BTEC

HIGHER NATIONALS

Aeronautical Engineering

Specification

First Teaching from September 2017

First Certification from 2018

Higher National Certificate Lvl 4

Higher National Diploma Lvl 5

Pearson

About Pearson

We are the world's leading learning company operating in countries all around the world. We provide content, assessment and digital services to learners, educational institutions, employers, governments and other partners globally. We are committed to helping equip learners with the skills they need to enhance their employability prospects and to succeed in the changing world of work. We believe that wherever learning flourishes so do people.

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Summary of changes in Pearson BTEC Higher Nationals in Aeronautical Engineering Issue 5

Summary of changes made between previous issue and this current issue	**Page number**
Branding Added new front cover Applied updated Pearson BTEC Higher Nationals branding colour, font and tables throughout the spec	1-288
2.7 How Pearson BTEC Higher Nationals in Aeronautical Engineering provide both transferable employability skills and academic study skills Correction. Changed word from moderated to verified	11
4.2.3 Meeting local needs (MLN) Updated section and guidance	31
4.2.4 Pearson BTEC Higher National Commissioned Development Updated section and guidance	32
6.3.2 Making assessment decisions using criteria Correction. Changed word from moderated to 'verified' Correction. Changed word from mark to 'grade' Correction. Changed word from marks to 'grades'	57
4.2 Programme structures New optional units added to the pathway tables at Level 4 so no need to request these units to MLN in future: *Unit 75: Industry 4.0* *Unit 76: Introduction to Professional Engineering Management* *Unit 77: Industrial Robots* *Unit 78: Programmable Logic Controllers* *Unit 79: Computer Aided Design (CAD) for Engineering*	*26*
5.4.7 Assessment feedback Correction to term used from 'marking' to 'grading' and 'mark(s)' to 'grade(s)'	47

Summary of changes made between previous issue and this current issue	**Page number**
6.4 Planning and record keeping Removed requirement for spreadsheet only, as Programme Leaders must have assessment plans that can be in any appropriate format.	60
Unit 1: Engineering Design Corrected assessment criteria (LO2) – Clarified and improved grammar in P5 and M3 Amended assessment criteria (LO3) o Amended P7 to ensure holistic assessment and scaffolding principle o Deleted assessment criteria M5 o Amended M4 to ensure holistic assessment and scaffolding principle o Amended D3 to clarify requirement Amended assessment criteria (LO4) o Renumbered M6 to M5 o Clarified and improved grammar of M5 and D4 to ensure holistic assessment and scaffolding principle	72-78
Unit 2: Engineering Maths Corrected LO2 – removed the following *'~~by using appropriate computer software packages~~'* Corrected Essential Content (LO1) – replaced term *'circular'* with *'trigonometric'* Insertion into Essential Content (LO2) – inserted the line *'Charts, graphs and tables to present data'* Amended Essential Content (LO4) – Revised section on *'Integration of functions'* Amended Assessment Criteria (LO1) o inserted '*logarithmic*' into P3 o removed '*statistical*' from D1 Amended Assessment Criteria (LO2) – Clarified P4 to ensure holistic assessment and scaffolding principle	79-84

Summary of changes made between previous issue and this current issue	**Page number**
Amended Assessment Criteria (LO3) – Corrected requirement in M3 Amended Assessment Criteria (LO4) – Replaced term '*circular*' with '*trigonometric*' in P8	
Unit 3: Engineering Science Corrected LO1 – Replaced term *'computational'* with *'qualitative'* Amended Essential Content (LO2) – Replaced term *'objects'* with *'beams'* and inserted term *'uniformly'* Amended Essential Content (LO3) – Replaced term *'plastics'* with *'polymers'* Amended Assessment Criteria (LO1) – Corrected command verb and replaced term *'computational'* with *'qualitative'* in D1 Amended Assessment Criteria (LO2) o Clarified P3 o Amended P5 to ensure holistic assessment and scaffolding principle o Clarified and amended D2 to ensure holistic assessment and scaffolding principle Amended Assessment Criteria (LO3) o Replaced *'electrical and magnetic'* with '*electromagnetic*' in M3 o Clarified requirement in D3 Amended Assessment Criteria (LO4) – Clarified P8, P9, P10 and D4 to ensure holistic assessment and scaffolding principle	85-90
Unit 39: Further Mathematics Amended Essential Content (LO2) – Inserted '*and 3x3*' in Matrix Methods section Amended Assessment Criteria (LO1) – Changed command verb in M1 Amended Assessment Criteria (LO2) o Corrected command verb in P4 o Inserted *'for a 3x3 matrix'* into M2 to ensure holistic assessment and scaffolding principle o Amended to ensure holistic assessment and scaffolding principle	158-164

Summary of changes made between previous issue and this current issue	**Page number**
Amended Assessment Criteria (LO3) – Changed command verb in D3 Amended Assessment Criteria (LO3) o Amended command verbs in P9 and P10 o Amended to ensure holistic assessment and scaffolding principle	
Unit 55: Aircraft Flight Control Systems Amended Essential Content (LO1) o Inserted '*artificial feel and trim*' in '*Flight control*' section o Removed the term '*gust lock*'	165-172
11 Appendices	
Added mapping for new units to Appendix 2	270
Added mapping for new units to Appendix 3	272
Added Recognition of prior Learning as Appendix 6	281-288

If you need further information on these changes or what they mean, contact us via our website at: qualifications.pearson.com/en/support/contact-us.html.

Contents

1. Introduction

BTEC is one the world's most successful and best-loved applied learning brand, 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 Pearson BTEC Higher National in Aeronautical Engineering meet the academic requirements for the Engineering Council Engineering Technician Standard (**Eng**Tech).

2. Programme purpose and objectives

2.1 Purpose of the Pearson BTEC Higher Nationals in Aeronautical Engineering

The purpose of Pearson 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 Pearson BTEC Higher Nationals in Aeronautical Engineering

The objectives of the Pearson 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 Pearson 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 Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering

The Pearson BTEC 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 Pearson BTEC 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 Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering

The Pearson BTEC 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 Pearson BTEC 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 Pearson BTEC 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 Pearson BTEC 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 Pearson 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.

Pathway	Typical Job Roles after HNC	Typical Job Roles after HND
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 Pearson 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 Pearson BTEC Higher National in Aeronautical 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 BTEC 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 EABs 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. EABs are for guidance and support only and **must** be customised and amended according to localised needs and requirements. All assignments must still be verified 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, Pearson 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 Pearson BTEC Higher National qualification

You should 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 Pearson BTEC Higher National, through Recognition of Prior Learning. (For further information please refer to *section 8* of this document.)

3.2.1 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.

3.2.2 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/).

3.2.3 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.

3.2.4 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 Pearson BTEC Higher Nationals. For some units, specific resources are required, this is clearly indicated in the unit descriptors.

3.2.5 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.

3.2.6 Modes of delivery

Subject to approval by Pearson, centres are free to deliver Pearson 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 (partial).

3.2.7 Recommendations for employer engagement

Pearson 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.

3.2.8 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.

3.2.9 Student employability

All Pearson 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 Pearson 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

3.6.1 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.

3.6.2 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/).

3.6.3 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.

3.6.4 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.

3.7.1 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.

3.7.2 Student malpractice

Student malpractice refers to any act by a student that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Heads of Centres are required to report incidents of any suspected student malpractice that occur during Pearson external assessments. Student malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form should be emailed to candidatemalpractice@pearson.com. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions 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.

Failure to report malpractice constitutes staff or centre malpractice.

3.7.3 Staff and centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

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. All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice). The form, supporting documentation and as much information as possible should be emailed to pqsmalpractice@pearson.com

Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More-detailed guidance on malpractice can be found in the latest version of the document *Suspected Malpractice in Examinations and Assessments*, available at www.jcq.org.uk/exams-office/malpractice

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* (www.jcq.org.uk).

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.

3.7.4 Sanctions and appeals

Wherever 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), and they 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

Total Qualification Time (TQT) 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.

4.2.1 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.

Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering (120 credits)		Unit credit	Level
Core unit *Mandatory*	**1 Engineering Design**	15	4
Core unit *Mandatory*	**2 Engineering Maths**	15	4
Core unit *Mandatory*	**3 Engineering Science**	15	4
Core unit *Mandatory*	**4 Managing a Professional Engineering Project (Pearson-set)**	15	4
Specialist unit *Mandatory*	**24 Aircraft Aerodynamics**	15	4
Optional unit	**Plus one optional unit from optional bank group A (see below)**	15	4
Optional unit	**Plus one optional unit from optional bank group A (see below)**	15	4
Optional unit	**Plus one optional unit from optional bank group A (see below)**	15	4

Higher National Certificate Optional Unit Bank		Unit credit	Level
Optional Bank Group A			
Optional unit	**23 Computer Aided Design and Manufacture (CAD/CAM)**	15	4
Optional unit	**25 Aircraft Electrical Power and Distribution Systems**	15	4
Optional unit	**26 Airframe Mechanical Systems**	15	4
Optional unit	**27 Composite Materials for Aerospace Applications**	15	4
Optional unit	**28 Turbine Rotary Wing Mechanical and Flight Systems**	15	4
Optional unit	**75 Industry 4.0**	15	4
Optional unit	**76 Introduction to Professional Engineering Management**	15	4
Optional unit	**77 Industrial Robots**	15	4
Optional unit	**78 Programmable Logic Controllers**	15	4
Optional unit	**79 Computer Aided Design (CAD) for Engineering**	15	4

4.2.2 Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering

The Pearson BTEC 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).

Pearson BTEC Higher National Diploma in Aeronautical Engineering (240 credits)		Unit credit	Level
Level 4 units:			
Core unit *Mandatory*	**1 Engineering Design**	15	4
Core unit *Mandatory*	**2 Engineering Maths**	15	4
Core unit *Mandatory*	**3 Engineering Science**	15	4
Core unit *Mandatory*	**4 Managing a Professional Engineering Project (Pearson-set)**	15	4
Specialist unit *Mandatory*	**24 Aircraft Aerodynamics**	15	4
Optional unit	**Plus one optional unit from Level 4 Optional Unit Bank Group A (see below)**	15	4
Optional unit	**Plus one optional unit from Level 4 Optional Unit Bank Group A (see below)**	15	4
Optional unit	**Plus one optional unit from Level 4 Optional Unit Bank Group A (see below)**	15	4
Level 5 units:			
Core unit *Mandatory*	**34 Research Project**	30	5
Core unit *Mandatory*	**35 Professional Engineering Management (Pearson-set)**	15	5
Specialist unit *Mandatory*	**39 Further Mathematics**	15	5
Specialist unit *Mandatory*	**55 Aircraft Flight Control Systems**	15	5

Pearson BTEC Higher National Diploma in Aeronautical Engineering (240 credits)		Unit credit	Level
Optional unit	**Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)**	15	5
Optional unit	**Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)**	15	5
Optional unit	**Plus one optional unit from Level 5 Optional Unit Bank Group C (see below)**	15	5

Level 4 Optional Unit Bank		Unit credit	Level
Optional Unit Bank Group A			
Optional unit	**23 Computer Aided Design and Manufacture (CAD/CAM)**	15	4
Optional unit	**25 Aircraft Electrical Power and Distribution Systems**	15	4
Optional unit	**26 Airframe Mechanical Systems**	15	4
Optional unit	**27 Composite Materials for Aerospace Applications**	15	4
Optional unit	**28 Turbine Rotary Wing Mechanical and Flight Systems**	15	4
Optional unit	**75 Industry 4.0**	15	4
Optional unit	**76 Introduction to Professional Engineering Management**	15	4
Optional unit	**77 Industrial Robots**	15	4
Optional unit	**78 Programmable Logic Controllers**	15	4
Optional unit	**79 Computer Aided Design (CAD) for Engineering**	15	4

Level 5 Optional Unit Bank		**Unit credit**	**Level**
Optional Unit Bank Group C:			
Optional unit	**56 Aircraft Propulsion Principles and Technology**	15	5
Optional unit	**57 Aircraft Structural Integrity**	15	5
Optional unit	**58 Avionic Systems**	15	5
Optional unit	**59 Aircraft Gas Turbine Engine Design and Performance**	15	5
Optional unit	**60 Advanced Composite Materials for Aerospace Applications**	15	5
Optional unit	**61 Advanced Turbine Rotary Wing Mechanical and Flight Systems**	15	5

4.2.3 Meeting local needs (MLN)

Centres should note that Pearson BTEC Higher National qualifications have been developed in consultation with centres, employers and relevant professional organisations. The units were designed to meet the skill needs of the sector and thereby allow coverage of the full range of employment within the sector. Centres should make maximum use of the choices available to them within the specialist pathways 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 to use units from other RQF Pearson BTEC Higher National qualifications, through the MLN process (refer to *Commissioned qualification design and validation service* of our website http://qualifications.pearson.com or get in touch your Pearson regional contact for application details. Centres will need to justify the rationale for importing units from other RQF Pearson BTEC Higher National specifications. **Meeting local need applications must be made in advance of delivery and before 31 January in the year of student registration.**

The flexibility to import standard units from other RQF Pearson BTEC Higher National specifications is **limited to a maximum of 30 credits in a BTEC HNC qualification and a maximum of 60 credits in a BTEC HND qualification (30 credits at Level 4 and 30 credits at Level 5).** This is an overall maximum of units that can be imported. MLN units cannot be used at the expense of the mandatory units in any qualification nor can the qualification's rules of combination, as detailed in the specification, be compromised. It is the responsibility of the centre requesting the MLN to ensure that approved units are used only in eligible combinations .

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:

Qualification	Import at Level 4	Import at Level 5
Pearson BTEC Level 4 Higher National Certificate in Aeronautical Engineering	30	-
Pearson BTEC Level 5 Higher National Diploma in Aeronautical Engineering	30	30

4.2.4 Pearson BTEC Higher National Commissioned Development

Where MLN does not provide enough flexibility in terms of qualification structure, centres can request design and development of units by Pearson to meet their specific needs. This is offered by the following types of developments; full commission or partial commission.

We would be pleased to discuss your ideas for a Pearson BTEC Higher National Commissioned Development. For more information please refer to the *Commissioned qualification design and validation service* on our website http://qualifications.pearson.com

Once the centre is ready to proceed with a commissioned development, an application must be made, which provides a clear rationale for the development request. Pearson will review the application and may confirm or deny the request. The commissioned unit(s) will be authored by Pearson, in full consultation within the commissioning centre. Applications must be made one year in advance of the first year of commissioned unit(s) delivery.

4.3 Pearson-Set Assignments

There are Pearson-set assignments, as part of Core units. 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, tutors will select a topic to further define the student's 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

The Unit Descriptor is how we define 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.

We have described each part of the unit, as below. You may refer to any of the Unit Descriptors in *Section 10* of this programme specification.

Unit Title	A broad statement of what the unit will cover.
Unit Code	The Ofqual unit designation
Unit Type	There are three unit types: core (mandatory to all pathways); specialist (mandatory to specific pathways); and optional (available to most pathways)
Unit level	All BTEC Higher National units are at Level 4 or Level 5
Credit value	The credit value is related to total qualification time (TQT) and unit learning hours (ULH), and is easy to calculate. 1 credit is equal to 10 ULH, so 15 credits are equal to 150 ULH. To complete a Higher National Certificate or Diploma students are expected to achieve the appropriate number of credits
Introduction	Some general notes on the unit, setting the scene, stating the purpose, outlining the topics and skills gained on completion of the unit
Learning Outcomes	The Learning Outcomes are explicit statements that clearly express what students will be able to do after the completion of the unit. There are, typically, four Learning Outcomes for each unit.

