Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge)

Specification

New Apprenticeship Standards – Specialist Qualification (England only)

First teaching September 2015

Issue 2

Edexcel, BTEC and LCCI qualifications

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This specification is Issue 2. Key changes are listed in the summary table on the next page. We will inform centres of any changes to this issue. The latest issue can be found on the Pearson website: qualifications.pearson.com

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All information in this specification is correct at time of publication.

ISBN 9781446953204

Summary of Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge) specification Issue 2 changes

Summary of changes made between previous issue and this current issue	Page/section number
Definition of TQT added	Section 2
Definition of sizes of qualifications aligned to TQT	Section 2
TQT value added	Section 3
Guided learning definition updated	Section 13

Earlier issue(s) show(s) previous changes.

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 Introducing the New Apprenticeships in England

Background

The government has produced an implementation plan[1] for the future of Apprenticeships in England, following the Richard Review (2012)[2]. The changes, which are in the implementation plan, move the design of Apprenticeships into the hands of employers to make them more rigorous and responsive to employers' needs. Employers will now undertake the design of an Apprenticeship for each occupation they identify as requiring apprentices.

From 2017/2018, it is intended that all Apprenticeships, in England, will use the new Apprenticeship Standards and Assessment Plans designed by employers and approved by the Department for Business, Innovation and Skills (BIS).

All new employer-designed Apprenticeships will:

- be based on the required level of skills, knowledge and competency to undertake a specific occupation well and operate confidently within a sector. This forms the standard for the Apprenticeship. The assessment of an apprentice will be against this standard. Apprentices will be awarded a certificate of completion only when they have demonstrated their ability in all areas of the standard
- use a single approach to assessment against the standard. This should include a range of assessment methods that covers the theoretical and practical elements of the Apprenticeship
- have a synoptic end-point assessment that requires the apprentice to use their skills, knowledge and behaviours effectively in an integrated way. Apprentices will be assessed largely at the end of an apprenticeship programme – with an expectation that, in most cases, at least two thirds of the assessment must take place at the end of the Apprenticeship
- have grading applied to the full Apprenticeship standard, with apprentices who successfully complete awarded a pass, merit or distinction. This will include a 'mastery mechanism' – apprentices will need to pass every aspect of their assessment in order to be successful, but not every aspect will necessarily be graded
- be of a minimum 12-month duration to ensure that Apprenticeships provide sustained and substantial training
- include a minimum of 20% off-the-job training, away from the day-to-day job
- have a stronger focus on English and mathematics. All apprentices working towards the new Apprenticeships must, if they have not achieved them already, achieve Level 1 mathematics and English qualifications as a part of their Apprenticeship. Over and above this, apprentices are, if they have not achieved them already, required to work towards Level 2 mathematics and English qualifications. For Apprenticeships at Level 3 and above, apprentices are required to achieve Level 2 mathematics and English qualifications.

[1] The Government's plans for implementing these reforms are set out in *The Future of Apprenticeships in England Implementation Plan,* published in October 2013.

[2] *The Richard Review of Apprenticeships*, November 2012.

2 The Aerospace Manufacturing Fitter Apprenticeship

Overview

The qualification in this specification relates to the Aerospace Manufacturing Fitter Apprenticeship.

This Apprenticeship is designed for learners who intend to work in the role of aerospace manufacturing fitter. People in this role are involved predominantly in highly-skilled, complex and specialist detailed work, assembling aircraft systems according to specific work instructions and using relevant hand- and machine tools, jigs and measuring equipment.

The Apprenticeship Standard requires that people working in this job role must be able to:

- use and interpret engineering data and documentation, such as engineering drawings and computer-generated printouts
- test and adjust the systems they have installed, ensuring individual components and assemblies meet the required specification
- comply with statutory regulations and organisational safety requirements
- work both individually and as part of a manufacturing team and, with minimum supervision, be responsible for the quality and accuracy of the work they undertake
- be proactive in finding solutions to problems and identifying areas for improving the business.

The Apprenticeship is recognised by the Institution of Engineering and Technology (IET), The Royal Aeronautical Society (RAeS), and the Institution of Mechanical Engineers (IMechE) at 'Engineering Technician' Level.

The Apprenticeship programme is structured as two phases. Phase One is the Foundation Phase, equivalent to Level 2, and Phase Two is the Development Phase, equivalent to Level 3.

In line with the Apprenticeship Assessment Plan, new knowledge and competence qualifications have been developed at Levels 2 and 3 to meet the requirements of these two phases.

Collectively these qualifications contribute a percentage towards the overarching Apprenticeship, which is at Level 3. Please see the table on the next page for details of the contributing qualifications.

Phase	Type of qualification	Qualification	Contribution % to the Apprenticeship
Foundation Phase	Competence (Pass only)	Pearson Level 2 Competence qualification in Aerospace and Aviation Engineering	20%
Foundation Phase	Technical knowledge (Pass/Merit/Distinction)	Pearson Level 2 Specialist qualification in Aerospace and Aviation Engineering	10%
Development Phase	Competence (Pass only)	Pearson Level 3 Competence qualification in Aerospace and Aviation Engineering	30%
Development Phase	Technical knowledge (Pass/Merit/Distinction)	Pearson Level 3 Specialist qualification in Aerospace and Aviation Engineering	15%

In addition, other requirements of the Apprenticeship include:

- assessment of behaviours – at Level 2 these are incorporated in the competence and knowledge qualifications, while at Level 3 they are linked directly to the requirements of Eng Tech registration. Behaviours contribute 15% to the overall standard, 5% at Level 2 and 10% at Level 3
- Foundation Phase Gateway Assessment – this is a formal 'gate review' at the end of the Foundation Phase to ensure that apprentices have a strong foundation of basic skills before progressing to the Development Phase. On completing all the Foundation Phase requirements and passing the Foundation Gateway Assessment, apprentices can progress to the Level 3 Development Phase of the Apprenticeship
- employer endorsement – brings together all the evidence in the Apprenticeship to date, through a synoptic viva interview and completion of the Eng Tech reporting form. This contributes 5% to the overall standard
- professional body assessment – independent assessment of evidence by the professional body. This contributes 5% to the overall standard.

The Apprenticeship is a minimum of 36 months, with an expectation of an average of 42 months.

The full Apprenticeship is certificated by the Federation for Industry Sector Skills and Standards (FISSS).

Pearson offers and certificates the qualification components of the Apprenticeship, this particular specification is for the Level 2 competence qualification listed in the table above. Centres should familiarise themselves with the requirements for all components of the Apprenticeship programme and communicate them clearly to learners.

The published Aerospace Manufacturing Fitter Standard and Assessment Plan can be found at www.gov.uk/government/publications/apprenticeship-standard-aerospace-manufacturing-fitter.

Qualification size

For all regulated qualifications, Pearson specify a total number of hours that it is estimated learners will require to complete and show achievement for the qualification – this is the Total Qualification Time (TQT). The TQT value indicates the size of a qualification.

Within the TQT, Pearson identifies the number of Guided Learning Hours (GLH) that we estimate a centre delivering the qualification might provide. Guided learning means activities, such as lessons, tutorials, online instruction, supervised study and giving feedback on performance, that directly involve tutors and assessors in teaching, supervising and invigilating learners. Guided learning includes the time required for learners to complete external assessment under examination or supervised conditions.

In addition to guided learning, other required learning directed by tutors or assessors will include private study, preparation for assessment and undertaking assessment when not under supervision, such as preparatory reading, revision and independent research.

TQT and credit values are assigned after consultation with users of the qualifications.

Qualifications for the new Apprenticeships Standards are generally available in the following sizes:

- Award – a qualification with a TQT value of 120 or less
- Certificate – a qualification with a TQT value in the range of 121–369
- Diploma – a qualification with a TQT value of 370 or more.

3 Qualification summary and key information

Qualification title	Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge)
Qualification Number (QN)	601/7390/7
Regulation start date	24/08/2015
Operational start date	01/09/2015
Approved age ranges	16–18 19+ Please note that sector-specific requirements or regulations may prevent learners of a particular age from embarking on this qualification. Please refer to *Section 7 Access and Recruitment*.
Assessment	Internal assessment **and** external assessment (onscreen).
Total Qualification Time (TQT)	720
Guided learning hours	515
Grading information	The qualification is graded Pass/Merit/Distinction. The externally assessed units are graded Pass only. The internally assessed units are graded Pass/Merit/Distinction.
Entry requirements	No prior knowledge, understanding, skills or qualifications are required before learners register for this qualification. However, centres must follow our access and recruitment policy (see *Section 7 Access and recruitment*).
Funding	The Trailblazer Apprenticeship funding rules can be found on the Skills Funding Agency's website at www.gov.uk/government/collections/sfa-funding-rules

Centres should use the Qualification Number (QN) when seeking funding for their learners.

The qualification title, units and QN will appear on each learner's certificate. You should tell your learners this when your centre recruits them and registers them with us. Further information about certification is in our *UK Information Manual*, available on our website.

4 Qualification purpose

Qualification objective

The Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge) has been developed through close collaboration with the Aerospace and Aviation Apprenticeship Employer Group, professional bodies and other awarding organisations.

The qualification is for learners employed as apprentices in the role of aerospace manufacturing fitter.

The qualification gives learners the opportunity to:

- develop the technical knowledge, understanding and skills required to meet the Aerospace Manufacturing Fitter Apprenticeship Standard. This includes areas such as mathematical techniques, business improvement techniques, principles of aircraft materials and airframe construction, aerodynamics and the theory of flight, and human factors and behaviours in aviation
- develop a range of positive attitudes and professional attributes that support successful performance in the aeronautical engineering work environment
- achieve a nationally-recognised Level 2 qualification.

Progression opportunities

Learners who achieve the Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge) qualification will have achieved 10% of the overarching Aerospace Manufacturing Fitter Apprenticeship requirements. On completion of the other Foundation Phase requirements, learners can progress to the Level 3 Development Phase of the Apprenticeship, and ultimately receive their Apprenticeship certification and recognition by professional engineering institutions at 'Engineering Technician' level. Alternatively, learners who have achieved the qualification and not completed the full Apprenticeship, could progress to engineering operative or semi-skilled fitter job roles in the engineering industry or to other qualifications such as the Pearson BTEC Level 3 Foundation Diploma in Engineering and the Pearson Edexcel Level 3 NVQ Diploma in Engineering Maintenance.

Industry support and recognition

This qualification is supported by:

- the Aerospace and Aviation Apprenticeship Employer Group, which includes: BAE Systems, Airbus, MSM Aerospace Fabricators, Rolls-Royce, GKN Aerospace, Marshall Aerospace and Defence Group, Magellan Aerospace UK Ltd, GTA England
- professional engineering institutions, which include: the Institution of Engineering and Technology (IET), the Institution of Mechanical Engineering (IMechE) and the Royal Aeronautical Society (RAeS)
- SEMTA, the Skills Council for the Engineering sector
- the National Forum of Engineering Centres (NFEC).

5 Qualification structure

Pearson BTEC Level 2 Diploma in Aerospace and Aviation Engineering (Foundation Knowledge)

The learner will need to meet the requirements outlined in the table below before the qualification can be awarded.

Minimum number of GLH that must be achieved	515
Number of mandatory units that must be achieved	5
Number of optional units that must be achieved	2

Unit number	Mandatory units	Level	GLH	How assessed
1	Principles of Aircraft Materials and Airframe Construction	2	60	Internal
2	Human Factors and Behaviours in Aviation	3	90	Internal
3	Principles of Aerodynamics and the Theory of Flight	2	90	External
4	Mathematics and Science for Engineering	2	105	External
5	Business Improvement Techniques	2	50	Internal
Unit number	**Optional units**	**Level**	**GLH**	**How assessed**
6	Principles of Aircraft Propulsion	2	60	Internal
7	General Engineering Principles	2	60	Internal
8	Principles of Aircraft Electrics and Systems	2	60	Internal
9	Principles of Welding and Fabrication	2	60	Internal
10	Principles of Aerospace Composite Materials	2	60	Internal
11	Principles of Mechanical Assembly and Fitting	2	60	Internal
12	Principles of Computer Aided Design (CAD)	2	60	Internal

Centres should be aware that the Level 2 qualification in this specification requires learners to meet the demands of a mandatory unit at Level 3. Centres are advised to consider the support, guidance and opportunities they give to learners in order to meet the demands of the higher-level unit during delivery and assessment of the qualification.

6 Centre resource requirements

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

General resource requirements

- Centres must have appropriate physical resources (for example IT, learning materials, teaching rooms) to support the delivery and assessment of the qualification.
- Staff involved in the delivery and assessment process must have relevant expertise and occupational experience.
- There must be systems in place that ensure continuing professional development (CPD) for staff delivering and assessing the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by learners.
- Centres must have in place robust internal verification procedures to ensure the quality and authenticity of learners' work as well as the accuracy and consistency of assessment decisions between assessors operating at the centre. For information on the requirements for implementing assessment processes in centres, please refer to the *New Apprenticeship Standards Quality Assurance Handbook and Delivery Guidance* on our website.
- Centres must deliver the qualifications in accordance with current equality legislation. For further details on Pearson's commitment to the Equality Act 2010, please see *Section 7 Access and recruitment.* For full details of the Equality Act 2010, please go to www.legislation.gov.uk

7 Access and recruitment

Our policy on 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 barriers that restrict access and progression
- there should be equal opportunities for all wishing to access the qualifications.

Centres must ensure that their learner recruitment process is conducted with integrity. This includes ensuring that applicants have appropriate information and advice about the qualification to ensure that it will meet their needs.

Centres should review applicants' prior qualifications and/or experience, considering whether this profile shows that they have the potential to achieve the qualification.

All learners undertaking an Apprenticeship Standard must be employed and have a contract of employment at the start of the first day of their Apprenticeship programme.

Prior knowledge, skills and understanding

No prior knowledge, understanding, skills or qualifications are required before learners register for this qualification.

Access to qualifications for learners with disabilities or specific needs

Equality and fairness are central to our work. Pearson's Equality Policy requires all learners to have equal opportunity to access our qualifications and assessments and that our qualifications are awarded in a way that is fair to every learner.

We are committed to making sure that:

- learners with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to learners who do not share that characteristic
- all learners achieve the recognition they deserve from undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

For learners with disabilities and specific needs, the assessment of their potential to achieve the qualification must identify, where appropriate, the support that will be made available to them during delivery and assessment of the qualification. Please see the information regarding reasonable adjustments and special consideration in *Section 9 Assessment*.

8 Programme delivery

Centres are free to offer this qualification using any mode of delivery that meets learners' and employers' needs. It is recommended that centres make use of a wide range of training delivery methods, including direct instruction in classrooms, simulated demonstrations, research or applied projects, e-learning, directed self-study, field visits and role play. Whichever mode of delivery is used, centres must make sure that learners have access to the resources identified in the specification and to the subject specialists delivering the units.

Centres must adhere to the Pearson policies that apply to the different models of delivery. Our policy *Collaborative arrangements for the delivery of vocational qualifications* is available on our website.

Those planning the programme should aim to involve employers as far as possible in the delivery of the qualification. This could be by:

- spending time with employers to better understand their organisational requirements and the methods of training that are most suitable, taking into consideration available resources and working patterns
- collaborating with employers to ensure that learners have opportunities in the workplace to implement the knowledge and skills developed through the training programme
- having regular meetings with employers to discuss learner progress, providing feedback and agreeing how any issues will be resolved
- developing projects or assessments with input from employers
- developing up-to-date and relevant teaching materials that make use of scenarios relevant to the sector and relevant occupations
- using 'expert witness' reports from employers to support assessment
- making full use of the variety of experience of work and life that learners bring to the programme.

Where legislation is taught, centres must ensure that it is current and up to date.

Please refer to The Trailblazer Apprenticeship Funding Rules for further information on the delivery and assessment of the new Apprenticeships. They can be found at www.gov.uk/government/collections/sfa-funding-rules

9 Assessment

The table below gives a summary of the assessment methods used in the qualification.

Units	Assessment methods
Unit 3 Unit 4	External assessment (onscreen)
Unit 1 Unit 2 Unit 5 Unit 6 Unit 7 Unit 8 Unit 9 Unit 10 Unit 11 Unit 12	Internal assessment

In administering internal and external assessments, centres need to be aware of the specific procedures and policies that apply to, for example, registration, entries and results. More information can be found in our *UK Information Manual*, available on our website.

Language of assessment

Assessments for internally-assessed units are in English only.

External assessments for units in this qualification will be available in English only.

A learner taking the qualification may be assessed in British or Irish Sign Language where it is permitted for the purpose of reasonable adjustment.

For further information on access arrangements, please refer to *Reasonable adjustments* later in this section.

Internal assessment

Most units in this qualification are internally assessed and subject to external standards verification. This means that centres set and mark the final summative assessment for each unit, using the examples and support that Pearson provides. Centres need to become an approved centre to offer the qualification, if they are not already, before conducting assessments. *Section 10* gives information on centre approval for offering this qualification.

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 delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity, completed independently by learners, that is separate from teaching, practice, exploration and other activities that learners complete with direction from tutors and assessors.

An assignment is issued to learners as an assignment brief with a defined start date, a completion date and clear requirements for the evidence that they need to provide. Assignments can be divided into tasks and may require several forms of evidence. A valid assignment will enable there to be a clear and formal assessment outcome based on the assessment criteria.

Designing effective assignments

Assignments must be fit for purpose as a tool to measure learning against the defined content and assessment criteria to ensure that final assessment decisions meet the required standard.

Centres should make sure that assignments enable learners to produce valid, sufficient, authentic and appropriate evidence that relates directly to the specified criteria within the context of the learning outcomes and unit content. Centres need to ensure that the generation of evidence is carefully monitored and controlled, and that it is produced to an appropriate timescale. This helps to make sure that learners are achieving to the best of their ability and at the same time that the evidence is genuinely their own.

An assignment that is fit for purpose and suitably controlled is one in which:

- the tasks that the learner is asked to complete provide evidence for a learning outcome that can be assessed using the assessment criteria
- the time allowed for the assignment is clearly defined and consistent with what is being assessed
- the centre has the required resources for all learners to complete the assignment fully and fairly
- the evidence the assignment will generate will be authentic and individual to the learner
- the evidence can be documented to show that the assessment and verification has been carried out correctly.

Recommended assignments are provided in the *Assessment guidance* section of a unit. In designing assignments, centres need to work within the structure of these assignments. Centres need to bear in mind the following points when developing their assignment briefs.

- Centres may choose to combine all or parts of different units into single assignments provided that all units and all their associated learning outcomes are fully addressed in the programme overall. If this approach is taken, centres need to make sure that learners are fully prepared so that they can provide all the required evidence for assessment and that centres are able to track achievement in the records.
- A learning outcome must always be assessed as a whole and must not be split into two or more assignments.

- 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.
- Centres do not have to follow the order of the learning outcomes of a unit in developing assignments but later learning outcomes often require learners to apply the content of earlier learning outcomes, and they may require learner to draw their learning together.
- As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning outcomes. The specified content is compulsory. The evidence for assessment need not cover every aspect of the teaching content as learners will normally be given particular examples, case studies or contexts in their assignments. For example, if a learner is carrying out one practical performance or an investigation of one organisation, then they will address all the relevant range of content that applies in that instance.

Providing an assignment brief

A good assignment brief is one that motivates learners to provide appropriate evidence of what they have learned through providing challenging and realistic tasks. An assignment brief should include:

- a vocational scenario, context or application for the tasks to be completed
- clear instructions to the learner about what they are required to do, normally set out through a series of tasks
- an audience or purpose for which the evidence is being provided
- an explanation of how the assignment relates to the unit(s) being assessed.

