft structural integrity care and maintenance programmes and regulations:

Inspection: nature and frequency of inspection, structural component access and component life considerations

Design of aircraft structural integrity care and maintenance programmes, policies and procedures

Hard time and on-condition monitored maintenance planning and its relationship to aircraft structure

Information sources and repair and maintenance actions: statistical information sources and corresponding reliability techniques; data collection and structural component history; maintenance reporting procedures; corrective action methodology and quality assurance procedures

Regulations e.g. European Aviation Safety Agency (EASA), Civil Aviation Authority (CAA), Ministry of Defence (MOD) and/or Aircraft Manufacturers regulations for the integrity and continuing airworthiness of aircraft structures, structural components and aging airframes
## Learning Outcomes and Assessment Criteria

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<tr>
<td><strong>LO1</strong> Evaluate the design criteria, properties and selection of metallic and composite aircraft structural materials</td>
<td><strong>D1</strong> Construct a case for the selection of common metallic and composite structural components in a given situation, assessing the choices made between different candidate materials</td>
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</tr>
<tr>
<td><strong>P1</strong> Discuss the design criteria and common metallic and composite material properties required for aircraft structural materials</td>
<td><strong>M1</strong> Explore the material properties and design criteria needed for the selection of common metallic and composite aircraft structural components, making choices between the selection of different candidate materials</td>
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<tr>
<td><strong>P2</strong> Select appropriate metallic and composite materials for aircraft structural components, using design criteria</td>
<td></td>
<td><strong>M2</strong> Investigate fatigue, the quantitative prediction of fatigue behaviour and the design methods used to mitigate its damaging effects to aircraft structure and structural components</td>
</tr>
<tr>
<td><strong>LO2</strong> Investigate aircraft structural fatigue, damage prediction and design against failure</td>
<td><strong>D2</strong> Analyse a given material selection decision to show how fatigue, the quantitative prediction of fatigue behaviour and the design methods used to mitigate its damaging effects to aircraft structure and structural components are used to justify the use of a particular material</td>
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<tr>
<td><strong>P3</strong> Discuss the nature of fatigue and the quantitative methods used to predict fatigue behaviour in aircraft structures</td>
<td></td>
<td><strong>P4</strong> Illustrate the design prevention methods used to mitigate the effects of aircraft structural damage from fatigue</td>
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<tr>
<td><strong>LO3</strong> Examine fibre composite adhesively bonded repairs to aircraft metallic and composite structures</td>
<td><strong>M3</strong> Discuss the properties of fibre matrix composite materials and the surface treatments, used for adhesively bonded structural repairs</td>
<td><strong>D3</strong> Critically evaluate how a particular composite repair decision was made. Include consideration of the composite material properties, repair requirements and the application of quantitative joint design methods chosen to ensure the integrity of the repair</td>
</tr>
<tr>
<td><strong>P5</strong> Review the properties of fibre matrix composite materials and surface treatments used for adhesively bonded structural repairs</td>
<td><strong>M4</strong> Explore the repair requirements and application of quantitative joint design methods that ensure the integrity of fibre composite adhesively bonded repairs to aircraft structures</td>
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<tr>
<td><strong>P6</strong> Show how the repair types, requirements, joint design criteria and methods used to ensure the integrity of fibre composite adhesively bonded repairs to aircraft structures are applied in practice</td>
<td></td>
<td><strong>M5</strong> Investigate how damage assessment methods, repair and maintenance policies, procedures and authority regulations ensure the correct repair, integrity and airworthiness of aircraft structures</td>
</tr>
<tr>
<td><strong>LO4</strong> Demonstrate how policies, procedures and regulations are used to ensure the integrity of aircraft structures</td>
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<td><strong>D4</strong> Construct a damage assessment report that shows how damage assessment methods, repair and maintenance policies, procedures and regulations are used to ensure the correct repair is selected to ensure integrity and airworthiness of aircraft structures</td>
</tr>
<tr>
<td><strong>P7</strong> Show how damage assessment methods, policies and procedures are used to ensure that aircraft structures are correctly repaired</td>
<td><strong>P8</strong> Illustrate how care and maintenance programmes, procedures and authority regulations ensure the integrity and airworthiness of aircraft structures</td>
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</table>
Recommended Resources

Textbooks

Journals
The following professional journals of the Institute of Mechanical Engineers published by Sage provide useful high level information on aircraft materials and structures that could be made available for library reference:

*Mechanical Engineers Part G Journal of Aerospace Engineering.*
*Mechanical Engineers Part L Journal of Materials Design and Applications.*

Websites
https://www.faa.gov/ Federal Aviation Administration
Aviation Maintenance Technician Handbook (E-Book)

Links
This unit links to the following related units:

*Unit 10: Materials and Properties Testing*
*Unit 27: Composite Materials for Aerospace Applications*
*Unit 60: Advanced Composite Materials for Aerospace Applications*
Unit 58: Avionic Systems

Unit code R/615/1535
Unit level 5
Credit value 15

Introduction

The term ‘avionics’ refers to the vast range of electronic systems used on any modern aircraft. These systems include those used for radio communication, navigation, weather radar, autopilot and instrument landing systems (ILS), as well as a host of other systems essential to supporting an aircraft whilst in flight and on the ground. All of these systems reduce the burden on the flight crew and significantly improve the safety and stability of the aircraft.

This unit will provide the student with a comprehensive introduction to the avionic systems used on modern aircraft. They will investigate several of these systems in detail and will gain an understanding of the technologies on which each of these systems is based as well as their practical application. The way these systems work together to minimise the workload on the flight crew and contribute to safe and fuel-efficient flight will also be covered.

The unit is divided into four key topic areas: aircraft radio communication systems, aircraft navigation systems, aircraft radar, and automatic flight control systems (AFCS).

On successful completion of this unit students will be able to interpret avionic system schematic diagrams, identify the practical application of components and sub-systems, and understand the principles on which they operate.

Learning Outcomes

By the end of this unit students will be able to:

1. Demonstrate the principles and practical application of HF, VHF and UHF aircraft radio communication systems.

2. Investigate the principles and practical application of aircraft navigation systems.

3. Investigate the principles and practical application of aircraft radar and ADS-B systems.

4. Demonstrate the principles and practical application of automatic flight control systems (AFCS).
Essential Content

LO1 Demonstrate the principles and practical application of HF, VHF and UHF aircraft radio communication systems

Principles of aircraft radio communication:
Electromagnetic waves
The electromagnetic wave spectrum
Frequency, wavelength and velocity of propagation
Wave propagation in free-space, waveguides and cables
Characteristic impedance
Radio propagation at HF, VHF and UHF
Antennas for HF, VHF and UHF radio communication
Isotropic radiators. Antenna gain and directivity
Feeders and cables for RF
Voltage standing wave ratio (VSWR)

Radio transmitter principles:
Oscillators
Phase-locked loops (PLL)
Digital frequency synthesis
Modulation: DSB AM, SSB, FM, PSK
Power amplifiers
Class of operation
Harmonic suppression
Antenna coupling
Standing wave ratio

Radio receiver principles:
Sensitivity and selectivity
The super-heterodyne principle
Mixers and IF amplifiers
Image and adjacent channel rejection
RF and IF filters
Demodulators (DSB AM and SSB)
Automatic gain control (AGC)
Automatic frequency control (AFC)
Digital signal processing (DSP) techniques
Software-defined radio (SDR) receivers
HF aircraft radio communication:
HF spectrum allocation, channels and channel spacing
Typical aircraft HF radio systems
HF radio antennas
Antenna coupling and loading
HF SSB voice communication
HF data-link (HFDL)

VHF aircraft radio communication:
VHF spectrum allocation, channels and channel spacing
Typical aircraft VHF radio systems
VHF radio antennas
VHF AM voice communication
VHF data-link (VHFDL)

LO2 Investigate the principles and practical application of aircraft navigation systems

Navigation systems principles:
Aircraft synchro and servo systems
Terrestrial magnetism and magnetic compass systems
Gyroscopic and inertial navigation principles
VHF Omni-directional Ranging (VOR) principles
Distance Measuring Equipment (DME) underpinning theory
Instrument Landing System (ILS) underpinning theory
Principles of air data systems
Principles of inertial navigation systems (INS)