Essential Content	This section covers the content that students can expect to study as they work towards achieving their Learning Outcomes.
Learning Outcomes and Assessment Criteria	Each unit sets out the 'Pass', 'Merit' and 'Distinction' criteria for that unit. When assignments are graded, a tutor will refer to this table, which connects the unit's Learning Outcomes with the student's work. This assignment may be graded at 'Pass', 'Merit' or 'Distinction level, depending on the quality of the students work.
Recommended Resources	Lists the resources appropriate to support the study of this unit. This includes books, journals and online material to support learning. The programme tutor may suggest alternatives and additions, usually with a local application or relevance.

Web resources – referencing:

Some units have web resources 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 web 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, which may be one of the following –

- research
- general reference
- tutorials
- training
- e-books
- report
- wiki
- article
- datasets
- development tool
- discussion forum

Web

[1] sdbs.db.aist.go.jp	[2] National Institute for Advanced Industrial Science and Technology (AIST) [3] Spectral Database for Organic Compounds, SDBS [4] (General reference)
[1] rsc.org	[2] Royal Society of Chemistry [3] Learn Chemistry [4] (General reference)

4.5 Professional Body collaboration

In redeveloping the Pearson BTEC Higher National qualifications in Aeuronautical 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 Aeronautical 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, expanded or mixed delivery

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

Condensed version:

Weeks 1 to 6	Week 7	Weeks 8 to 13	Week 14
Unit 1	Assessment	Unit 3	Assessment
Unit 2		Unit 4	

Expanded version:

Weeks 1 to 12	Weeks 13 and 14
Unit 1	**Assessment**
Unit 2	
Unit 3	
Unit 4	

Mixed version:

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Unit 1													**Assessment**
Unit 2						**Assessment**	**Unit 3**						
Unit 4													

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 chose 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.

Technique	Face-to-face	Distance learning
Lecture and seminars	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.	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.

Technique	Face-to-face	Distance learning
Practical demonstrations	Demonstration by a qualified operator of the appropriate and safe operation of both production and testing equipment.	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.
Workshops	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.	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.
Tutorials	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.	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.
Virtual Learning Environments (VLEs)	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.	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.

Technique	Face-to-face	Distance learning
Blended learning	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.	Offline learning enables students to develop autonomy and self-discipline by completing set activities and tasks with limited direction and traditional classroom-based constraints.
Work-based learning	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).	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.
Guest speakers	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.	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.

Technique	Face-to-face	Distance learning
Field trips	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.	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.

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 assessment 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 internal 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 assignment. The EE may also include the Pearson-set units in the centre visit sample of student work.

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.

6.0.1 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 feel 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 that 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 Pearson 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 Art and Design 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.

6.1.1 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 a hand-out 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.

6.1.2 Assessment decisions through applying unit-based criteria

Assessment decisions for Pearson 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 career-related attributes appropriate to the purpose of the qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if an M criterion requires the student to show 'analysis' and the related P criterion requires the student to 'explain', then to satisfy the M 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 1* 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 outcomes, 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), and 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.

6.1.3 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 EE. The Programme Leader registers annually with Pearson 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. Placement assessments must be carried out by appropriately qualified assessors.
- Your **External Examiner** (EE) will sample student work across assessors. Your EE will also want to see evidence of internal verification of assignments and assessed decisions.

6.1.4 Effective organisation

Internal assessment needs to be well organised so that 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.

6.1.5 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 they should use and reference source materials, including what would constitute plagiarism.

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

6.2 Setting effective assignments

6.2.1 Setting the number and structure of assessments

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 EABs 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.

6.2.2 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.

6.2.3 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

6.3.1 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 student's 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.)

6.3.2 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 1* of this document
- examples of verified assessed work
- your Programme Leader and assessment team's collective experience.

6.3.3 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's policies (see also *Section 3.6*).

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; 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 grade, 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 grades should be recorded and ratified by an appropriate assessment board, taking into account any mitigating circumstances that may have been submitted.

6.3.4 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 can suggest how to improve in the future.

6.3.5 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.

6.3.6 Repeat Units

In cases of students who, for the first assessment opportunity and resubmission opportunity, still fail to achieve a Pass for that unit specification:

- at the discretion of the centre 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 be repeated only once.

6.3.7 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 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 should have an assessment plan. 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 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

6.5.1 Conditions for the award

Conditions for the award of the HND

To achieve a Pearson BTEC Level 5 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 Level 4 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.

6.5.2 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.

6.5.3 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

Grade	Points
Pass	4
Merit	6
Distinction	8

Point boundaries

Grade	Point boundaries
Pass	420−599
Merit	600−839
Distinction	840 +

6.5.4 Modelled student outcomes

Pearson BTEC Level 4 Higher National Certificate

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	4	P	60	P	60	P	60	D	120	D	120
Core 2	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 3	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 4	15	4	4	P	60	P	60	M	90	M	90	M	90
Core 5	15	4	6	M	90	P	60	M	90	M	90	M	90
Core 6	15	4	6	M	90	P	60	M	90	M	90	M	90
Opt 1	15	4	6	M	90	M	90	D	120	D	120	D	120
Opt 2	15	4	6	M	90	M	90	D	120	D	120	D	120
TOTAL	120				600		540		690		870		810
GRADE					M		P		M		D		M

Pearson BTEC Level 5 Higher National Diploma

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	0	P	0	P	0	P	0	D	0	P	0
Core 2	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 3	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 4	15	4	0	P	0	P	0	M	0	M	0	M	0
Core 5	15	4	0	M	0	P	0	M	0	M	0	P	0
Core 6	15	4	0	M	0	P	0	M	0	D	0	U	0
Opt 1	15	4	0	M	0	P	0	D	0	D	0	D	0
Opt 2	15	4	0	M	0	P	0	D	0	D	0	D	0
Core 7	30	5	6	M	180	M	180	M	180	P	120	D	240
Core 8	15	5	6	M	90	M	90	M	90	P	60	D	120
Opt 3	15	5	6	M	90	M	90	D	120	P	60	D	120
Opt 4	15	5	6	M	90	P	60	D	120	P	60	D	120
Opt 5	15	5	6	M	90	P	60	D	120	M	90	M	90
Opt 6	15	5	6	M	90	P	60	M	90	M	90	P	60
Opt 7	15	5	6	M	90	P	60	M	90	M	90	M	90
TOTAL	240				720		600		810		570		840
GRADE					M		M		M		P		D

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 EE. 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 QAA FHEQ are subject to an independent assessment review by a Pearson appointed EE. 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 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Plan a design solution and prepare an engineering design specification in response to a stakeholder's design brief and requirements</td><td rowspan="2">D1 Compare and contrast the completed design specification against the relevant industry standard specification</td></tr>
<tr><td>P1 Produce a design specification from a given design brief

P2 Explain the influence of the stakeholder's design brief and requirements in the preparation of the design specification

P3 Produce a design project schedule with a graphical illustration of the planned activities</td><td>M1 Evaluate potential planning techniques, presenting a case for the method chosen

M2 Demonstrate critical path analysis techniques in design project scheduling/planning and explain its use</td></tr>
<tr><td colspan="2">LO2 Formulate possible technical solutions to address the student-prepared design specification</td><td rowspan="2">D2 Evaluate potential technical solutions, presenting a case for the final choice of solution</td></tr>
<tr><td>P4 Explore industry standard evaluation and analytical tools in formulating possible technical solutions

P5 Use appropriate design techniques to produce a possible design solution</td><td>M3 Apply the principles of modelling, simulation and/or prototyping, using appropriate software, to develop an appropriate design solution</td></tr>
</table>

Pass	Merit	Distinction
LO3 Prepare an industry-standard engineering technical design report		**D3** Evaluate the effectiveness of the industry standard engineering technical design report for producing a fully compliant finished product
P6 Prepare an industry-standard engineering technical design report **P7** Explain the role of design specifications and standards in the technical design report	**M4** Assess any compliance, safety and risk management issues specific to the technical design report	
LO4 Present to an audience a design solution based on the design report and evaluate the solution/presentation		**D4** Justify potential improvements to the design solution and/or presentation based on reflection and/or feedback
P8 Present the recommended design solution to the identified audience **P9** Explain possible communication strategies and presentation methods that could be used to inform the stakeholders of the recommended solution	**M5** Reflect on the effectiveness of the chosen communication strategy in presenting the design solution	

Recommended Resources

Textbooks

DUL, J. and WEERDMEESTER, B. (2008) *Ergonomics for beginners.* 3rd Ed. Boca Raton: CRC Press.

DYM, C. L., LITTLE, P. and ORWIN, E. (2014) *Engineering Design, a Project Based Introduction*. 4th Ed. Hoboken: Wiley.

GRIFFITHS, B. (2003) *Engineering Drawing for Manufacture.* London: Kogan Page Science.

REDDY, K. V. (2008) *Textbook of Engineering Drawing*. 2nd Ed. Hyderabad: BS Publications.

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.
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, trigonometric and hyperbolic functions

LO2 **Investigate applications of statistical techniques to interpret, organise and present data**

Summary of data:

Mean and standard deviation of grouped data

Pearson’s correlation coefficient

Linear regression

Charts, graphs and tables to present data

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 functions including:

- common/standard functions
- using substitution
- by 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

Pass	Merit	Distinction
LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples		**LO1 & LO2** **D1** Present data in a method that can be understood by a non-technical audience
P1 Apply dimensional analysis techniques to solve complex problems **P2** Generate answers from contextualised arithmetic and geometric progressions **P3** Determine solutions of equations using exponential, logarithmic, trigonometric and hyperbolic functions	**M1** Use dimensional analysis to derive equations	
LO2 Investigate applications of statistical techniques to interpret, organise and present data		
P4 Summarise data by calculating mean and standard deviation **P5** Calculate probabilities within both binomially distributed and normally distributed random variables	**M2** Interpret the results of a statistical hypothesis test conducted from a given scenario	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application</td><td rowspan="2">D2 Model the combination of sine waves graphically and analyse the variation in results between graphical and analytical methods</td></tr>
<tr><td>P6 Solve engineering problems relating to sinusoidal functions

P7 Represent engineering quantities in vector form, and use appropriate methodology to determine engineering parameters</td><td>M3 Use compound angle identities to combine individual sine waves into a single wave</td></tr>
<tr><td colspan="2">LO4 Examine how differential and integral calculus can be used to solve engineering problems</td><td rowspan="2">D3 Analyse maxima and minima of increasing and decreasing functions using higher order derivatives</td></tr>
<tr><td>P8 Determine rates of change for algebraic, logarithmic and circular functions

P9 Use integral calculus to solve practical problems relating to engineering</td><td>M4 Formulate predictions of exponential growth and decay models using integration methods</td></tr>
</table>

Recommended Resources

Textbooks

SINGH, K. (2011) *Engineering Mathematics Through Applications*. 2nd Ed. Basingstoke: Palgrave Macmillan.

STROUD, K. A. and BOOTH, D. J. (2013) *Engineering Mathematics*. 7th Ed. Basingstoke: Palgrave Macmillan.

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 qualitative 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 qualitative 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 beams 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, polymers 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

Pass	Merit	Distinction
LO1 Examine scientific data using both quantitative and qualitative methods		**D1** Analyse scientific data using both quantitative and qualitative methods
P1 Describe SI units and prefix notation **P2** Examine quantitative and qualitative data with appropriate graphical representations	**M1** Explain how the application of scientific method impacts upon different test procedures	
LO2 Determine parameters within mechanical engineering systems		**D2** Compare how changes in the thermal efficiency of a given system can affect its performance.
P3 Determine the support reactions of a beam carrying a combination of a concentrated load and a uniformly distributed load **P4** Use Archimedes' principle in contextual engineering applications **P5** Determine the effects of heat transfer on the dimensions of given materials	**M2** Determine unknown forces by applying d'Alembert's principle to a free body diagram	

Pass	Merit	Distinction
LO3 Explore the characteristics and properties of engineering materials		**D3** Compare and contrast theoretical material properties of metals and non-metals with practical test data
P6 Describe the structural properties of metals and non-metals with reference to their material properties **P7** Explain the types of degradation found in metals and non-metals	**M3** Review elastic and electromagnetic hysteresis in different materials	
LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties		**D4** Evaluate different techniques used to solve problems on a combined series-parallel RLC circuit using A.C. theory.
P8 Calculate currents and voltages in D.C. circuits using circuit theorems **P9** Describe how complex waveforms are produced from combining two or more sinusoidal waveforms. **P10** Solve problems on series RLC circuits with A.C. theory.	**M4** Explain the principles and applications of electromagnetic induction	

Recommended Resources

Textbooks

BIRD, J. (2012) *Science for Engineering*. 4th Ed. London: Routledge.

BOLTON, W. (2006) *Engineering Science.* 5th Ed. London: Routledge.

TOOLEY, M. and DINGLE, L (2012) *Engineering Science: For Foundation Degree and Higher National.* London: Routledge.

Journals

International Journal of Engineering Science.

International Journal of Engineering Science and Innovative Technology.

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 vial 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

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

Recommended Resources

Textbooks

PUGH, P. S. (1990) *Total Design: Integrated Methods for Successful Product Engineering*. Prentice Hall.

STRIEBIG, B., OGUNDIPE, A. and PAPADAKIS, M. (2015) *Engineering Applications in Sustainable Design and Development*. Cengage Learning.

ULRICH, K. and EPPINGER, S. (2011) *Product Design and Development*. 5th Ed. McGraw-Hill Higher Education.

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

Pass	Merit	Distinction
LO1 Describe the key principles of manufacturing using a CAD/CAM system		**D1** Critically evaluate using illustrative examples, the impact of different machining conditions and specifications on component manufacturing
P1 Describe the hardware and software elements of a typical CAD/CAM system **P2** Describe, with examples, the inputs and outputs of the CAD/CAM process **P3** Explain the different methods of component set up, work holding and tooling available on CNC machines	**M1** Analyse the suitability of different programming methods of CNC machines	
LO2 Produce 3D Solid models of a component suitable for transfer into a CAM system		**D2** Critically evaluate the effectiveness of using a CAD/CAM system and solid modelling to manufacture components
P4 Design and produce a CAD solid model of a component to be manufactured on a CNC machine **P5** Design a working drawing of a component containing specific manufacturing detail	**M2** Assess the importance of using different geometry manipulation methods for efficient model production	

Pass	Merit	Distinction
LO3 Use CAM software to generate manufacturing simulations of a component		**D3** Analyse the effect of applying different manufacturing techniques and modifications to achieve an optimised production time
P6 Use CAM software to generate a geometrically accurate CAD solid model of a component	**M3** Using CAM software generate cutter tool path simulations	
LO4 Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system		**D4** Critically analyse, giving illustrative examples the different methods of data transfer through a CAD/CAM system
P7 Detail a part program for a component using CAM software and transfer the part program to a CNC machine and manufacture a component **P8** Describe the structural elements of a CNC machining centre **P9** Review a component manufactured on a CNC machine to verify its accuracy	**M4** Analyse different methods of component inspection used in manufacturing	

Recommended Resources

Textbooks

KUNWOO LEE, (2000) *Principles of CAD/CAM/CAE*. Pearson.