Forms of evidence

Centres may use a variety of forms of evidence, provided that they are suited to the type of learning outcome being assessed. For many units, the practical demonstration of skills is necessary and for others, learners will need to carry out their own research and analysis. The units give information on what would be suitable forms of evidence. Centres may choose to use different suitable forms for evidence to those proposed. Overall, learners should be assessed using varied forms of evidence.

Some of the main forms of evidence include:

- written task or reports
- projects
- time-constrained simulated activities with observation records and supporting evidence
- observation and recordings of performance in the workplace
- sketchbooks, working logbooks, reflective journals
- presentations with assessor questioning.

The form(s) of evidence selected must:

- allow the learner to provide all the evidence required for the learning outcome and the associated assessment criteria at all grade levels
- allow the learner to produce evidence that is their own independent work

- allow a verifier to independently reassess the learner 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 learners are enabled to produce independent work. For example, if learners are asked to use real examples, then best practice would be to encourage them to use their own experiences.

For information on the requirements for implementing assessment processes in centres, please refer to the *BTEC UK Quality Assurance Handbook* on our website.

Making valid assessment decisions

Authenticity of learner work

Once an assessment has begun, learners must not be given feedback on progress towards fulfilling the targeted criteria.

An assessor must assess only work that is authentic, i.e. learners' own independent work. Learners must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work.

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

Assessors must complete a declaration that:

- the evidence submitted for this assignment is the learner's own
- the learner has clearly referenced any sources used in the work
- they understand that false declaration is a form of malpractice.

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 learner is not authentic. The assessor must then take appropriate action using the centre's policies for malpractice. More information is given later in this section.

Making assessment decisions using unit-based criteria

Assessment decisions for the qualification are based on the specific criteria given in each unit and set at each grade level. The assessment criteria for a unit are hierarchical and holistic. For example, if an M criterion requires the learner to show 'analysis' and the related P criterion requires the learner to 'explain', then to satisfy the M criterion a learner will need to cover both 'explain' and 'analyse'. The unit assessment grid shows the relationships between the criteria so that assessors can apply all the criteria to the learner's evidence at the same time.

Assessors make judgements using the criteria and must show how they have reached their decisions in the assessment records. The evidence from a learner 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 *Assessment guidance* section of each unit, which gives examples and definitions related to terms used in the assessment criteria
- the centre's Lead Internal Verifier and assessment team's collective experience supported by the information provided by Pearson.

When a learner has completed the assessment for a unit then the assessment team will give an assessment outcome for the unit. This is given according to the highest level for which the learner is judged to have met all the criteria. Therefore:

- to achieve a distinction, a learner must have satisfied all the distinction criteria (and therefore the Pass and Merit criteria); these define outstanding performance across the unit as a whole
- to achieve a Merit, a learner must have satisfied all the Merit criteria (and therefore the Pass criteria) through high performance in each learning outcome.

To achieve a Pass, a learner must have satisfied all the Pass criteria for the learning outcomes, showing coverage of the unit content and, therefore, attainment at the stated level of the qualification. The award of a Pass is a defined level of performance and cannot be given solely on the basis of a learner completing assignments. Learners who do not satisfy the Pass criteria should be reported as Unclassified.

Dealing with late completion of assignments

Learners must have a clear understanding of the centre's policy on completing assignments by the stated deadlines. Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission, in line with centre policies.

For assessment to be fair, it is important that learners are all assessed in the same way and that some learners are not advantaged by having additional time or the opportunity to learn from others.

If a late completion is accepted, then the assignment should be assessed normally using the relevant assessment criteria.

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 formally and reported to learners.

The information given to the learner:

- 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
- must be validated by an Internal Verifier before it is given to the learner.

Resubmissions and retakes

On 1 September 2014, Pearson introduced a framework to support centres in delivering high-quality internal assessments for BTEC Firsts and Nationals, the framework can be found on the BTEC delivery pages of our website. The rules presented in the framework do not apply to BTEC Specialist programmes, Entry Level to Level 3, however we do recommend the approach as best practice. As the rules are therefore not mandatory for BTEC Specialist programmes, they will not be checked as part of the standards verification and quality assurance process.

Administrative arrangements for internal assessment

Records

Centres are required to retain records of assessment for each learner. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information can be found in our *UK Information Manual*. We may ask to audit centre records so they must be retained as specified.

Reasonable adjustments to assessments

Centres are able to make adjustments to assessments to take account of the needs of individual learners, in line with the guidance given in the Pearson document *Supplementary guidance for reasonable adjustment and special consideration in vocational internally assessed units*. In most instances, adjustments can be achieved by following the guidance, for example allowing the use of assistive technology or adjusting the format of the evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. Any reasonable adjustment must reflect the normal learning or working practice of a learner in a centre or working within the occupational area.

Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document *Adjustments for candidates with disabilities and learning difficulties, Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational qualifications*.

Both documents are on the policy page of our website.

Special consideration

Centres must operate special consideration in line with the guidance given in the Pearson document *Supplementary guidance for reasonable adjustment and special consideration in vocational internally assessed units*. Special consideration may not be applicable in instances where:

- assessment requires the demonstration of practical competence
- criteria have to be met fully
- units/qualifications confer licence to practice.

Centres cannot apply their own special consideration; applications for special consideration must be made to Pearson and can be made on a case-by-case basis only. A separate application must be made for each learner. Certification claims must not be made until the outcome of the application has been received.

Further information on special consideration can be found in the Joint Council for Qualifications (JCQ) document *Adjustments for candidates with disabilities and learning difficulties, Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational qualifications*.

Both of the documents mentioned above are on our website.

Appeals against assessment

Centres must have a policy for dealing with appeals from learners. Appeals may relate to assessment decisions being incorrect or assessment not being conducted fairly. The first step in such a policy is a consideration of the evidence by a Lead Internal Verifier or other member of the programme team. The assessment plan should allow time for potential appeals after learners have been given assessment decisions.

Centres must document all learners' appeals and their resolutions. Further information on the appeals process can be found in the document *Enquiries and appeals about Pearson vocational qualifications policy*, which is available on our website.

External assessment

The table below gives information about the type and availability of external assessments that are available for this qualification. Centres should check this information carefully together with the relevant unit specification and the sample assessment materials so that they can timetable learning and assessment periods appropriately.

Unit 3: Principles of Aerodynamics and the Theory of Flight	
Type of assessment	This unit is externally assessed using an onscreen test. Pearson sets and marks the test. The test is Pass/Fail. The assessment must be taken by the learner under examination conditions. A Pass grade will be determined by learners achieving a defined pass mark for the onscreen test. Learners will be allowed to use rough paper for working.
Length of assessment	The external assessment will be 60 minutes.
Number of marks	40
Assessment availability	On demand
First assessment availability	January 2016

Unit 4: Mathematics and Science for Engineering	
Type of assessment	This unit is externally assessed using two onscreen tests. Pearson sets and marks the tests. The tests are Pass/Fail. The assessments must be taken by the learner under examination conditions. In order to pass the 'Mathematics and Science for Engineering' unit, learners must achieve a Pass in both of the tests. No compensation will apply across the two assessments for the unit. A Pass grade will be determined by learners achieving a defined pass mark for both onscreen assessments. Learners will be allowed to use rough paper for working. A formula sheet will be provided for both tests. Learners may use non-programmable calculators.
Length of assessment	**Mathematics for Engineering**: the external assessment will be 70 minutes. **Science for Engineering**: the external assessment will be 70 minutes.
Number of marks	**Mathematics for Engineering**: 60 **Science for Engineering**: 50
Assessment availability	On demand
First assessment availability	January 2016

The external assessment assesses all the learning outcomes in the units to meet the standard specified by the related assessment criteria. All the content in each unit is mandatory for the assessments.

Centres need to make sure that learners are:

- fully prepared to sit the external assessments
- entered for the tests at appropriate times, with due regard for resit opportunities as necessary.

Sample assessment materials

Each externally-assessed unit has a set of sample assessment materials (SAMs). The SAMs are there to provide an example of what the external assessment will look like in terms of the feel and level of demand of the assessment.

The SAMs show the range of possible question types that may appear in the actual assessments and give a good indication of how the assessments will be structured. While SAMs can be used for practice with learners, as with any assessment the content covered and specific details of the questions asked will change in each assessment. A copy of each SAM can be downloaded from our website.

Administrative arrangements for external assessment

Access arrangements requests

Access arrangements are agreed with Pearson before an assessment. They allow learners with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

Access arrangements should always be processed at the time of registration. Learners will then know what type of arrangements are available in place for them.

Granting reasonable adjustments

For external assessment, a reasonable adjustment is one that Pearson agree to make for an individual learner. A reasonable adjustment is defined for the individual learner and informed by the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, including:

- the needs of the learner with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the learner with the disability and other learners.

Adjustment may be judged unreasonable and not approved if it involves unreasonable costs, timeframes or affects the integrity of the assessment.

Special consideration requests

Special consideration is an adjustment made to a learner's mark or grade after an external assessment to reflect temporary injury, illness or other indisposition at the time of the assessment. An adjustment is made only if the impact on the learner is such that it is reasonably likely to have had a material effect on that learner being able to demonstrate attainment in the assessment.

Centres are required to notify us promptly of any learners that they believe have been adversely affected and request that we give special consideration. Further information can be found in the special requirements section on our website.

Conducting external assessments

Centres must make arrangement for the secure delivery of external assessments. All centres offering external assessments must comply with the Joint Council for Qualifications (JCQ) document Instructions for the Conduct of Examinations (ICE). The current version of this document is available on our website.

Dealing with malpractice in assessment

Malpractice means acts that undermine the integrity and validity of assessment, the certification of qualifications and/or may damage the authority of those responsible for delivering the assessment and certification.

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

Malpractice may arise or be suspected in relation to any unit or type of assessment within the qualification. For further details on malpractice and advice on preventing malpractice by learners, please see Pearson's *Centre Guidance: Dealing with Malpractice*, available on our website.

The procedures we ask you to adopt vary between units that are internally assessed and those that are externally assessed.

Internal assessment

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. The *Centre Guidance: Dealing with Malpractice* document gives full information on the actions we expect you to take.

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

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

External assessment

External assessment means all aspects of units that are designated as external in this specification, including preparation for tasks and performance. For these assessments, centres must follow the JCQ procedures set out in the latest version of the document *JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures* (available on the JCQ website, www.jcq.org.uk).

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

Learner malpractice

The head of centre is required to report incidents of suspected learner malpractice that occur during Pearson examinations. We ask centres to complete JCQ Form M1 (www.jcq.org.uk/malpractice) and email it with any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc.) to the Investigations Team at pqsmalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

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

Teacher/centre malpractice

The head of centre is required to inform Pearson's Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. The head of centre is requested to inform the Investigations Team by submitting a JCQ M2(a) form (downloadable from www.jcq.org.uk/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff, 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 learners) 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 learners and centre staff suspected of malpractice of their responsibilities and rights, please see 6.15 of *JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures*.

Pearson reserves the right in cases of suspected malpractice to withhold the issuing of results/certificates while an investigation is in progress. Depending on the outcome of the investigation, results and/or certificates may not be released or they may be withheld.

We reserve the right to withhold certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

Sanctions and appeals

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

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

- mark reduction for affected external assessments
- disqualification from the qualification
- debarment from registration for Pearson qualifications for a period of time.

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

- working with centres to create an improvement action plan
- requiring staff members to receive further training
- placing temporary blocks on the centre's certificates
- placing temporary blocks on registration of learners
- debarring staff members or the centre from delivering Pearson qualifications
- suspending or withdrawing centre approval status.

The 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 the head of centre (on behalf of learners 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 on our website. In the initial stage of any aspect of malpractice, please notify the Investigations Team (via pqsmalpractice@pearson.com) who will inform you of the next steps.

10 Centre recognition and approval centre recognition

Centres offering New Apprenticeship Standards qualifications must be listed on the Skills Funding Agency's Register of Training Organisations and have a contract to deliver the New Apprenticeship Standards qualifications.

Centres that have not previously offered Pearson Specialist qualifications need to apply for and be granted centre recognition and approval to offer individual qualifications.

Existing Pearson centres seeking approval to offer New Apprenticeship Standards qualifications, will be required to submit supplementary evidence for approval, aligned to the associated New Apprenticeship Standards and Assessment Strategies.

Guidance on seeking approval to deliver BTEC qualifications is available on our website, qualifications.pearson.com

Approvals agreement

All centres are required to enter into an approval agreement with Pearson, in which the head of centre or principal agrees to meet all the requirements of the qualification specification and to comply with the policies, procedures, codes of practice and regulations of Pearson and relevant regulatory bodies. If centres do not comply with the agreement, this could result in the suspension of certification or withdrawal of centre or qualification approval.

11 Quality assurance of centres

Quality assurance is at the heart of vocational qualifications and Apprenticeships. Centres are required to declare their commitment to ensuring quality and to giving learners appropriate opportunities that lead to valid and accurate assessment outcomes.

Pearson uses external quality assurance processes to verify that assessment, internal quality assurance and evidence of achievement meet nationally defined standards. Our processes enable us to recognise good practice, effectively manage risk and support centres to safeguard certification and quality standards.

Our Standards Verifiers provide advice and guidance to enable centres to hold accurate assessment records and assess learners appropriately, consistently and fairly. Centres offering Specialist qualifications as part of the New Apprenticeship Standards will usually receive two standards verification visits per year (a total of two days per year). The exact frequency and duration of Standards Verifier visits will reflect the level of risk associated with a programme, taking account of the:

- number of assessment sites
- number and throughput of learners
- number and turnover of assessors
- number and turnover of internal verifiers
- amount of previous experience of delivery.

If a centre is offering both the Specialist qualification and Competence-based qualification within a New Apprenticeship Standard, wherever possible, we will allocate the same Standards Verifier for both qualifications. We will work closely with centres offering New Apprenticeship Standards qualifications, so we can monitor and continuously improve our associated quality assurance arrangements.

Further guidance can be found in the *New Apprenticeship Standards Quality Assurance Handbook and Delivery Guidance* available on our website.

12 Understanding the qualification grade

This section explains the rules that we apply in providing an overall qualification grade for each learner.

The externally-assessed units are assessed at Pass/Fail only. These units must be passed before a grade for the qualification may be awarded. However, these units do not contribute to the overall grade of the qualification.

The internally-assessed units are assessed using a grading scale of Distinction, Merit, Pass and Unclassified. All mandatory and optional internally-assessed units contribute to the overall qualification grade.

The final grade awarded for a qualification represents a holistic performance across all of the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units will be balanced by a lower outcome in others.

In the event that a learner achieves more than the required number of optional units, the mandatory units, along with the optional units with the highest grades, will be used to calculate the overall result, subject to the eligibility requirements of the qualification.

Awarding and reporting for the qualification

The awarding and certification of these qualifications will comply with the requirements of the Office of Qualifications and Examinations Regulation (Ofqual).

Eligibility for an award

To achieve any qualification grade learners must:

- achieve a pass grade, or higher in all units within a valid combination, and
- achieve the minimum number of points at a grade threshold.

It is the responsibility of the centre to ensure that a correct unit combination is adhered to.

Calculation of the qualification grade

The table below shows the minimum thresholds for calculating each grade. The table will be kept under review over the lifetime of the qualification. In the event of any change, centres will be informed before the start of teaching for the relevant cohort and an updated table will be issued on our website.

Points thresholds

P	20
M	26
D	36

Note that externally-assessed units do not count towards the grade profile but must be achieved for a grade to be awarded.

Learners who do not meet the minimum requirements for a qualification grade to be awarded will be recorded as Unclassified (U) and will not be certificated. They may receive a Notification of Performance for individual units. Our *Information manual* gives full information.

Points available for internal units

The table below shows the number of **points** available for internal units. For each internal unit, points are allocated depending on the grade awarded.

	All internal units
U	0
Pass	4
Merit	6
Distinction	8

Claiming the qualification grade

Subject to eligibility, Pearson will automatically calculate the qualification grade for learners when the internal unit grades are submitted and the qualification claim is made. Learners will be awarded qualification grades for achieving sufficient number of points in the ranges shown in the *Calculation of qualification grade* table. Note that all units – two externally assessed and five internally assessed – have to be achieved at Pass or higher to be awarded the qualification.

To allow for a weaker performance in some units to be balanced by a stronger performance in others, there is an element of compensation built into the grading model.

Examples of grade calculations

Example 1: Achievement with P grade

	GLH	Type (internal/ external)	Grade	Unit points
Unit 1: Principles of Aircraft Materials and Airframe Construction	60	Internal	P	4
Unit 2: Human Factors and Behaviours	90	Internal	M	6
Unit 5: Business Improvement Techniques	50	Internal	M	6
Optional Unit A	60	Internal	P	4
Optional Unit B	60	Internal	P	4
Total			**P**	**24**

The learner passes both externally-assessed units, passes all five internally-assessed units, and achieves two Merits. Total points scored are 24 and the learner achieves a Pass grade.

Example 2: Achievement with M grade

	GLH	Type (internal/ external)	Grade	Unit points
Unit 1: Principles of Aircraft Materials and Airframe Construction	60	Internal	M	6
Unit 2: Human Factors and Behaviours	90	Internal	M	6
Unit 5: Business Improvement Techniques	50	Internal	M	6
Optional Unit A	60	Internal	P	4
Optional Unit B	60	Internal	P	4
Total			**M**	**26**

The learner passes both externally-assessed units, passes all five internally-assessed units and achieves three Merits. Total points scored are 26 and the learner achieves a Merit grade.

Example 3: Achievement with D grade

	GLH	Type (internal/ external)	Grade	Unit points
Unit 1: Principles of Aircraft Materials and Airframe Construction	60	Internal	M	6
Unit 2: Human Factors and Behaviours	90	Internal	M	6
Unit 5: Business Improvement Techniques	50	Internal	D	8
Optional Unit A	60	Internal	D	8
Optional Unit B	60	Internal	D	8
Total			**D**	**36**

The learner passes both externally-assessed units, passes all five internally-assessed units and achieves three distinctions and two Merits. Total points scored are 36 and the learner achieves a distinction grade.

Example 4: Non-achievement

	GLH	Type (internal/ external)	Grade	Unit points
Unit 1: Principles of Aircraft Materials and Airframe Construction	60	Internal	M	6
Unit 2: Human Factors and Behaviours	90	Internal	M	6
Unit 5: Business Improvement Techniques	50	Internal	P	4
Optional Unit A	60	Internal	U	0
Optional Unit B	60	Internal	P	4
Total			**U**	**20**

The learner has sufficient points for a Pass grade but has not achieved the minimum requirement of a Pass, or above, in all units.

13 Units

Each unit in the specification is set out in a similar way. There are two types of unit format:

- internal units
- external units.

This section explains how the units are structured. It is important that all tutors, assessors, internal verifiers and other staff responsible for the programme review this section.