Area navigation:
Principles of area navigation (RNAV)
Contributory systems (VOR and DME)
Line of sight range (LOS)
RNAV equipment, control and display units (CDU)
RNAV geometry
Navigational databases
Required navigation performance (RNP)
Flight management systems (FMS):
- Principles of FMS
- Lateral and vertical navigations
- Advantages of FMS
- Flight management computer systems (FMCS)
- FMCS control and display units (CDU)
- CDU information pages and displays
- System initialisation

Global navigation satellite systems (GNSS):
- Global positioning system (GPS)
- GPS principles
- GPS segments (space, control and user)
- GPS signals and codes
- GPS accuracy and errors

LO3 Investigate the principles and practical application of aircraft radar and ADS-B systems

Radar principles:
- Primary and secondary radar systems
- The radar range equation
- Pulsed and continuous wave (CW) radar systems
- Duty cycle, peak and average power

Weather radar systems:
- Weather radar principles
- Radar antennae (parabolic and flat plate)
- Radar transmitters, receivers and displays
- Electronic flight instrument displays (EFIS)
- Cloud formation and the detection of precipitation

Surveillance radar systems:
- Surveillance radar principles
- Primary surveillance radar (PSR) and secondary surveillance radar (SSR)
- Radar transponders
- Air traffic control (ATC) radar (modes A, C and S)
- Traffic alert and collision avoidance systems (TCAS)

ADS-B systems:
- Automatic dependent surveillance-broadcast (ADS-B) principles
- ADS-B transmitting and receiving equipment
LO4  **Demonstrate the principles and practical application of automatic flight control systems (AFCS)**

*Autopilot and flight director principles:*
- Servo principles
- Feedback systems
- Demand, command, and feedback signals
- Gyro principles
- Vertical gyro
- Autopilot modes
- Three-axis control
- Pitch control
- Roll control
- Yaw damping
## Learning Outcomes and Assessment Criteria

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<tr>
<td><strong>LO1</strong> Demonstrate the principles and practical application of HF, VHF and UHF aircraft radio communication systems</td>
<td><strong>D1</strong> Critically evaluate the performance of a typical HF SSB or VHF AM transceiver in terms of receiver sensitivity, selectivity, output power and modulation depth for AM or peak-envelope-power (PEP) for SSB, frequency accuracy and stability</td>
<td></td>
</tr>
<tr>
<td><strong>P1</strong> Illustrate the relationship between frequency, wavelength and velocity of propagation of an electromagnetic wave</td>
<td><strong>M1</strong> Explore the main features and characteristics of radio wave propagation at HF, VHF and UHF</td>
<td></td>
</tr>
<tr>
<td><strong>P2</strong> Explore the functional elements of AM radio receivers and transmitters</td>
<td><strong>M2</strong> Discuss full-carrier amplitude and suppressed carrier single-sideband modulation techniques (DSB AM and SSB)</td>
<td></td>
</tr>
<tr>
<td><strong>P3</strong> Interpret key performance specifications of an aircraft voice communication system</td>
<td><strong>M3</strong> Discuss a typical VHF antenna for use on an aircraft and justify the need for a matched antenna system in terms of radiated power and voltage standing wave ratio</td>
<td></td>
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<tr>
<td><strong>P4</strong> Discuss a typical radio data-link system (HFDL or VHFDL) for use in an aircraft</td>
<td><strong>M4</strong> Discuss the underpinning principles of VOR- and DME-based navigation aids</td>
<td></td>
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<tr>
<td><strong>LO2</strong> Investigate the principles and practical application of aircraft navigation systems</td>
<td><strong>D2</strong> Critically assess the benefits of area-based navigation (RNAV) when compared with satellite-based navigation for a typical modern civil transport aircraft</td>
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<tr>
<td><strong>P5</strong> Demonstrate the typical arrangement of remote indicating compass for use on a typical modern civil aircraft</td>
<td><strong>M5</strong> Review the principles of gyroscope-based inertial navigation and its limitations in providing accurate global aircraft navigation</td>
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<tr>
<td><strong>P6</strong> Explore the range of navigational aids and techniques available for use in a typical modern civil aircraft</td>
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<tr>
<td>LO3</td>
<td>Investigate the principles and practical application of aircraft radar and ADS-B systems</td>
<td>D3</td>
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<tr>
<td>P7</td>
<td>Differentiate between primary and secondary radar systems and describe an example of each</td>
<td>M6</td>
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<tr>
<td>P8</td>
<td>Discuss the use of radar in air traffic control (ATC) applications</td>
<td>M7</td>
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<tr>
<td>P9</td>
<td>Illustrate the functional components of an aircraft weather radar system</td>
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<tr>
<td>P10</td>
<td>Explore the benefits of ADS-B as a means of providing real-time data</td>
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<tr>
<td>LO4</td>
<td>Demonstrate the principles and practical application of automatic flight control systems (AFCS)</td>
<td>D4</td>
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<tr>
<td>P11</td>
<td>Discuss the reasons for using closed loop feedback in automatic flight control systems</td>
<td>M8</td>
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<tr>
<td>P12</td>
<td>Illustrate key autopilot control modes and describe their function in relation to an aircraft’s attitude and stability</td>
<td>M9</td>
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Recommended Resources

Textbooks

Links
This unit links to the following related units:
Unit 16: Instrumentation and Control Systems
Unit 19: Electrical and Electronic Principles
Unit 59: Aircraft Gas Turbine Engine Design and Performance

Unit code Y/615/1536
Unit level 5
Credit value 15

Introduction

Gas turbine engines have become the major source of propulsive power for modern-day commercial and military aircraft, due to their superior power output and efficiency savings in relation to their reciprocating piston counterparts. The current imperatives are for engines to be designed that are quieter, cleaner, more efficient, have greater power and improved performance.

This unit introduces students to the thermo-fluid principles and propulsion cycles used to assess the overall efficiencies of gas turbine engines, and to the design and performance of the turbomachinery, intake, combustion and exhaust modules that provide the propulsive thrust, as well as to the relationship between their design, performance and effect on the environment.

On successful completion of this unit students will be able to determine gas turbine engine performance using thermo-fluid principles and propulsion cycle efficiencies; examine the design and performance of aircraft gas turbine engine turbomachinery, intake, combustion and exhaust modules; and investigate the factors affecting the design, performance and environmental impact of gas turbine powered aircraft operation.

Learning Outcomes

By the end of this unit students will be able to:

2. Evaluate the design and performance of aircraft gas turbine engine turbomachinery.
3. Evaluate the design and performance of aircraft gas turbine engine intake, combustion and exhaust modules.
4. Investigate the factors affecting the design, performance and environmental impact of gas turbine powered aircraft operation.
Essential Content

**LO1** Determine gas turbine engine performance, using thermo-fluid principles and propulsion cycle efficiencies

*Thermo-fluid principles applied to propulsion cycles:*

Gas laws and the characteristic gas equation \( pv = mRT \), specific heat capacities for fluids

Perfect gas processes; constant volume, constant pressure, isothermal, adiabatic, reversible adiabatic (isentropic), polytropic; ratio of specific heats and the adiabatic index \( c_p/c_v = \gamma \)

Concept of entropy, entropy change and specific entropy change in non-isentropic processes, representation of entropy change on T – s diagrams

Constant pressure/Joule cycle: isentropic compression, reversible constant pressure heat supply, isentropic expansion, reversible constant pressure heat rejection; representation on p – V and T – s diagrams; air standard efficiency and work ratio

Newton’s laws and propulsive thrust; gross thrust, intake drag force, net thrust, net thrust with pressure thrust, thrust power

Fluid flow in open systems, potential, kinetic and heat energy of the working fluid, steady flow energy equation (SFEE) and the concept of enthalpy and specific enthalpy

Compressible fluid flows: through ducts and nozzles, static \( (p, T, h, \text{ pressure, temperature, specific enthalpy}) \) and stagnation \( (p_0, T_0, h_0) \) properties; ram pressure rise, ram pressure ratio; sonic velocity

\[ a = \sqrt{\gamma RT} \]; flow through shockwaves, representation of normal shock on T – s diagram