McMAHAN, C. and BROWNE, J. (1999) *CADCAM: Principles, Practice and Manufacturing Management*. Prentice Hall.

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 ($L=C_L 1/2\rho V^2 S$) and drag ($D=C_D 1/2\rho V^2 S$) 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 anhedral 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

Pass	Merit	Distinction
LO1 Examine standard atmospheric properties and aerodynamic principles affecting flight		**D1** 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
P1 Describe the nature of the ISA and the changes that take place to the properties of the air with changing altitude **P2** Assess, using theoretical calculations and experimental results how lift and drag forces are generated from low speed airflows over aerofoil sections	**M1** 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	
LO2 Describe the nature and effect of forces that act on aircraft in flight		**D2** 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
P3 Describe how wing planform, the boundary layer, atmospheric events and aero-elasticity, effect the generation and distribution of lift and drag **P4** Calculate the forces that act on aircraft in straight and level flight and during manoeuvres	**M2** 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	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Demonstrate the nature of high speed airflows and their effect on fixed wing aircraft design</td><td rowspan="2">D3 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></tr>
<tr><td>P5 Discuss the relationship between the speed of sound and Mach number and the nature of transonic and supersonic airflows over aerofoil surfaces

P6 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><td>M3 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></tr>
<tr><td colspan="2">LO4 Investigate the nature and methods used to control and stabilise fixed-wing aircraft</td><td rowspan="2">D4 Analyse aircraft control and stabilisation devices and methods and their interaction, for aircraft that fly in the transonic and supersonic speed range</td></tr>
<tr><td>P7 Explore the nature and operation of aircraft primary controls and secondary controls, lift augmentation and drag inducing devices

P8 Describe the nature of static and dynamic stability and how aircraft are stabilised about their axes of rotation</td><td>M4 Illustrate aircraft control and stabilisation devices and methods and their interaction</td></tr>
</table>

Recommended Resources

Textbooks

ANDERSON Jr, J. D. (2016) *Introduction to Flight*. 8th International Student Ed. McGraw-Hill.

BARNARD, R. H. and PHILPOTT, D. R. (2010) *Aircraft Flight*. 4th Ed. Pearson.

DINGLE, L. and TOOLEY, M. (2013) *Aircraft Engineering Principles*. 2nd Ed. Routledge.

Journals

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

The Aeronautical Journal. Cambridge University Press. Covering all aspects of aerospace engineering and research.

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:

BatteriesDC 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

Pass	Merit	Distinction
LO1 Identify internal and external sources of aircraft power and their application in modern civil and military aircraft		**D1** Assess a typical transport aircraft (civil or military) in terms of its electrical supply requirements and the available power sources
P1 Categorise aircraft systems as essential, needed for flight, and non-essential **P2** Outline available sources of power as batteries, DC generators, AC generators (engine driven), AC generators (APU driven) and external ground power **P3** Distinguish between different types of aircraft load in terms of supply voltage, current demand and duty cycle	**M1** Explain the need for multiple sources of aircraft power **M2** Explain the need for an auxiliary power unit (APU) in a large aircraft	

Pass	Merit	Distinction
LO2 Explain the principles and application of aircraft DC power sources		**D2** Evaluate the performance of an aircraft DC voltage regulator over a range of different drive shaft speeds and load currents
P4 Identify and describe the characteristics of lead-acid, nickel-cadmium, nickel-metal hydride and lithium batteries for use in aircraft **P5** Outline and describe the construction of an aircraft DC generator **P6** Outline different types of DC voltage regulator, including vibrating contact, carbon pile and solid-state	**M3** Explain the principle of operation of an aircraft DC generator **M4** Illustrate the characteristics of series, shunt and compound wound aircraft DC generators **M5** Explain the need to regulate the DC output from an aircraft generator	
LO3 Explain the principles and application of aircraft AC power sources		**D3** Evaluate the performance of a three-phase AC generating system over a range of different load currents and load power factors
P7 Identify and describe the construction of an aircraft AC generator **P8** Describe, with the aid of labelled circuit diagrams, star and delta connected three-phase AC sources and loads **P9** Describe, with the aid of a labelled diagram, the construction and electrical arrangement of an integrated drive generator (IDG)	**M6** Explain the advantages of three-phase AC power when compared with single-phase AC systems **M7** Illustrate the advantages and disadvantages of frequency wild and constant frequency AC generating systems	

Pass	Merit	Distinction
LO4 Illustrate the function and operation of the components and sub-systems used in aircraft electrical power distribution systems		**D4** 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
P10 Outline the need for, and function of, a DC to DC inverter **P11** Outline the need for, and function of, a power factor corrector **P12** Outline the need for, and function of, a harmonic suppressor **P13** Outline the need for, and function of, a transformer/rectifier unit (TRU) **P14** Outline the need for, and function of, an essential services bus	**M8** Justify the arrangement of an aircraft electrical bus distribution system **M9** Explain, with the aid of a labelled diagram, the principle of the current transformer **M10** Illustrate, with the aid of a labelled diagram, the principle of power factor correction **M11** Explain the function of a bus power control unit (BPCU)	

Recommended Resources

Textbooks

EISMIN, T. (2013) *Aircraft Electricity and Electronics*. 6th Ed. McGraw-Hill Education.

TOOLEY, M. and DINGLE, L. (2013) *Aircraft Engineering Principles.* Taylor & Francis Aerospace and Aviation Engineering.

TOOLEY, M. and WYATT, D. (2009) *Aircraft Electrical and Electronic Systems*. Butterworth-Heinemann.

Websites

https://www.faa.gov/	Aircraft Electrical Systems (FAA) AMT Airframe Handbook: Ch 9 Air Craft 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

Pass	Merit	Distinction
LO1 Explore how the design and operation of hydraulic systems contribute to safe flight		**D1** 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, assessing the contribution made by each system to safe flight
P1 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	**M1** 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	
P2 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		

Pass	Merit	Distinction
LO2 Examine how the design and operation of cabin environmental control systems contribute to the safety of the airframe and personnel		**D2** 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
P3 Describe pneumatic system requirements and the control and distribution of air supplies to the aircraft services **P4** Discuss the design and operation of oxygen, air-conditioning and pressurisation systems and the function of their components under normal and emergency operating conditions	**M2** Explain the design and operation of oxygen, pneumatic air supply, air-conditioning and pressurisation systems and components under normal and emergency operating conditions	
LO3 Investigate how the layout and operation of protection systems contribute to safe flight		**D3** 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
P5 Discuss the layout and operation of aircraft ice protection systems and function of system components, under normal and emergency operating conditions **P6** Describe the layout and operation of aircraft fire detection and extinguishing systems and function of their components under normal and emergency operating conditions	**M3** Illustrate the layout and operation of ice protection and fire detection and extinguishing systems and associated components under normal and emergency operating conditions	

Pass	Merit	Distinction
LO4 Explain how the layout and operation of airframe fuel systems ensures a continuous safe supply to the aircraft engines		**D4** 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
P7 Discuss the properties, use and safe handling of aircraft fuels and the nature and function of airframe fuel system components **P8** Describe the layout and operation of airframe fuel systems for all operating modes	**M4** 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	

Recommended Resources

Textbooks

MOIR, I. and SEABRIDGE, A. (2008) *Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration (Aerospace Series)*. 3rd Ed. Chichester: Wiley.

PARR, A. (2011) *Hydraulics and Pneumatics: A technician and engineers guide.* 3rd Ed. Imprint Butterworth Heinemann Ltd.

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**

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.

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>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Distinguish between the different constituents of composite materials used in aerospace engineering</td><td rowspan="2">D1 Explain how coatings and surface materials are used to protect composite structures from environmental factors, including lightning strike</td></tr>
<tr><td>P1 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

P2 Compare matrices used in aerospace engineering, including thermoset, thermoplastic, metal and ceramic, and examine their benefits and typical applications</td><td>M1 Summarise the benefits of different core materials and numerically show the benefits of sandwich panels</td></tr>
</table>

Pass	Merit	Distinction
LO2 Compare key manufacturing processes used in aerospace composite production		**D2** Appraise how liquid resin systems are being introduced into aerospace composite manufacture and discuss their advantages and disadvantages
P3 Describe why balanced and symmetrical laminates are important in composite design and explain where an unbalanced layup may be beneficial **P4** Compare the various types of tooling materials used in aeronautical composite manufacture and highlight a tooling feature specific to each manufacturing method	**M2** Compare three automated manufacturing methods and describe their benefits, limitations, applications and associated costs	
LO3 Correlate defects, their identification and evaluation		**D3** Compare six NDT methods and describe their advantages, disadvantages, applications and associated costs
P5 List and describe manufacturing and in-service defects and attribute a possible effect of the defects **P6** Describe BVID and explain how this would present itself in both a solid composite structure and a sandwich panel	**M3** Describe the testing carried out at OEM/DA to define allowable defect limits on flight critical components	

Pass	Merit	Distinction
LO4 Review repair methods and techniques stated in Structural Repair Manuals (SRM) or Aircraft Repair Manual (ARM) from the Design Authority (DA)		**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
P7 Describe both the mechanical and chemical preparation required for bonding of metallic and composite parts **P8** Using a structural repair manual, summarise the different allowable repair types and their restrictions	**M4** Mechanically compare bonded and bolted composite joints and explain the benefits of four different bonded joint designs	

Recommended Resources

Textbooks

HULL, D. and Clyne, T. W. (1996) *An Introduction to Composite Materials*. 2nd ed. Cambridge: Cambridge University Press.

MATTHEWS, F. L. and RAWLINGS, R. D. (1999) *Composite Materials: Engineering and Science.* Cambridge: Woodhead Publishing.

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

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the mechanical airframe control systems associated with rotary wing flight and explain the interrelationships between flight systems in modern integrated flight controls		**D1** Discuss how Integrated Modular Avionics systems receive inputs from and provide outputs to the mechanical and auto flight control systems, including the need for redundancy
P1 Describe the function and characteristics of the mechanical flight controls fitted to rotary wing aircraft **P2** Identify the different types of operating systems that can be utilised to operate the mechanical flight control systems	**M1** Describe the mechanical and electrical functions of a rotary wing auto flight system	
LO2 Explain the operation of rotary wing transmission systems and determine the efficiency of transmission system components		**D2** Using given test data determine the mechanical parameters of a typical main rotor epicyclic gearbox
P3 Describe the layout, component function and operation of the transmission systems fitted to a turbine-powered helicopter **P4** Explain the principles of operation of both NOTAR and Fenestron tail rotors	**M2** Illustrate, with the aid of diagrams, the operation of clutches and free wheel units, in all modes, in a typical rotary wing aircraft powered by at least two turbine engines	

Pass	Merit	Distinction
LO3 Identify the requirements and system operation of typical rotary wing hydraulic systems and design a hydraulic system to solve a given application		**D3** Explore the effects on dual hydraulic helicopter systems when it suffers a single hydraulic system failure
P5 Using standard hydraulic symbols, design a helicopter hydraulic schematic that incorporates at least two independent hydraulic systems **P6** Explain the operation of a typical hydraulic system in normal operation	**M3** Explain how rotary wing hydraulic systems interface with other aircraft systems, such as autopilot	
LO4 Justify the need for Health and Usage Monitoring Systems (HUMS) and the methods used to combat airframe fatigue failure		**D4** Evaluate the practical solutions helicopter manufacturers offer to combat vibration at the source
P7 Describe the sources of vibration and its effects on a helicopter **P8** Explain the techniques used by engineers to adjust flying controls and rotors for optimal performance	**M4** Explain the reasons why Health Usage Monitoring is an integral part of modern helicopter operations and how it is used to combat fatigue failure	

Recommended Resources

Textbooks

COYLE, S. (2009) *Cyclic and Collective.* Lebanon: Eagle Eye Solutions.

MOIR, I. and SEABRIDGE, A. (2008) *Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration*. 3rd Ed. Wiley.

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.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Conduct the preliminary stages involved in the creation of an engineering research project		**D1** Produce a comprehensive project proposal that evaluates and justifies the rationale for the research
P1 Produce a research project proposal that clearly defines a research question or hypothesis **P2** Discuss the key project objectives, the resulting goals and rationale	**M1** Analyse the project specification and identify any project risks	
LO2 Examine the analytical strategies and techniques used to work on the literature review and data analysis and collection stages of the research project		**D2** Critically analyse literature sources utilised, data analysis conducted and strategies to deal with challenges
P3 Conduct a literature review of published material, either in hard copy or electronically, that is relevant to your research project **P4** Examine appropriate research methods and approaches to primary and secondary research	**M2**Analyse the strategies used to overcome the challenges involved in the literature review stage **M3** Discuss merits, limitations and pitfalls of approaches to data collection and analysis	

Pass	Merit	Distinction
LO3 Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context		**D3** Critically evaluate how the research experience enhances personal or group performance within an engineering context
P5 Reflect on the effectiveness and the impact the experience has had upon enhancing personal or group performance	**M4** Evaluate the benefits from the findings of the research conducted	
LO4 Explore the communication approach used for the preparation and presentation of the research project's outcomes		**D4** Critically reflect how the audience for whom the research was conducted influenced the communication approach used for the preparation and presentation of the research project's outcomes
P6 Explore the different types of communication approaches that can be used to present the research outcomes **P7** Communicate research outcomes in an appropriate manner for the intended audience	**M5** Evaluate how the communication approach meets research project outcomes and objectives	

Recommended Resources

Textbooks

LEONG, E. C., LEE-HSIA, C. H. and WEE ONG, K. K. (2015) *Guide to Research Projects for Engineering Students – Planning, Writing and Presenting.* Apple Academic Press Inc.

OBERLENDER, G. D. (2014) *Project Management for Engineering and Construction*. 3rd Ed. McGraw-Hill Education.

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**

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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology</td><td rowspan="2">D1 Specify and analyse the challenges encountered when meeting the requirements for successfully managing engineering activities, and make justified recommendations to overcome these challenges</td></tr>
<tr><td>P1 Evaluate the risk evaluation theories and practices associated with the management of engineering projects

P2 Assess elements and issues that impact the successful management of engineering activities</td><td>M1 Critically evaluate the main elements and issues that impact the successful management of engineering activities</td></tr>
<tr><td colspan="2">LO2 Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation</td><td rowspan="2">D2 Critically evaluate contingencies that might prevent the delivery plan meeting the requirements of a sector-specific organisation</td></tr>
<tr><td>P3 Develop an engineering services delivery plan applying the appropriate sector-specific requirements

P4 Determine the engineering management tools needed for designing an engineering services delivery plan</td><td>M2 Evaluate how each step of the delivery plan developed meets the requirements of a sector specific organisation</td></tr>
</table>

Pass	Merit	Distinction
LO3 Develop effective leadership skills, and individual and group communication skills		**D3** Critically evaluate effective ways for the coaching and mentoring of disillusioned colleagues or of a poorly performing team
P5 Describe the steps for effective persuasion and negotiation **P6** Explain the steps for managing effective group meetings **P7** Outline the steps to deliver an effective presentation	**M3** Evaluate leadership styles and effective communication skills using specific examples in an organisational context	
LO4 Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment		**D4** Evaluate and provide justifications on why it is necessary to be active and up to date with the engineering profession's new developments and discoveries
P8 Discuss the context of social responsibility for scientists and engineers **P9** Explore the ways in which an engineer can engage in continuing professional development	**M4** Summarise the engineering profession ethical standards and patterns of behaviour	

Recommended Resources

Textbooks

BURNES, B. (2014) *Managing change*. 6th edn. Harlow, England: Pearson Education.