Internal units

Section	Explanation
Unit number	The number is in a sequence in the specification. Where a specification has more than one qualification, numbers may not be sequential for an individual qualification.
Unit title	This is the formal title of the unit that will appear on the learner's certificate. .
Level	All units and qualifications have a level assigned to them. The level assigned is informed by the level descriptors defined by Ofqual, the qualifications regulator. .
Unit type	This says if the unit is mandatory or optional for the qualification. See structure information in *Section 5* for full details.
GLH	Guided Learning Hours (GLH) is the number of hours that a centre delivering the qualification needs to provide. Guided learning means activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, for example lectures, tutorials, online instruction and supervised study.
Assessment type	This says how the unit is assessed – i.e. whether it is internal or external. See structure information in *Section 5* for full details.
Unit introduction	This is designed with learners in mind. It indicates why the unit is important, what will be learned and how the learning might be applied in the workplace.
Learning outcomes	These help to define the scope, style and depth of learning of the unit.
What needs to be learnt	This section sets out the required teaching content of the unit. Content is compulsory except when shown as 'e.g.'. Learners should be asked to complete summative assessment only after the teaching of content for the unit or learning outcome(s) has been covered.

Assessment and grading criteria	Assessment criteria specify the standard required by the learner to achieve each learning outcome. Each learning outcome has Pass criteria. In addition to Pass criteria, each learning outcome has Merit or both Merit and Distinction criteria.

Section	Explanation
Tutor guidance	This section gives information to support the implementation of assessment. It is important that this information is used carefully, alongside the assessment criteria.
Required resources	This section lists any specific resources that are needed to be able to teach and assess the unit.
Assessment guidance	This information gives guidance for each learning outcome or assignment of the expectations for Pass, Merit and Distinction standard. This section contains examples and essential clarification.
Programme of suggested assignments	This section shows a programme of suggested assignments that covers the Pass, Merit and Distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.
Suggested reading/resources	lists resource materials that can be used to support the teaching of the unit, for example books, journals, websites.

External units

Section	Explanation
Unit number	The number is in a sequence in the specification. Where a specification has more than one qualification, numbers may not be sequential for an individual qualification.
Unit title	This is the formal title of the unit that will appear on the learner's certificate.
Level	All units and qualifications have a level assigned to them. The level assigned is informed by the level descriptors defined by Ofqual, the qualifications regulator.
Unit type	This says if the unit is mandatory or optional for the qualification. See structure information in *Section 5* for full details.
GLH	Guided Learning Hours (GLH) is the number of hours that a centre delivering the qualification needs to provide. Guided learning means activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, for example lectures, tutorials, online instruction and supervised study.
Assessment type	This says how the unit is assessed – i.e. whether internal or external. See structure information in *Section 5* for full details.
Unit introduction	This is designed with learners in mind. It indicates why the unit is important, what will be learned and how the learning might be applied in the workplace.
Learning outcomes	These help to define the scope, style and depth of learning of the unit.
Assessment criteria	Assessment criteria specify the standard required by the learner to achieve each learning outcome. Each learning outcome has Pass criteria only.
Essential content	For external units, all the content is obligatory, the depth of content is indicated in the assessment outcomes and sample assessment materials (SAMs). The content will be sampled through the external assessment over time, using the variety of questions or tasks shown.
Summary of assessment	This sets out the type of external assessment used and the way in which it is used to assess achievement.
Resources	This section lists any specific resources that are needed to be able to teach and assess the unit.
Suggested reading/resources	lists resource materials that can be used to support the teaching of the unit, for example books, journals, websites.

Unit 1: Principles of Aircraft Materials and Airframe Construction

Level:	**2**
Unit type:	**Mandatory**
Guided learning hours:	**60**
Assessment type:	**Internal**

Unit introduction

To enable engineers to carry out research, upgrade aircraft design, ensure that aircraft are airworthy, and to try to prevent defects and corrosion, they need sound knowledge and understanding of aircraft materials and their construction.

In this unit, you will investigate and gain knowledge about ferrous and non-ferrous materials such as steel and aluminium alloys. You will learn about their characteristics and properties, and the types of heat treatment used on them. You will also gain knowledge of non-metal materials, including the composites and plastics used in aircraft construction, their defects, repair techniques and preservation. You will learn about how fabric and wood are used to construct aircraft, their properties, inspection techniques, defects and methods of repair. You will then learn about types of corrosion, including causes of corrosion, methods of identification, and prevention of corrosion. Finally, you will investigate the structural strength, classification, structure and airworthiness of aircraft.

Learning outcomes

In this unit you will:

1. Know about aircraft ferrous and non-ferrous materials
2. Know about composite and other, non-metallic, materials
3. Know about wood and fabric airframe construction
4. Understand corrosion in aircraft materials
5. Understand the general concepts of airframe structure and construction.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know about aircraft ferrous and non-ferrous materials
Ferrous materials used in aircraft • Alloying elements: carbon, chromium, nickel, vanadium, molybdenum, manganese, silicon • Material properties, e.g. density, strength, elasticity, ductility, malleability, toughness, hardness, brittleness, creep and fatigue resistance, work hardening, corrosion resistance, hot and cold performance • Identification markings on stock material **Heat treatment (applications of alloy steels)** • Annealing • Tempering • Quench hardening • Normalising • Surface hardening • Carburising • Nitriding • Flame hardening • Induction hardening **Non-ferrous metals used in aircraft** • Common alloying elements – copper, magnesium silicon, zinc • Properties, e.g. density, strength, elasticity, ductility, malleability, toughness, hardness, brittleness, creep and fatigue resistance, work hardening, corrosion resistance, hot and cold performance • Advanced alloys, e.g. titanium and aluminium/lithium alloys • Identification marks on stock material **Heat treatment (applications of non-ferrous materials)** • Annealing • Solution treatment • Precipitation hardening • Stabilisation treatment

Learning outcome 2: Know about composite and other, non-metallic, materials

Composite and other, non-metallic, materials

- Fibres, e.g. glass, carbon, boron, aramid
- Typical resins
- Sandwich structures
- Plastics
- Polymers, e.g. thermoplastics, thermosetting, elastomers
- Sandwich construction

Sealants and bonding agents

- Polyurethane
- Silicones
- Thread locking compound
- Resins
- Adhesives and glues

Composite materials

- Typical defects/deterioration
  - defects/deterioration: cracking, warping, splitting, disbonding, delamination, Barely Visible Impact Damage (BVID)
  - detection: visual inspection, tap test, ultrasonic, infrared
- Repair techniques
  - composite materials: pre-impregnated layup (prepreg), wet layup
  - repair techniques: fibre orientation, autoclave, vacuum bag, typical repair tools, safety precautions, surface finish

Preservation and maintenance of non-metallic materials

- Inspection
- Protective treatments
- Material storage procedures

Learning outcome 3: Know about wood and fabric airframe construction

Construction methods

- Structural members
- Fabric or plywood skin
- Type of joints
- General direction of grain
- Reinforcement
- Use of glues, screws and other fasteners

Types of wood

- Spruce
- Fir
- Pine
- Cedar
- Plywood

Types of glue

- Resorcinol – formaldehyde resin
- Epoxy resin

Detecting defects in wooden structures

- Visual inspection
- Joint testing
- Measurement
- Odour

Repairing wooden structures

- Splicing
- Scarf joint
- Reinforcement
- Replacement
- Patching (scarf, splayed, oval, plug)

Fabrics used in aeroplanes

- Types of fabric
  - cotton
  - linen
  - Dacron™
  - fibre glass
  - properties (classification of fabrics, stitching and lacing, anti-tear tape)

Learning outcome 3: Know about wood and fabric airframe construction

- Inspection methods
  - visual inspection
  - fabric punch tester
  - tensile testing

Common defects found in fabrics

- Tears, deterioration of fabric due to: humidity, extremes of temperature, chemical action, fungal growth, erosion, brittleness, slackness, peeling of re-enforcing fabric from plywood panels

Methods of repairing fabric coverings

- Small tears – sew together and dope a pinked patch on top
- Larger tear – sewn-in patch repairs
- Un-sewn doped-on patch repairs
- Panel replacement

Learning outcome 4: Understand corrosion in aircraft materials

Types of corrosion

- Types: surface, pitting, intergranular, fretting, crevice, exfoliation, filiform

Corrosion in ferrous and non-ferrous metals

- Methods of identifying: visual inspection, x-ray, chemical analysis of samples
- Causes: environment, wear, stress, fatigue
- Formation: microbiological action, direct chemical action, galvanic action process
- Susceptible materials (teels, aluminium alloys, magnesium alloys, copper alloys)
- Prevention:
  - methods: design, protection, lubrication, stress and fatigue reduction, selection of appropriate materials

Learning outcome 5: Understand the general concepts of airframe structure and construction

Airworthiness requirements for structural strength

- Strength-to-weight ratio
- Rigidity
- Flexibility

Classification of aircraft structure

- Primary
- Secondary
- Tertiary

Physical effects of flying on aircraft structures

- Stress
- Strain
- Bending
- Compression
- Shear
- Torsion
- Tension
- Hoop stress
- Fatigue

Component construction methods

- Construction components stressed skin, formers, stringers, longerons, bulkheads, frames, doublers, struts, ties, beams, floor structures, reinforcement
- Methods: skinning, anti-corrosive protection
- Components: wing, empennage, fuselage and engine attachments

Structural assembly techniques

- Riveting
- Bolting
- Bonding
- Securing aircraft during assembly

Surface protection and cleaning

- Chromating
- Anodising
- Painting
- Polishing
- Use of solvents and detergents

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Know about aircraft ferrous and non-ferrous materials		
P1 Describe the basic characteristics, properties and identification of ferrous materials used in aircraft		D1 Compare and contrast different types of heat treatment for alloy steels and non-ferrous materials
P2 Describe heat treatment and applications of alloy steels	M1 Explain the purpose of heat treatment on ferrous materials used within the aircraft structure and the benefit this has	
P3 Describe characteristics, properties and identification of non-ferrous metals used in aircraft		
P4 Describe heat treatment and applications of non-ferrous materials	M2 Explain the purpose of heat treatment on non-ferrous material used within the aircraft structure and the benefit this has	

Learning outcome 2: Know about composite and other, non-metallic, materials		
P5 Describe characteristics, properties and identification of composite and other, non-metallic materials	M3 Explain the use of different composites in aircraft structure	
P6 Describe characteristics, properties and identification of sealants and bonding agents		
P7 Describe detection of typical defects/deterioration in composite material		
P8 Explain typical repair techniques for composite materials	M4 Explain the importance of choosing the correct repair techniques for aircraft composite materials	D2 Justify the application of a method in a typical repair situation with particular reference to maintaining structural integrity and minimising deterioration
P9 Explain the preservation and maintenance of non-metallic materials		

Learning outcome 3: Know about wood and fabric airframe construction		
P10 Describe construction methods for wooden airframe structures		
P11 Describe characteristics and properties of the types of wood and glue used in aeroplanes		
P12 Describe methods of detecting defects in wooden structures		
P13 Describe methods of repairing wooden structures		
P14 Describe characteristics, properties and types of fabric used in aeroplanes		
P15 Describe inspection methods for fabrics		
P16 Describe the common defects found in fabrics		
P17 Describe common methods of repairing fabric coverings		

Learning outcome 4: Understand corrosion in aircraft materials		
P18 Describe types of corrosion and methods of identifying these in ferrous and non-ferrous metals	M5 Explain the effects of corrosion on materials and structures and the prevention techniques used against corrosion	
P19 Describe the causes and formation of corrosion in ferrous and non-ferrous metals		
P20 Identify materials that are susceptible to corrosion and methods to prevent corrosion		
P21 Describe methods of corrosion removal and repair	M6 Explain the structural strength considerations to be taken into account when repairing aircraft structure	

Learning outcome 5: Understand the general concepts of airframe structure and construction		
P22 Explain the airworthiness requirements for structural strength		
P23 Explain the classification of aircraft structure		
P24 Describe the physical effects of flying on aircraft structures	M7 Explain the effects of flying on aircraft structures outside the flight envelope	
P25 Describe construction methods for various airframe components		
P26 Describe structural assembly techniques	M8 Explain the importance of typical securing devices used during aircraft assembly	D3 Evaluate the consequences of not selecting the correct securing devices
P27 Describe methods of surface protection and cleaning	M9 Explain the importance of surface protection and of regular inspection regimes for aircraft surfaces	

Tutor guidance

Required resources

The resources needed for this unit are:

- example metals and alloy and methods of heat treatment for demonstrations
- example non-metals, sealants, bonding agents for demonstrations
- example metals and non-metal defects
- example wood and glues, fabrics and typical defects
- examples of corrosion of ferrous and non-ferrous metals
- access to the internet.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know about aircraft ferrous and non-ferrous materials

Assignment title: Ferrous and non-ferrous materials

For distinction, learners will use the knowledge and understanding they have gained from the Pass and Merit criteria to make a comparison of the similarities and differences, advantages and disadvantages of the type of heat treatment for alloy steels and non-ferrous materials. This could be presented in the form of a table.

For merit, learners will apply their knowledge of heat treatment of ferrous materials and non-ferrous materials from the Pass criteria to give valid reasons for using, for example, annealing and the benefits of carrying out this type heat treatment.

For pass, learners will need to give valid descriptions of at least two examples of ferrous and at least two examples of non-ferrous, materials used in aircraft, for example carbon steel and stainless steel, aluminium alloy and copper. They will need to include the basic characteristics, useful properties and markings used to identify them. Learners will then need to provide features of the types of heat treatment undergone by alloy steels and non-ferrous materials and their applications. Labelled diagrams or flow charts of the steps involved would be supportive evidence.

Learning outcome 2: Know about composite and other, non-metallic, materials

Assignment title: Composite and other, non-metallic materials

For distinction, learners will need to provide evidence to support the application of their selected method and show how it ensures structural integrity and minimises deterioration.

For merit, learners will need to provide valid reasons for the use of at least three different composites. Learners will need to consider the repair techniques covered in the pass criteria and explain the importance of selecting the correct techniques, for example by using an autoclave or by using a vacuum bag. This could be presented in the form of a table.

For pass, learners will need to provide valid descriptions of a minimum of two non-metallic materials, for example carbon fibre reinforced plastic and sandwich structures, and describe their basic characteristics, useful properties and markings that identify them. This can be expanded to include the use of sealants and bonding agents. Learners will need to provide information on the features of three different types of defect/deterioration and how they are detected. They will then need to provide clear details about the suitability of typical repair techniques for composite materials and how preservation and maintenance are carried out. Evidence can be supported by use of labelled diagrams and appropriate tables.

Learning outcome 3: Know about wood and fabric airframe construction

Assignment title: Wood and fabric airframe construction

For pass, learners will need to include relevant features of construction methods for wooden airframe structures in their description, such as the types of joints and fasteners used. They will need to provide details of relevant information of types of wood, glue and fabric used in aeroplane construction. They will then need to include information about the methods used to detect defects in wooden structures and fabrics, for example visual techniques, tensile and joint testing. This can be expanded to provide details and types of common defects and the reasons for common defects. Learners will then provide information on methods used to repair wooden structures and fabrics. The use of relevant labelled diagrams and technical information would support their evidence where appropriate.

Learning outcome 4: Understand corrosion in aircraft materials

Assignment title: Corrosion in aircraft materials

For Merit, learners will need to include information about the effects of corrosion on materials, the importance of preventative techniques and the reasons for their use. They will then need to specify why during the repair of aircraft its structural strength must be maintained. The use of case studies, relevant labelled diagrams and technical information would support their evidence where appropriate.

For Pass, learners will need to give information of at least three different types of corrosion and include the methods used to identify them, their causes and how the corrosion has taken place. Learners will also need to name materials susceptible to corrosion such as different steels and non-ferrous alloys and provide the details of the methods used to prevent corrosion taking place. This can be expanded by providing information about stages of corrosion removal and repair. Evidence can be supported by use of labelled diagrams.

Learning outcome 5: Understand the general concepts of airframe structure and construction

Assignment title: Airframe structure and construction

For distinction, learners will use the knowledge and understanding they have gained from the pass and merit criteria to weigh up the possible consequences of using the wrong devices to secure aircraft during the assembly process.

For merit, learners will use the knowledge and understanding they have gained from completing the pass criteria to provide appropriate information of the effects of flying outside the flight envelope in terms of the capabilities of the aircraft design, for example the effects on the aircraft of diving at high speeds. They will also need to weigh up the importance of using the correct securing devices during assembly and fitting, and why it is important to protect and carry out regular inspections on surfaces.

For pass, learners will need to provide evidence for reasons why airframe structures are required to have a defined structural strength to be airworthy. This can be expanded to include specified details and reasons for the classification of an aircraft structure, for example the primary structure is made up of the major load-bearing structural members of the airframe, which it needs to be airworthy. This can be expanded to include physical effects on structures, for example bending, compression and shear forces acting on structural load bearing members. Learners need to provide information on the methods and the techniques for assembling various airframe components and methods used to protect and clean appropriate surfaces. The use of relevant, labelled detailed diagrams and technical information would support their evidence where appropriate.

Programme of suggested assignments

The table below shows a programme of suggested assignments that covers the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know about aircraft ferrous and non-ferrous materials	Ferrous and non-ferrous materials	You have been asked to produce some introductory exemplar training materials about ferrous and non-ferrous materials and heat treatment for new engineering apprentices.	An illustrated technical report based on a range of ferrous and non-ferrous materials and heat treatment.
Learning outcome 2 – Know about composite and other, non-metallic, materials	Composite and other, non-metallic, materials	You have been asked to provide information about composites and other non-metallic materials for the organisation's in-house monthly magazine.	An illustrated technical report showing, for example, diagrams, annotated photographs.
Learning outcome 3 – Know about wood and fabric airframe construction	Wood and fabric airframe construction	You have been asked to present information about wood and fabric construction for aerospace structures.	A technical, written report that includes labelled diagrams.
Learning outcome 4 – Understand corrosion in aircraft materials	Corrosion in aircraft materials	You have been asked to give a presentation to a team on corrosion and methods of preventing corrosion.	A technical written report that includes labelled diagrams.
Learning outcome 5 – Understand the general concepts of airframe structure and construction	Airframe structure and construction	You have been asked to give a presentation to a number of new apprentices on aircraft structure and construction.	A technical written report that includes labelled diagrams.

Suggested reading/resources

Book

Boyce A, Clarke S, Derbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book* (Pearson, 2010) ISBN 9781846907234

Websites

Composites in Aviation	www.youtube.com/watch?v=wXxn-8OA8Ac
Elemental Business Carbon Materials – BBC iPlayer	www.bbc.co.uk/programmes/p01pz6yx
Elements: Carbon(C) – Materials – BBC iPlayer	www.bbc.co.uk/programmes/p02rnvcm
Fabrics for aircraft	www.overallaircraft.com/Article1%20page%202%20fabric%20improvements.htm
GCSE Bitesize Metals and their corrosion	www.bbc.co.uk/schools/gcsebitesize/design/resistantmaterials/materialsmaterialsrev2.shtml
The Institute of Materials, Minerals and Mining	www.iom3.org/
Introduction to composites	www.youtube.com/watch?v=WYqCnEvTRUQ
Materials World magazine	www.iom3.org/materials-world-magazine
Metals and their corrosion	www.youtube.com/watch?v=0_UDX21rPSE
The Royal Society of Chemistry – Composite Materials	www.rsc.org/search-results/?q=composite%20materials
Self-healing airplane wings 'to fix tiny cracks'	www.bbc.co.uk/news/technology-33047859
STEM metals and their corrosion	www.nationalstemcentre.org.uk/elibrary/search?term=metals+and+their+corrosion&order=score
National STEM centre – *It's a Material World*	www.nationalstemcentre.org.uk/elibrary/resource/2726/it-s-a-material-world
National STEM centre – *Future in Composite Technologies*	www.nationalstemcentre.org.uk/elibrary/resource/4192/future-in-composite-technologies

Unit 2: Human Factors and Behaviours in Aviation

Level:	**3**
Unit type:	**Mandatory**
Guided learning hours:	**90**
Assessment type:	**Internal**

Unit introduction

To enable engineers working in aviation to work effectively and efficiently as individuals and as team members, they need an understanding of human factors and behaviours in the workplace. They also need an understanding of factors that affect human performance in the workplace.