Isentropic flow relationships; \( T_0/T \) and \( p_0/p \) in terms of the adiabatic index \( \gamma \) and Mach number \( (M) \) and mass flow parameters in terms of continuity equation and the characteristic gas equation where mass flow

\[
\begin{align*}
(m) &= \frac{pAM\sqrt{\gamma RT}}{RT}.
\end{align*}
\]

*Gas turbine propulsion cycles and engine performance prediction:*

The *ideal* turbojet cycle: station numbering; intake airflow adiabatic and without friction, isentropic compression in flight; isentropic compression through compressor; constant pressure heat addition in the combustor; isentropic expansion through turbine; frictionless adiabatic flow through jetpipe; isentropic expansion through exit nozzle; cycle representation on T – s diagram
Component losses: aerodynamic through ducts and over bodies, thermodynamic heat losses and incomplete energy release from fuels; thermodynamic imperfections, compression and expansion processes depart from the ideal

Component isentropic efficiencies to account for losses, through intake, compressor, combustor, turbine, jetpipe and final nozzle

Turbojet cycle calculations using realistic component isentropic efficiencies

Turboprop cycle: differences from pure turbojet; stage numbering, power turbine, driveshaft, reduction gearbox and propeller; representation on T – s diagram; cycle calculations

High bypass turbofan cycle: differences from turbojet and turboprop; stage numbering proportion of bypass flow, bypass ratio, hot and cold exit nozzles; representation on T – s diagram; cycle calculations

Measures of performance: propulsive efficiency $\eta_p = \frac{2}{1+(V_j/V_a)}$, thermal efficiency $\eta_t = 0.5m(V_j^2 - V_a^2)/fc$ and overall efficiency $\eta_t = m(V_j - V_a)V_a/fc$ ($f =$ fuel flow rate, $C =$ calorific value of fuel, $m =$ mass flow rate)

Performance comparisons between turbojet, turboprop and turbofan

**LO2** Evaluate the design and performance of aircraft gas turbine engine turbomachinery

**Axial flow compressors:**

Function and advantages over centrifugal type

Multi-stage configuration, disc, stator and rotor action, pressure and temperature rise, pressure ratio

Stage aerodynamics and operation: flow of air through a stage, use of velocity triangles; stage power and work and use of the Euler equation, stage flow and temperature rise coefficients

Primary (boundary layer) losses and secondary (corner, blade tip) losses, pressure loss coefficient

Compressor performance characteristics and mapping: stage matching; overall pressure ratio against inlet mass flow function maps, the working line, stability line and stability margin

Compressor operating problems outside limits; mild and deep surge, blade stall and flutter, methods of control

**Fans:**

High bypass; functions and mechanical design of fan blades, disc and casing, interaction as part of the compression system; military use low bypass fans, function and configuration of fan rotor blades, discs and blisks, fan casing and guide vanes
**Centrifugal compressors:**
Modern usage and design configuration; functions of impeller, rotating guide vanes, diffuser vanes and casing; operating principles, pressure and velocity changes through compressor

**Turbines:**
Turbine: types impulse, reaction and impulse-reaction; functions and configuration
Aerodynamic operation and performance: turbine geometry, use of velocity triangles, axial velocity against blade speed, changes in whirl velocity across stage, mass flow, power calculations, efficiency contours, blades and nozzle guide vanes (NGV)
Turbine design methodology: mechanical design of discs, blade attachments and blades to meet; aerodynamic requirements, mechanical and thermal stresses, vibration, fatigue and creep requirements
Turbine disc, blade and NGV cooling methods, coatings and materials

**LO3** Evaluate the design and performance of aircraft gas turbine engine intake, combustion and exhaust modules

**Air intakes:**
Types, circular, asymmetrical, external compression, variable geometry, supersonic
Intake aerodynamic performance: ideal and real airflow behaviour, flow through intake under static, climbing and high speed conditions; flow matching and loss characteristics
Design and performance: air velocity control to compressor, use of variable geometry design; aerodynamic performance and design features of subsonic high bypass fan; throat sizing, lip sizing, diffuser design; airframe intake integration, nacelle and cowling design features

**Combustion systems:**
Combustor types and design architecture: multiple combustion chamber, tubo-annular, annular; fuel injector vaporisers and fuel spray nozzles.
Combustor performance: diffuser performance and stability, dilution zone performance, dilution zone mixing performance
Combustion losses and efficiencies: performance criteria, efficiency of combustion, system pressure losses and losses due to dissociation, outlet temperature distribution, stability and light-up limits
Flame stabilisation: definition and measures of stability performance; factors controlling stability, fuel type, fuel-air-ratio, gas velocity, temperature and pressure, flame holder size and shape
Exhausts:
Function, design and operational performance of jetpipe nozzles, thrust
reversers, after burners; directional and velocity control of hot and cool gas
flows; thrust control and augmentation performance; noise reduction methods

LO4 Investigate the factors affecting the design, performance and
environmental impact of gas turbine powered aircraft operation

Design and performance:
Measures of performance including: specific thrust = output thrust/engine
inlet mass flow, specific power = output power/engine inlet mass flow,
specific fuel consumption (sfc) = fuel flow rate/output thrust or power, where
sfc is measured in kilogrammes of fuel burnt per hour per Newton of thrust or
kg/hr/N
Effect of gas turbine cycle parameters on performance: effect of compressor
pressure ratio and turbine entry temperature (TET) on sfc, specific thrust and
power
Off-design performance: effects on gross thrust and momentum drag with
Mach number for turbojet and turbofan engines
Effect and implications of thermal and propulsive efficiency on aircraft specific
fuel consumption and thrust performance of turbojet and high bypass
turbofan aircraft
Combustion design and performance: methods used to ensure high
combustion efficiency, flame stability, minimisation of pressure losses and low
emissions
Thrust enhancement including use of variable area nozzles, reheat, water and
water/methanol
Design trade-offs between gas turbine engine production and operating costs,
performance and effects on the environment

Environmental impact:
Noise measurement and limits including decibel (dB) rating, noise limit
regulation
Sources of aircraft noise and its reduction including fan, exhaust jet, low-
pressure turbine and combustor noise, turbine engine noise testing
Nature and effects on the environment of gas turbine operating emissions
including: health risks from global warming and acid rain, carbon dioxide
(CO₂), water vapour (H₂O), contrails and the production of (H₂O) and
sulphuric acid (H₂SO₄), carbon monoxide (CO), oxides of nitrogen (NOₓ) and
sulphur (SOₓ), and smoke particulates
Airport pollution, including noise and emissions monitoring and the effect of
the introduction of the standard landing and take-off cycle (LTO)
Modern gas turbine emission reduction methods, including the control of unburnt hydrocarbons and carbon monoxide (CO), improvements in combustor design, use of high bypass turbofan engines, relationship of top turbine temperature (TTT), engine performance and the production and control of oxides of nitrogen (NOₓ)