DEARDEN, H. (2013) *Professional Engineering Practice: Reflections on the Role of the Professional Engineer.* CreateSpace Independent Publishing Platform.

KARTEN, N. (2010) *Presentation Skills for Technical Professionals.* IT Governance Ltd.

LOCK, D. (2013) *Project Management*. 10th Ed. Routledge.

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.

4 Review models of engineering systems using ordinary differential equations.

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 and 3x3 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

Pass	Merit	Distinction
LO1 Use applications of number theory in practical engineering situations		**D1** Test the correctness of a trigonometric identity using de Moivre's Theorem
P1 Apply addition and multiplication methods to numbers that are expressed in different base systems **P2** Solve engineering problems using complex number theory **P3** Perform arithmetic operations using the polar and exponential form of complex numbers	**M1** Solve problems using de Moivre's Theorem	
LO2 Solve systems of linear equations relevant to engineering applications using matrix methods		**D2** Validate solutions for the given engineering linear equations using appropriate computer software
P4 Calculate the determinant of a set of given linear equations using a 3x3 matrix **P5** Solve a system of three linear equations using Gaussian elimination	**M2** Determine the solution to a set of given engineering linear equations using the Inverse Matrix Method for a 3x3 matrix	

Pass	Merit	Distinction
LO3 Approximate solutions of contextualised examples with graphical and numerical methods		**D3** Critically evaluate the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods
P6 Estimate solutions of sketched functions using a graphical estimation method **P7** Calculate the roots of an equation using two different iterative techniques **P8** Determine the numerical integral of engineering functions using two different methods	**M3** Solve engineering problems and formulate mathematical models using graphical and numerical integration	
LO4 Review models of engineering systems using ordinary differential equations		**D4** Critically evaluate first- and second-order differential equations when generating the solutions to engineering situations using models of engineering systems
P9 Formulate and solve first order differential equations related to engineering systems **P10** Formulate and solve second order homogeneous and non-homogeneous differential equations related to engineering systems **P11** Calculate solutions to linear ordinary differential equations using Laplace transforms	**M4** Demonstrate how different models of engineering systems using first-order differential equations can be used to solve engineering problems	

Recommended Resources

Textbooks

BIRD, J. (2014) *Higher Engineering Mathematics*. 7th Ed. London: Routledge.

SINGH, K. (2011) *Engineering Mathematics Trough Applications*. Basingstoke: Palgrave Macmillan.

STROUD, K. A. and BOOTH, D. J. (2013) *Engineering Mathematics*. 7th Ed. Basingstoke: Palgrave Macmillan.

Journals

Communications on Pure and Applied Mathematics. Wiley.

Journal of Engineering Mathematics. Springer.

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, artificial 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

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>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Determine how the construction, layout and operation of mechanical flight control systems contribute to safe flight control</td><td rowspan="2">D1 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></tr>
<tr><td>P1 Discuss the control of fixed wing aircraft about their axes of rotation

P2 Investigate the function, layout and operation of mechanical flight control systems and components</td><td>M1 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></tr>
<tr><td colspan="2">LO2 Investigate how the design and operation of hydraulic powered flight control systems contribute to safe flight control</td><td rowspan="2">D2 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></tr>
<tr><td>P3 Discuss the design and operation of hydraulically power flight control system components

P4 Illustrate the design and operation of hydro-mechanical and electro-hydraulic powered flight control systems</td><td>M2 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></tr>
</table>

Pass	Merit	Distinction
LO3 Investigate how the development and operation of fly-by-wire flight control systems contribute to safe flight control		**D3** Show how the development and operation of fly-by-wire control systems and components has contributed to safe flight control
P5 Discuss the development and benefits of fly-by-wire control systems and components **P6** Illustrate the operation of fly-by-wire control systems and components	**M3** Justify the development and operation of fly-by-wire control systems and components, identifying the contribution made by these systems to safe flight control	
LO4 Show how the functions and operation of autopilot and autoland flight control systems contribute to safe flight control		**D4** 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
P7 Discuss the functions and operation of a modern autopilot system and components **P8** Illustrate the functions and operation of modern instrument and fully automated landing systems and components	**M4** 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	

Recommended Resources

Textbooks

MOIR, I. and SEABRIDGE, A. (2008) *Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration (Aerospace Series)*. 3rd Ed. Chichester: Wiley.

WYATT, D. (2015) *Aircraft Flight Instruments and Guidance Systems.* 1st Ed. Routledge.

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, scavenge 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

Pass	Merit	Distinction
LO1 Determine how thermodynamic and mechanical principles are applied to aircraft propulsion		**D1** 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
P1 Describe the thermodynamic principles applied to reciprocating piston engine and aircraft gas turbine engine operating cycles **P2** Describe the mechanical principles applied to the production of propulsive thrust by piston-propeller and gas turbine engine driven aircraft	**M1** 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	
LO2 Examine the construction, function and operation of gas turbine engines and components		**D2** 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
P3 Illustrate the construction and operation of turbojet, turbofan, turboshaft and turboprop gas turbine engines **P4** Describe the function and operation of gas turbine engine, intake, compressor, combustor, turbine and exhaust components	**M2** 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	

Pass	Merit	Distinction
LO3 Examine the layout, function and operation of the fluid control and monitoring systems of gas turbine engines		**D3** Analyse the layout and operation of engine, fluid, control and monitoring systems and assess the effect that the operation of their major components has on each system
P5 Illustrate the layout and operation of engine fuel, lubrication and internal air fluid systems **P6** Describe the function and operation of engine electro-mechanical, electronic and FADEC control systems and engine monitoring systems	**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	
LO4 Describe the construction, function and operation of piston engines and systems		**D4** Evaluate the constructional features and operation of aircraft reciprocating piston engines and their associated ancillaries and supporting systems, assessing the operational benefits for the choice and layout of the major components, for each supporting system
P7 Describe the construction, operation and installation of aircraft reciprocating piston engines **P8** Illustrate the function and operation of engine fuel, lubrication, ignition, control and starter systems	**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	

Recommended Resources

Textbooks

Royce, R. (2015) *The Jet Engine.* 5th edn. Chichester, West Sussex: John Wiley & Sons.

SARAVANAMUTTOO, H. I. H., ROGERS, G. F. C., COHEN, H., STRAZNICKY, P. V. (2009) *Gas Turbine Theory*. 6th Ed. Pearson.

TOOLEY, M., and DINGLE, L. (2012) *Engineering Science, Part III*. Routledge.

Journals

The Aeronautical Journal. Cambridge University Press. Covering all aspects of aerospace.

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 (ρ), stiffness (elastic modulus E), strength (yield stress σ_y), shear strength (τ), structural efficiency measured by, specific stiffness (E/ρ) and specific strength (σ/ρ), fatigue resistance, fatigue stress (σ_{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 ($\sigma_c = \sigma_f V_f + \sigma_m V_m$ and $E_c = E_f V_f + E_m V_m$)

Off-axis stiffness and strength in tension normal and parallel to fibres ($\sigma_1 = \sigma \cos^2\theta$ and $\sigma_2 = \sigma \sin^2\theta$) and shear stress parallel to fibres ($\tau_{12} = 1/2\ \sigma \sin 2\theta$)

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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Evaluate the design criteria, properties and selection of metallic and composite aircraft structural materials</td><td rowspan="2">D1 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></tr>
<tr><td>P1 Discuss the design criteria and common metallic and composite material properties required for aircraft structural materials

P2 Select appropriate metallic and composite materials for aircraft structural components, using design criteria</td><td>M1 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></tr>
<tr><td colspan="2">LO2 Investigate aircraft structural fatigue, damage prediction and design against failure</td><td rowspan="2">D2 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></tr>
<tr><td>P3 Discuss the nature of fatigue and the quantitative methods used to predict fatigue behaviour in aircraft structures

P4 Illustrate the design prevention methods used to mitigate the effects of aircraft structural damage from fatigue</td><td>M2 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>
</table>

Pass	Merit	Distinction
LO3 Examine fibre composite adhesively bonded repairs to aircraft metallic and composite structures		**D3** 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
P5 Review the properties of fibre matrix composite materials and surface treatments used for adhesively bonded structural repairs **P6** 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	**M3** Discuss the properties of fibre matrix composite materials and the surface treatments, used for adhesively bonded structural repairs **M4** Explore the repair requirements and application of quantitative joint design methods that ensure the integrity of fibre composite adhesively bonded repairs to aircraft	
LO4 Demonstrate how policies, procedures and regulations are used to ensure the integrity of aircraft structures		**D4** 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
P7 Show how damage assessment methods, policies and procedures are used to ensure that aircraft structures are correctly repaired **P8** Illustrate how care and maintenance programmes, procedures and authority regulations ensure the integrity and airworthiness of aircraft structures	**M5** Investigate how damage assessment methods, repair and maintenance policies, procedures and authority regulations ensure the correct repair, integrity and airworthiness of aircraft structures	

Recommended Resources

Textbooks

ASHBY, M. F. (2010) *Materials Selection in Mechanical Design.* 4th Ed. Elsevier.

BAKER, A., DUTTON, S., KELLY, D., (2004) *Composite Materials for Aircraft Structures.* 2nd Ed. American Institute of Aeronautics and Astronautics (AIAA).

JANSSEN, M., ZUIDEMA, J., WANHILL, R., (2009) *Fracture Mechanics*. Spoon Press, imprint of Taylor & Francis.

MOURITZ, P. A. (2012) *Introduction to Aerospace Materials.* Woodhead Publishing.

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

Pass	Merit	Distinction
LO1 Demonstrate the principles and practical application of HF, VHF and UHF aircraft radio communication systems		**D1** 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
P1 Illustrate the relationship between frequency, wavelength and velocity of propagation of an electromagnetic wave **P2** Explore the functional elements of AM radio receivers and transmitters **P3** Interpret key performance specifications of an aircraft voice communication system **P4** Discuss a typical radio data-link system (HFDL or VHFDL) for use in an aircraft	**M1** Explore the main features and characteristics of radio wave propagation at HF, VHF and UHF **M2** Discuss full-carrier amplitude and suppressed carrier single-sideband modulation techniques (DSB AM and SSB) **M3** 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	

Pass	Merit	Distinction
LO2 Investigate the principles and practical application of aircraft navigation systems		**D2** Critically assess the benefits of area-based navigation (RNAV) when compared with satellite based navigation for a typical modern civil transport aircraft
P5 Demonstrate the typical arrangement of remote indicating compass for use on a typical modern civil aircraft **P6** Explore the range of navigational aids and techniques available for use in a typical modern civil aircraft	**M4** Discuss the underpinning principles of VOR- and DME-based navigation aids **M5** Review the principles of gyroscope-based inertial navigation and its limitations in providing accurate global aircraft navigation	
LO3 Investigate the principles and practical application of aircraft radar and ADS-B systems		**D3** Critically evaluate the performance of an SDR-based ADS-B receiver and the data obtained during the typical flight of a modern commercial transport aircraft
P7 Differentiate between primary and secondary radar systems and describe an example of each **P8** Discuss the use of radar in air traffic control (ATC) applications **P9** Illustrate the functional components of an aircraft weather radar system **P10** Explore the benefits of ADS-B as a means of providing real-time data	**M6** Illustrate the relationship between peak power, mean power and duty cycle of a primary radar system **M7** Distinguish between the three basic ATC transponder modes (A, C and S)	

Pass	Merit	Distinction
LO4 Demonstrate the principles and practical application of automatic flight control systems (AFCS)		**D4** Analyse performance of the flight director system of a modern civil transport or general aviation (GA) aircraft in terms of the individual autopilot system components and the contribution that they collectively make to the attitude, stability and course of the aircraft
P11 Discuss the reasons for using closed loop feedback in automatic flight control systems **P12** Illustrate key autopilot control modes and describe their function in relation to an aircraft's attitude and stability	**M8** Illustrate the principle of three-axis control of an aircraft's attitude M9 Illustrate the function of a yaw damper	

Recommended Resources

Textbooks

COLLINSON, R. (2011) Introduction to Avionics Systems. Springer

Croucher, P. (2015) *Avionics in Plain English*. Calgary, Alberta: Electrocution.

MOIR, I., SEABRIDGE, A. and JUKES, M. (2013) *Civil Avionics Systems*. Wiley-Blackwell.

TOOLEY, M. and WYATT, D. (2007) *Aircraft Communication and Navigation Systems*. Butterworth-Heinemann.

WYATT, D. (2015) *Aircraft Flight Instruments and Guidance Systems.* Routledge.

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:

1 Determine gas turbine engine performance, using thermo-fluid principles and propulsion cycle efficiencies.

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, 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 (γ) and Mach number (M) and mass flow parameters in terms of continuity equation and the characteristic gas equation where mass flow

$$(\mathbf{m}) = \frac{pAM\sqrt{(\gamma RT)}}{RT}.$$

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 $\eta_p = 2/1+(V_j/V_a)$, thermal efficiency

$\eta_t = 0.5\boldsymbol{m}(V_j{}^2 - V_a{}^2)/\boldsymbol{f}C$ and overall efficiency $\eta_t = \boldsymbol{m}(V_j - V_a)V_a/\boldsymbol{f}C$ (**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 (CO_2), water vapour (H_2O), contrails and the production of (H_2O) and sulphuric acid (H_2SO_4), carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur (SO_x), 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 (NO_x)

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

Pass	Merit	Distinction
LO1 Determine gas turbine engine performance, using thermo-fluid principles and propulsion cycle efficiencies		**D1** Apply thermo-fluid principles and turbojet, turboprop and turbofan propulsion cycles and component efficiencies to predict engine performance in given examples
P1 Illustrate how thermo-fluid principles contribute to the operation of aircraft gas turbine propulsion cycles **P2** Explore turbojet, turboprop and turbofan propulsion cycles to predict engine performance	**M1** Demonstrate how thermo-fluid principles and turbojet, turboprop and turbo fan propulsion cycles are used to predict engine performance	
LO2 Evaluate the design and performance of aircraft gas turbine engine turbomachinery		**D2** 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
P3 Illustrate the design configuration, aerodynamic operation and performance characteristics of axial flow and centrifugal compressors and fan modules **P4** Compare the types, mechanical design, operation and performance characteristics of turbine modules	**M2** 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	

Pass	Merit	Distinction
LO3 Evaluate the design and performance of aircraft gas turbine engine intake, combustion and exhaust modules		**D3** 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
P5 Discuss the types, functions and design features that aid the aerodynamic and thrust performance of air intakes and exhausts **P6** Discuss the types of combustion methods and design features of combustion systems and their components, that aid engine performance	**M3** Illustrate the design features and aerodynamic and thermo-fluid operation of air intake, combustion and exhaust modules and their components, stipulating the contribution made by each module to thrust production and overall engine performance	
LO4 Investigate the factors affecting the design, performance and environmental impact of gas turbine powered aircraft operation		**D4** 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
P7 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 **P8** Discuss the nature of environmental noise and emissions produced from gas turbine engines and the methods used to mitigate their effects	**M4** 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	

Recommended Resources

Textbooks

CUMPSTY, N. and HEYES, A. (2016) *Jet Propulsion. 3rd Ed*. Cambridge University Press.