In this unit, you will learn about how vital it is in the aviation industry to pay attention to detail of the factors and behaviours that affect human performance in the workplace. This is to ensure that errors, incidents and accidents are kept to an absolute minimum. You will gain an understanding of the importance of human factors, features and limitations of human performance, and aspects of social psychology in an aeronautical engineering environment. You will also gain an understanding of how personal factors, physical aspects of the working environment and categories of work tasks can affect human performance. You will study aspects of communication in the workplace, error models and risk assessments in aeronautical engineering.

Learning outcomes

In this unit you will:

1. Understand why human factors are important in aviation
2. Understand features and limitations of human performance
3. Understand aspects of social psychology
4. Understand personal factors that affect human performance
5. Understand how physical aspects of the working environment affect human performance
6. Understand how categories of tasks can affect human performance
7. Understand communication in the workplace
8. Understand error models within aeronautical engineering
9. Understand risk assessments in aeronautical engineering environments.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Understand why human factors are important in aviation
• The term 'human factors': meaning and how it is used in aviation (SHEL Model, Murphy's Law, anthropometry, Dirty Dozen, ergonomics) **Importance** • Safety of employees, passengers, people on the ground etc. • Safety of assets, e.g. aircraft, equipment • Long-term health of employees • Efficiency of the organisation **Categories of human factors** • Working environment • Work patterns • Social habits • Workload • Communication • Employee health

Learning outcome 2: Understand features and limitations of human performance

Seeing images and their interpretation

- Main parts of the eye
- How each part of the eye reacts to light
- Rods and cones
- Seeing in high and low light
- Peripheral vision
- Interpretation by the brain

Hearing sounds and their interpretation

- Main parts of the ear
- Vulnerable parts of the ear
- Effect of noise – percussive, prolonged high intensity, varying pitch
- Noise Induced Hearing Loss (NIHL)

Human memory limitations

- Time from exposure to information
- Form that information is in (audio, visual, words, pictures etc.)
- Fatigue
- Age
- Complexity of information
- Artificial stimulants/depressants
- Stress
- Low motivation
- Poor health
- Types (iconic, echoic, episodic, semantic)

Factors affecting attention span

- Overconfidence
- Boredom
- Fatigue
- Complexity of information
- Artificial stimulants/depressants

Degraded eyesight and hearing effects

- Individually and in combination (such as in older people)
- Sight, e.g. long- and short sight, optical illusion, including the strobe effect, persistence, moving from light area to work in the dark, optimum lighting for typical tasks, use of spectacles and magnifiers
- Hearing, e.g. high and low tone deafness, tinnitus, hearing damage, poor communication
- Social isolation (at work and at home)

Challenging environments and risks

- At height and in confined spaces, e.g. claustrophobia, fear of heights, limited access/egress to a large space
- Uncomfortable climate
- Specific tasks, e.g. inspections on fuselage crown or in equipment bays
- Low concentration
- Rushing the task
- Cutting corners
- Poor vision

Learning outcome 3: Understand aspects of social psychology

Individual and group responsibility

- Outline of a typical organisation (must include aviation maintenance)
- Typical roles and responsibilities
- Individuals and groups or teams
- Individual responsibility when working alone and within a team
- Group or team responsibilities
- Overview of group and inter-group dynamics, e.g. rivalry, polarisation, 'social loafing'

Motivation and demotivation

- Fulfilling individual needs
- Maslow's Hierarchy of Needs
- Herzberg Satisfaction Theory
- Individual motivation
- Motivation by management
- Characteristics of motivation and demotivation
- Effect of internal and external factors, e.g. management decisions, staffing and resources, workload (very high or very low), organisational culture, personal situation

Peer pressure, e.g.

- Conformity and non-conformity
- Pressure from co-workers, not management
- Advice and pressure from more experienced colleagues to adopt particular work practices
- How it can affect performance of maintenance tasks

Company culture

- Overview of different types of culture, e.g. safety, organisational, shift, team, social, individual
- Time constraints ('can do' culture, 'press-on-itis')

Team working

- What is a team?
- Advantages and disadvantages of team working
- Belbin Team Theory
- Team identity
- Working with other teams

- Ownership of tasks
- Communication
- Cooperation
- Mutual support

Engineering manager and supervisor – primary responsibilities

- Difference between management and supervisor roles
- What should an employee expect from a supervisor, e.g. motivation, support, guidance?
- Engineering organisations, e.g. Part-145, military maintenance organisation

Leadership basic concepts

- What is a leader?
- Different leadership styles (autocratic/democratic)
- The basic characteristics of a leader
- How and when any individual might provide leadership, e.g. passing on knowledge and experience to colleagues
- Organising and directing group tasks
- Inspection and reporting on the work of others

Learning outcome 4: Understand personal factors that affect human performance

Personal health and fitness effects

- Legal requirement for individual physical and mental fitness while at work
- Types of medical condition that might affect work, e.g. minor illness (cold, 'flu, sickness etc.)
- Major physical illness, e.g. heart attack, stroke, cancer
- Mental illness, e.g. depression
- Minor physical injury, e.g. sprained wrist, pulled muscle, cramp
- Major physical injury, e.g. broken bones, lacerations
- Effects of toxins and other substances, e.g. carbon monoxide, alcohol, drugs
- Gradual deterioration in physical condition

Effects of stress

- Define 'stress' (eustress, distress, acute stress, chronic stress, hypo stress, hyper stress)
- Sources: home, e.g. family illness, divorce , work (organisational, task related)
- Types: acute and chronic stress
- Signs of stress (physical, health, behaviour, cognitive, other)
- Explanation of how stress can affect individual performance at work

Effects of setting time deadlines

- Actual, perceived and self-imposed deadlines
- Effects of time pressure and deadlines
- Managing time pressure and deadlines

Work overload and underload

- Definition of work overload and underload
- Results of work overload and underload
- Factors determining workload
- Workload management

Effects of shift work on sleep and fatigue

- What is sleep?
- Five stages of sleep
- Circadian rhythms
- Fatigue (causes, symptoms)
- Working at night
- Types of shift pattern

Effects of alcohol, medication and substance abuse

- Removal of alcohol from the blood
- Effects while fatigued, hungry or combined with medication
- Types, effects, short- and long-term consequences of abuse of: alcohol, prescription medication, over-the-counter medication, illegal drugs
- Effects on individual work performance

Personal legal obligations, e.g.

- Alcohol limits and legal requirements for aircraft engineers
- CAP 562/AN47
- Transport legislation/AN45
- Health and safety legislation
- Legal requirements for hearing protection
- Correct protection for frequency range

Maintaining individual professional currency, e.g.

- Refresher training
- Reading briefing material
- Notices and amendments to maintenance procedures
- Reading professional journals
- Undertaking up-skilling and further licence training

Learning outcome 5: Understand how physical aspects of the working environment affect human performance

Effects of noise on, e.g.

- Concentration
- Communication

Effects of fumes on, e.g.

- Concentration
- Communication
- Longer term effects
- Safe oxygen levels

Varying illumination effects, e.g.

- Ability to see detail
- Moving between areas of different illumination, including well-lit hangar and night flight line
- Strobe effect and propellers

Climate variation effects, e.g.

- Cold/wet, warm/dry, hot/humid environments

Exposure to constant motion and vibration, e.g.

- Working at height on scissor platforms and cherry picker
- Unsteady platforms
- Use of rotating or percussive tools

Working environment layout, e.g.

- The three components of a working environment: layout, cleanliness, ease of movement between work areas
- Lighting, noise, atmosphere, temperature etc.
- Social environment
- Tasks, tools and information

Learning outcome 6: Understand how categories of tasks can affect human performance

Planning task execution, e.g.

- Defining the task
- Defining the resources
- Personal skills and proficiency
- Information

Effects of physically demanding work relating to, e.g.

- Health and physical condition, effects of age
- Work environment
- Physical effort

Effects of repetitive tasks relating to, e.g.

- Ignoring manuals, job cards etc.
- Complacency
- Making assumptions

Visual inspection requirements, e.g.

- Importance of good eyesight
- Knowledge of the inspection area
- Illumination
- Concentration
- Systematic search

Complex systems aspects, e.g.

- Simple system: transparent to the engineer
- Complex system: opaque to the engineer
- Clear understanding of the purpose of the system
- System-specific training
- Pooling of knowledge and skills
- Clear and comprehensive information and guidance

Learning outcome 7: Understand communication in the workplace
Good communication • Within and between groups, e.g. prevention of accidents • Maintaining good working relations • Organisational efficiency **Accurate work logging, e.g.** • Formal work logging • Shift logging • Shift handover • Task staging • Duplicate • Inspection • Stage sheets/check **Modes of communication, e.g.** • Verbal • Written • Body language • Workplace social culture • Communication between all levels of an organisation

Learning outcome 8: Understand error models within aeronautical engineering
Error models, e.g. • Induced • Variable • Reversible/irreversible • Slips, lapses and mistakes • The 'Swiss Cheese Model' **Types of error, e.g.** • Complacency • Environmental capture • Rule-based errors • Violations • Individual practices and habits • Errors associated with visual inspection • Latent/active errors **Error-incident-accident chain, e.g.** • Self-discipline • Safety management system • Anonymous and blame-free reporting • Training • Logging and analysis

Learning outcome 9: Understand risk assessments in aeronautical engineering environments

Risk assessment terms

- Hazard
- Risk
- Severity
- Likelihood (probability)

Five steps

1 – Identify hazards

2 – Decide who might be harmed and how

3 – Evaluate risks and decide on precautions

4 – Record findings and implement them

5 – Review and update

Associated risks for workplace hazards

- Step 1 – Identify hazards

Conclusions from risk assessments

- Step 2 — Decide who might be harmed and how
- Recommend ways of eliminating or reducing, to an acceptable level, a range of identified risks

Manage workplace emergencies

- Step 3 — Evaluate risks and decide on precautions
- Step 4 — Record findings and implement them; reduce the likelihood of them happening
- Step 5 – Review and update; policies, procedures, regular training, management of workplace emergency situations such as fire, spillage, personal injury etc.

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Understand why human factors are important in aviation		
P1 Explain the term 'human factors' in aviation		
P2 State the reasons why human factors are important in the aeronautical engineering workplace	M1 Describe the importance of human factors for an individual working within the aviation industry and the consequences of ignoring the psychology of human factors	D1 Evaluate the importance of human factors for the aviation industry
P3 State the categories of human factors that are important to aeronautical engineering staff		
Learning outcome 2: Understand features and limitations of human performance		
P4 Explain how images are seen and interpreted by humans		
P5 Explain how sounds are heard and interpreted by humans		
P6 Explain how human memory can become limited		
P7 State the factors that affect mental attention span		
P8 Describe effects on human performance and behaviour of degraded eyesight and hearing		
P9 Explain how working in challenging environments presents risk to personal safety and airworthiness	M2 Analyse the potential consequences of human errors caused by working in challenging environments	

Learning outcome 3: Understand aspects of social psychology		
P10 Explain areas of individual and group responsibility in aerospace engineering environments	M3 Explain the advantages and disadvantages of group responsibility	D2 Evaluate the importance of balancing group and individual responsibilities within an aeronautical engineering environment
P11 Explain motivation and demotivation	M4 Explain the importance of achieving an optimum level of motivation amongst staff	D3 Evaluate the potential effects on organisational performance of varying levels of motivation within an aeronautical engineering workforce
P12 Explain 'peer pressure' and its effects		
P13 Describe how company culture can compromise best working practices		
P14 Explain concepts of team working		
P15 Explain the primary responsibilities of engineering managers and supervisors		
P16 Describe the basic concepts of leadership		
Learning outcome 4: Understand personal factors that affect human performance		
P17 Explain the effects that personal health and fitness have on work performance		
P18 Explain sources and types of stress and the effects within a working environment		
P19 Explain effects of setting time deadlines on individual work performance	M5 Compare the effects on team performance of individuals working to their own perceptions of deadlines and individuals working to agreed group deadlines	D4 Evaluate the benefits of clearly defined and agreed work deadlines within an aerospace engineering organisation
P20 Explain the concept of work overload and underload		

P21 Explain the effects of shift work on sleep and fatigue		
P22 Explain the effects of alcohol, medication and substance abuse and how it affects individual work performance		
P23 Explain the personal legal obligations of individuals working in the aerospace industry		
P24 Explain the importance of maintaining individual professional currency	M6 Evaluate the benefits to an aircraft engineering organisation of staff undertaking Continuing Professional Development	
Learning outcome 5: Understand how physical aspects of the working environment affect human performance		
P25 Explain the effects of noise on individuals and groups		
P26 Explain the effects of fumes on individual performance		
P27 Explain the effects of varying illumination on individual performance		
P28 Explain the effects of variations in climate on individual performance		
P29 Explain the effects of exposure to constant motion and vibration while working		
P30 Explain the effects of layout of a working environment on individual performance		

Learning outcome 6: Understand how categories of tasks can affect human performance		
P31 Explain the importance of planning the execution of a task		
P32 Explain the effects of physically demanding work on individual performance		
P33 Explain the effects of repetitive tasks on individual performance		
P34 Explain aspects of visual inspection		
P35 Explain aspects of working on complex systems		
Learning outcome 7: Understand communication in the workplace		
P36 Explain the importance of good communication in the workplace	M7 Explain the common communication protocols used in the aviation industry to enhance flight safety	
P37 Explain the importance of accurate work logging		
P38 Explain modes of communication between individuals and teams		
P39 Explain the importance of information dissemination		

Learning outcome 8: Understand error models within aeronautical engineering		
P40 Explain the error models and theories used in aeronautical engineering		
P41 Explain types of error that occur during work on aircraft	M8 Explain the prevention techniques for different types of error that could occur during work on an aircraft	
P42 Describe the error-incident-accident chain	M9 Explain the methods used to prevent incidents and accidents within the aerospace industry	
P43 Describe methods of managing and avoiding errors		
Learning outcome 9: Understand risk assessments in aeronautical engineering environments		
P44 Define the terms associated with risk assessment		
P45 Describe the five steps to risk assessment		
P46 Describe the associated risks for workplace hazards		
P47 Describe conclusions from risk assessments		
P48 Explain how to manage workplace emergencies		

Tutor guidance

Required resources

The resources needed for this unit are:

- the internet
- a library or learning resource centre.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Understand why human factors are important in aviation

Learning outcome 2: Understand features and limitations of human performance

Assignment title: Human factors and human performance

For distinction, learners will review the knowledge and understanding they have gained from completing the pass and merit criteria to draw conclusions about the importance of human factors for the aviation industry.

For merit, learners will apply their knowledge from the pass criteria to provide relevant information, highlighting the importance of the psychology of human factors and consequences of ignoring it, for example providing a good safe working environment and an acceptable workload. This could be presented as a table using important features and consequences. Learners will be required to examine the causes of human error and provide details of their interpretation of the potential consequences. This could be carried out using case studies.

For pass, learners will need to give the meaning and definition of the term 'human factors' and detail how it is used in aviation and its related concepts such as the SHEL model. Learners should give a minimum of two reasons why human factors are important in the workplace and document the importance to aeronautical engineering staff of at least three different categories. Learners will need to provide clear details of features and limitations of human performance in relation to eyesight and hearing, and the effects of their degradation. The use of relevant labelled diagrams could support their evidence where appropriate. Learners will need to include clear details of and valid reasons for the limitations of human memory, and give a minimum of three factors that affect attention span, for example fatigue owing to working long hours in challenging environments. They will then need to give clear details of reasons why this can be a risk to personal safety and airworthiness.

Learning outcome 3: Understand aspects of social psychology

Learning outcome 4: Understand personal factors that affect human performance

Assignment title: Social psychology and personal factors

For distinction, learners will use their knowledge and understanding from the pass and merit criteria to balance the strengths and weaknesses of working as an individual or as a member within a group to achieve overall targets. Learners will need to review a case study of an organisation with varying levels of motivation to draw valid conclusions of the potential effects on organisational performance. Learners will need to assess the value of the benefits to both the employees and organisation to make valid judgements.

For merit, learners will apply their knowledge form the pass criteria to provide clear details of the advantages and disadvantages of the group responsibility. This could be presented in the form of a table. Learners will need to give valid reasons for achieving an optimum level of motivation, such as achieving goals and lowering levels of staff absence. Learners will need to make an appropriate comparison of the effects on team performance from individuals own perceptions of deadlines and individuals working to agreed group deadlines and draw conclusions from the advantages and disadvantages. Learners will then need to appraise the benefits of staff undertaking continuing professional development to draw valid conclusions with regard to the organisation's aims and goals.

For pass, learners will outline a typical aerospace organisation focusing on the roles and responsibilities of individuals and groups within aviation maintenance. The use of relevant labelled diagrams could support their evidence where appropriate. Learners need to specify characteristics of, and valid reasons for, motivation and demotivation, and how peer pressure can affect the staff performance in an aviation maintenance environment. This could include reference to behavioural theories, for example Maslow's Hierarchy of Needs. They will need to provide relevant information of how company culture can affect working practices, such as working in a 'can do' culture. Learners will need to explain the concepts of team working, including characteristics of and valid reasons for. They will also need to explain the primary responsibilities of supervisors and managers and give relevant information of what is meant by leadership in an aviation engineering environment. Learners will need to specify details of the effects on individuals of personal factors including shift work, work overload, alcohol, medication and substance abuse. They will also need to specify details of the effects within a working environment of a minimum of four sources and four types of stress. This can be expanded to include clear details of how these personal factors affect human performance in an aviation engineering environment, and appropriate reasons why. This could be presented in an appropriate table or chart. Learners will need to give clear details and reasons for the importance of personal responsibilities including legal obligations such as following the requirements for hearing protection and maintaining their professional currency, for example keeping up to date through continuing professional development.

Learning outcome 5: Understand how physical aspects of the working environment affect human performance

Learning outcome 6: Understand how categories of tasks can affect human performance

Assignment title: Physical aspects of the working environment and categories of tasks

For pass, learners will need to provide valid reasons for the effects on individual, and where appropriate group, performance of physical aspects of the working environment. This should include the effects of noise, fumes, varying illumination and climate, exposure to constant motion and vibration, and the layout of the working environment. The evidence could be presented in a table or mind map using examples. This could be expanded to include how categories of tasks affect human performance, including the importance of planning, the effects of physically demanding work and repetitive tasks, the aspects of visual inspection and working on complex systems.

Learning outcome 7: Understand communication in the workplace

Assignment title: Communication

For merit, learners will need to provide details and functions of communication protocols such as communication between ground personnel and aircraft personnel to enhance flight safety.

For pass, learners will need to provide clear details of, and give valid reasons for, the importance of good communication, information dissemination and the need for accurate work logging, for example for shift handover. They will also need to provide clear details of the different modes of communication in the aviation workplace. The use of examples/templates of modes could support their evidence.

Learning outcome 8: Understand error models within aeronautical engineering

Learning outcome 9: Understand risk assessments in aeronautical engineering environments

Assignment title: Error models and risk assessment

For merit, learners will apply their knowledge from the pass criteria to provide clear details and functions of using prevention techniques for a minimum of three different types of error. Learners will then provide clear details of methods used to prevent incidents and accidents, such as developing and following accurate procedures and practices.