Review future design innovations to reduce environmental pollution: development of more electric engines, use of smart and lighter materials, reduction in fuel burn, introduction of non-hydrocarbon fuels, improvements in engine/airframe integration
## Learning Outcomes and Assessment Criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Determine gas turbine engine performance, using thermo-fluid principles and propulsion cycle efficiencies</td>
<td><strong>D1</strong> Apply thermo-fluid principles and turbojet, turboprop and turbofan propulsion cycles and component efficiencies to predict engine performance</td>
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<tr>
<td><strong>P1</strong> Illustrate how thermo-fluid principles contribute to the operation of aircraft gas turbine propulsion cycles</td>
<td><strong>M1</strong> Demonstrate how thermo-fluid principles and turbojet, turboprop and turbofan propulsion cycles are used to predict engine performance</td>
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<tr>
<td><strong>P2</strong> Explore turbojet, turboprop and turbofan propulsion cycles to predict engine performance</td>
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<tr>
<td><strong>LO2</strong> Evaluate the design and performance of aircraft gas turbine engine turbomachinery</td>
<td><strong>D2</strong> Analyse the design of and contribution made by axial and centrifugal compressors, fans and turbine modules and their components to engine performance and suggest ways of improving performance</td>
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<tr>
<td><strong>P3</strong> Illustrate the design configuration, aerodynamic operation and performance characteristics of axial flow and centrifugal compressors and fan modules</td>
<td><strong>M2</strong> Explore the design and aerodynamic and thermo-fluid operation of axial and centrifugal compressors, fan and turbine modules, and their components, to show the contribution made by each module to engine performance</td>
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<tr>
<td><strong>P4</strong> Compare the types, mechanical design, operation and performance characteristics of turbine modules</td>
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<tr>
<td><strong>LO3</strong> Evaluate the design and performance of aircraft gas turbine engine intake, combustion and exhaust modules</td>
<td><strong>M3</strong> Illustrate the design features and aerodynamic and thermo-fluid operation of air intake, combustion and exhaust modules and their components to assess areas for improving performance</td>
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<tr>
<td><strong>P5</strong> Discuss the types, functions and design features that aid the aerodynamic and thrust performance of air intakes and exhausts</td>
<td><strong>P6</strong> Discuss the types of combustion methods and design features of combustion systems and their components, that aid engine performance</td>
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<tr>
<td><strong>P6</strong> Discuss the types of combustion methods and design features of combustion systems and their components, that aid engine performance</td>
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<tr>
<td><strong>LO4</strong> Investigate the factors affecting the design, performance and environmental impact of gas turbine powered aircraft operation</td>
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<tr>
<td><strong>P7</strong> Discuss how gas turbine engine performance is measured and how, through better design, improvements in thrust production, fuel efficiency and emissions are achieved in gas turbine engines</td>
<td><strong>M4</strong> Demonstrate how gas turbine engine performance is improved and the production of environmental noise and emissions is reduced through better design features, improved materials and operating procedures</td>
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<tr>
<td><strong>P8</strong> Discuss the nature of environmental noise and emissions produced from gas turbine engines and the methods used to mitigate their effects</td>
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<tr>
<td><strong>D3</strong> Critically evaluate the design features and aerodynamic and thermo-fluid operation of air intake, combustion and exhaust modules and their components to assess areas for improving performance</td>
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<tr>
<td><strong>D4</strong> Critically evaluate how gas turbine engine performance may be improved and how reductions in environmental noise and emissions may be achieved through better design, improved materials and operating procedures</td>
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Recommended Resources

Textbooks
A simple guide to the aerodynamic and thermodynamic design and performance of jet engines.

Journals

Links
This unit links to the following related units:
Unit 13: Fundamentals of Thermodynamics and Heat Engines
Unit 38: Further Thermodynamics
Unit 57: Aircraft Structural Integrity
Unit 60: Advanced Composite Materials for Aerospace Applications

Unit code D/615/1537
Unit level 5
Credit value 15

Introduction

Over the past 25 years, the use of advanced composite materials in aircraft primary structures has increased significantly. Driven by the demand for fuel-efficient, lightweight and high stiffness structures that have fatigue durability and corrosion resistance, modern large commercial aircraft are designed with more than 50% composite materials. Despite the many advantages, composite structural certification becomes challenging due to the lack of experience in large-scale structures, complex interactive failure mechanisms, sensitivity to temperature and moisture, and scatter in the data, especially regarding fatigue.

This unit explores the advantages and the complexities of designing components with advanced composite materials and will provide an insight into the requirements and testing of aerospace composite structures.

On successful completion of this unit students will be able to evaluate a composite design for manufacture, calculate the mechanical properties of composite materials, explain their failure mechanisms, describe environmental degradation of materials, explain post-consumer recycling issues and evaluate new sustainable materials for aerospace use.

Learning Outcomes

By the end of this unit a student will be able to:
1. Evaluate composite designs for manufacture.
2. Calculate the mechanical properties of composite materials.
3. Assess the failure mechanisms of aerospace composite materials.
Essential Content

LO1  Evaluate composite designs for manufacture

**Tooling:**
Understand the different tooling materials used and the relative merits such as cost and longevity. Understand the key tooling features, including the importance of draft angles. Identify the appropriate tooling for a range of composite designs using simple as well as complex multi-part tooling.

**Materials:**
Select the appropriate material for a composite design, taking into account the types of material fibres, tows, bundles and yarns available used and how they affect material properties, including fibre volume fractions.

Distinguish the manufacturing properties of different materials, including material drape, gapping, inter-yarn slippage and buckling, and how these can affect the properties of the final component.

Explain the process required for material qualification for flight approval and the associated timescales and costs.

**Modelling:**
Summarise how a CAD model can be used to predict material response under load, provide aeroelastic tailoring and show fibre paths. Use a CAD/CAM model to show how a composite design can be manufactured efficiently.

**Finishing processes:**
Explain how tooling design can minimise the finishing processes required on a component, machining, drilling, sanding, cutting, etc.

LO2  Calculate the mechanical properties of composite materials

**Elastic properties:**
Outline equations for predicting ply properties and the differences between anisotropic and unidirectional lamina. Use models to calculate elastic response of fibre composites.

**Mechanical properties:**
Calculation, backed up by testing, of tensile strength, compressive strength, shear strength and elastic response.

**Matrix properties:**
Appraise the effects on the finished material of altering cure cycle parameters, including rheology of thermoset resins, mixtures rule, glass transition temperature and post curing. Define a cure cycle for a material...
Composite properties:
Explain sizing and resin compatibility
Calculate interfacial bonding and shear strength and explain what environmental factors can affect bond strength
For a range of composite materials, including MMC and CMC, show the coefficient of thermal expansion and explain thermally induced stresses and the effect on strength

LO3 Assess the failure mechanisms of aerospace composite materials

Failure mechanisms:
Explain and analyse fracture toughness for different composite materials using a range of techniques including Griffiths model and Weibull distribution
Explain notch strength and sensitivity
Differentiate between the fatigue properties of composites and metals: fatigue and endurance limits, defect sensitivity. Discuss fatigue testing of composite aerospace components and structures

Failure modes:
Identify a variety of failure modes within composite materials and discuss the effect on mechanical properties: matrix failure, fibre failure, delamination, debonding, fibre pull out

Life prediction:
The life of critical aerospace components is calculated using data from testing. Critique how the results of these tests are used to calculate safe life, including the use of factors

LO4 Critique environmental effects on aerospace composite materials, post-consumer disposal issues and the future of sustainable composites in aerospace

Environmental effects:
Compare the effects of environmental conditions on composite material properties and discuss how these are tested: hydrothermal sensitivity, creep, UV, lightning strike, fuels and aerospace fluids and chemicals

 Protections:
Select the correct protective methods for composite materials in a range of situations. Review future advances in composite coatings

Post-consumer disposal:
Explain the process of post-use disposal of composite aerospace components, considering cost, protection of intellectual property and recyclability
**Sustainable composites:**

Assess sustainable composites as an alternative to traditional materials. Define the method for analysing alternative materials for use in aerospace, considering: mechanical properties, process suitability, environmental effects and aerospace qualification requirements.
# Learning Outcomes and Assessment Criteria

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<tr>
<td><strong>LO1</strong> Evaluate composite designs for manufacture</td>
<td><strong>D1</strong> Critique how modelling is used to predict mechanical responses of structures. Include discussions on aeroelastic tailoring predictions</td>
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<tr>
<td><strong>P1</strong> Explain the design philosophy of composite structures and how using CAD/CAM can minimise finishing processes</td>
<td><strong>M1</strong> Compare the drape characteristics of four reinforcements detailing the restrictions and subsequent effect on manufacture methods</td>
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<td><strong>P2</strong> Investigate the various types of tooling materials commonly used and identify three types of tooling features used in aerospace composite manufacture</td>
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<tr>
<td><strong>LO2</strong> Calculate the mechanical properties of composite materials</td>
<td><strong>D2</strong> Evaluate cure monitoring and how it can be used to calculate exact mechanical properties of polymer composites, including the effects of post-curing</td>
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<tr>
<td><strong>P3</strong> Differentiate between tensile strength, transverse strength, compression strength, shear strength and flexural strength of polymer composite materials</td>
<td><strong>M2</strong> Analyse the fatigue response of polymer composites and show why they perform better than basic metallic materials under fatigue</td>
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<td><strong>P4</strong> Classify elastic properties of fibre composites, acknowledging the effect of fibre length</td>
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<td><strong>LO3</strong> Assess the failure mechanisms of aerospace composite materials</td>
<td><strong>D3</strong> Show how the toughness of a composite is theoretically calculated</td>
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<tr>
<td><strong>P5</strong> Differentiate between and identify causes of tensile failure, longitudinal failure, compressive failure, interlaminar shear failure and fatigue failure of PMC, CMC and MMC</td>
<td><strong>M3</strong> Critically evaluate crack growth both at microstructural level and macroscopic level in PMCs, MMC and CMCs</td>
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<tr>
<td><strong>P6</strong> Investigate how mechanical testing results are used to calculate the safe life of an aerospace component</td>
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<tr>
<td><strong>LO4</strong> Critique environmental effects on aerospace composite materials, post-consumer disposal issues and the future of sustainable composites in aerospace</td>
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<td><strong>D4</strong> Investigate the current sustainable materials that are being produced for aerospace and compare these to the traditional aerospace composites</td>
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<tr>
<td><strong>P7</strong> Evaluate lightning strike protection strategies for composite aircraft</td>
<td><strong>M4</strong> Critically analyse the issues with post-consumer disposal of aerospace structures, paying particular attention to the issues around intellectual property of design</td>
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<tr>
<td><strong>P8</strong> Review environmental effects on aerospace composites and describe how coatings and paints are used to counteract these effects</td>
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Recommended Resources