A simple guide to the aerodynamic and thermodynamic design and performance of jet engines.

Royce, R. (2015) *The Jet Engine. 5th edn*. Chichester, West Sussex: John Wiley & Sons.

SARAVANAMUTTOO, H. I. H., ROGERS, G. F. C., COHEN, H. and STRAZNICKY, P. V. (2009) *Gas Turbine Theory*. 6th Ed. Pearson.

TOOLEY, M. and DINGLE, L. (2012) *Engineering Science, Part III*. Routledge.

Journals

The Aeronautical Journal. Cambridge University Press. Covering all aspects of aerospace.

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.
4. Critique environmental effects on aerospace composite materials, post-consumer disposal issues and the future of sustainable composites in aerospace.

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

Pass	Merit	Distinction
LO1 Evaluate composite designs for manufacture		**D1** Critique how modelling is used to predict mechanical responses of structures. Include discussions on aeroelastic tailoring predictions
P1 Explain the design philosophy of composite structures and how using CAD/CAM can minimise finishing processes **P2** Investigate the various types of tooling materials commonly used and identify three types of tooling features used in aerospace composite manufacture	**M1** Compare the drape characteristics of four reinforcements detailing the restrictions and subsequent effect on manufacture methods	
LO2 Calculate the mechanical properties of composite materials		**D2** Evaluate cure monitoring and how it can be used to calculate exact mechanical properties of polymer composites, including the effects of post-curing
P3 Differentiate between tensile strength, transverse strength, compression strength, shear strength and flexural strength of polymer composite materials **P4** Classify elastic properties of fibre composites, acknowledging the effect of fibre length	**M2** Analyse the fatigue response of polymer composites and show why they perform better than basic metallic materials under fatigue	

Pass	Merit	Distinction
LO3 Assess the failure mechanisms of aerospace composite materials		**D3** Show how the toughness of a composite is theoretically calculated
P5 Differentiate between and identify causes of tensile failure, longitudinal failure, compressive failure, interlaminar shear failure and fatigue failure of PMC, CMC and MMC **P6** Investigate how mechanical testing results are used to calculate the safe life of an aerospace component	**M3** Critically evaluate crack growth both at microstructural level and macroscopic level in PMCs, MMC and CMCs	
LO4 Critique environmental effects on aerospace composite materials, post-consumer disposal issues and the future of sustainable composites in aerospace		**D4** Investigate the current sustainable materials that are being produced for aerospace and compare these to the traditional aerospace composites
P7 Evaluate lightning strike protection strategies for composite aircraft **P8** Review environmental effects on aerospace composites and describe how coatings and paints are used to counteract these effects	**M4** Critically analyse the issues with post-consumer disposal of aerospace structures, paying particular attention to the issues around intellectual property of design	

Recommended Resources

Textbooks

Gay, D. (2014*) Composite Materials: Design and Applications*. 3rd edn. Boca Raton, Florida: CRC Press.

Harris, B. (1999) *Engineering Composite Materials*. 2nd edn. London: Maney Publishing

Jones, R.M. (1998) *Mechanics of Composite Materials*. 2nd edn. Philadelphia, PA: Taylor & Francis.

LIN, K. Y. (2015) *Composite Materials: Materials, Manufacturing, Analysis, Design and Repair.* 2nd Ed. CreateSpace Independent Publishing Platform.

RANA, S. and FANGUEIRO, S. (2016) *Advanced Composite Materials for Aerospace Engineering: Processing, Properties and Applications.* Woodhead Publishing.

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 airscrew 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 ($L=C_L 1/2\rho V^2 S$) and drag ($D=C_D 1/2\rho V^2 S$) 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 ([illegible] = [illegible]Δ[illegible])

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

Pass	Merit	Distinction
LO1 Explore standard atmospheric properties and aerodynamic principles affecting flight of a rotary winged aircraft		**D1** 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
P1 Discuss the nature of the ISA and the changes that take place to the properties of the air with changing altitude **P2** Illustrate, using theoretical calculations and experimental results, how lift and drag forces are generated from low speed airflows over aerofoil sections **P3** Discuss the nature of the airflow, lift and drag generation created by a helicopter's main and tail rotor blades	**M1** 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	
LO2 Illustrate the nature and effect of forces of rotary wing aircraft directional flight control		**D2** 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
P4 Demonstrate how gyroscopic precession and lift differentials can be used to control a rotary winged aircraft in flight **P5** Illustrate the aerodynamic and airflow effects created by the rotor blades of a rotary winged aircraft	**M2** Evaluate, using theoretical calculations, the nature of flight forces during manoeuvres and how these forces are affected by geometrical and external factors	

Pass	Merit	Distinction
LO3 Explore rotary wing aircraft directional flight control		**D3** Evaluate through analytical methods the power required to allow a helicopter to maintain altitude in a hover
P6 Discuss the use of the gyroscopic precession effect in the control of a rotary wing aircraft in the six planes of movement **P7** Describe generation of the lift force, control and aerodynamic limitations of an Autogyro helicopter	**M3** 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	
LO4 Investigate the nature of different rotary winged aircraft design variations and features		**D4** Analyse the aerodynamic properties of BERP main rotor blade and evaluate the advantages and disadvantages of the design
P8 Explore the development of the main rotor blade and tail rotor design, including the British Experimental Rotor Project (BERP) **P9** Show how the aerodynamic use of rotary wing aircraft tail planes and other external aerodynamic design features **P10** Discuss the flight characteristics of 'tilt rotor' and Autogyro rotary aircraft	**M4** Explore counter rotating twin rotor helicopter aerodynamic control and stabilisation	

Recommended Resources

Textbooks

ANDERSON Jr, J. D. (2016) *Introduction to Flight*. 8th International Student Ed. McGraw-Hill.

BARNARD, R. H. and PHILPOTT, D. R. (2010) *Aircraft Flight*. 4th Ed. Pearson.

DINGLE, L. and TOOLEY, M. (2013) *Aircraft Engineering Principles*. 2nd Ed. Routledge.

SEDDON, J. (2011) *Basic Helicopter Principles*. 3rd Ed. Wiley.

WAGTENDONK, W. J. (2007) *Principles of Helicopter Flight*. 2nd Ed. Aviation Supplies & Academics.

Journals

The Aeronautical Journal. Cambridge University Press. Covering all aspects of aerospace engineering and research.

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

Unit 75: Industry 4.0

Unit code	**F/617/3949**
Unit level	**4**
Credit value	**15**

Introduction

Industry 4.0 is the term that has been adopted to describe the 'fourth' industrial revolution currently underway, at present, in the manufacturing and commercial sectors of our society. It is a revolution based on the integration of cyber-physical systems with the Internet of Things and services. For the manufacturing sector, this integration has been enabled by successfully combining high performance computing, the internet and the development of advanced manufacturing technologies. Industry 4.0 is changing the way the world's most successful companies produce the products that their global customers demand.

The aim of this unit is to provide a principle understanding of why and how smart factories are changing the face of manufacturing. Students are first introduced to the factors and consequences behind industrial revolutions and the definition of smart factories followed by the wide range of technologies that make smart factories work. Students will then be able to reflect on successful case studies of transitioning to Industry 4.0 followed by considering possible future directions with respect to Industry 5.0 – personalisation.

On successful completion of this unit students will be able to investigate and evaluate industrial revolutions along with the characteristics and technologies of smart factories. As potential managers, students will also be able to assess the implications of moving to Industry 4.0 and anticipate the likely features of a fifth industrial revolution.

Learning Outcomes

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

1 Investigate the factors leading to the fourth industrial revolution and the characteristics of a smart factory

2 Review the range of cyber-physical technologies shaping Industry 4.0 and the benefits to suppliers, producers and customers

3 Examine the factors manufacturers need to consider when transitioning from Industry 3.0 to 4.0

4 Explore futuristic trends in manufacturing and the factors shaping Industry 5.0.

Essential Content

LO1 **Investigate the factors leading to the fourth industrial revolution and the characteristics of a smart factory**

Aspects of industrial revolutions:

Energy

Transportation

social mobility

socio-economics

business

emerging technologies

science

materials

communications

geography.

Areas of impact of industrial revolutions:

Workforce

Skills

Efficiency

Change management.

Characteristics of a smart factory:

Connectivity

Flexibility

Scalability

Agility

Autonomy

Efficiency.

Techniques relevant to smart factories:

Data analytics

Forecasting

Data visualisation

Quality control.

Practical support:

Physical and decision-making support.

LO2 **Review the range of cyber-physical technologies shaping Industry 4.0 and the benefits to suppliers, producers and customers**

Cyber-physical production systems (CPPS):

Definition

Characteristics

Architecture

Benefits and applications

Support and training for the workforce.

Internet of things (IoT) features:

Artificial intelligence (AI)

Connectivity

Sensors

Platforms.

Wireless communication protocols:

NFC

RFID

Bluetooth

Low-Energy Wireless

Zigbee

Z-Wave

Thread

LTE-A

WiFi-Direct

LPWAN

Light Fidelity (Lifi).

Data analytics:

Definition

Big Data; types – streaming, spatial, time series, prescriptive, predictive and decisive analytics.

Cloud computing:

Types – Saas, IaaS, Paas

Benefits for IoT; developments – edge computing.

LO3 **Examine the factors manufacturers need to consider when transitioning from Industry 3.0 to 4.0**

Data management:

Collection

Storage

Visualisation.

Cyber-security:

Integrated security

Encryption

Risk analysis

Authorisation.

Process and governance:

Managing self-optimisation

Supply chains

Customers.

Workforce:

New roles

Skills gap

Training

Change management

Restructuring of organisations

Employment demographics

Relationship between technological unemployment and education.

Functional safety standards

IEC 61508 (Electrical, Electronic and Programmable Electronic Devices)

IEC 61511 (Industrial Processes)

IEC 62061 (Machinery)

ISO 10218 (Industrial Robots)

IEC 61784, EN 50159, IEC 62280 (Networking)

IEC 62443 (Security).

LO4 **Explore futuristic trends in manufacturing and the factors shaping Industry 5.0**

Stakeholders:

Manufacturing organisations

Governments

Regulator

Professional associations

Suppliers

Market analysts

Educational institutions

Non-profit organisations.

Emerging technologies:

Cognitive computing

3D printing

Augmented reality

Block chain

AI

Voice-controlled user interfaces

Virtual reality.

Standardisation of technologies:

Application interfaces

Integration points

Automation technologies.

Supplier, manufacturer and customer integration: customer as a user contributor.

Customisation:

Harmonisation of human intelligence and cognitive computing

Collaborative robots

Mass personalisation for customers

Role of the human designer.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the factors leading to the fourth industrial revolution and the characteristics of a smart factory		**D1** Evaluate the socio-economic impact of industrial revolutions and the global response to Industry 4.0
P1 Investigate the key milestones of industrial revolutions leading to the smart factory **P2** Describe the characteristics of an Industry 4.0 compliant smart factory	**M1** Analyse the key historical factors that have contributed to industrial revolutions leading to Industry 4.0 compliant smart factories	
LO2 Review the range of cyber-physical technologies shaping Industry 4.0 and the benefits to suppliers, producers and customers		**D2** Evaluate the design and implementation of a cyber-physical systems architecture for Industry 4.0 based manufacturing systems
P3 Examine the relationship between cyber-physical production systems (CPPS) and the Internet of Things (IoT) **P4** Review a range of wireless communication protocols available for the smart factory	**M2** Analyse the principles and benefits of cloud computing and its role with suppliers, manufacturers and customers within Industry 4.0 **M3** Investigate the challenges and solutions regarding data analytics in smart factories	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Examine the factors manufacturers need to consider when transitioning from Industry 3.0 to 4.0</td><td rowspan="2">D3 Evaluate the organisational impact and change management methods used when transitioning from Industry 3.0 to 4.0</td></tr>
<tr><td>P5 Examine the considerations and challenges manufacturers need to consider when implementing data collection and data management for a smart factory

P6 Explore the transition from Industry 3.0 to 4.0, within a manufacturing sector</td><td>M4 Explore the functional safety considerations when transitioning to a fully automated smart factory</td></tr>
<tr><td colspan="2">LO4 Explore futuristic trends in manufacturing and the factors shaping Industry 5.0.</td><td rowspan="2">D4 Evaluate the future of manufacturing in Industry 5.0 and beyond</td></tr>
<tr><td>P7 Explore the key factors and stakeholders that are causing a transition from Industry 4.0 to 5.0</td><td>M5 Analyse the skills and roles of the modern manufacturing workforce in Industry 5.0</td></tr>
</table>

Recommended Resources

Textbooks

BARKAI, J. (2016) *The Outcome Economy: How the Industrial Internet of Things is Transforming Everyday Business*. Scotts Valley: CreateSpace Independent Publishing Platform.

GILCHRIST, A. (2016) *Industry 4.0: The Industrial Internet of Things*. New York: Apress.

WINDPASSINGER, N. (2017) *Digitize or Die: Transform your Organisation, Embrace the Digital Evolution, Rise above the Competition*. New York: IoT Hub.

YANEZ, F. (2017) *The Goal is Industry 4.0: Technologies and Trends of the Fourth Industrial Revolution*. Independent Publisher.

YANEZ, F. (2017) *The 20 Key Technologies of Industry 4.0 and Smart Factories: The Road to the Digital Factory of the Future*. Independent Publisher.

Websites

www.infineon.com	Infineon Discoveries, Cloud Computing, Safety and Security with Robots, Industry 4.0, Big Data (General Reference)
www.analog.com	Analog Devices Functional Safety and Industry 4.0 (Article)
www.eurogeography.eu	Eurogeo Depots (General Reference)
www.supplychaingamechanger.com	Supply Chain Game Changer The Industrial Revolution – From Industry 1.0 to Industry 5.0! (Article)

www.advantech.com	AdvanTech Building a Wireless Remote Monitoring and Management System for China's Leading Electrical Appliance Manufacturer (Case study)
www.plattform-i40.de	Plattform Industrie 4.0 Network Based Communication for Industry 4.0 (Article)
kingstar.com	KingStar Industry 4.0: Key Design Principles (Article)

Unit 76: Introduction to Professional Engineering Management

Unit code R/617/3938

Unit level 4

Credit value 15

Introduction

Engineers design, develop, manufacture, construct, operate and maintain the physical infrastructure and content of the human society we inhabit. The responsibilities that engineers bear for the safety of the people who use the outputs of their work, and the environment in which they operate, are enormous. Engineers must adopt a professional approach to their work, personal development and relationship with society and the environment.

This unit introduces students to the roles, responsibilities and behaviours of professional engineers, including the ethical and regulatory frameworks that exist to support and guide their work to maintain published standards.

Methods of personal and professional development will be examined, as will the role of reflection for learning and practice, the cycle of reflection and the importance of reflective writing in the process of development. The student will also be introduced to engineering and people management tools, together with the importance of effective communication techniques.

On successful completion of this unit the student will understand the demands of being a professional engineer and be able to construct a personal development plan for their career that meets the required standards for their role and the environment in which they operate.