For pass, learners will need to provide clear details and functions of error models such as the 'Swiss Cheese Model'. The use of relevant labelled diagrams will support their evidence where appropriate. They will then need to provide clear details of the types of error and why they occur when working on aircraft. Learners will describe the concept of the error-incident-accident chain, including how it is used in aviation. This can be expanded to include methods of how to manage and avoid errors. Learners will need to describe the meaning of risk assessment in an aeronautical engineering environment to include a minimum of two terms such as hazard and severity. They will need to include information about the five steps to risk assessment. The evidence could be presented in an appropriate table or risk assessment template form.

This can be expanded to specify valid features of associated risks in the workplace and recommendations of how to reduce risks. For example, using the functions and objectives of organisational procedures and practices to manage workplace emergencies.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. Alternatively, you can integrate learning outcomes 1 to 7 into one assignment and learning outcomes 8 and 9 into one assignment. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Understand why human factors are important in aviation **Learning outcome 2** – Understand features and limitations of human performance	Human factors and human performance	You have been asked to produce some introductory exemplar training materials on the role of human factors, their features and limitations.	A written report with labelled diagrams, use of case studies and tables where appropriate.
Learning outcome 3 – Understand aspects of social psychology **Learning outcome 4** – Understand personal factors that affect human performance	Social psychology and personal factors	You have been asked to produce introductory materials on social psychology and personal factors that affect human performance.	A written report with use of case studies, labelled diagrams and tables.
Learning outcome 5 – Understand how physical aspects of the working environment affect human performance **Learning outcome 6** – Understand how categories of tasks can affect human performance	Physical aspects of the working environment and categories of tasks	You have been asked to give a presentation to a number of new learners on how the working environment and tasks carried out can affect human performance.	A written report with use of case studies, labelled diagrams and tables.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 7 – Understand communication in the workplace	Communication	You are leading a group of fellow learners on how to communicate within the aviation workplace environment.	A written report with examples/ templates where appropriate.
Learning outcome 8 – Understand error models within aeronautical engineering **Learning outcome 9** – Understand risk assessments in aeronautical engineering environments	Error models and risk assessment	You have been asked to contribute to a session on error models and ways of reducing incidents and accidents in the aviation maintenance environment.	A technical written report, including labelled diagrams and tables where appropriate.

Alternative model of assignments

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcomes 1 to 7	Staff performance in an aeronautical engineering environment	You have been asked to carry out a study of staff performance in an aeronautical engineering environment. Divide your report into three sections using the titles below. 1 –Aspects of social psychology and the importance of human factors 2 – Human performance in the workplace – categories of tasks, physical aspects of the working environment and communication 3 – Features and limitations of human performance	A written report, including case studies, labelled diagrams and tables where appropriate.
Learning outcome 8 – Understand error models within aeronautical engineering **Learning outcome 9** – Understand risk assessments in aeronautical engineering environments	Error models and risk assessment	You have been asked to contribute to a session on error models and ways of reducing incidents and accidents in the aviation maintenance environment.	A technical written report, including labelled diagrams and tables where appropriate.

Suggested reading/resources

Books

HSE – *Essentials of Health and Safety at Work* (HSE Books, 2006) ISBN 9780717661794

Patankar M S, Taylor J C – *Applied Human Factors in Aviation Maintenance: A Practical Guide to Improving Safety* (Ashgate, 2004) ISBN 9780754619406

Swanson R – *Analysis for Improving Performance: Tools for Diagnosing Organizations & Documenting Workplace Expertise* (Berrett Koehler, 2007) ISBN 9781576753415

Websites

Aviation Safety Network	www.avaition-safety.net
Business Education Resource (Learning Zone)	www.bized.co.uk
Civil Aviation Authority (CAA):	www.caa.co.uk
CAP 715 – *Introduction to Aircraft Maintenance Engineering Human Factors*	
CAP 716 – *Aviation Maintenance Human Factors*	
CAP 718 – *Human Factors in aircraft maintenance and inspection*	
CAP 719 – *Fundamental Human Factors Concepts*	
Health and Safety Executive	www.hsegov.uk/humanfactors/index.htm
Human factors in aviation	www.boeing.com/commercial/aeromagazine/aero_08/human_textonly.html
The Times 100 case studies	www.thetimes100.co.uk
YouTube – Managing Human Error	www.youtube.com/watch?v=5jk0uAVdBC4
YouTube – Swiss cheese model	www.youtube.com/watch?v=QdLZFiUonPk
YouTube –*5 Aviation Accidents Caused by Human Factors* | *IHF*	www.ihf.co.uk/blog/2014/07/5-aviation-accidents-caused-by-human-factors/

Unit 3: Principles of Aerodynamics and the Theory of Flight

Level:	**2**
Unit type:	**Mandatory**
Guided learning hours:	**90**
Assessment type:	**External**

Unit introduction

There are very clear relationships between the atmosphere, an aircraft and the effect of forces acting on it when it is on the ground and in flight. This unit will help you to understand how aircraft fly and how they are controlled and stabilised, from large passenger aircraft to modern jet fighter aircraft to helicopters.

You will develop an understanding of the atmosphere in which aircraft fly, including the impact of airflows and forces acting on an aircraft in flight and on the ground and how lift and drag affect aircraft performance. The nature of subsonic airflow over aerodynamic sections and over the aircraft at large is considered, including the forces that result from such airflow and the effect these forces have on the aircraft.

You will look at the characteristics of the basic wing planforms, including the impact of airflow, atmospheric conditions, for example frost build-up and how low subsonic, high subsonic and transonic speed airflows affect planform design.

You will look in depth at how aircraft are controlled and stabilised. You will consider the operation and effect of the primary aircraft control surfaces and the nature of stability and control of an aircraft in flight, including the major components on an aircraft that affect stability in flight. A range of primary and secondary flight controls and lift augmentation devices, and how they work, are covered.

A range of flight control surfaces is also covered, including the way in which they are used to control the aircraft axes.

Learning outcomes

In this unit you will:

1. Know the nature of airflow around aerodynamic bodies
2. Know the characteristics of the basic wing planform
3. Know the forces acting on an aircraft in flight
4. Understand basic aircraft control using primary control surfaces
5. Understand the nature of aircraft stability and control
6. Know the purpose and operation of a range of secondary control surfaces.

Learning outcomes, assessment criteria and essential content

What needs to be learnt
Learning outcome 1: Know the nature of airflow around aerodynamic bodies
AC 1.1 Describe how air flows around an aerodynamic body • Know the nature of airflow, including streamline, laminar and turbulent flow, free stream flow, up and down wash, vortices; compressibility effects at higher subsonic speeds • Know about viscosity effects and the boundary layer, including resistance to motion, velocity gradient, shear rate, boundary layer separation (transition point, separation point) **AC 1.2 Know how an aerofoil stalls and the effect a stall has on an aircraft in flight** • Know aerofoil terminology and characteristics, including aerofoil profile, camber, upper, lower and mean camber lines, chord line, leading and trailing edge, thickness to chord ratio or fineness ratio, angle of attack (AOA), angle of incidence (AOI) symmetrical and cambered aerofoils • Describe pressure and flow changes at low, medium and high angles of attack and explain aerofoil stall effects **AC 1.3 Describe how lift and drag affect aircraft performance** • Lift: describe the factors affecting lift, including aerofoil shape, lift coefficient, angle of attack, air density, airspeed and stall • Drag: know different types of drag, including total, induced (trailing vortex), profile skin friction, profile form, interference; describe common methods of drag reduction; know how the following contribute to drag reduction: polished surfaces, fairings, special materials, aerodynamic shape
Learning outcome 2: Know the characteristics of the basic wing planform
AC 2.1 Describe the basic wing planforms and their typical applications • Know about wing planform designs for aircraft subject to low subsonic, high subsonic and transonic speed airflows; know about rectangular, elliptical, straight, tapered, swept, and delta planforms; applications: low subsonic, high subsonic and transonic speed airflows; generation of lift • Calculate dimensions for basic wing planforms; dimensions: span, aspect ratio, taper ratio, gross wing area, wash in, wash out; describe the airflow over each basic wing planform; airflow: in normal flight, at or near stall; planforms: rectangular, tapered, swept, delta • Describe the effect of ice, snow and frost build-up on the performance of aerofoils; effects: change of shape, increase in weight, variation in thickness

Learning outcome 3: Know the forces acting on an aircraft in flight

AC 3.1 Describe the forces acting on an aircraft in flight

- Describe airflow with reference to Bernoulli's principle; describe static pressure changes resulting from changes in angle of attack (including around the stall); describe the airflow as the velocity changes; describe effects including changes in lift and drag; know the relationship between lift, weight, thrust and drag forces for straight and level flight
- Describe the effects of streamlining an object in an airflow; definition of streamlining; effects: reduction of compression shockwaves, reduction in drag; know the factors affecting drag including aerofoil shape, angle of attack, drag coefficient, airspeed, streamlining, damage to lift producing surfaces, ice and frost accretion

AC 3.2 Know the importance of the speed of sound to high-speed aircraft

- Describe how the speed of sound can vary with height, air density, temperature; state the meaning of terms related to high-speed flight; know the terms: speed of sound, subsonic flight, transonic flight, supersonic flight, Mach number, Critical Mach number (MachCrit)
- Describe problems that can occur when an aircraft approaches the speed of sound: problems: shockwave, buffet, increased drag, control reversal, tuck-under; describe design features peculiar to high-speed flight; features of wings, fuselage, engine intakes, control surfaces

Learning outcome 4: Understand basic aircraft control using primary control surfaces

AC 4.1 Describe the meaning of 'aircraft control'

- Describe the operation and effect of the primary aircraft control surfaces; describe how elevators, ailerons and rudders support control about the aircraft axes
- Know about control in roll, pitch and yaw; describe manoeuvring about lateral, longitudinal and normal axes

AC 4.2 Describe typical aircraft performance

- Describe different phases of flight; phases: straight and level flight, climb, descent, glide, turn; describe how turning flight changes the loading on an airframe; describe how turning flight is related to the stall

AC 4.3 Explain the influence of load factor on aerodynamic performance

- Define load factor and explain its effect on lift generated; state how load factor changes alter the aircraft's flight characteristics
- Explain the term 'flight envelope'; explain flight envelope in terms of the loading analysis to which the aircraft design must comply; describe the dependency of the flight envelope on: aircraft gross weight, configuration of the aircraft (cleanliness, external stores, position of flaps, position of landing gear), symmetry of loading, altitude

Learning outcome 5: Understand the nature of aircraft stability and control

AC 5.1 Explain stability and control of an aircraft in flight

- Know about flight force, including couples (lift/weight and thrust/drag), action about centre of gravity (C of G) and centre of pressure (CoP); describe stable, unstable and neutrally stable states of equilibrium; understand diagrams that use force vectors to show the different states; explain the nature of aircraft flight stability; stability: definitions for static, dynamic and passive stability around the longitudinal, lateral and directional axis
- Know the different types of stability, including short period pitch oscillation, long period pitch oscillation (phugoid), Dutch roll, and weather cocking; know the differences between statically stable, unstable and neutral aircraft, including static and positive stability, negative stability (unstable), zero stability (neutral); describe how banking of an aircraft is used to balance the centripetal force and component of lift in a constant radius turn (static stab and control)

AC 5.2 Describe major components on an aircraft that affect stability in flight

- Describe longitudinal static stability, including trim and stability, centre of pressure and aerodynamic centre movement; describe the effect of the tailplane, the C of G position and the effect of loading of stores and cargo
- Describe the balancing aerodynamic force from the tailplane; using the principle of moments, determine balancing forces needed to maintain aircraft in static equilibrium
- Describe lateral static stability, including yawing stability (yawing motion or weathercocking, use of fin, keel surface and wing dihedral), rolling stability (use of high wings and sweepback), use of anhedral
- Describe directional stability; describe how the fin (vertical stabiliser) corrects yawing motion, describe how the keel surface area (including area of fin) behind the C of G affects directional stability
- Describe methods of enhancing stability, including adjusting the centre of gravity, design of lifting and control surfaces (wings, canards, tailplane)

AC 5.3 Explain the principles of balancing control surfaces

- Explain the reason for balancing, including how flutter can occur and the purpose and methods of mass balance/aerodynamic balance

AC 5.4 Describe the purpose of lift augmentation devices and how they work

- Define 'lift augmentation'; know that lift needs augmentation under certain flight conditions, including short take-off and landing, slow speed flight, high altitude take-off/landing
- Know the purpose and operation of: flaps, slats and slots, vortex generators, boundary layer control

Learning outcome 6: Know the purpose and operation of a range of secondary control surfaces

AC 6.1 Describe the operation of high drag devices, by stating the limitations in flight and on the ground of: spoilers, lift dumpers and speed brakes

- Know how a high lift device alters the flow characteristics of an aerofoil; characteristics: airflow separation, changes in lift and drag coefficients
- Know how the total drag of an aircraft is generated; know that total drag is generated by induced drag, pressure or form drag, skin friction, interference drag, parasite drag

AC 6.2 Describe the secondary effects of roll and yaw and methods of overcoming them

- Describe airflow over control surfaces; describe the effect of adverse yaw on roll rate; state ways of counteracting adverse yaw and the role of differential ailerons, frise ailerons and roll spoilers; describe the secondary roll effect of applying rudder and state why this is worse in V-tailed aircraft; describe the coordinated use of rudder and aileron; describe the use of rudder limiters

AC 6.3 Describe the arrangement and operation of alternative and combined flying controls

- Describe the arrangement, operation and reasons for: spoilers, all-moving tailplane (slab/stabilator), ailerons, canards, elevons, ruddervators, flaperons, tailerons
- Know the performance of trailing edge high-lift devices; state advantages, disadvantages with respect to aerodynamic effectiveness and operation of the following devices: plain flap, split flap, slotted flap, fowler flap
- Know the performance of leading edge high-lift devices; state advantages, disadvantages with respect to aerodynamic effectiveness and operation of the following devices: Krueger flap, leading edge droop, slots, slats

AC 6.4 Describe the aerodynamic problems caused by asymmetric flap operation

- Describe asymmetric flap and the effect on aircraft attitude, including asymmetric flap and how it happens, effect on aircraft attitude

AC 6.5 Describe the purpose and operation of devices to prevent stalls

- Know the operation of stall strips/wedges; know methods of boundary layer control: blown air, suction devices, vortex generators

Summary of assessment

This unit is externally assessed using an onscreen test. The test lasts for 60 minutes and has 40 marks.

The questions will be multiple choice, where the learner will be required to select the correct response to a question from one of four options. Where appropriate, questions may contain diagrams, graphics or graphs. Each test item will have an accessibility panel that allows a learner to zoom in and out and apply a colour filter. There will be no videos or sound.

Test items will sample the amplification provided for each targeted criteria, this will include the indicative demand identified within the text.

Pearson sets and marks the test. The assessment is available onscreen.

A pass grade will be determined by learners achieving a defined cut score for the onscreen test.

Learners will be allowed to use rough paper for working.

Resources

There are no specific resources needed for this unit.

Suggested reading/resources

Books

Barnard R and Philpott D – *Aircraft Flight: A Description of the Physical Principles of Aircraft Flight, 4th Edition* (Prentice Hall, 2010) ISBN 9780273730989

Dingle L and Tooley M – *Aircraft Engineering Principles 2nd Edition* (Routledge, 2013) ISBN 9780080970844

Kermode A, Barnard R and Philpott D – *Mechanics of Flight 12th Edition* (Pearson, 2012) ISBN 9780273773511

Journal

Aerospace International, published by the Royal Aeronautical Society (monthly)

Unit 4: Mathematics and Science for Engineering

Level:	**2**
Unit type:	**Mandatory**
Guided learning hours:	**105**
Assessment type:	**External**

Unit introduction

Engineers utilise mathematical and scientific principles and concepts in their day-to-day to working. This unit gives you the knowledge and understanding you need to be able to apply these principles and concepts in your own engineering role.

You will learn about arithmetic, algebra and graphs and apply your knowledge to solve problems. You will also learn how to use a range of units, including imperial, US customary and SI units, when solving engineering problems. You will learn the principles of statics, kinetics and dynamics and apply them to solve problems. You will develop knowledge about the nature of matter and the properties of the Earth's atmosphere, which is of significant importance in an aerospace environment.

Learning outcomes

In this unit you will:

1. Be able to use arithmetic and algebra to solve problems
2. Be able to use simple graphs
3. Be able to use different units in engineering problems
4. Know the nature of matter
5. Know principles of statics
6. Understand principles of kinetics
7. Understand principles of dynamics
8. Understand principles of fluid dynamics
9. Know properties of the earth's atmosphere.