Textbooks

Links
This unit links to the following related units:
Unit 27: Composite Materials for Aerospace Applications
Unit 58: Avionic Systems
Unit 61: Advanced Turbine Rotary Wing Aircraft Mechanical and Flight Systems

Unit code H/615/1538
Unit level 5
Credit value 15

Introduction

Since the conception of the idea of flight, rotary wing heavier-than-air flying machines have been considered. For example, Leonardo da Vinci created the ‘Helical Air Screw’ at the turn of the 16th century. It is believed that although the aircrew was built, it never flew due its very poor lift-to-weight ratio. At the turn of the 20th century, the early pioneers of flight built and attempted to fly a number of rotary wing aircraft. Some failed in spectacular style; however, some actually achieved limited flight. The development of the rotary wing aircraft we see today started in the 1940s and then rapidly advanced in the 1950s and 60s.

These early aeronautical engineers had to overcome many significant differences between principles of flight for fixed wing and rotary wing aircraft. The nature of the rotary winged aircraft creates many diverse fluid flows, physical gyroscopic effects and dissymmetry of lift and torque reactions, to name a few of the aerodynamic differences.

This unit introduces students to the atmosphere in which rotary wing aircraft operate in, the scientific principles that underpin flight theory, how the aerodynamic forces are generated throughout all phases and transitions of rotary wing flight. It also includes the specific design features that are essential to maintain stability and directional control.

On successful completion of this unit students will be able to examine the properties of the atmosphere relating to rotary wing flight and aerodynamic principles and apply them to aircraft flight, examine the generation, nature and effects of aerodynamic forces during flight, and examine the key design features that control and maintain airflows around a rotary wing aircraft. The student will also be able to investigate the nature and methods used to stabilise and control rotary aircraft.
Learning Outcomes

By the end of this unit students will be able to:

1. Explore standard atmospheric properties and aerodynamic principles affecting flight of a rotary winged aircraft.
2. Illustrate the nature and effect of forces of rotary wing aircraft directional flight control.
3. Explore rotary wing aircraft directional flight control.
4. Investigate the nature of different rotary winged aircraft design variations and features.
**Essential Content**

**LO1** Explore standard atmospheric properties and aerodynamic principles affecting flight of a rotary winged aircraft

*The standard atmosphere:*

The composition of the air and different layers of the real atmosphere

Nature of the International Standard Atmosphere (ISA); need, function, definitions of standard properties

Use of tables and hydrostatic, temperature lapse rate and state equations to determine the changing parameters (temperature, pressure, density, viscosity) of the air in the ISA, with changing altitude

*Aerodynamic principles:*

Airflow definitions: laminar, turbulent, compressible and incompressible flows

Nature of low speed airflow over aerofoil sections; aerofoil terminology, viscosity effects, boundary layer, aerodynamic shape, pressure and flow changes with differing angle of attack (AOA) and airspeeds

Determine experimentally and analytically lift \((L=\frac{1}{2}\rho V^2S)\) and drag \((D=\frac{1}{2}\rho V^2S)\) forces over aerofoil sections subject to low speed airflows, how lift and drag forces interact over aircraft wings and the significance of the lift/drag ratio as a measure of performance

Define and use the continuity, energy, Bernoulli, isentropic and Reynolds number fluid flow equations to determine low speed airflow parameters

Nature of airflows, generated lift and drag created by the main and tail rotor blades

**LO2** Illustrate the nature and effect of forces of rotary wing aircraft directional flight control

*Rotational and aerodynamic forces acting on rotary wing aircraft:*

Define rotation effects of gyroscopic precession and rigidity

The effects of gyroscopic and lift/drag force generation

Rotor blade geometric twist, flapping/coning, tip path plane, lead and lag

Ground effect, ideal wake, Blade loading, vortex ring state
LO3  **Explore rotary wing aircraft directional flight control**

*Rotary wing aircraft control:*

The use of gyroscopic precession effect in control of a rotary wing aircraft in the six planes of movement

Application of aerodynamic force and the pendulum effect in control of a rotary wing aircraft in the six planes of movement

*Nature of flight forces and airflow:*

The nature of main rotor lift and drag forces whilst a helicopter is in the hover, transitional and forward flight

Determine analytically the momentum theory for hover and climb \( \vec{\mathbf{F}} = \vec{\mathbf{M}} \Delta \vec{\mathbf{V}} \)

Determine gravitational and aerodynamic forces during straight and level flight, steady coordinated turn, ascending and descending flight

The lift and drag force parameters, autorotational flight

LO4  **Investigate the nature of different rotary winged aircraft design variations and features**

*Design features:*

Development of the main rotor blade and tail rotor design including the British Experimental Rotor Project (BERP)

Examine the use and benefits of twin counter rotating main rotors

Rotary wing aircraft tail planes and other external aerodynamic design features

*Other types of rotary wing aircraft:*

Tilt rotor aircraft and Autogyro helicopters
# Learning Outcomes and Assessment Criteria

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<thead>
<tr>
<th>Pass</th>
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<tbody>
<tr>
<td><strong>LO1</strong> Explore standard atmospheric properties and aerodynamic principles affecting flight of a rotary winged aircraft</td>
<td><strong>D1</strong> Analyse the properties of the air in the ISA, with changing altitude and the relationship between fluid flow equations and the generation of lift and drag affecting flight</td>
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</tr>
<tr>
<td><strong>P1</strong> Discuss the nature of the ISA and the changes that take place to the properties of the air with changing altitude</td>
<td><strong>M1</strong> Evaluate quantitatively how the properties of the air in the ISA change with altitude and the differences between the lift and drag forces found from theoretical calculations and experimental results</td>
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</tr>
<tr>
<td><strong>P2</strong> Illustrate, using theoretical calculations and experimental results, how lift and drag forces are generated from low speed airflows over aerofoil sections</td>
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</tr>
<tr>
<td><strong>P3</strong> Discuss the nature of the airflow, lift and drag generation created by a helicopter’s main and tail rotor blades</td>
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<td></td>
</tr>
<tr>
<td><strong>LO2</strong> Illustrate the nature and effect of forces of rotary wing aircraft directional flight control</td>
<td><strong>D2</strong> Assess the effect and nature of flight forces on a rotary winged aircraft airframe, throughout all phases and conditions of flight, including the nature and significance of the load, horizontal and vertical velocity limits</td>
<td></td>
</tr>
<tr>
<td><strong>P4</strong> Demonstrate how gyroscopic precession and lift differentials can be used to control a rotary winged aircraft in flight</td>
<td><strong>M2</strong> Evaluate, using theoretical calculations, the nature of flight forces during manoeuvres and how these forces are affected by geometrical and external factors</td>
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<tr>
<td><strong>P5</strong> Illustrate the aerodynamic and airflow effects created by the rotor blades of a rotary winged aircraft</td>
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<td>Pass</td>
<td>Merit</td>
<td>Distinction</td>
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</tr>
<tr>
<td><strong>LO3</strong> Explore rotary wing aircraft directional flight control</td>
<td><strong>D3</strong> Evaluate through analytical methods the power required to allow a helicopter to maintain altitude in a hover</td>
<td></td>
</tr>
<tr>
<td><strong>P6</strong> Discuss the use of the gyroscopic precession effect in the control of a rotary wing aircraft in the six planes of movement</td>
<td><strong>M3</strong> Illustrate, using vector representation, the application of aerodynamic forces and the pendulum effect in control of a rotary wing aircraft in the six planes of movement</td>
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<tr>
<td><strong>P7</strong> Describe generation of the lift force, control and aerodynamic limitations of an Autogyro helicopter</td>
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<tr>
<td><strong>LO4</strong> Investigate the nature of different rotary winged aircraft design variations and features</td>
<td><strong>D4</strong> Analyse the aerodynamic properties of BERP main rotor blade and evaluate the advantages and disadvantages of the design</td>
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<tr>
<td><strong>P8</strong> Explore the development of the main rotor blade and tail rotor design, including the British Experimental Rotor Project (BERP)</td>
<td><strong>M4</strong> Explore counter rotating twin rotor helicopter aerodynamic control and stabilisation</td>
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<td><strong>P9</strong> Show how the aerodynamic use of rotary wing aircraft tail planes and other external aerodynamic design features</td>
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<td><strong>P10</strong> Discuss the flight characteristics of ‘tilt rotor’ and Autogyro rotary aircraft</td>
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</table>
Recommended Resources