Learning Outcomes

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

1 Describe the role of the professional engineer and the ethical and regulatory codes that govern this role

2 Demonstrate effective leadership and communication skills

3 Explore the importance of social responsibility when developing personal and professional standards in manufacturing organisations

4 Review the role of reflection, appropriate to the work of a professional engineer.

Essential Content

LO1 **Describe the role of the professional engineer and the ethical and regulatory codes that govern this role**

The role of the professional engineer:

Roles and levels of responsibility

The professional framework

Role of Chartered Engineer

Roles of Incorporated Engineer and Engineering Technician

Function of professional bodies and the Engineering Council

Legal and ethical responsibilities

Consequences of failure.

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

Role and responsibilities of the UK Engineering Council and the professional engineering institutions (PEIs)

Content of the UK Standard for Professional Engineering Competence (UKSPEC)

Regulation of the roles of Chartered Engineer, Incorporated Engineer and Engineering Technician.

International regulatory regimes and agreements:

European Federation of International Engineering Institutions

European Engineer (Eur Ing)

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 **Demonstrate effective leadership and communication skills**

Leadership:

Leadership styles, and their effectiveness and appropriateness

Organisational ethos and culture; commitment to equality and diversity

Managing teams; participation and feedback; negotiation; human error evaluation; setting up support structures for team members; appropriateness of coaching and mentoring.

Communication skills:

Listening, non-verbal communication, clarity and brevity, friendliness, confidence, empathy, open-mindedness, respect, feedback and picking the right medium.

Communication with groups:

Group expectations; dealing with reactions and disagreements; allowing and encouraging participation; acting on agreed outcomes; negative communication; motivating disillusioned colleagues; persuasion and negotiation.

Equality and diversity

Ensuring work produced and the approach to work is inclusive and takes proper account of equality of opportunity and the diverse nature of the population.

LO3 **Explore the importance of social responsibility when developing personal and professional standards in manufacturing organisations**

Becoming a professional engineer:

Social responsibility in the engineering profession

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

Methods of Continuing Professional Development (CPD)

Creating and managing a career plan.

LO4 **Review the role of reflection, appropriate to the work of a professional engineer**

Reflection for learning:

The difference between reflection and evaluation

Reflection for learning.

The cycle of reflection:

Reflection in action and reflection on action

How to use reflection to inform future behaviour, particularly with respect to sustainable performance.

Reflective writing:

Writing as a reflective process

The difference between a reflective log and a diary; importance of creating and regularly completing a reflective log

Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way.

Continuing professional development (CPD):

The role of the reflective log in informing and driving CPD

Employee and employer benefits of CPD

Peer review; receiving and giving

The role of the engineering institutes in CPD

CPD planning and refining

CPD opportunities, e.g. workshops, site visits, lectures, short courses.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the role of the professional engineer and the ethical and regulatory codes that govern this role		**D1** Evaluate the effect of ethical frameworks on the day-to-day work of a professional engineer
P1 Describe the roles and responsibilities of the professional engineer within the Engineering Councils framework **P2** Identify the principal UK codes and regulations which control the work of the professional engineer	**M1** Analyse the main areas of influence exercised by the professional bodies in the UK on the work of the professional engineer	
LO2 Demonstrate effective leadership and communication skills		**D2** Evaluate the most effective methods for the coaching and mentoring of disillusioned colleagues or of a poorly performing team
P3 Demonstrate the process for effective persuasion and negotiation **P4** Outline the steps for managing effective group communications	**M2** Analyse leadership styles and effective communication skills using specific examples in an organisational context	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Explore the importance of social responsibility when developing personal and professional standards in manufacturing organisations</td><td rowspan="4">LO3 & LO4

D3 Evaluate the role of a socially responsible engineer and how the engineer can draw on a range of Continuing Professional Development opportunities</td></tr>
<tr><td>P5 Describe how social responsibility in engineering can support development in manufacturing

P6 Outline the ways in which a professional engineer can remain up to date with new developments and discoveries</td><td>M3 Analyse the ethical standards and patterns of behaviour that apply to the engineering profession</td></tr>
<tr><td colspan="2">LO4 Review the role of reflection, appropriate to the work of a professional engineer.</td></tr>
<tr><td>P7 Undertake the completion of a reflective log

P8 Review the ‘cycle of reflection’ and its role in the effective completion of a reflective log</td><td>M4 Analyse the benefits of continuing professional development from an employee and an employer perspective</td></tr>
</table>

Recommended Resources

Textbooks

DEARDEN, H. (2013) *Professional Engineering Practice: Reflections on the Role of the Professional Engineer*. Scotts Valley: CreateSpace Independent Publishing Platform.

KARTEN, N. (2010) *Presentation Skills for Technical Professionals*. Cambridge: IT Governance.

Websites

www.engc.org.uk	Engineering Council
	UK-SPEC – UK Standard for Professional Engineering Competence (General Reference)
www.ewb-uk.org	Engineering without Borders Becoming a Professional Engineer (General Reference)

Links

This unit links to the following related units:

Unit 4: Managing a Professional Engineering Project

Unit 35: Professional Engineering Management

Unit 77: Industrial Robots

Unit code	**L/617/3940**
Unit level	**4**
Credit value	**15**

Introduction

Industrial robotics is the present and future of automated manufacturing and is an unstoppable reality. With the emergence of lighter, smarter and safer industrial robot models that are increasingly easy to interface, the demand has never been so high and is expected to grow year on year. Popular applications for industrial robots include welding, painting, assembly and materials handling. Modern industrial robots are now an integral part of cyber-physical mechatronic systems contributing to Industry 4.0 manufacturing.

The aim of this unit is for students to investigate the range, operation and benefits of industrial robots within manufacturing applications. Among the topics included are industrial robot selection, and programming and safety protocols that anticipate future developments in industrial robot technology.

On successful completion of this unit students will have an understanding of the electrical, mechanical, hydraulic and pneumatic operation of common industrial robots, how to select and program an industrial robot for a given requirement, taking account of safety considerations, and how to assess the economic future of robot technologies in manufacturing.

Learning Outcomes

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

1 Describe the operational characteristics, selection criteria and applications of industrial robots within manufacturing industries

2 Explain the safety standards associated with industrial robots

3 Program an industrial robot for automated process application

4 Investigate the global economic scope of industrial robots and integration into smart factories.

Essential Content

LO1 **Describe the operational characteristics, selection criteria and applications of industrial robots within manufacturing industries**

Types and selection:

Operational characteristics: Cartesian, cylindrical, spherical, toroidal, SCARA

Selection: number of axes; load, orientation, speed, travel, precision, environment and duty cycle parameters (LOSTPED); anthropomorphic robots

Common Brands: e.g. Fanuc, Yaskawa and ABB.

Applications:

Welding, painting, material handling, packaging, assembly, inspection, dangerous and robust working environments, repetitive tasks.

Operation and characteristics of 6-axis industrial robots:

Controller: motion controller, motor drives, power supplies, human−machine interface (HMI)

Manipulator: sensing, brakes, axis motor, effector motor, environment sensing

Tooling: grippers, types, interfaces

Axis operation: purpose of each axis, work area, reach, wrist roll, pitch and yaw motion, rotation, home position and calibration

End effectors: types of gripper tools and hands, two-jaw, vacuum and magnetic.

LO2 **Explain the safety standards associated with industrial robots**

Safety standards:

Functional Safety: IEC61508, Hazard and Risk Assessment

Robot and robot system safety: ANSI/RIA R15.06-2012, BS EN ISO 10218:2011

Cell safety features: operating envelope, space restrictions; operating safeguards, emergency stops, guarding, barriers, interlocks, light curtains, laser, two-hand controls, scanners, floor mats; barrier sizing - around, under, through, over (AUTO)

Operational modes, user interfaces.

LO3 **Program an industrial robot for automated process application**

Software:

E.g. data objects, instruction lists, BASIC, MATALB, Python, Yaskawa, MotoSim Enhanced Graphic Virtual Robot Control, ABB, RobotStudio, Fanuc Roboguide, Denso Wincaps III.

Robot application programming:

Types: joint-level, robot-level and high-level programming

Command and control: graphical user interfaces, point-n-click, scheduling software

Tasking software: drag-n-drop, specific application deployment, scripted language, lead by the nose

Online: joysticks, pendants, jogging, modifying existing positions

Computer simulation offline programming.

Controlling robots with programmable logic controllers (PLCs; see Unit 18)

Robot commands: motion, interlock and sensor

Manufacturers' languages: ABB Rapid, Kuka KRL, Yaskawa Inform.

LO4 **Investigate the global economic scope of industrial robots and integration into smart factories**

Economic scope:

Major markets: Japan, USA, China, South Korea, Germany

Application demand: automotive, electrical and electronics, metal

Robot density; impact on workforce; training of workforce.

Advances in robot technology:

Machine vision, artificial intelligence (AI), collaborative robots (cobots), edge computing, simplified integration, networked robots, cloud robotics, virtual reality robots; training of robots; role of robotics in Industry 4.0.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the operational characteristics, selection criteria and applications of industrial robots within manufacturing industries		**LO1 & LO2**
P1 Review the types of industrial robots and their applications within manufacturing industries **P2** Describe selection criteria for industrial robot applications	**M1** Analyse the features and operation of six axis robots within manufacturing applications	**D1** Evaluate the selection of a safety-compliant industrial robot system for a given manufacturing application
LO2 Explain the safety standards associated with industrial robots		
P3 Outline the principles and methods of functional safety analysis within automated manufacturing **P4** Explain the safety criteria for robot cells within manufacturing applications	**M2** Develop hazard and risk assessment for an industrial robot manufacturing system	

Pass	Merit	Distinction
LO3 Program an industrial robot for automated process application		**D2** Design, develop and test a robot program for a series of automated industrial tasks
P5 Investigate the range of programming languages and methods available for industrial robots **P6** Program an industrial robot to perform a simple task	**M3** Analyse offline and online programming methods for industrial robots	
LO4 Investigate the global economic scope of industrial robots and integration into smart factories.		**D3** Evaluate the global economics of increased robot density in smart factories and the impact on the human workforce
P7 Assess the advantages and scope of collaborative robots over traditional methods **P8** Investigate advances in industrial robot technology	**M4** Analyse the benefits of artificial intelligence within industrial robotics and contribution to Industry 4.0	

Recommended Resources

Textbooks

ENGELBERGER J.F. (2012) *Robotics in Practice: Management and Applications of Industrial Robots*. Berlin: Springer.

NAGAT F. and WATANABE, K. (2013) *Controller Design for Industrial Robots and Machine Tools: Applications to Manufacturing Processes*. Cambridge: Woodhead Publishing in Mechanical Engineering.

PERLBERG J. (2016) *Industrial Robotics*. Boston: Cengage Learning.

PIRES, J. (2006) *Industrial Robots Programming: Building Applications for the Factories of the Future*. Berlin: Springer.

Websites

www.machinedesign.com	Machine Design The difference between, Cartesian, six-axis and SCARA robots (General Reference)
www.nipponpulse.com	Nippon Pulse America Basics of servomotor control (General Reference)
www.iso.org	International Organization for Standardization Robots and robotic devices – safety requirements for industrial robots (General Reference)
www.robotics.org	Robotics Online Robotic resources, emerging markets, safety and standards (General Reference)
www.ifr.org	International Federation of Robotics Executive Summary World Robotics Industrial Robots (General Reference)

Links

This unit links to the following related units:

Unit 75: Industry 4.0

Unit 78: Programmable Logic Controllers (PLCs)

Unit 78: Programmable Logic Controllers

Unit code	**Y/617/3942**
Unit level	**4**
Credit value	**15**

Introduction

The programmable logic controller (PLC) has revolutionised the automation industry. Since Richard Morley's Modicon invention at General Motors in the 1970s, the PLC has been the standard solution for industrial automation. Today PLCs can be found in everything from manufacturing equipment to vending machines, and PLC system development for automated systems is a highly specialised and demanding area of engineering.

The aim of this unit is to enable students to understand the rationale behind the use of programmable logic controllers and their applications in industry. The unit combines practical skills and knowledge in developing PLC applications from real scenarios with theoretical principles, such as communication and networking protocols.

On successful completion of this unit students will have developed an understanding of the evolution, types and applications of PLCs. They will know how to select and develop a PLC system, integrate features of functional safety based on their understanding of risk management, and evaluate the wide range of communication technologies available on modern PLCs.

Learning Outcomes

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

1 Describe the design, operation and selection of PLC systems

2 Explore Functional Safety within PLC systems

3 Develop a PLC program for an automated process system

4 Review how PLCs exchange information and process signals with other devices.

Essential Content

LO1 **Describe the design, operation and selection of PLC systems**

PLC architecture and operation:

central processing unit (CPU), data memory, program memory, speed, scan time, power supply, output current rating

Input/output (I/O) interface: digital, analogue, relay, transistors, TRIACs, opto-coupling.

PLC types and selection:

Compact, modular and rack-mounted

Distributed control systems and programmable automated controllers

PLC manufacturers.

LO2 **Explore Functional Safety within PLC systems**

Functional Safety standards

Evolution of Safety and Risk management

IEC61508 (Electrical, Electronic and Programmable Equipment)

IEC61131 (PLCs), IEC61131-3 (Languages)

IEC61511 (Process Control) IEC62061 (Machinery)

Hazard and risk assessment

Hazard and operability analysis (HAZOP)

Failure modes and effects analysis (FMEA)

Fault tree analysis (FTA)

Safety integrity levels, redundancy (back-up or failsafe).

LO3 **Develop a PLC program for an automated process system**

Logic control circuits

AND, OR, NAND, NOR, XOR, combinational logic, latching circuits.

Number systems

Binary, decimal, hexadecimal, octal number representation and conversion.

Memory: bits, bytes, nibbles, word, long/double

Signed and unsigned values.

PLC programming

Industrial Standard IEC61131; PLC software tools

Ladder logic operation: rungs, input, process, output

Variables: Boolean, integer, floating point

Inputs, outputs, delay functions, timers, counters, latches, registers, comparison blocks, math operators, function blocks, simulation, debugging, hardware testing, fault finding.

Documentation

Requirements and specification, flow chart, functional chart, sequence table, input/output or allocation list, wiring diagram, test data.

LO4 **Review how PLCs exchange information and process signals with other devices**

Digital communication basics

Digital versus analogue communication: analogue to digital conversion (ADC), digital to analogue conversion (DAC)

Sampling rate, resolution, errors

Noise: decoding, encoding, pulse code modulation (PCM)

Elements of a digital communication system; digital communication medium.

PLC communication and networking

Fieldbus, profibus, modbus, ethernet, profinet

OSI model, RS232, RS485, USB, parallel, serial

Controlled area network (CAN)

Supervisory control and data acquisition (SCADA)

Remote terminal unit (RTU)

Human–machine interface (HMI).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the design, operation and selection of PLC systems		**D1** Justify the selection of a programmable logic controller for a given application
P1 Describe the architecture and operation of programmable logic controllers **P2** Compare the design and applications of Compact, modular and rack-mounted PLCs **P3** Describe the range of input/output devices and PLC interface techniques	**M1** Analyse the suitability of programmable logic controllers (PLCs) with programmable automation controllers (PACs) for given applications	
LO2 Explore Functional Safety within PLC systems		**D2** Evaluate functional safety and the integration of functional safety within PLC systems to minimise hazards and risks
P4 Explore the requirement of functional safety within industrial PLC systems **P5** Compare the range of IEC6113-3 languages and their applications	**M2** Apply functional safety analysis on a PLC based automated process system.	