Learning outcomes, assessment criteria and essential content

What needs to be learnt
Learning outcome 1: Be able to use arithmetic and algebra to solve problems

AC 1.1 Perform arithmetical calculations
• Add, subtract, multiply, divide, positive and negative integers, decimals and fractions; reduce fractions; convert between mixed numbers and improper fractions
• Convert between decimals and fractions; express values to a given number of decimal places; order positive and negative integers, decimals and fractions; use the symbols =, ≠, <, >, ≤, ≥
AC 1.2 Prioritise and use basic functions within arithmetical calculations
• Understand and use BIDMAS, including powers, roots and reciprocals
AC 1.3 Manipulate fractions and decimals to solve problems
• Identify and work with fractions in ratio problems; interpret fractions and percentages as operators; identify and work with decimals to solve problems
AC 1.4 Manipulate ratios, proportions, and percentages to solve problems
• Use ratio notation, including reduction to simplest form; divide a given quantity into two parts in a given part: part or part: whole ratio; express the division of a quantity into two parts as a ratio; apply ratio to real contexts and problems
• Use proportion as equality of ratios; solve problems involving direct and inverse proportion
• Use percentages: define percentage as 'number of parts per hundred'; interpret percentages and percentage changes as a fraction or a decimal, and interpret these multiplicatively; express one quantity as a percentage of another; compare two quantities using percentages
• Perform engineering calculations involving ratios and proportion; solve problems involving percentage change, including percentage increase/decrease and original value problems
AC 1.5 Calculate areas and volumes
• State and use formulae for areas of:
  ○ triangles
  ○ rectangles
  ○ circles
  ○ work out areas of composite shapes made from rectangles, triangles, circles and/or semicircles
  ○ use appropriate units

- State and use formulae for volumes of:
  - triangular prisms
  - cuboids
  - cylinders
  - use appropriate units

AC 1.6 Calculate simple powers of numbers

- Calculate squares, square roots, cubes and cube roots; use positive integer powers and associated real roots (square, cube and higher); recognise powers of 2, 3, 4, 5; estimate powers and roots of any given positive number

AC 1.7 Manipulate algebraic expressions

- Substitute numerical values into formulae and expressions, including scientific formulae; change the subject of a formula, where the subject appears only once
- Simplify, change the form of and evaluate algebraic expressions by:
  - collecting like terms
  - multiplying a single term over a bracket
  - taking out common factors
  - expanding products of two or more binomials

Learning outcome 2: Be able to use simple graphs

AC 2.1 Apply the basic principles of graphical representation

- Know about axes, grid lines, origin, scales; working with coordinates in all four quadrants; identify constant, linear, quadratic, cubic and trigonometric functions, straight-line graphs in the coordinate plane (use the form $y = mx+c$)
- Find the equation of the line through two given points or through one point with a given gradient; identify gradients and intercepts of linear functions graphically and algebraically

AC 2.2 Extract data from graphs used in engineering

- Interpret graphs, including graphs of linear functions, quadratic and trigonometric functions
- Interpret graphs of non-standard functions in real contexts to find approximate solutions to problems such as simple kinematic problems involving distance, speed and acceleration
- Calculate or estimate gradients of graphs and areas under graphs and interpret results in cases such as distance-time graphs, velocity-time graphs, ICAO temp/altitude, fuel data, engine performance

Learning outcome 3: Be able to use different units in engineering problems

AC 3.1 Solve problems using equations of motion, force, work, power and energy

- State base units and symbols for: time, length, mass; state and use derived units and associated formulae for: speed, velocity, acceleration, force, work, power and energy
- Know the difference between speed, velocity and acceleration; know and use the relationship between average speed, distance moved and time; average speed = distance moved/time taken
- Know and use equations of motion:
  - $a = \frac{v-u}{t}$; $v = u + at$; $v^2 - u^2 = 2as$; $s = \frac{1}{2}(u + v)t$; $s = ut + \frac{1}{2}at^2$
  - use the equation: Force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2), $F = m \times a$
- Use the relationship between work, force and distance moved in the direction of the force: work done = force × distance moved; $W = F \times d$; know that work done is equal to energy transferred; describe power as the rate of transfer of energy or the rate of doing work; power = work done/time taken;

  $P = \frac{W}{t}$; carry out simple calculations
- Know and use the relationship: gravitational potential energy = mass × acceleration due to gravity × height; $GPE = m \times g \times h$; know and use the relationship: kinetic energy = $\frac{1}{2}$ × mass × velocity squared $KE = \frac{1}{2} \times m \times v^2$

AC 3.2 Solve problems involving imperial, US customary and SI units

- State the meaning of prefixes used with SI units: state the meaning of prefixes and identify symbols for micro, milli, kilo, mega; convert between prefixes using both positive and negative indices; state the imperial units and representative symbols, including US gallons and US (short) ton; state US customary units used in aviation
- Convert between imperial, US customary and SI units:
  - imperial: inch, foot, yard, mile, stone, pound, ounce, tonne, square foot, cubic inch, cubic foot, fluid ounce, pint, gallon, mile per hour, horsepower
  - US customary: US fluid ounce, US fluid pint, US quart, US gallon, US (short) ton, US ounce, US pound, hundredweight; foot-pound force, Fahrenheit
  - SI units: kilometre, metre, centimetre, millimetre, kilogram, gram, square metre, cubic metre, litres, metre per second, metre per second per second, newton, joule, watt, kelvin

Learning outcome 4: Know the nature of matter

AC 4.1 Describe the structure of atoms

- Know that atoms consist of a central nucleus, composed of protons and neutrons, surrounded by electrons, orbiting in shells; know the meaning and representation of the terms 'atomic number', 'mass number' and 'relative atomic mass', the relative charge and relative mass of a proton, a neutron and an electron; know that atoms contain equal numbers of protons and electrons

AC 4.2 Explain concepts of chemical elements

- Define 'element'; know about elements as metals or non-metals according to their position in the Periodic Table; know how elements are different from one another – know that the Periodic Table is an arrangement of elements in order of atomic number; elements are arranged in the Periodic Table in order of increasing atomic number, in rows called periods; elements with similar properties are placed in the same vertical column – these columns are called groups
- Understand basic element structure – deduce the electronic configurations of the first 20 elements from their positions in the Periodic Table and in the form 2.8.1; understand the connection between the number of outer electrons and the position of an element in the Periodic Table; understand why elements in the same group of the Periodic Table have similar chemical properties

AC 4.3 Explain concepts of chemical compounds

- Define molecule, compound, mixture; use the Periodic Table to recognise elements and formulae of simple compounds

Chemical bonds

- Ionic compounds: describe the formation of ions by the gain or loss of electrons; understand ionic bonding as a strong electrostatic attraction between oppositely charged ions; understand the relationship between ionic charge and the melting point and boiling point of an ionic compound
- Covalent substances: describe the formation of a covalent bond by the sharing of a pair of electrons between two atoms; understand covalent bonding as a strong attraction between the bonding pair of electrons and the nuclei of the atoms involved in the bond; understand that substances with simple molecular structures are gases or liquids, or solids with low melting points; explain the high melting and boiling points of substances with giant covalent structures in terms of the breaking of many strong covalent bonds
- Metallic crystals: understand that a metal can be described as a giant structure of positive ions surrounded by a sea of delocalised electrons; explain the electrical conductivity and malleability of a metal in terms of its structure and bonding

AC 4.4 Describe the three 'classical' states of matter

- Solid, liquid and gas:
  - know the arrangement, movement and energy of the particles in each of the three states of matter
  - know how the interconversions of solids, liquids and gases are achieved and recall the names used for these interconversions; explain the changes in arrangement, movement and energy of particles during these interconversions

Learning outcome 5: Know principles of statics

AC 5.1 Explain forces, moments and couples

- Forces and stress: be able to apply the formulae force ($F = ma = mg$), mass/weight relationship ($W = mg$); understand the vector representation of forces, moments and couples using simple diagrams
- Apply these principles to simply supported beams (weight of beam, concentrated load, uniformly distributed load, reactions); understand that the upward forces on a light beam, supported at its ends, vary with the position of a heavy object placed on the beam

AC 5.2 Make calculations involving forces, moments and couples

(Using SI units only)

- Force: be able to interpret free-body force diagrams to represent forces on a particle or on a rigid body; carry out calculations for force, moments, couples; be able to use the equation for the moment of a force: moment of force = Fx where x is the perpendicular distance between the line of action of the force and the axis of rotation
- Know and use the principle of moments for a simple system of parallel forces acting in one plane; be able to use the concept of centre of gravity of a body and apply the principle of moments to a body in equilibrium

AC 5.3 Explain stress, strain, elasticity, compression, shear, tensile and torsion

- Define and explain the basics of: stress, strain, elasticity, compression, shear, torsion; be able to use the Hooke's law equation, $F = kx$, where k is the stiffness of the object; understand that the initial linear region of a force-extension graph is associated with Hooke's law; explain elastic behaviour as the ability of a material to recover its original shape after the forces causing deformation have been removed
- Be able to use the relationships:
  - (tensile/compressive) stress = force/cross-sectional area
  - (tensile/compressive) strain = change in length/original length
  - Young's modulus = stress/strain; be able to interpret force-extension and force-compression graphs; understand the terms limit of proportionality, elastic limit, yield point, elastic deformation and plastic deformation and be able to apply them to these graphs

Learning outcome 6: Understand principles of kinetics

AC 6.1 Explain basic principles of rotational movement

- Explain and apply basic principles of uniform circular movement; be able to express angular displacement in radians and in degrees, and convert between these units; understand what is meant by angular velocity and be able to use the equations: $v = \omega r$ and $T = 2\pi/\omega$
- Centrifugal/centripetal acceleration; be able to use the equations: $a = v^2/r = r\omega^2$
- Understand that a resultant force (centripetal force) is required to produce and maintain circular motion; be able to use the equations for centripetal force: $F = ma = mv^2/r = mr\omega^2$; carry out calculations involving rotational motion

AC 6.2 Explain basic principles of periodic motion

- Explain and apply basic principles of periodic motion:
  - define pendular movement; be able to use the equation for a simple pendulum $T = 2\pi \sqrt{l/g}$
  - understand the simple theory of:
  - vibration
  - harmonics
  - resonance

Learning outcome 7: Understand principles of dynamics

AC 7.1 Explain principles of dynamics involving heat

- Explain and use the basic principles: energy transfers from one place to another by conduction, convection, radiation; units – joule(J) as the unit of energy, watt (W) as the unit of power; be able to use the equations relating power, time and energy transferred or work done $P = \frac{E}{t}$; and $P = \frac{W}{t}$
- Efficiency: be able to use the equations:
  - efficiency = useful energy output/total energy input
  - efficiency = useful power output/total power input

AC 7.2 Explain gyroscopic principles

- Explain the purpose of a gyroscope and its application in aircraft; understand the function of component parts of a basic gyroscope (including spinning mass, gimbals); explain safety precautions for working with gyroscopic equipment

AC 7.3 Explain properties of simple mechanical systems

- Explain and use basic lifting system principles: velocity ratio, mechanical advantage, efficiency; carry out calculations involving simple mechanical systems
- Understand coefficient of friction, static and dynamic friction; be able to use the formula $F = \mu R$

Learning outcome 8: Understand principles of fluid dynamics

AC 8.1 Explain properties of solids, liquids and gases

- Know about the basic properties including shape, viscosity, volume, compressibility; be able to use the equation density = m/V; know the difference between density and specific gravity; know that barometers measure pressure
- Explain pressure, buoyancy and upthrust in liquids; be able to use the relationship upthrust = weight of fluid displaced; be able to solve problems involving pressure at depth in a fluid; use the relationship: $P = \rho gh$
- Effects of compressibility in a fluid:
    - explain basic principles (water is incompressible and gases are compressible); understand that the pressure at a point in a fluid which is at rest acts equally in all directions; qualitative effects of contaminants (corrosion, cavitation, foaming, sludges and gel, decomposition)

AC 8.2 Explain the Venturi effect

- Understand that there is a reduction in fluid pressure when a fluid flows through a constricted section of pipe; understand Bernoulli's principle that the air pressure in a tube goes down when the velocity of the air in the tube increases; simplified form of Bernoulli's equation: static pressure + dynamic pressure = total pressure; understand how the Venturi effect and the Bernoulli principle are used in engineering design (hydraulics, pneumatics, carburation, pitot)

Learning outcome 9: Know properties of the Earth's atmosphere

AC 9.1 Describe the relationship between the three main temperature scales (Fahrenheit, centigrade and kelvin)

- Know why there is an absolute zero of temperature which is -273 degrees centigrade; describe the kelvin scale of temperature and be able to convert between the kelvin and Celsius scales; know that an increase in temperature results in an increase in the average speed of gas molecules; know that the kelvin temperature of the gas is proportional to the average kinetic energy of its molecules
- Describe the qualitative relationship between pressure and kelvin temperature for a gas in a sealed container; use the relationship between the pressure and kelvin temperature of a fixed mass of gas at constant volume: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$; use the relationship between the pressure and volume of a fixed mass of gas at constant temperature: $P_1V_1 = P_2V_2$

AC 9.2 Describe the composition and structure of the Earth's atmosphere

- Percentages of gases: know that dry air contains 78% nitrogen, 21% oxygen, 0.9% argon, 0.04% carbon dioxide, and small amounts of other gases. Air also contains water vapour, approximately 1% at sea level, and 0.4% over the entire atmosphere; know about the layers of the atmosphere: exosphere, thermosphere, mesosphere, stratosphere, troposphere

AC 9.3 Explain how pressure, density and temperature vary with altitude

- Understand pressure, density and temperature variations in the different layers of the atmosphere; know that density is calculated from measurements of temperature, pressure and humidity; understand ISA graphs showing temperature and pressure variations at different altitudes; explain and illustrate the relationship between atmospheric pressure, absolute pressure and differential pressure using simple examples; explain the need for a standard atmosphere; understand standard measurements, particularly of altitude; standardisation of instruments/displays, engine performance

Summary of assessment

This unit is externally assessed using two onscreen tests as follows:

Test 1: Mathematics for Engineering

This is based on learning outcomes 1 to 3. The test lasts for 70 minutes and has 60 marks.

Test 2: Science for Engineering

This is based on learning outcomes 4 to 9. The test lasts for 70 minutes and has 50 marks.

The questions in both tests will be predominantly multiple choice, where the learner will be required to select the correct response to a question from one of four options. The question may be supported with a picture and the options may be in the form of pictures or text. Other formats may include multiple-response questions – where learners will be required to select two from five options; process, order, drag and drop – where learners will be required to drag and drop the stages of a process into the correct order; line matching, linking two from five options and filling in the blank (numerical), where the learner will enter a numerical answer. There will be no videos or sound. Where appropriate, questions in both tests may contain diagrams, graphics or graphs. Each test item will have an accessibility panel that allows a learner to zoom in and out and apply a colour filter. Test items will sample the amplification provided for each targeted criteria, this will include the indicative demand identified within the text.

Pearson sets and marks the tests. The assessments are available onscreen.

In order to pass this unit learners must achieve a pass in both of the tests. No compensation will apply across the two assessments for the unit.

A pass grade will be determined by learners achieving a defined pass mark for both onscreen tests.

Learners may use a non-programmable calculator for both tests.

Learners will be allowed to use rough paper for working.

A formula sheet will be provided for both tests.

Resources

Learners will need electronic scientific calculators.

Suggested reading/resources

Books

Bird J – *Engineering Mathematics Seventh Edition* (Routledge, 2014)
ISBN 9780415662802

Bird J – *Basic Engineering Mathematics Sixth Edition* (Routledge, 2014)
ISBN 9780415662789

Bird J – *Science for Engineering Fifth Edition* (Routledge, 2015)
ISBN 9781138826885

Bolton W – *Engineering Science Sixth Edition* (Routledge, 2015)
ISBN 9781138828933

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Student Book* (Pearson, 2010) ISBN 9781846907241

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907265

Fuller A, Greer A, Taylor G W – *BTEC National Mathematics for Technicians* (Nelson Thornes, 2004) ISBN 9780748779499

Stroud K.A. – *Engineering Mathematics 7th Edition* (Industrial Press Inc., 2013)
ISBN 9780831134709

Tooley M and Dingle L – *BTEC National Engineering 3rd Edition* (Routledge, 2010)
ISBN 9780123822024

Journal

New Scientist	Reed Business Information

Websites

www.freestudy.co.uk	Engineering Council open learning tutorials
www.nationalstemcentre.org.uk	Science, mathematics and engineering learning resources

Unit 5: Business Improvement Techniques

Level:	**2**
Unit type:	**Mandatory**
Guided learning hours:	**50**
Assessment type:	**Internal**

Unit introduction

Engineers need knowledge of business improvement techniques to ensure that they are working efficiently and effectively and to support organisations in ensuring they are competitive in a continuously changing business climate.

In this unit, you will gain knowledge of continuous improvement techniques from their application in the workplace. This will include improving quality and safety, reducing waste and cost, and investigating the improvement cycle. You will also gain an understanding of what is meant by workplace organisation, the effects of being unorganised and the benefits of being organised. You will learn about visual management as a business improvement technique. Finally, you will develop an understanding of problem-solving techniques.

As a future engineer, you will need an understanding of the role of business improvement techniques in the workplace environment.

Learning outcomes

In this unit you will:

1. Know what is meant by continuous improvement
2. Understand what is meant by workplace organisation
3. Know what is meant by visual management
4. Understand problem-solving techniques.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know what is meant by continuous improvement
Benefits • Reduced cost, e.g. production • Improved quality, e.g. reduced defects • Improved safety, e.g. safe to use • Improved working practices, e.g. reduced operator motion • Improved delivery, e.g. reduced transportation time, reduced lead time • Reduction of waste, e.g. over processing, excess inventory • Resource utilisation, e.g. reduced waiting time • Improved customer satisfaction, e.g. meeting customer requirements **Categories of work** • Value added • Non-value added • Waste **Categories of waste** • Transport • Inventory • Motion • Waiting • Overproduction • Over processing • Defects • Skills/unrecognised people potential
Learning outcome 2: Understand what is meant by workplace organisation
Unorganised work environment effects • Poor quality • Increased costs • Reduced efficiency • Poor delivery times • Poor morale/teamwork • Poor health and safety

Learning outcome 3: Know what is meant by visual management

Good visual management benefits, e.g.

- Accurate and relevant
- Eye-catching
- Simple
- Greater ownership

Types of visual management, e.g.

- Shadow boards
- PDCA worksheets
- Colour coding
- Floor footprints
- Storyboards
- Gauges
- Photographs/pictures
- Labelling
- Lights
- Schedule boards
- Kanban (pull systems)
- Graphs
- Management boards
- Other area-specific types of visual management

Learning outcome 4: Understand problem-solving techniques

Techniques, e.g.

- Tally charts
- Flow charts
- Histogram/Pareto chart
- Benchmarking
- Process mapping
- Correlation diagram
- Run diagram
- Statistical process control
- Control charts
- Gantt charts
- Root cause paths
- Value stream maps
- Ishikawa diagrams (cause and effect, fishbone)
- Brainstorming
- Mind mapping
- 5 Why analysis

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Know what is meant by continuous improvement		
P1 Explain the meaning of continuous improvement		
P2 Outline the benefits of applying continuous improvement techniques	M1 Describe the consequences of not following a structured approach when applying continuous improvement	
P3 Define each stage of the Plan – Do – Check – Act (PDCA) improvement cycle		
P4 Define the three categories of work: o Value added o Non-value added o Waste	M2 Describe the methods used for increasing Value added, Reducing Non-Value added and reducing waste	D1 Explain the long-term consequences if the three categories of work are not taken into account when carrying out a continuous improvement activity
P5 Define the different categories of waste		

Learning outcome 2: Understand what is meant by workplace organisation		
P6 Explain the meaning of workplace organisation		
P7 Outline the benefits of having an organised working environment	M3 Explain the methods that can be used to improve workplace organisation and the consequences an unorganised work environment may have	D2 Justify the methods for sustaining good workplace organisation
P8 Describe the effect an unorganised work environment may have		
P9 Explain the importance of Standard Operating Procedures (SOPs) within workplace organisation		
Learning outcome 3: Know what is meant by visual management		
P10 Explain the meaning of visual management		
P11 Describe the benefits of applying good visual management	M4 Explain the benefits of using different types of visual management, including examples of which types may suit specific situations	D3 Explain the consequences if visual management is not applied and kept up-to-date
P12 Describe different types of visual management		
Learning outcome 4: Understand problem-solving techniques		
P13 Explain what is meant by a problem within a work environment		
P14 Describe the benefits of solving work related problems	M5 Explain the benefits of using different techniques for identifying and analysing problems and benefits of methods used to stop problem reoccurrence	
P15 Outline different techniques used for identifying and analysing problems		
P16 Explain the importance of applying the appropriate corrective action and eliminating the root cause of a problem		D4 Explain the consequences if the root cause of a problem is not found

Tutor guidance

Required resources

The resources needed for this unit are:

- the internet
- case studies on business improvement techniques.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know what is meant by continuous improvement

Learning outcome 2: Understand what is meant by workplace organisation

Assignment title: Continuous improvement in the workplace organisation

For distinction, learners will need to give reasons for their conclusions about the possible consequences for an organisation of not taking into account the three categories of work, for example losing competitive edge, reduction in profit margin and loss of valued customers. Learners will need to give valid reasons to support the methods for sustaining good workplace organisation.

For merit, learners will need to use their knowledge of the pass criteria to give the consequences of not following a structured approach, for example not comparing the actual results against defined targets in the checking stage. Learners will give features and information about methods of reducing waste and investigate an organisation's processes, rules and techniques that can be adapted to add value or reduce non added-value. This could be completed by use of a case study and presented in a table. Learners will need to provide clear details of, and reasons for, methods to improve workplace organisation and the possible consequences of an unorganised workplace. This could be presented in a table.

For pass, learners will need to give clear details of and conclusions about the overall process of continuous improvement within an organisation. They will need to outline the relevant features of at least four benefits. Learners will need to scope the meaning of the Plan-Do-Check-Act cycle of continuous improvement. This could be presented as a relevant labelled Deming circle/cycle. They will then need to scope the meaning of the three categories of work and categories of waste. Learners will need to give an example of workplace organisation and detail its overall purpose of providing a product or service, its aims and culture, and the functions of its departments/divisions. This can be presented as a detailed, relevant labelled diagram/chart.