Textbooks

Journals
*Aerospace* (the magazine of the Royal Aeronautical Society). With articles on all areas of aerospace including innovation and design for flight.

Websites
http://www.av8n.com/ AV8N
See How it Flies
(E-Book)

Links
This unit links to the following related units:
*Unit 24: Aircraft Aerodynamics*
*Unit 28: Turbine Rotary Wing Mechanical and Flight Systems*
11. Appendices
# Appendix 1: Mapping of HND in Engineering against FHEQ Level 5

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>KU</td>
<td>Knowledge and Understanding</td>
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<tr>
<td>CS</td>
<td>Cognitive Skills</td>
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<td>AS</td>
<td>Applied Skills</td>
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<td>TS</td>
<td>Transferable Skills</td>
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</table>

The qualification will be awarded to students who have demonstrated:

<table>
<thead>
<tr>
<th>FHEQ Level 5 descriptor</th>
<th>Engineering HND Programme Outcome</th>
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</thead>
<tbody>
<tr>
<td>Knowledge and critical</td>
<td>KU1 Knowledge and understanding of the fundamental principles and practices of the contemporary global engineering industry.</td>
</tr>
<tr>
<td>understanding of the</td>
<td>KU2 Knowledge and understanding of the external engineering environment and its impact upon local, national and global levels of strategy, behaviour, management and sustainability.</td>
</tr>
<tr>
<td>well-established</td>
<td>KU3 Understanding and insight into different engineering practices, their diverse nature, purposes, structures and operations and their influence upon the external environment.</td>
</tr>
<tr>
<td>principles of their</td>
<td>KU4 A critical understanding of the ethical, environmental, legal, regulatory, professional and operational frameworks within which engineering operates.</td>
</tr>
<tr>
<td>area(s) of study, and</td>
<td>KU5 A critical understanding of processes, practices and techniques for effective management of products, processes, services and people.</td>
</tr>
<tr>
<td>of the way in which those principles have developed.</td>
<td>KU6 A critical understanding of the evolving concepts, theories and models within the study of engineering across the range of operational alternatives.</td>
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<td>KU7 An ability to evaluate and analyse a range of concepts, theories, models and techniques to make appropriate engineering operational and management decisions.</td>
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<td>FHEQ Level 5 descriptor</td>
<td>Engineering HND Programme Outcome</td>
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<tr>
<td>KU8</td>
<td>An appreciation of the concepts and principles of CPD, staff development, team dynamics, leadership and reflective practice as strategies for personal and people development.</td>
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<td>KU9</td>
<td>Knowledge and understanding of how the key areas of engineering and the environment it operates within influence the development of people and businesses.</td>
</tr>
<tr>
<td>KU10</td>
<td>An understanding of the skills, techniques and methodologies used to resolve problems in the workplace.</td>
</tr>
<tr>
<td>KU11</td>
<td>Knowledge and understanding of the human-machine interaction to inform the development of good design and fitness for purpose.</td>
</tr>
<tr>
<td>FHEQ Level 5 descriptor</td>
<td>Engineering HND Programme Outcome</td>
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<tr>
<td>Ability to apply underlying concepts and principles outside the context in which they were first studied, including, where appropriate, the application of those principles in an employment context.</td>
<td>CS1 Apply knowledge and understanding of essential concepts, principles and models within the contemporary global engineering industry.</td>
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<td>AS1 Evidence the ability to show customer relationship management skills and develop appropriate policies and strategies to meet stakeholder expectations.</td>
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<td>AS2 Apply innovative engineering ideas to design and develop new products or services that respond to the changing nature of the engineering industry and the global market.</td>
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<td>AS3 Integrate theory and practice through the investigation, evaluation and development of practices and products in the workplace.</td>
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<tr>
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<td>AS4 Develop outcomes for customers using appropriate practices and data to make justified recommendations.</td>
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<td>CS2 Develop different strategies and methods to show how resources (human, financial, environmental and information) are integrated and effectively managed to successfully meet objectives.</td>
</tr>
<tr>
<td>Knowledge of the main methods of enquiry in the subject(s) relevant to the named award, and ability to evaluate critically the appropriateness of different approaches to solving problems in the field of study.</td>
<td>CS3 Critically evaluate current principles and operational practices used within the engineering industry as applied to problem solving.</td>
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<td>CS4 Apply project management skills and techniques for reporting, planning, control and problem solving.</td>
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<td></td>
<td>CS5 Recognise and critically evaluate the professional, economic, social, environmental and ethical issues that influence the sustainable exploitation of people, resources and businesses.</td>
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<td>CS6 Critique a range of engineering information technology systems and operations and their application to maximise and successfully meet strategic objectives.</td>
</tr>
<tr>
<td>An understanding of the limits of their knowledge, and how this influences analysis and interpretations based on that knowledge.</td>
<td>TS1 Develop a skill set to enable the evaluation of appropriate actions taken for problem solving in specific engineering contexts.</td>
</tr>
<tr>
<td>FHEQ Level 5 descriptor</td>
<td>Engineering HND Programme Outcome</td>
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<tr>
<td>TS2</td>
<td>Develop self-reflection, including self-awareness, to become an effective self-managing student, appreciating the value and importance of the self-reflection process.</td>
</tr>
<tr>
<td>TS3</td>
<td>Undertake independent learning to expand on own skills and delivered content.</td>
</tr>
</tbody>
</table>

Typically, holders of the qualification will be able to:

<table>
<thead>
<tr>
<th>FHEQ Level 5 descriptor</th>
<th>Engineering HND Programme Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a range of established techniques to initiate and undertake critical analysis of information, and to propose solutions to problems arising from that analysis.</td>
<td>TS4 Competently use digital literacy to access a broad range of research sources, data and information.</td>
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<td></td>
<td>CS7 Interpret, analyse and evaluate a range of engineering data, sources and information to inform evidence-based decision-making.</td>
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<td></td>
<td>CS8 Synthesise knowledge and critically evaluate strategies and plans to understand the relationship between theory and actual world engineering situations.</td>
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<tr>
<td>Effectively communicate information, arguments and analysis in a variety of forms to specialist and non-specialist audiences, and deploy key techniques of the discipline effectively.</td>
<td>TS5 Communicate confidently and effectively, both orally and in writing, both internally and externally with engineering professionals and other stakeholders.</td>
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<tr>
<td></td>
<td>TS6 Demonstrate strong interpersonal skills, including effective listening and oral communication skills, as well as the associated ability to persuade, present, pitch and negotiate.</td>
</tr>
<tr>
<td>Undertake further training, develop existing skills and acquire new competences that will enable them to assume significant responsibility within organisations.</td>
<td>TS7 Identify personal and professional goals for continuing professional development in order to enhance competence to practise within a chosen engineering field.</td>
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<td></td>
<td>TS8 Take advantage of available pathways for continuing professional development through Higher Education and Professional Body Qualifications.</td>
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</table>
Holders will also have:

<table>
<thead>
<tr>
<th>FHEQ Level 5 descriptor</th>
<th>Engineering HND Programme Outcomes</th>
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<tbody>
<tr>
<td>The qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and decision-making.</td>
<td>TS9 Develop a range of skills to ensure effective team working, project and time management, independent initiatives, organisational competence and problem-solving strategies.</td>
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<td></td>
<td>TS10 Reflect adaptability and flexibility in approach to engineering; showing resilience under pressure and meeting challenging targets within given deadlines.</td>
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<td>TS11 Use quantitative skills to manipulate data, evaluate and verify existing theory.</td>
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<td></td>
<td>CS9 Evaluate the changing needs of the engineering industry and have the confidence to self-evaluate and undertake additional CPD as necessary.</td>
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<td></td>
<td>TS12 Develop emotional intelligence and sensitivity to diversity in relation to people, cultures and environments.</td>
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</table>
## Appendix 2: HNC/HND Engineering Programme Outcomes for Learners

<table>
<thead>
<tr>
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<th>Applied skills</th>
<th>Transferable skills</th>
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<tr>
<td>Unit</td>
<td>Knowledge and Understanding</td>
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<td>Applied skills</td>
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## Appendix 3: Level 5 Higher National Diploma in Engineering: mapping of transferable employability and academic study skills

<table>
<thead>
<tr>
<th>Skill Set</th>
<th>Cognitive Skills</th>
<th>Intra-personal Skills</th>
<th>Interpersonal Skills</th>
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<tr>
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<td>Problem Solving</td>
<td>Critical Thinking/Analysis</td>
<td>Decision Making</td>
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<td>Critical Thinking/Analysis</td>
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<th>Critical Thinking/Analysis</th>
<th>Decision Making</th>
<th>Effective Communication</th>
<th>Digital Literacy</th>
<th>Numeracy</th>
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<th>Plan Prioritise</th>
<th>Self Management</th>
<th>Independent Learning</th>
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</table>
Appendix 4: Glossary of command verbs used for internally assessed units

This is a summary of the key terms used to define the requirements within units:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
</table>
| Analyse            | Present the outcome of methodical and detailed examination either:  
|                    | ● breaking down a theme, topic or situation in order to interpret and study the interrelationships between the parts and/or  
|                    | ● of information or data to interpret and study key trends and interrelationships. Analysis can be through activity, practice, written or verbal presentation.       |
| Apply              | Put into operation or use. Use relevant skills/knowledge/understanding appropriate to context.                                                                                                           |
| Arrange            | Organise or make plans.                                                                                                                                                                                    |
| Assess             | Offer a reasoned judgement of the standard/quality of a situation or a skill informed by relevant facts.                                                                                                    |
| Calculate          | Generate a numerical answer with workings shown.                                                                                                                                                         |
| Communicate        | Convey ideas or information to others. Create/construct skills to make or do something, for example a display or set of accounts.                                                                           |
| Compare            | Identify the main factors relating to two or more items/situations or aspects of a subject that is extended to explain the similarities, differences, advantages and disadvantages.  
<p>|                    | This is used to show depth of knowledge through selection of characteristics.                                                                                                                             |
| Compose            | Create or make up or form.                                                                                                                                                                                 |
| Create/Construct   | Skills to make or do something, for example a display or set of accounts.                                                                                                                                   |
| Critically analyse | Separate information into components and identify characteristics with depth to the justification.                                                                                                          |
| Critically evaluate| Make a judgement taking into account different factors and using available knowledge/experience/evidence where the judgement is supported in depth.                                                       |
| Define             | State the nature, scope or meaning.                                                                                                                                                                          |
| Demonstrate        | Show knowledge and understanding.                                                                                                                                                                          |</p>
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe</td>
<td>Give an account, including all the relevant characteristics, qualities and events.</td>
</tr>
<tr>
<td>Determine</td>
<td>To conclude or ascertain by research and calculation.</td>
</tr>
<tr>
<td>Design</td>
<td>Plan and present ideas to show the layout/function/workings/object/system/process.</td>
</tr>
<tr>
<td>Develop</td>
<td>Grow or progress a plan, ideas, skills and understanding.</td>
</tr>
<tr>
<td>Differentiate</td>
<td>Recognise or determine what makes something different.</td>
</tr>
<tr>
<td>Discuss</td>
<td>Consider different aspects of a theme or topic, how they interrelate, and the extent to which they are important.</td>
</tr>
<tr>
<td>Discuss</td>
<td>Give an account that addresses a range of ideas and arguments.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Work draws on varied information, themes or concepts to consider aspects, such as:</td>
</tr>
<tr>
<td></td>
<td>● strengths or weaknesses</td>
</tr>
<tr>
<td></td>
<td>● advantages or disadvantages</td>
</tr>
<tr>
<td></td>
<td>● alternative actions</td>
</tr>
<tr>
<td></td>
<td>● relevance or significance</td>
</tr>
<tr>
<td></td>
<td>Students’ enquiries should lead to a supported judgement showing relationship to its context. This will often be in a conclusion. Evidence will often be written but could be through presentation or activity.</td>
</tr>
<tr>
<td>Explain</td>
<td>To give an account of the purposes or reasons.</td>
</tr>
<tr>
<td>Explore</td>
<td>Skills and/or knowledge involving practical research or testing.</td>
</tr>
<tr>
<td>Identify</td>
<td>Indicate the main features or purpose of something by recognising it and/or being able to discern and understand facts or qualities.</td>
</tr>
<tr>
<td>Illustrate</td>
<td>Make clear by using examples or provide diagrams.</td>
</tr>
<tr>
<td>Indicate</td>
<td>Point out, show.</td>
</tr>
<tr>
<td>Interpret</td>
<td>State the meaning, purpose or qualities of something through the use of images, words or other expression.</td>
</tr>
<tr>
<td>Investigate</td>
<td>Conduct an enquiry or study into something to discover and examine facts and information.</td>
</tr>
<tr>
<td>Justify</td>
<td>Students give reasons or evidence to:</td>
</tr>
<tr>
<td></td>
<td>● support an opinion</td>
</tr>
<tr>
<td></td>
<td>● prove something is right or reasonable.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Outline</td>
<td>Set out the main points/characteristics.</td>
</tr>
<tr>
<td>Plan</td>
<td>Consider, set out and communicate what is to be done.</td>
</tr>
<tr>
<td>Produce</td>
<td>To bring into existence.</td>
</tr>
<tr>
<td>Reconstruct</td>
<td>To assemble again/reorganise/form an impression.</td>
</tr>
<tr>
<td>Report</td>
<td>Adhere to protocols, codes and conventions where findings or judgements are set down in an objective way.</td>
</tr>
<tr>
<td>Review</td>
<td>Make a formal assessment of work produced.</td>
</tr>
<tr>
<td></td>
<td>The assessment allows students to:</td>
</tr>
<tr>
<td></td>
<td>• appraise existing information or prior events</td>
</tr>
<tr>
<td></td>
<td>• reconsider information with the intention of making changes, if necessary.</td>
</tr>
<tr>
<td>Show how</td>
<td>Demonstrate the application of certain methods/theories/concepts.</td>
</tr>
<tr>
<td>Stage and manage</td>
<td>Organisation and management skills, for example running an event or a business pitch.</td>
</tr>
<tr>
<td>State</td>
<td>Express.</td>
</tr>
<tr>
<td>Suggest</td>
<td>Give possible alternatives, produce an idea, put forward, for example, an idea or plan, for consideration.</td>
</tr>
<tr>
<td>Undertake/carry out</td>
<td>Use a range of skills to perform a task, research or activity.</td>
</tr>
</tbody>
</table>
This is a key summary of the types of evidence used for BTEC Higher Nationals:

<table>
<thead>
<tr>
<th>Type of evidence</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case study</td>
<td>A specific example to which all students must select and apply knowledge.</td>
</tr>
<tr>
<td>Project</td>
<td>A large scale activity requiring self-direction of selection of outcome, planning, research, exploration, outcome and review.</td>
</tr>
<tr>
<td>Independent research</td>
<td>An analysis of substantive research organised by the student from secondary sources and, if applicable, primary sources.</td>
</tr>
<tr>
<td>Written task or report</td>
<td>Individual completion of a task in a work-related format, for example, a report, marketing communication or set of instructions, giving information.</td>
</tr>
<tr>
<td>Simulated activity/ role play</td>
<td>A multi-faceted activity mimicking realistic work situations.</td>
</tr>
<tr>
<td>Team task</td>
<td>Students work together to show skills in defining and structuring activity as a team.</td>
</tr>
<tr>
<td>Presentation</td>
<td>Oral or through demonstration.</td>
</tr>
<tr>
<td>Production of plan/business plan</td>
<td>Students produce a plan as an outcome related to a given or limited task.</td>
</tr>
<tr>
<td>Reflective journal</td>
<td>Completion of a journal from work experience, detailing skills acquired for employability.</td>
</tr>
<tr>
<td>Poster/leaflet</td>
<td>Documents providing well-presented information for a given purpose.</td>
</tr>
</tbody>
</table>
### Appendix 5: Assessment Methods and Techniques for Higher Nationals

<table>
<thead>
<tr>
<th>Assessment Technique</th>
<th>Description</th>
<th>Transferable Skills Development</th>
<th>Formative or Summative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic graphic display</td>
<td>This technique asks students to create documents providing well-presented information for a given purpose. Could be hard or soft copy.</td>
<td>Creativity</td>
<td>Formative</td>
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<tr>
<td></td>
<td></td>
<td>Written Communication</td>
<td>Summative</td>
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<td></td>
<td></td>
<td>Information and Communications Technology</td>
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<td></td>
<td></td>
<td>Literacy</td>
<td></td>
</tr>
<tr>
<td>Case Study</td>
<td>This technique present students with a specific example to which they must select and apply knowledge.</td>
<td>Reasoning</td>
<td>Formative</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>Summative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analysis</td>
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</tr>
<tr>
<td>Discussion Forum</td>
<td>This technique allows students to express their understanding and perceptions about topics and questions presented in the class or digitally, for example online groups, blogs.</td>
<td>Oral/written Communication</td>
<td>Formative</td>
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<td>Appreciation of Diversity</td>
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<td>Critical Thinking and Reasoning</td>
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<td></td>
<td></td>
<td>Argumentation</td>
<td></td>
</tr>
<tr>
<td>Examination</td>
<td>This technique covers all assessment that needs to be done within a centre-specified time constrained period on-site. Some units may be more suited to an exam-based assessment approach, to appropriately prepare students for further study such as progression on to Level 6 programmes or to meet professional recognition requirements.</td>
<td>Reasoning</td>
<td>Summative</td>
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<tr>
<td></td>
<td></td>
<td>Analysis</td>
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<td></td>
<td></td>
<td>Written Communication</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
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<tr>
<td></td>
<td></td>
<td>Interpretation</td>
<td></td>
</tr>
<tr>
<td>Independent Research</td>
<td>This technique is an analysis of research organised by the student from secondary sources and, if applicable, primary sources.</td>
<td>Information and Communications Technology</td>
<td>Formative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Literacy</td>
<td></td>
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<td></td>
<td></td>
<td>Analysis</td>
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</tr>
<tr>
<td>Oral/Viva</td>
<td>This technique asks students to display their knowledge of the subject via questioning.</td>
<td>Oral Communication</td>
<td>Summative</td>
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<td></td>
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<td>Critical Thinking</td>
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<tr>
<td></td>
<td></td>
<td>Reasoning</td>
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<tr>
<td>Assessment Technique</td>
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<td>Formative or Summative</td>
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<tr>
<td>Peer Review</td>
<td>This technique asks students to provide feedback on each other’s performance. This feedback can be collated for development purposes.</td>
<td>Teamwork</td>
<td>Formative</td>
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<td></td>
<td></td>
<td>Negotiation</td>
<td>Summative</td>
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<td></td>
<td></td>
<td>Collaboration</td>
<td></td>
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<tr>
<td>Presentation</td>
<td>This technique asks students to deliver a project orally or through demonstration.</td>
<td>Oral Communication</td>
<td>Formative</td>
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<tr>
<td></td>
<td></td>
<td>Creativity</td>
<td>Summative</td>
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<td>Critical Thinking</td>
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<td></td>
<td></td>
<td>Reasoning</td>
<td></td>
</tr>
<tr>
<td>Production of an Artefact/Performance or Portfolio</td>
<td>This technique requires students to demonstrate that they have mastered skills and competencies by producing something. Some examples are project plans, using a piece of equipment or a technique, building models, developing, interpreting, and using maps.</td>
<td>Creativity</td>
<td>Summative</td>
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<td></td>
<td></td>
<td>Interpretation</td>
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<td>Written and oral Communication</td>
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<td>Decision-making</td>
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<td>Initiative</td>
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<td>Information and Communications</td>
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<td></td>
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<td>Technology</td>
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<td></td>
<td></td>
<td>Literacy, etc.</td>
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</tr>
<tr>
<td>Project</td>
<td>This technique is a large-scale activity requiring self-direction, planning, research, exploration, outcome and review.</td>
<td>Written Communication</td>
<td>Summative</td>
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<td>Information Literacy</td>
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<tr>
<td></td>
<td></td>
<td>Creativity</td>
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<td></td>
<td>Initiative</td>
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</tr>
<tr>
<td>Role Playing</td>
<td>This technique is a type of case study, in which there is an explicit situation established, with students playing specific roles, understanding what they would say or do in that situation.</td>
<td>Written and Oral Communication</td>
<td>Formative</td>
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<tr>
<td></td>
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<td>Leadership</td>
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<td>Information Literacy</td>
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<td>Creativity</td>
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<td>Initiative</td>
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<td>Assessment Technique</td>
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<td>Formative or Summative</td>
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</tr>
<tr>
<td>Self-reflection</td>
<td>This technique asks students to reflect on their performance, for example, to write statements of their personal goals for the course at the beginning of the course, what they have learned at the end of the course and their assessment of their performance and contribution; completion of a reflective journal from work experience, detailing skills acquired for employability.</td>
<td>Self-reflection</td>
<td>Summative</td>
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<td></td>
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<td>Written Communication</td>
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<td>Initiative</td>
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<td></td>
<td></td>
<td>Decision-making</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
<td></td>
</tr>
<tr>
<td>Simulated Activity</td>
<td>This technique is a multi-faceted activity based on realistic work situations.</td>
<td>Self-reflection</td>
<td>Formative</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>Summative</td>
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<td></td>
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<td>Initiative</td>
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<tr>
<td></td>
<td></td>
<td>Decision-making</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Written Communication</td>
<td></td>
</tr>
<tr>
<td>Team Assessment</td>
<td>This technique asks students to work together to show skills in defining and structuring an activity as a team. All team assessment should be distributed equally, each of the group members performing their role, and then the team collates the outcomes, and submits it as a single piece of work.</td>
<td>Collaboration</td>
<td>Formative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teamwork</td>
<td>Summative</td>
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<td></td>
<td></td>
<td>Leadership</td>
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<tr>
<td></td>
<td></td>
<td>Negotiation</td>
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<td></td>
<td></td>
<td>Written and Oral Communication</td>
<td></td>
</tr>
<tr>
<td>Time-constrained</td>
<td>This technique covers all assessment that needs to be done within a centre-specified time constrained period on-site.</td>
<td>Reasoning</td>
<td>Summative</td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td>Analysis</td>
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<td></td>
<td></td>
<td>Critical thinking</td>
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<td></td>
<td></td>
<td>Interpretation</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Written Communication</td>
<td></td>
</tr>
<tr>
<td>Top Ten</td>
<td>This technique asks students to create a ‘top ten’ list of key concepts presented in the assigned reading list.</td>
<td>Teamwork</td>
<td>Formative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creativity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analysis</td>
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<tr>
<td></td>
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<td>Collaboration</td>
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<tr>
<td>Assessment Technique</td>
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</tr>
</tbody>
</table>
| Written Task or Report | This technique asks students to complete an assignment in a structured written format, for example, a project plan, a report, marketing communication, set of instructions, giving information. | Reasoning
Analysis
Written Communication
Critical Thinking
Interpretation | Summative |