Pass	Merit	Distinction
LO3 Develop a PLC program for an automated process system		**D3** Evaluate the PLC program for an automated process system and make justifiable modifications
P6 Translate a digital logic control circuit into an equivalent PLC program **P7** Produce design and planning documentation associated with the preparation of a PLC program **P8** Design and develop a functionally safe PLC program for an automated process system	**M3** Apply methods of testing and debugging hardware and software in PLC systems	
LO4 Review how PLCs exchange information and process signals with other devices.		**D4** Evaluate Fieldbus and Ethernet Technologies for industrial manufacturing applications
P9 Describe the characteristics and methods of digital data communication for PLCs **P10** Review common communication technologies available on a range of PLCs	**M4** Assess the use and integration of SCADA and HMI's with PLCs in industry	

Recommended Resources

Textbooks

BOLTON, W. (2015) *Programmable Logic Controllers*. 6th ed. Amsterdam: Newnes.

PETRUZELLA, F.D. (2010) *Programmable Logic Controllers*. New York: McGraw Hill Education.

Websites

library.automationdirect.com	Library Automation Direct History of the PLC Industrial ethernet or fieldbus network (General Reference)
www.iec.ch	International Electrotechnical Commission IEC61508 Standard, IEC61131 Standard (General Reference)

Links

This unit links to the following related units:

Unit 55: Aircraft Flight Control Systems

Unit 75: Industry 4.0

Unit 77: Industrial Robots

Unit 79: Computer Aided Design (CAD) for Engineering

Unit code M/617/6409

Unit level 4

Credit value 15

Introduction

Computer Aided Design (CAD) is the use of computer technology in engineering industries, enabling the exploration of design ideas, the visualising of concepts and to simulate how a design will look and perform in the real world prior to production. The ability to analyse, modify and optimise a Computer Generated Image (CGI), object and/or 3D environment is an integral part of the design process in all areas of engineering.

This unit aims to provide students with opportunities to develop their understanding and knowledge of CAD software applications used in engineering, and the practical skills to utilise the technology within their own creative work.

On successful completion of this unit students will be able to understand the current and prospective uses of CAD technology within engineering, and be able to produce CAD drawing, objects, 3D environments and visualisations.

Learning Outcomes

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

1. Discuss the role of CAD in different engineering contexts and its influence on design and manufacturing processes in areas of specialist practice.
2. Use 2D and 3D CAD software to produce visualisations and technical drawings.
3. Present drawings and renderings, for a given project, produced using CAD software.
4. Evaluate the way in which CAD software may integrate into production processes.

Essential Content

LO1 **Discuss the role of CAD in different engineering contexts and its influence on design and manufacturing processes in areas of specialist practice.**

CAD hardware

CAD software applications

Products produced using CAD

Computer data storage of CAD files

CAD as used in Product design

Computer Aided Manufacturing (CAM)

Computer Aided Engineering (CAE)

3D printing technology

Sustainability

LO2 **Use 2D and 3D CAD software to produce visualisations and technical drawings.**

Conventions

Orthogonal Drawings

Isometric/Axonometric Drawings

Technical Drawings

Scale

Line thickness/line types

Annotation

3D Modelling Conventions

Solid modelling

Surface modelling

Materials/surface finishes

Lighting

LO3 **Present drawings and renderings, for a given project, produced using CAD software.**

Drawing formatting

Drawing sizes/sheet sizes

Visual representation

Accurate scaling

Title blocks

Output formats

File types

Printing methods

Rendering methods

Wireframe

Hidden line

Shaded

Photorealistic

LO4 **Evaluate the way in which CAD software may integrate into production processes.**

Digital and non-digital workflows

Integrating with other software

Digital Production

Digital Prototyping

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Discuss the role of CAD in different engineering contexts and its influence on design and manufacturing processes in areas of specialist practice.</td><td rowspan="2">D1 Assess recent developments in CAD/CAM techniques and practices and their use in industry.</td></tr>
<tr><td>P1 Analyse the use of Computer Aided Design (CAD) in different Engineering contexts.

P2 Compare traditional and CAD-enabled processes in Engineering.</td><td>M1 Evaluate how the use of CAD may be beneficial, or problematic, in different Engineering contexts.</td></tr>
<tr><td colspan="2">LO2 Use 2D and 3D CAD software to produce visualisations and technical drawings.</td><td rowspan="2">D2 Produce finished 2D and 3D CAD outputs; which are accurately scaled, providing key technical information and communicate dimensions, materials and surface finishes.</td></tr>
<tr><td>P3 Produce 2D drawings, exploring the technical and physical parameters of an Engineering project.

P4 Develop 3D models and visualisations to experiment with form, material and surface finish.</td><td>M2 Use 2D and 3D CAD drawings and visualisations as part of an iterative Engineering development process.</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Present drawings and renderings, for a given project, produced using CAD software.</td><td rowspan="4">LO3 & LO4

D3 Present finished 2D and 3D CAD outputs; integrating the use of related software and traditional production techniques to develop outputs that communicate the technical and aesthetic properties of an Engineering project.</td></tr>
<tr><td>P5 Prepare a set of CAD drawings for a given project.

P6 Evaluate the ability of CAD to enhance a project workflow.</td><td>M3 Use industry standard conventions in the production and presentation of 2D and 3D CAD output.</td></tr>
<tr><td colspan="2">LO4 Evaluate the way in which CAD software may integrate into production processes.</td></tr>
<tr><td>P7 Evaluate the integration of CAD/CAM into own design and development process.

P8 Discuss how CAD may impact upon the design process.</td><td>M4 Compare traditional and CAD enabled production in relation to efficiency and accuracy.</td></tr>
</table>

Recommended Resources

Textbooks

OMURA, G. and BENTON, B.C. (2018) *Mastering AutoCAD 2019 and AutoCAD LT 2019.* Sybex.

LIPSON, H. and KURMAN, M. (2013) *Fabricated: The new world of 3D printing*. John Wiley.

Shumaker, T.M., Madsen D.A. and Madsen D.P. (2019) *AutoCAD and Its Applications Basics 2019*. Goodheart-Willcox.

Links

This unit links to the following related units:

Unit 1: Engineering Design

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

11 Appendices

Appendix 1: Mapping of HND in Engineering against FHEQ Level 5

Key	
KU	Knowledge and Understanding
CS	Cognitive Skills
AS	Applied Skills
TS	Transferable Skills

The qualification will be awarded to students who have demonstrated:

FHEQ Level 5 descriptor		**Engineering HND Programme Outcome**
Knowledge and critical understanding of the well-established principles of their area(s) of study, and of the way in which those principles have developed.	KU1	Knowledge and understanding of the fundamental principles and practices of the contemporary global engineering industry.
	KU2	Knowledge and understanding of the external engineering environment and its impact upon local, national and global levels of strategy, behaviour, management and sustainability.
	KU3	Understanding and insight into different engineering practices, their diverse nature, purposes, structures and operations and their influence upon the external environment.
	KU4	A critical understanding of the ethical, environmental, legal, regulatory, professional and operational frameworks within which engineering operates.
	KU5	A critical understanding of processes, practices and techniques for effective management of products, processes, services and people.
	KU6	A critical understanding of the evolving concepts, theories and models within the study of engineering across the range of operational alternatives.
	KU7	An ability to evaluate and analyse a range of concepts, theories, models and techniques to make appropriate engineering operational and management decisions.

FHEQ Level 5 descriptor		Engineering HND Programme Outcome
	KU8	An appreciation of the concepts and principles of CPD, staff development, team dynamics, leadership and reflective practice as strategies for personal and people development.
	KU9	Knowledge and understanding of how the key areas of engineering and the environment it operates within influence the development of people and businesses.
	KU10	An understanding of the skills, techniques and methodologies used to resolve problems in the workplace.
	KU11	Knowledge and understanding of the human-machine interaction to inform the development of good design and fitness for purpose.
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.	CS1	Apply knowledge and understanding of essential concepts, principles and models within the contemporary global engineering industry.
	AS1	Evidence the ability to show customer relationship management skills and develop appropriate policies and strategies to meet stakeholder expectations.
	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.
	AS3	Integrate theory and practice through the investigation, evaluation and development of practices and products in the workplace.
	AS4	Develop outcomes for customers using appropriate practices and data to make justified recommendations.
	CS2	Develop different strategies and methods to show how resources (human, financial, environmental and information) are integrated and effectively managed to successfully meet objectives.

FHEQ Level 5 descriptor		Engineering HND Programme Outcome
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.	CS3	Critically evaluate current principles and operational practices used within the engineering industry as applied to problem solving.
	CS4	Apply project management skills and techniques for reporting, planning, control and problem solving.
	CS5	Recognise and critically evaluate the professional, economic, social, environmental and ethical issues that influence the sustainable exploitation of people, resources and businesses.
	CS6	Critique a range of engineering information technology systems and operations and their application to maximise and successfully meet strategic objectives.
An understanding of the limits of their knowledge, and how this influences analysis and interpretations based on that knowledge.	TS1	Develop a skill set to enable the evaluation of appropriate actions taken for problem solving in specific engineering contexts.
	TS2	Develop self-reflection, including self-awareness, to become an effective self-managing student, appreciating the value and importance of the self-reflection process.
	TS3	Undertake independent learning to expand on own skills and delivered content.

Typically, holders of the qualification will be able to:

FHEQ Level 5 descriptor		Engineering HND Programme Outcomes
Use a range of established techniques to initiate and undertake critical analysis of information, and to propose solutions to problems arising from that analysis.	TS4	Competently use digital literacy to access a broad range of research sources, data and information.
	CS7	Interpret, analyse and evaluate a range of engineering data, sources and information to inform evidence-based decision-making.
	CS8	Synthesise knowledge and critically evaluate strategies and plans to understand the relationship between theory and actual world engineering situations.
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.	TS5	Communicate confidently and effectively, both orally and in writing, both internally and externally with engineering professionals and other stakeholders.
	TS6	Demonstrate strong interpersonal skills, including effective listening and oral communication skills, as well as the associated ability to persuade, present, pitch and negotiate.
Undertake further training, develop existing skills and acquire new competences that will enable them to assume significant responsibility within organisations.	TS7	Identify personal and professional goals for continuing professional development in order to enhance competence to practise within a chosen engineering field.
	TS8	Take advantage of available pathways for continuing professional development through Higher Education and Professional Body Qualifications.

Holders will also have:

FHEQ Level 5 descriptor		Engineering HND Programme Outcomes
The qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and decision-making.	TS9	Develop a range of skills to ensure effective team working, project and time management, independent initiatives, organisational competence and problem-solving strategies.
	TS10	Reflect adaptability and flexibility in approach to engineering; showing resilience under pressure and meeting challenging targets within given deadlines.
	TS11	Use quantitative skills to manipulate data, evaluate and verify existing theory.
	CS9	Evaluate the changing needs of the engineering industry and have the confidence to self-evaluate and undertake additional CPD as necessary.
	TS12	Develop emotional intelligence and sensitivity to diversity in relation to people, cultures and environments.

Appendix 2: HNC/HND Engineering Programme Outcomes for Learners

	Knowledge and Understanding											Cognitive skills									Applied skills				Transferable skills											
Unit	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12
1	X			X	X	X	X		X	X	x	x	x	x	x	x	x	x	x	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X
2	X											x						x					X		X			X								
3	X											x						x					X		X			X								
4	X	X	X	X	X	X	X	X	X	X												X	X		X		X				X	X	X	X	X	X
24	X											x										X	X											X	X	
25	X																	x																X		
26	X											X										X	X											X		
27	X																							X	X									X		
28	X											x											X											X		
34	X	X	X	X	X	X	X					x																						X		
35	X	X	X	X	X	X	X	X		X	x		x	x	x	x	x	x	x	X	X	X		X	X	X	X		X		X	X	X	X		
39	X											x						x					X		X			X						X		

	Knowledge and Understanding											Cognitive skills									Applied skills				Transferable skills											
Unit	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12
55	X											x		X				x																	X	
56	X											x						x						X					X						X	
57	X											x												X					X						X	
58	X											x												X											X	
59	X											x						x						X					X						X	
60	X											x												X					X						X	
61	X											x														X									X	
75	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x				x	x	x	x	
76	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
77	x					x	x											x								x										
78	x					x	x											x								x										
79	x	x	x				x				x		x				x	x						x	x			x				x		x		x

Appendix 3: Pearson BTEC Level 5 Higher National Diploma in Engineering: mapping of transferable employability and academic study skills

Skill Set	Cognitive Skills							Intra-personal Skills				Interpersonal Skills		
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent Learning	Self Reflection	Team Work	Leadership	Cultural Awareness
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X		X	X	X			X	X				
3	X	X		X	X	X			X	X				
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X
24	X	X			X	X				X	X			
25	X	X			X	X				X	X			
26	X	X			X	X				X	X			
27	X	X	X	X		X	X	X	X	X	X			
28	X	X			X	X				X	X			
34	X	X	X	X	X	X	X	X	X	X	X			X
35	X	X	X	X	X	X	X	X	X	X	X	X	X	X
39	X	X	X	X	X	X		X	X	X	X			

Skill Set	Cognitive Skills							Intra-personal Skills				Interpersonal Skills		
Unit	Problem Solving	Critical Thinking/ Analysis	Decision Making	Effective Communication	Digital Literacy	Numeracy	Creativity	Plan Prioritise	Self Management	Independent Learning	Self Reflection	Team Work	Leadership	Cultural Awareness
55	X	X	X		X	X		X	X	X	X			
56	X	X	X		X	X		X	X	X	X			
57	X	X			X	X		X	X	X	X			
58	X	X			X	X		X	X	X	X			
59	X	X			X	X		X	X	X	X			
60	X	X			X	X		X	X	X	X			
61	X	X			X	X		X	X	X	X			
70	X	X			X	X		X	X	X	X	X		
71	X	X			X	X		X	X	X	X	X		
72	X	X	X	X	X		X	X	X	X	X			
73	x	x	x			x				x	x			
74	x	x	x	x		x				x				
75	x	x	x	x	x		x	x	x	x	x	x		x
76	x	x	x	x			x	x	x	x	x	x	x	x
77	x	x	x	x	x	x	x	x	x			x		
78	x	x	x	x	x	x	x	x	x			x		
79	x	x	x	x	x	x	x	x	x	x	x	x		x

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:

Term	Definition
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. 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.

Term	Definition
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.
Describe	Give an account, including all the relevant characteristics, qualities and events.
Determine	To conclude or ascertain by research and calculation.
Design	Plan and present ideas to show the layout/function/workings/object/system/ process.
Develop	Grow or progress a plan, ideas, skills and understanding.
Differentiate	Recognise or determine what makes something different.
Discuss	Consider different aspects of a theme or topic, how they interrelate, and the extent to which they are important.
Discuss	Give an account that addresses a range of ideas and arguments.
Evaluate	Work draws on varied information, themes or concepts to consider aspects, such as: • strengths or weaknesses • advantages or disadvantages • alternative actions • relevance or significance 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.
Explain	To give an account of the purposes or reasons.
Explore	Skills and/or knowledge involving practical research or testing.
Identify	Indicate the main features or purpose of something by recognising it and/or being able to discern and understand facts or qualities.
Illustrate	Make clear by using examples or provide diagrams.
Indicate	Point out, show.