This can be expanded to include the relevant features of working in both an organised and unorganised working environment. For example, working where there is high or poor morale or where there is a good or poor health and safety record, in organised and unorganised environments respectively. Learners will also need to give reasons for the importance of following standard operating procedures (SOPs). For example, producing good quality products, or maintaining health and safety procedures.

Learning outcome 3: Know what is meant by visual management

Assignment title: Visual management

For distinction, learners will use their knowledge and understanding, from the pass and merit level criteria of visual management effectively to give valid reasons for the possible consequences when visual management is not applied effectively and kept up to date. This could be completed by the use of a case study.

For merit, learners will need to identify different types of visual management and evidence their benefits, for example the benefit of using floor footprints is that they give directions, provide a safe environment and are suitable where there is a lot of machinery and movement of vehicles in a busy workshop. This could be completed by the use of a valid case study.

For pass, learners need to detail what visual management is, giving a minimum of four reasons as to why applying it can be a benefit to an organisation, e.g. using improved communication techniques to increase efficiency and effectiveness. They must also give the features of a minimum of six different types of visual management.

Learning outcome 4: Understand problem-solving techniques

Assignment title: Problem-solving techniques

For distinction, learners will use their knowledge and understanding, from the pass and merit criteria, of problem solving effectively to give valid reasons for the possible consequences if the root cause of a problem is not found. This could be completed by the use of a case study

For merit, learners need to identify different problem-solving techniques, for example the benefit of using a Gantt chart is that is allows for identification and analysis of where a problem is occurring in the workplace schedule of a project, and its continued use can prevent the problem reoccurring.

For pass, learners need to provide a reasoned view of what is meant by a problem, giving an example of a workplace problem such as lack of effective communication from directors to senior management. This can be expanded to include relevant features of the benefits of solving work-related problems, and a summary of at least eight different techniques used to identify and solve workplace problems. Learners will need to give valid reasons for the importance of taking corrective action and removing the root cause of problems.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know what is meant by continuous improvement **Learning outcome 2** – Understand what is meant by workplace organisation	Continuous improvement in the workplace organisation	You have been asked to produce some introductory exemplar training materials for new recruits on how your department works towards continuous improvement.	A written report to include case studies, tables, labelled diagrams/charts, Deming cycle.
Learning outcome 3 – Know what is meant by visual management	Visual management	You have been asked to prepare materials for new employees on the types and benefits of visual management.	A written report to include case studies, and tables.
Learning outcome 4 – Understand problem-solving techniques	Problem-solving techniques	You have been asked to lead a tutorial with new engineers on the use of problem-solving techniques.	A written report to include case studies, tables, labelled diagrams/ bar charts, visual techniques and Gantt charts.

Suggested reading/resources

Books

Boyce A, Cooke E, Jones R, Mantovani B, Roberts D and Weatherill B – *BTEC Level 3 National Engineering Student Book* (Pearson, 2010) ISBN 9781846907241

Sayer N J and Williams B – *Lean for Dummies* (Wiley & Sons, 2012) ISBN 9781118117569

Swanson A R – *Analysis for Improving Performance* (Berrett-Koeler, 2007) ISBN 9781576753415

Womack J and Jones D – *Lean Thinking, 2nd Edition* (Free Press, 2006) ISBN 9780743249270

Websites

Business Education (Learning Zone)	www.Bized.co.uk
Deming Cycle	www.balancedscorecard.org/Resources/Articles-White-Papers/The-Deming-Cycle
Institute of Engineering and Technology	www.theiet.org/resources/
Introduction to BITs	www.youtube.com/watch?v=AKSMLe-louc
PDCA cycle	www.mindtools.com/pages/article/newPPM_89.htm
Problem-solving techniques	www.problem-solving-techniques.com/
Standard Operating Procedures	www.sop-standard-operating-procedure.com/
Team roles and leadership	www.businessballs.com
TES Business Management	www.tes.co.uk/teaching-resources/
The Times 100 Case Studies	www.thetimes100.co.uk
Visual management	www.youtube.com/watch?v=eyGIP5o1CoU

Unit 6: Principles of Aircraft Propulsion

Level:	**2**
Unit type:	**Optional**
Guided learning hours:	**60**
Assessment type:	**Internal**

Unit introduction

Have you ever wondered how aircraft are able to fly such long distances and at such speed? The answer lies in the advanced propulsion technology used in aircraft engine design.

In this unit, you will learn about different engine designs and how the different sections of gas turbine and piston engines combine to allow power to be generated. You will also learn about propeller design and how this has an impact on, for example, helicopter flight. In addition to the design of engines and propellers, there are different effects and factors that influence how aeroplanes, helicopters, gyros etc. are able to fly. You will explore these factors in this unit. The aerodynamic principles that allow aircraft to stay in the air, generate lift and maximise fuel efficiency are key and you will explore them in this unit.

Learning outcomes

In this unit you will:

1. Understand the principles of aircraft gas turbine engines
2. Understand the operation of gas turbine engines
3. Know the principles of aircraft piston engines and their performance
4. Know the construction of aircraft piston engines
5. Understand propeller theory
6. Know the aspects of rotary wing aerodynamics.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Understand the principles of aircraft gas turbine engines
Need for gas turbine propulsion • Limitations of a piston engine • Requirement to fly high and fast • Fuel economy • Power **Motion and energy** • Newton's Third Law of Motion • Force • Work • Power • Energy • Acceleration **Shaped ducts** • Inlet • Convergent and divergent ducts • Intake design: e.g. pod, side, bifurcated, wing root, bellmouth, variable geometry, chin • Intake, S-duct **Effect shaped ducts have on gas flows** • Velocity • Temperature • Acceleration • Intake anti-icing **Constructional arrangement of turbojet, turbofan, turboshaft and turboprop engines** • Compressor • Combustion • Turbine • Exhaust • Engine spools • Gearboxes, including output drives • Propellers and rotors

Learning outcome 2: Understand the operation of gas turbine engines

Operation

- Compressor section
  - purpose
  - axial flow compressor
  - centrifugal compressor
  - single, twin and multi spool compressors
  - rotors
  - stators
  - airflow
- Combustion section
  - purpose
  - typical materials
  - combustion chambers
  - air/fuel ratio
- Turbine section
  - purpose
  - materials
  - LP and HP turbines
- Exhaust section
  - purpose
  - jet pipe/exhaust unit/propelling nozzle
  - noise suppression
  - reverse thrust
  - thrust augmentation
- The main gas turbine engine types
  - the Brayton cycle
  - turbojet
  - turboprop
  - turboshaft
  - bypass (fan) engine
  - torque producing engines
  - thrust producing engines
  - engine rating and factors affecting performance

Learning outcome 3: Know the principles of aircraft piston engines and their performance

Measuring efficiency of a reciprocating engine

- Description and simple calculations for the following efficiencies:
  - thermal: e.g. the ratio of work done to fuel used, expressed in heat or work units
  - mechanical: e.g. the ratio of power developed by expanding gas in the cylinders to the power delivered to the output shaft
  - volumetric: e.g. the volume of fuel/air charge (temperature and pressure corrected) compared with the total piston displacement of the engine (expressed as a percentage)

Operating principles of different types of reciprocating engine

- Top dead centre (TDC), bottom dead centre (BDC), clearance
- Volume, bore, stroke, swept volume, firing order, ignition timing, valve timing, 'heat engine', 'reciprocating engine'
- Methods of ignition (spark and compression), arrangement of each
- The Otto cycle – events during induction, compression, power and exhaust strokes
- Requirements for an engine suitable for aircraft: e.g. reliability, durability, maintainability, compactness, high power/weight ratio, high specific power output, fuel economy, low vibration, flexibility, cost

Different engine configurations and their firing order

- Basic layout of in-line, vee and opposed engines
- Importance of numbering cylinders and different
- Manufacturer conventions for similar engines
- Firing order in different engine configurations
- Effect of the number of cylinders on smoothness of running

Factors affecting engine power

- Icing
- Altitude
- Temperature
- Ram air
- Barometric pressure
- Humidity
- Manifold pressure
- Brake specific fuel consumption (BSFC) and calculate from given data

Fuel/air mixture

- Approximate fuel/air ratios:
  - rich best power mixture
  - lean best power mixture
  - cruise power mixture
  - 'Stoichiometric' mixture
- Effects of varying mixtures at different power settings
- Causes of pre-ignition, backfire etc.

Learning outcome 4: Know the construction of aircraft piston engines

Construction and assembly, testing and function of the crank case and its contents

- Constructional features, function, classification, materials of items including: crank shaft, cam shafts, sumps, counterweights, vibration dampers, ball bearings (including thrust bearings, representative plain and roller bearings, oil seals)
- Typical defects to be found in the above, with causes and corrective action
- Routine inspection and replacement of seals, packing and gaskets
- Routine inspection of crankshafts and measurement of run-out
- Maintenance of magnesium castings
- Torque loading of components

Construction, assembly and function of accessory gearboxes

- Purpose
- Typical design
- Components
- Lubrication
- Location
- Fitting
- Operation
- Maintenance
- Routine inspection
- Typical defects, causes and corrective action

Construction, assembly, testing and function of cylinders, pistons and connecting rod assemblies

- Constructional features, function, classification, materials of: pistons, gudgeon pins (fixed and floating), piston rings, cylinders, cylinder heads and connecting rods
- Typical defects associated with each of the above – routine inspection, detection, cause, corrective action
- Types of cylinder bore surface – rough, smooth, reasons for each, precautions when working with each, types of piston ring for each
- Maintenance of piston rings – gap measurement, adjustment
- Piston ring stagger – reasons
- Compression testing – equipment, methods, typical results, limits
- Removing and fitting cylinder assemblies
- Attachment of cylinder heads and bores

Construction, assembly, testing and function of inlet and exhaust manifolds

- Constructional features, function and materials of exhaust and inlet manifolds
- Attachment, gaskets and seals, routine inspection, typical defects, corrective action

Construction, assembly, testing and function of valve mechanisms

- Cam followers, push rods, inlet and exhaust valves sodium filled exhaust valves, seats, guides, springs, rocker assemblies, tappets (including hydraulic)
- Valve springs, fitting, number on each valve, prevention of binding
- Checking of valve for bowing of stems, pitting, glazing and chipping
- Valve clearances: purpose, procedure for checking and adjustment on engines with camshafts, effects of excessive valve clearance on valve timing and engine performance
- Typical defects, routine inspection, causes, corrective action associated with valves and their operating mechanisms

Construction, assembly, testing and function of propeller reduction gearboxes

- Purpose, construction, attachment to engine, propeller attachment, lubrication, routine inspection, typical faults, causes and corrective actions

Learning outcome 5: Understand propeller theory

Blade element theory

- General configuration: fixed and variable pitch
- Parts of the propeller, features of the blades
- Division of the blades into an infinite number of thin elements used to calculate total forces on the blade

Effects of varying blade angles, angle of attack and rotational speed on the propeller blade

- Coarse and fine pitch
- Combinations of rotational speed, blade angle and angle of attack in different phases of flight

Calculating propeller slip

- Geometric pitch and effective pitch

Learning outcome 6: Know the aspects of rotary wing aerodynamics

Terminology related to rotary wing aerodynamics

- Rotary wing flight: rotor blade architecture, production of lift by rotor blades considered as a spinning disc, control of lift and conversion into motion in vertical and horizontal planes, control of helicopter attitude and motion by altering rotor blade, rotor blade behaviour, e.g. flap up, flap down, coning, blade tip vortex
- Configurations of rotorcraft, e.g. autogyro, dual rotor, single rotor

Gyroscopic precision

- Application of basic gyroscope theory to a rotary wing aircraft
- Definition of gyroscopic precession and effect on a spinning mass, e.g. rotor blades

Torque reaction and directional control

- How torque is generated on helicopter with a single turning main rotor
- How dual rotor systems cancel out the torque
- Different types of anti-torque system, e.g. variable pitch tail rotor, Fenestron (fan-in-tail), low pressure air duct producing a 'Coanda effect' lift force
- How directional control is achieved

Dissymmetry of lift, blade tip stall

- Definition of lift dissymmetry
- Cause, e.g. differential relative airflow across the main rotor disc in forward flight
- Effect on the aircraft without correction
- Designed-in corrective action, e.g. flap up and flap down
- Effect of increasing forward speed leading to retreating blade tip stall
- Limiting effect on top speed (VNE)

Translating tendency and its correction

- Definition of translation tendency (drift) in a hovering single rotor helicopter
- Counteracting translation tendency, e.g. tilting the main rotor mast, adjustment of flight control rigging, bias on the cyclic pitch control

Coriolis effect and its compensation

- Definition of the Coriolis effect (law of conservation of angular momentum)
- Effect on spinning rotor blades
- Effect on flight
- Counteraction measures, e.g. underslung rotor, dampers, blade twist

Ground effect

- Definition of ground effect and illustration of airflow through the rotor and underneath the aircraft

Vortex ring state, power settling, over-pitching

- Definition of vortex ring state (settling with power)
- Conditions under which it happens: e.g. low forward speed with high upflow into the rotor, descending exit from a ground effect hover, autorotation recovery
- Effects, e.g. loss of rotor efficiency, secondary vortex ring, uncommanded pitch and roll oscillations, little or no cyclic authority
- Corrective action, e.g. increase forward speed and/or partially lower the collective
- Definition of over-pitching

Autorotation and its effects

- Principles of autorotation, freewheeling unit, use of controls
- Autorotation with forward speed – blade regions
- Vertical autorotation – blade regions
- Effects of excessively high or low autorotation RPM

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Understand the principles of aircraft gas turbine engines		
P1 Explain the need for gas turbine propulsion		
P2 Describe how the laws of motion and energy apply to the operation of gas turbine engines		
P3 Describe shaped ducts and their effects on gas flows		
P4 Describe the constructional arrangement of turbojet, turbofan, turboshaft and turbo-prop engines	M1 Compare the power to weight ratio of each constructional arrangement of turbojet, turbofan, turboshaft and turbo-prop engines, giving justification for their use on various types of aircraft	
Learning outcome 2: Understand the operation of gas turbine engines		
P5 Describe the operation of a compressor section	M2 Explain the effects of the atmosphere (temperature, humidity, air pressure, density, atmospheric layers on the operation of each gas turbine engine section/type	D1 Compare the normal operating envelopes of each engine type (covers all of LO2 and LO3)
P6 Describe the operation of a combustion section		
P7 Describe the operation of a turbine section		
P8 Describe the operation of an exhaust section		
P9 Describe the operation of the main gas turbine engine types		

Learning outcome 3: Know the principles of aircraft piston engines and their performance		
P10 Describe the ways in which the efficiency of a reciprocating engine is measured	M3 Explain the effects of the atmosphere (temperature, humidity, air pressure, density, atmospheric layers) on the operation of each piston engine type	
P11 Describe the operating principles of different types of reciprocating engine		
P12 Describe what is meant by piston displacement and compression ratio		
P13 Describe different engine configurations and their firing order		
P14 Describe the factors affecting engine power		
P15 Describe fuel/air mixture and the effects of altering it		
Learning outcome 4: Know the construction of aircraft piston engines		
P16 Describe the construction and assembly, testing and function of the crank case and its contents		
P17 Describe the construction, assembly testing and function of accessory gearboxes		
P18 Describe the construction, assembly, testing and function of cylinders, pistons and connecting rod assemblies		
P19 Describe the construction, assembly, testing and function of inlet and exhaust manifolds		
P20 Describe the construction, assembly, testing and function of valve mechanisms		
P21 Describe the construction, assembly, testing and function of propeller reduction gearboxes		

Learning outcome 5: Understand propeller theory		
P22 Explain blade element theory		
P23 Explain the effects of varying blade angles, angle of attack and rotational speed on the propeller blade	M4 Explain the effects on fuel consumption and efficiency of flight with varying blade angles, angle of attack and rotational speed	
P24 Explain and calculate propeller slip		
P25 Explain the aerodynamic, centrifugal and thrust forces on a propeller		
P26 Explain the torque effect of a propeller	M5 Explain the effect of propeller torque on an aircraft on the ground and in flight	
P27 Explain the effect of relative airflow on a blade's angle of attack		
P28 Explain vibration and resonance produced by a propeller	M6 Explain how propeller-related vibration and resonance are monitored	D2 Explain how propellers are adjusted and balanced to minimise vibration

Learning outcome 6: Know the aspects of rotary wing aerodynamics		
P29 Describe terminology related to rotary wing aerodynamics		
P30 Describe the effects of gyroscopic precision		
P31 Describe torque reaction and directional control		
P32 Describe dissymmetry of lift, blade tip stall		
P33 Describe the translating tendency and its correction		
P34 Describe the Coriolis effect and its compensation		
P35 Describe ground effect	M7 Explain the impact of the ground effect on the speed and lift of an aircraft	D3 Explain the influence on aircraft design of the ground effect
P36 Describe vortex ring state, power settling, over-pitching		
P37 Describe the principles of auto-rotation and its effects		

Tutor guidance

Required resources

The resources needed for this unit are:

- aircraft propulsion system artefacts/models
- relevant standards and manufacturers information
- a learning centre/library
- the internet.

Visits to aerospace workshops/hangers would be advantageous in showing the construction and operation of aircraft propulsion systems and part systems/components.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Understand the principles of aircraft gas turbine engines

Learning outcome 2: Understand the operation of gas turbine engines

Learning outcome 3: Know the principles of aircraft piston engines and their performance

Learning outcome 4: Know the construction of aircraft piston engines

Assignment title: Aircraft engines

For distinction, learners could produce a conclusion to their presentation comparing the normal operating envelopes of each engine type described. This comparison should consider where gas turbine engines are used rather than aircraft piston engines, detailing the advantages and disadvantages for each. An indication of which types of aircraft use specific engines, and the reasons for this, could be incorporated into this comparison.

For merit, learners should go beyond the descriptions provided for the pass criteria by incorporating, within their presentations, a comparison of the power to weight ratio of each constructional arrangement of turbojet, turbofan, turboshaft and turboprop engines. This comparison could be presented in the form of a table, with values listed for each engine type. The comparative element should indicate why the engine with the best power to weight ratio is not selected for all engines and the reasons for this. Illustrations of how the engines are used in various types of aircraft would then allow learners to justify their use. Further use of the graphical techniques suggested for the pass criteria would allow learners to detail how each of the following atmospheric features (temperature, humidity, air pressure, density, atmospheric layers) has an effect on the operation of each gas turbine and piston engine section/type previously described.

For pass, learners could base their evidence on a visit to a factory, aerodrome, maintenance facility etc. They could produce a video, or construct a presentation. Learners could indicate that aircraft engines can be separated into two types – turbine and piston engines. They could then deliver a two-part presentation based on these types. The first part of the presentation should explain at least two reasons why gas turbine engines are required. Using appropriate illustrations, learners should consider the laws of motion and energy and give a clear description of how they apply to the operation of gas turbine engines. Learners could use a range of graphical means to support their presentation such as annotated photographs/models/illustrations/video clips. These should allow them to show how gas flows through a gas turbine engine, focusing on the effect of shaped ducts on this gas flow.