Term	Definition
Interpret	State the meaning, purpose or qualities of something through the use of images, words or other expression.
Investigate	Conduct an enquiry or study into something to discover and examine facts and information.
Justify	Students give reasons or evidence to: • support an opinion • prove something is right or reasonable.
Outline	Set out the main points/characteristics.
Plan	Consider, set out and communicate what is to be done.
Produce	To bring into existence.
Reconstruct	To assemble again/reorganise/form an impression.
Report	Adhere to protocols, codes and conventions where findings or judgements are set down in an objective way.
Review	Make a formal assessment of work produced. The assessment allows students to: • appraise existing information or prior events • reconsider information with the intention of making changes, if necessary.
Show how	Demonstrate the application of certain methods/theories/concepts.
Stage and manage	Organisation and management skills, for example running an event or a business pitch.
State	Express.
Suggest	Give possible alternatives, produce an idea, put forward, for example, an idea or plan, for consideration.
Undertake/ carry out	Use a range of skills to perform a task, research or activity.

This is a key summary of the types of evidence used for BTEC Higher Nationals:

Type of evidence	**Definition**
Case study	A specific example to which all students must select and apply knowledge.
Project	A large scale activity requiring self-direction of selection of outcome, planning, research, exploration, outcome and review.
Independent research	An analysis of substantive research organised by the student from secondary sources and, if applicable, primary sources.
Written task or report	Individual completion of a task in a work-related format, for example, a report, marketing communication or set of instructions, giving information.
Simulated activity/ role play	A multi-faceted activity mimicking realistic work situations.
Team task	Students work together to show skills in defining and structuring activity as a team.
Presentation	Oral or through demonstration.
Production of plan/business plan	Students produce a plan as an outcome related to a given or limited task.
Reflective journal	Completion of a journal from work experience, detailing skills acquired for employability.
Poster/leaflet	Documents providing well-presented information for a given purpose.

Appendix 5: Assessment Methods and Techniques for Pearson BTEC Higher Nationals

Assessment Technique	Description	Transferable Skills Development	Formative or Summative
Academic graphic display	This technique asks students to create documents providing well-presented information for a given purpose. Could be hard or soft copy.	Creativity	Formative
		Written Communication	Summative
		Information and Communications Technology	
		Literacy	
Case Study	This technique present students with a specific example to which they must select and apply knowledge.	Reasoning	Formative
		Critical Thinking	Summative
		Analysis	
Discussion Forum	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.	Oral/written Communication	Formative
		Appreciation of Diversity	
		Critical Thinking and Reasoning	
		Argumentation	
Examination	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.	Reasoning	Summative
		Analysis	
		Written Communication	
		Critical Thinking	
		Interpretation	

Assessment Technique	Description	Transferable Skills Development	Formative or Summative
Independent Research	This technique is an analysis of research organised by the student from secondary sources and, if applicable, primary sources.	Information and Communications Technology	Formative
		Literacy	
		Analysis	
Oral/Viva	This technique asks students to display their knowledge of the subject via questioning.	Oral Communication	Summative
		Critical Thinking	
		Reasoning	
Peer Review	This technique asks students to provide feedback on each other's performance. This feedback can be collated for development purposes.	Teamwork	Formative
		Negotiation	Summative
		Collaboration	
Presentation	This technique asks students to deliver a project orally or through demonstration.	Oral Communication	Formative
		Creativity	Summative
		Critical Thinking	
		Reasoning	
Production of an Artefact/Perfor mance or Portfolio	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.	Creativity	Summative
		Interpretation	
		Written and oral Communication	
		Decision-making	
		Initiative	
		Information and Communications	
		Technology	
		Literacy, etc.	

Assessment Technique	**Description**	**Transferable Skills Development**	**Formative or Summative**
Project	This technique is a large-scale activity requiring self-direction, planning, research, exploration, outcome and review.	Written Communication	Summative
		Information Literacy	
		Creativity	
		Initiative	
Role Playing	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.	Written and Oral Communication	Formative
		Leadership	
		Information Literacy	
		Creativity	
		Initiative	
Self-reflection	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.	Self-reflection	Summative
		Written Communication	
		Initiative	
		Decision-making	
		Critical Thinking	
Simulated Activity	This technique is a multi-faceted activity based on realistic work situations.	Self-reflection	Formative
		Critical Thinking	Summative
		Initiative	
		Decision-making	
		Written Communication	

Assessment Technique	Description	Transferable Skills Development	Formative or Summative
Team Assessment	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.	Collaboration	Formative
		Teamwork	Summative
		Leadership	
		Negotiation	
		Written and Oral Communication	
Time-constrained Assessment	This technique covers all assessment that needs to be done within a centre-specified time constrained period on-site.	Reasoning	Summative
		Analysis	
		Critical thinking	
		Interpretation	
		Written Communication	
Top Ten	This technique asks students to create a 'top ten' list of key concepts presented in the assigned reading list.	Teamwork	Formative
		Creativity	
		Analysis	
		Collaboration	
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	Summative
		Analysis	
		Written Communication	
		Critical Thinking	
		Interpretation	

Appendix 6: Recognition of Prior Learning

QCF Pearson BTEC Level 4 Higher National Certificate in Engineering unit content mapped to the Level 4 units available in the Pearson BTEC Higher National Engineering programmes (RQF)

HNCs in Engineering: Unit Mapping Overview

This mapping document is designed to support centres who wish to recognise student achievement in older QCF Higher Nationals within the new RQF suites. The document demonstrates where content is covered in the new suite, and where there is new content to cover to ensure full coverage of learning outcomes.

P – Partial mapping (some topics from the old unit appear in the new unit)

X – Full mapping + new (all the topics from the old unit appear in the new unit, but new unit also contains new topic(s))

N – New unit

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN programme	Level of similarity between units
1	Engineering Design	8	P
2	Engineering Mathematics	1	P
3	Engineering Science	2	X
4	Managing a Professional Engineering Project		New Unit
5	Renewable Energy		New Unit
6	Mechatronics	57	P
7	Machining and Metal Forming Processes	10	P
8	Mechanical Principles	4	P
9	Materials, Properties and Testing	21	P
10	Mechanical Workshop Practices	13	P
11	Fluid Mechanics	41	X
12	Engineering Management	38	P
13	Fundamentals of Thermodynamics and Heat Engines	61	P

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN programme	Level of similarity between units
14	Production Engineering for Manufacture	9	P
15	Automation, Robotics and PLCs	22 32	P P
16	Instrumentation and Control Systems	55	P
17	Quality and Process Improvement	20 30 36	P P P
18	Maintenance Engineering	43 44 54	P P P
19	Electrical and Electronic Principles	5	X
20	Digital Principles		N
21	Electrical Machines	65	P
22	Electronic Circuits and Devices	39	P
23	Computer Aided Design and Manufacture (CAD/CAM)	19	X
24	Aircraft Aerodynamics	83	X
25	Aircraft Electrical Power & Distribution Systems	82	
26	Airframe Mechanical Systems		N
27	Composite Materials for Aerospace Applications		N
28	Turbine Rotary Wing Mechanical and Flight Systems		N
29	Electro, Pneumatic and Hydraulic Systems	24	P
30	Operations and Plant Managements	45 46 47	P P P
31	Electrical Systems and Fault Finding		N
32	CAD for Maintenance Engineers		N

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN programme	Level of similarity between units
73	Materials Engineering with Polymers	155	X
74	Polymer Manufacturing Processes	156	X
75	Industry 4.0		N
76	Introduction to Professional Engineering Management		N
77	Industrial Robots		N
78	Programmable Logic Controllers		N
79	Computer Aided Design (CAD) for Engineering		N
80	Welding Technology	154	X
81	Welding Inspection	153	X

HNCs in Engineering: Unit Mapping Depth

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Engineering Design	8	Engineering Design	Unit 8: LO1 Unit 8: LO2 Unit 8: LO3 No Match	Unit 1: LO1 Unit 1: LO2 Unit 1: LO3 Unit 1: LO4 No match
2	Engineering Mathematics	1	Analytical Methods for Engineers	Unit 1: LO2 Unit 1: LO3 Unit 1: LO4	Unit 2: LO1 No match Unit 2: LO3 Unit 2: LO4 Unit 2: LO2
3	Engineering Science	2	Engineering Science	Unit 2: LO1/2 Unit 2: LO3/4	Unit 3: LO2 Unit 3: LO4 Unit 3: LO1 No match Unit 3: LO3 No match
4	Managing a Professional Engineering Project		New unit, no equivalent		
5	Renewable Energy		New unit, no equivalent		
6	Mechatronics	57	Mechatronics	Unit 57: LO1 Unit 57: LO3	Unit 6: LO1 Unit 6: LO3 No match Unit 6: LO2 Unit 6: LO4 No match
7	Machining and Metal Forming Processes	10	Manufacturing Process	Unit 10: LO1 Unit 10: LO2	Unit 7: LO1 Unit 7: LO4 Unit 7: LO2 No match Unit 7: LO3 No match
8	Mechanical Principles	4	Mechanical Principles	Unit 4: LO2 Unit 4: LO3 Unit 4: LO4	Unit 8: LO1 Unit 8: LO2 No match Unit 8: LO3/4 Unit 8: LO3/4

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
9	Materials, Properties and Testing	21	Materials Engineering	Unit 21: LO1 Unit 21: LO2 Unit 21: LO3 Unit 21: LO4	Unit 9: LO2 No match Unit 9: LO3 Unit 9: LO1 Unit 9: LO4
10	Mechanical Workshop Practices	10	Manufacturing Process	Unit 10: LO1	Unit 10: LO2 Unit 10: LO1 No match Unit 10: LO3 No match Unit 10: LO4 No match
11	Fluid Mechanics	41	Fluid Mechanics	Unit 41: LO1 Unit 41: LO2 Unit 41: LO3 Unit 41: LO4	Unit 11: LO1 Unit 11: LO2 Unit 11: LO3 Unit 11: LO4
12	Engineering Management	38	Managing People in Engineering	Unit 38: LO1/2 Unit 38: LO3	Unit 12: LO1 Unit 12: LO2 Unit 12: LO3 No match Unit 12: LO4 No match
13	Fundamentals of Thermodynamics and Heat Engines	61	Engineering Thermodynamics	Unit 61: LO1 Unit 61: LO2 Unit 61: LO4	Unit 13: LO1 Unit 13: LO4 Unit 13: LO3 No match Unit 13: LO2
14	Production Engineering for Manufacture	9	Manufacturing Planning and Scheduling Principles	Unit 9: LO1 Unit 9: LO4	Unit 14: LO1 Unit 14: LO2 Unit 14: LO3 No match Unit 14: LO4 No match
15	Automation, Robotics and PLCs	22 & 32	Programmable Logic Controllers (22) and Industrial Robot Technology (32)	Unit 22: LO1 Unit 32: LO2 Unit 22: LO2 Unit 32: LO3	Unit 15: LO1 Unit 15: LO2 Unit 15: LO3 Unit 15: LO4

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
16	Instrumentation and Control Systems	55	Instrumentation and Control Systems	Unit 55: LO1 Unit 55: LO2	Unit 16: LO1 Unit 16: LO1 & LO2 Unit 16: LO 3 No match Unit 16: LO4 No match:
17	Quality and Process Improvement	20, 30 & 36	Quality & Business Improvement (20), Quality Assurance & Management (30) and Statistical Process Control (36)	Unit 36: LO1 Unit 20: LO2 & Unit 30: LO2	Unit 17: LO1 Unit 17: LO2 No match Unit 17: LO3 No match Unit 17: LO4
18	Maintenance Engineering	44, 45	Plant Maintenance and Decommissioning (44), Plant Operations and Performance (45)	Unit 45: LO 1/2 Unit 44: LO1/2 Unit 44: LO3	Unit 18: LO1 Unit 18: LO2 Unit 18: LO3 No Match Unit 18: LO4
19	Electrical and Electronic Principles	5	Electrical and Electronic Principles	Unit 5: LO3	Unit 19: LO1 No match Unit 19: LO2 Unit 19: LO3 No match Unit 19: LO4 No match
20	Digital Principles		New unit, no equivalent		
21	Electrical Machines	65	Utilisation of Electrical Energy	Unit 65: LO1 Unit 65: LO5	Unit 21: LO1 Unit 21: LO2 Unit 21: LO3 No Match Unit 21: LO4 No match
22	Electronic Circuits and Devices	39	Electronic Principles	Unit 39: LO2 Unit 39: LO3 Unit 39: LO4	Unit 22: LO1 Unit 22: LO2 Unit 22: LO3 Unit 22: LO4 No match
23	Computer Aided Design and Manufacture (CAD/CAM)	19	Computer-aided Design and Manufacture	Unit 19: LO1 Unit 19: LO2 Unit 19: LO3	Unit 23: LO1 Unit 23: LO2 Unit 23: LO3 Unit 23: LO4 No match

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
24	Aircraft Aerodynamics	83	Aerodynamic Principles and Aircraft Design	Unit 83: LO1 Unit 83: LO2 Unit 83: LO3 Unit 83: LO4	Unit 24: LO1 Unit 24: LO2 Unit 24: LO3 Unit 24: LO4
25	Aircraft Electrical Power & Distribution Systems	82	Aircraft Systems Principles and Applications	Unit 82: LO2	Unit 25: LO1 No match Unit 25: LO2 Unit 25: LO3 No match Unit 25: LO4 No match
26	Airframe Mechanical Systems		New unit, no equivalent		
27	Composite Materials for Aerospace Applications		New unit, no equivalent		
28	Turbine Rotary Wing Mechanical and Flight Systems		New unit, no equivalent		
29	Electro, Pneumatic and Hydraulic Systems	24	Applications of Pneumatics and Hydraulics	Unit 24: LO1 Unit 24: LO3	Unit 29: LO1 No match Unit 29: LO2 Unit 29: LO3 Unit 29: LO4 No match
30	Operations and Plant Managements		New unit, no equivalent		
31	Electrical Systems and Fault Finding		New unit no equivalent		
32	CAD for Maintenance Engineers		New unit, no equivalent		
33	Fundamentals of Nuclear Power Engineering		New unit no equivalent		

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
73	Materials Engineering with Polymers	155	Materials Engineering with Polymers	Unit 155: LO1 Unit 155: LO2 Unit 155: LO3 Unit 155: LO4	Unit 73: LO1 Unit 73: LO2 Unit 73: LO3 Unit 73: LO4
74	Polymer Manufacturing Processes	156	Polymer Manufacturing Processes	Unit 156: LO1 Unit 156: LO2 Unit 156: LO3 Unit 156: LO4	Unit 74: LO1 Unit 74: LO2 Unit 74: LO3 Unit 74: LO4
75	Industry 4.0		New unit, no equivalent		
76	Introduction to Professional Engineering Management		New unit no equivalent		
77	Industrial Robots		New unit, no equivalent		
78	Programmable Logic Controllers		New unit no equivalent		
79	Computer Aided Design (CAD) for Engineering		New unit, no equivalent		
80	Welding Technology	154	Welding Technologies	Unit 154: LO1 Unit 154: LO2 Unit 154: LO3 Unit 154: LO4	Unit 80: LO1 Unit 80: LO2 Unit 80: LO3 Unit 80: LO4
81	Welding Inspection	153	Welding Inspection	Unit 153: LO1 Unit 153: LO2 Unit 153: LO3 Unit 153: LO4	Unit 81: LO1 Unit 81: LO2 Unit 81: LO3 Unit 81: LO4

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