Graphical representations of gas turbine engines could also be used to allow learners to demonstrate how the compressor, combustion, turbine, and exhaust sections operate, as well as the constructional arrangements of turbojet, turbofan, turboshaft and turboprop engines. This part of the assignment could be completed with the help of additional annotated diagrams to describe the operation of the main gas turbine engine types.

The second part of the presentation could, once again, make use of annotated photographs/models/illustrations/video clips, this time of aircraft piston/reciprocating engine systems/components. These should allow learners to illustrate (with supporting description) ways in which the efficiency of these engines is measured, the operating cycles for different types, the terms piston displacement and compression ratio, the different engine configurations and firing order, and the factors affecting engine power and fuel/air mixture along with the effects of altering it. Similarly, appropriate graphical presentation techniques might be used to help learners show the construction and assembly and testing and function of the following: crank case and its contents, cylinders, pistons and connecting rod assemblies, inlet and exhaust manifolds, valve mechanisms, propeller reduction gearboxes, along with the construction, assembly and function of accessory gearboxes. With each of these graphical presentations learners would be expected to give a verbal description of what each illustration is showing in terms of how the parts are arranged, put together and operate.

Learning outcome 5: Understand propeller theory

Learning outcome 6: Know the aspects of rotary wing aerodynamics

Assignment title: Rotary wing technology

For distinction, learners could use existing/further graphical illustrations to help them explain how aircraft design features are influenced by ground effect, clearly showing the influence ground effect has on an aircraft and how design features help to counteract this. Where learners have used diagrams to indicate how vibration/resonance is produced by a propeller, a detailed verbal explanation of how these propellers are adjusted and balanced would be expected at distinction level.

For merit, learners could extend their explanations from the pass criteria to consider the effects on fuel consumption and efficiency of flight. Learners would be expected to provide detailed reasoning of how varying blade angles, adjustment of the angle of attack and rotational speed are key factors. This could be illustrated using a table of comparative fuel use, when different values of the above are in operation. Similarly, learners could reflect on the different effects of propeller torque when an aircraft is on the ground and in the air, again using comparative values. The use of monitoring techniques, for propeller-related vibration/resonance, could be explained with illustrations/explanations of instruments/techniques used. Similarly, the description of ground effect could be extended to consider the impact it has on the speed and lift of aircraft, with clear reasons why it has this effect.

For pass, learners could produce an illustrated report that allows the appropriate unit content to be addressed. Illustrations of propeller blades could be presented, allowing a detailed discussion, supported by detailed annotations, which explains blade element theory, and the effects of varying blade angles, angle of attack and rotational speed on the propeller blade. Calculations should be presented to help learners explain propeller slip and the torque effect of a propeller. Illustrations could also be used to help show the effect of relative airflow on a blade's angle of attack and the vibration and resonance produced by a propeller. These illustrations should allow the learner to give clear details of these effects. The report could contain a glossary of terminology related to rotary wing aerodynamics. Further illustrations could be used to allow all the relevant details to be shown and described; specifically the effects of gyroscopic precision, torque reaction, directional control, dissymmetry of lift, blade tip stall, translating tendency (and its correction), the Coriolis effect (and its compensation), ground effect, vortex ring state, power setting, overpitching and the principles of auto rotation (and its effects). Alternatively, each of the above could be represented in a table with a definition and illustration.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Understand the principles of aircraft gas turbine engines **Learning outcome 2** – Understand the operation of gas turbine engines **Learning outcome 3** – Know the principles of aircraft piston engines and their performance **Learning outcome 4** – Know the construction of aircraft piston engines	Aircraft engines	You have been asked to prepare a presentation, for aircraft designers, on the different types of propulsion technology available for small aeroplanes.	A presentation with annotated photographs Assessor observation record
Learning outcome 5 – Understand propeller theory **Learning outcome 6** – Know the aspects of rotary wing aerodynamics	Rotary wing technology	You have been asked by your manager to give an overview, to a team of workshop technicians, of the considerations when designing propulsion units for helicopters and other rotary wing aircraft.	An illustrated report with written responses and calculations

Suggested reading/resources

Books

Filippone A – *Flight Performance of Fixed and Rotary Wing Aircraft* (Butterworth-Heinemann Ltd, 2006) ISBN 9780750668170

Leyman D S – *A Simple Guide to Understanding Jet Engines* (EBB and Folks Enterprise, 2008) ISBN 9789834397500

Rolls Royce – *The Jet Engine* (Wiley-Blackwell, 5th Edition, 2015) ISBN 9781119065999

Websites

BBC Bitesize – marking out	www.bbc.co.uk/schools/gcsebitesize/design/resistantmaterials/processtechniquesrev2.shtml
Dynamic aerodynamics	www.dynamicflight.com/aerodynamics/
NASA – Introduction to propulsion	ww.grc.nasa.gov/www/k-12/airplane/bgp.html
Piston engines and turboprop engines	www.shorelineaviation.net/news---events/bid/50442/Piston-Engine-Aircraft-vs-Turboprop-Engine-Aircraft
Propulsion Systems: Basic Concepts	adg.stanford.edu/aa241/propulsion/propulsionintro.html

Unit 7: General Engineering Principles

Level: 2

Unit type: Optional

Guided learning hours: 60

Assessment type: Internal

Unit introduction

Have you ever wondered how aircraft are able to fly such long distances, in a range of extreme environments? The answer lies in the ability of skilled engineers to successfully select and use a range of materials that combine a number of factors, such as strength to weight ratio, low cost and availability. Engineering technicians need to be able to identify materials that are specified on engineering drawings and other documents. Some materials are identified easily, others are not so easy to tell apart. This is particularly true of the different grades of steel, polymers, composites, ceramics and alloys. Very often, an engineering technician has to select raw materials in the form of wire, bars, sheet, tube and plate. It is essential for engineering technicians to select the correct material if a product or a replaced component is to be fit for its intended purpose.

In this unit, will develop your knowledge of a range of common materials as well as their properties. You will learn about how these materials are used and describe how heat treatment has an impact on their performance. You will be expected to identify a range of ferrous, non-ferrous and non-metallic materials and know about the form in which they are obtained. You will also need to know about the properties that make individual materials suitable for particular tasks. This unit will help you to develop your knowledge of the different ways technical data is communicated, how this is presented and how information can be used to assist in the marking out and manufacture of components and assemblies. You will also gain knowledge of how components are manufactured by developing an understanding of work holding, tool types and tool holding. Finally, you will learn how IT/ICT is used in applications such as Computer Numerical Control (CNC).

Learning outcomes

In this unit you will:

1. Know how to select engineering materials
2. Understand the properties of materials and the effects of heat treatment
3. Know forms of communication used within engineering
4. Know the basic tools and techniques used in engineering
5. Know measurement and marking out techniques
6. Know about the types of Computer Numerical Control (CNC) machines and their uses.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know how to select engineering materials
Classifications, e.g. • Metallic (pure metals and alloys, ferrous and non-ferrous) • Non-metallic materials • Composites • Natural materials • Thermoplastics • Thermosetting plastics • Ceramics • Polymers • Smart materials **Materials, e.g.** • Low carbon/mild steel • High carbon steel • Stainless steel • Cast iron • Aluminium/aluminium alloys • Brass/brass alloys • Plastics • Composites **Factors** • Properties • Surface finish • Cost • Quantity • Processing requirements • Mode of delivery **Form of supply, e.g.** • Sheet • Plate • Bar • Wire • Section

- Extrusions
- Castings
- Wrought
- Forgings
- Pipe and tube
- Hot and cold rolled
- Ingots
- Pressings
- Other specific forms of supply

Learning outcome 2: Understand the properties of materials and the effects of heat treatment

Mechanical properties

- Density
- Manufacturability
- Strength (yield, tensile, fracture)
- Elastic limit
- Proportional limit
- Ductility
- Toughness
- Fatigue

Effects of heat treatment, e.g.

- Increase in property
- Decrease in property
- No change to property
- Hardening
- Softening

Heat treatment processes

- Tempering
- Annealing
- Normalising

Material properties

- Heat resistance
- Thermal and electrical conductivity
- Thermal and electrical insulation
- Wear resistance
- Corrosion resistance

- Load-bearing capacity
- Shear strength
- Weight
- Cost

Learning outcome 3: Know forms of communication used within engineering

Forms of communication

- Verbal
- Written
- Electronic
- Graphical

Conventions/layouts, e.g.

- Isometric
- Oblique
- First and third angle projection
- Other types of drawing (detail, assembly, circuit and wiring, block diagrams)
- Sketches

Types, e.g.

- Presentation
- Line types
- Abbreviations
- Hatching
- Symbols
- Sections

Uses of IT/ICT

- Computer Aided Design (CAD)
- Computer Aided Manufacture (CAM)
- Computer Numerical Control (CNC)
- Simulation packages
- Rapid prototyping/3D printing

Learning outcome 4: Know the basic tools and techniques used in engineering

Work and tool holding methods, e.g.

- Vices
- Clamps
- Jigs
- Fixtures
- Collets
- Chucks
- Sleeves
- Angle plates
- Mandrels

Tool types, e.g.

- Hand tools
- Turning tools, e.g. used for facing off, thread cutting, taper turning, drilling, boring
- Milling/routing tools, e.g. used for slot drilling, end milling, face milling, use of a rotary table

Basic crew thread forms

- Metric
- Imperial
- Other alternatives

Basic methods of work assembly

- Thermal
- Adhesive
- Mechanical

Learning outcome 5: Know measurement and marking out techniques

Sources, e.g.

- Engineering drawings
- Circuit drawings
- Sketches
- Work instructions
- Electronically-held data
- Data sheets
- Reference charts

Types, e.g.

- Rules
- Tapes
- Scribers and scribing blocks
- Squares
- DTIs
- Verniers
- Trammels
- Protractors
- Micrometers (metric and imperial)
- Surface plate
- Combination sets
- Roughness comparison gauges

Methods, e.g.

- Degreasing
- Bluing
- Deburring

Techniques, e.g.

- Using templates
- Using marking datum
- Hole centres
- Centre lines
- Angular and radial profiles

Aids to marking out, e.g.

- Marking out tables and plates
- Angle plates
- Parallel strips
- Vee blocks
- Jack screws
- Clamps
- Vices

Errors, e.g.

- Observation errors
- Recording errors
- Unit errors
- Calibration errors

Learning outcome 6: Know about the types of Computer Numerical Control (CNC) machines and their uses
CNC machine types: • 2-axis CNC lathe • Turnmill centre • Milling machine • Router • Machining centre

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Know how to select engineering materials		
P1 Describe different classifications of materials used within engineering applications		
P2 Describe the range of materials commonly used within engineering applications		
P3 Describe the factors that make materials suitable for different engineering applications	M1 Explain why different materials are suitable for different engineering applications based on their chemical composition, physical or mechanical properties	D1 Compare different materials and explain the advantages and disadvantages of each for different engineering applications
P4 Describe different forms of supply of engineering materials		
Learning outcome 2: Understand the properties of materials and the effects of heat treatment		
P5 Explain what is meant by the mechanical properties of materials		
P6 Describe different effects heat can have on the properties of different types of material	M2 Explain the benefits of applying heat treatment to some materials and which treatments would suit the material's properties	
P7 Explain why different properties make materials suitable for different engineering applications		

Learning outcome 3: Know forms of communication used within engineering		
P8 Describe the merits and limitations of different forms of communication		
P9 Describe basic drawing conventions/layouts	M3 Explain where and when different types of drawing conventions, layouts, lines, detailing and dimensioning would be used	D2 Justify their benefits within specific applications
P10 Describe different types of lines, detailing, and dimensioning		
P11 Outline how IT/ICT is applied within engineering		
Learning outcome 4: Know the basic tools and techniques used in engineering		
P12 Describe different work and tool holding methods and their applications within engineering	M4 Compare different work holding methods and a minimum of three different tool holding methods for each of the following: ○ Turning ○ Milling ○ Mechanical assembly	
P13 Describe tool types and their uses	M5 Compare different types of tool for each of the following: ○ Turning ○ Milling ○ Mechanical assembly	
P14 Outline the basic screw thread forms and their uses		
P15 Outline the basic methods of work assembly		

Learning outcome 5: Know measurement and marking out techniques		
P16 Describe the sources of information used in engineering to support marking out activities		
P17 Describe different types of measuring and marking out equipment commonly used		
P18 Describe surface preparation methods and the importance of surface preparation before marking out	M6 Explain the process for carrying out a measuring and marking out activity, including the tools and equipment used and the possible consequences if it is not carried out correctly	
P19 Describe different measuring and marking out techniques		D3 Compare different measuring and marking out techniques including supporting work pieces and explain the advantages and disadvantages of each
P20 Describe methods of supporting work pieces whilst measuring or marking out		
P21 Describe the errors that can occur when measuring and marking out		
Learning outcome 6: Know about the types of Computer Numerical Control (CNC) machines and their uses		
P22 Describe the differences between traditional and CNC machining techniques/machine tools	M7 Compare the machining techniques and the tools used for machining on different CNC machines, including the advantages and disadvantages of each for specific applications	
P23 Describe the key features and techniques of different types of CNC machine		D4 Justify the use of different CNC machines and techniques for the production of specific products or components
P24 Outline how different CNC machines are used to produce given products or components		

Tutor guidance

Required resources

The resources needed for this unit are:

- a workshop/laboratory with relevant material testing equipment
- heat treatment facilities
- engineering workshops including a range of manual machines (lathes, drilling machines, milling machines) and CNC/CAM facilities
- workshop tools, tool holding, work holding facilities, components, measuring instruments, hand and power tools, assembly facilities, marking out facilities
- engineering drawing facilities including CAD workstations/software
- relevant standards and manufacturers' information
- health and safety information and PPE
- a learning centre/library
- the internet.

Visits to engineering workshops would be advantageous in showing small-scale/batch/one-off production techniques.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know how to select engineering materials

Learning outcome 2: Understand the properties of materials and the effects of heat treatment

Assignment title: Material selection

For distinction, learners should consider at least three different engineering applications and produce a comparison of the use of different materials in each case, clearly outlining the advantages and disadvantages of each material, based on factors such as temperature, strength, weight etc. A tabular approach could be used.

For merit, learners should go beyond the description given in the pass criteria of the factors that determine the use of materials for specific applications by explaining why the specific chemical composition, physical or mechanical properties of their selected materials make them useful in the given application, for example why copper might be used in aircraft wiring. Similarly, they could extend their description of the effects of heat by explaining the key benefits of the heat treatment of specific materials, linking this to properties and explaining why enhancing/improving these properties is desirable in a specific engineering setting.

For pass, learners should describe a range of materials, along with their mechanical properties and classifications, using at least four different examples of each. For each of the materials identified, they should identify an engineering application. This could be related to aerospace, for example, use in jet engines, aircraft structural components, fly by wire applications . This could also be related to automotive applications, such as use in engines, braking systems, suspension components, car body panels etc. Learners should ensure that the factors, such as cost, surface finish, processing requirements etc., that make the selected material appropriate for these applications are described (at least three materials should be considered here). Learners should also consider and describe the form of supply for a range of engineering materials used in applications, ensuring that at least seven forms of supply are evidenced. Electrical conductors supplied in wire form or pipe work supplied in tubular form would be typical examples here. Finally, learners should describe the effect of heat and heat treatment on a selection of the materials identified, describing a minimum of three of these effects. The importance here is that learners can identify, for example, a heat treatment process that will make a material ductile and thus easy to bend and form; another example might be a requirement for a given material to have a hard surface and a related description of which heat treatment process could provide this for the material.

Learning outcome 3: Know forms of communication used within engineering

Assignment title: Engineering communication

For distinction, learners should justify the benefits of, for example, different types of drawing convention and layout in at least two specific engineering applications.

For merit, learners could go beyond the description given in the pass criteria of drawing conventions/layouts by explaining why a range of applications might require different drawing layouts/conventions to be used, for example the use of circuit diagrams to allow maintenance technicians to fault find and repair hydraulic/pneumatic/electrical systems. This should also include an explanation of where different lines, detailing and dimensions are used in specific applications, for example in component/assembly drawings.

For pass, learners should present the four different forms of communication with the positive (merits) and negative (limitations) aspects described for each. A tabular approach would be useful here. They should then describe five different drawing conventions and layouts. This could be extended by presenting a drawing of an engineering component, (this could be aerospace relevant), and describing different types of line, detailing and dimensioning technique used in the drawing. This drawing and/or other component drawings could be used as examples of how IT/ICT is used in engineering. Screenshots/images could be used to help outline at least three different software/hardware applications, as detailed in the unit content.

Learning outcome 4: Know the basic tools and techniques used in engineering

Learning outcome 5: Know measurement and marking out techniques

Learning outcome 6: Know about the types of Computer Numerical Control (CNC) machines and their uses

Assignment title: Engineering component manufacture

For distinction, learners should compare at least three of the different measuring, marking out and work piece support techniques used in the marking out of the given component/s. Learners could consider the advantages and disadvantages of each, for example the benefits and limitations of using 'marking blue', the importance of using surface plates, where and why Vee blocks are used.

Learners should justify the use of the three CNC machines identified previously with specific reference to the given component/s. This justification could compare the features of CNC machines with conventional machines and consider the ability to programme machines for specific parts/routines and save these programmes for future/repetitive use. Learners could link the use of ICT and CAD drawings with the ability to transfer the data straight from the CAD file to the CNC machine.

For merit, learners should go beyond the description given in the pass criteria of basic tools and techniques by comparing (for turning, milling and mechanical assembly) three different work holding methods for each (such as the use of an angle plate, four jaw chuck and three jaw chuck on a lathe), three different types of tool for each (such as a slot drill, end mill and face mill on a milling machine) and three different tool holding methods (such as a pneumatic nut runner, torque wrench and socket wrench for mechanical assembly). These should link to the component/s previously identified. Methods should be compared for turning, milling, and mechanical assembly. Similarly, learners should go beyond describing measuring and marking out by explaining the process and indicating the possible consequences if the process is not carried out correctly, for example parts not being machined/manufactured correctly. Photographic evidence, accompanied by a narrative of a complete marking out exercise, based on the given component/s could be used. When considering CNC machines, learners should compare machining techniques for specific applications. For example, why one CNC machine might be used for circular components (such as valve stems) whilst another might be used for machining turbine blades.

For pass, learners could consider component parts relevant to aerospace and describe the process of manufacture. The parts would need to be selected carefully to ensure that certain features/characteristics are present and allow all of the learning outcomes covered by this assignment to be addressed. Preferably, an assembly of parts, featuring basic screw threads, would be used. Evidence presented should start with a description of at least five sources of information that are used when marking out component parts. These descriptions should indicate how the information is presented (charts, tables, drawings) and how the sources are accessed. This could be followed with descriptions of how at least nine types of measurement and marking out tools/equipment are used. Descriptions of three methods of surface preparation and their importance should be given, and the use of at least four marking out techniques. Ideally, this could be evidenced through photographs of the learner carrying out appropriate measuring and/or marking out activities, with a description by the learner of the activities being carried out; typically this could be an annotation to each photograph indicating how the activity is carried out, what the tool looks like and how it is used. The learner should ensure that descriptions and evidence also cover at least five different methods of supporting work pieces during the measuring/marking out process. There should be further descriptions reflecting on the errors that can occur when measuring and marking out. Photographic evidence, preferably showing a step-by-step process, with appropriate annotation would be a useful approach. Learners should then consider the manufacture of the component parts describing the different work and tool holding methods and their application. The description should consider at least six methods (across both work and tool holding methods). Learners should consider at least three tool types used in the manufacture of the parts with appropriate descriptions of the tool and its operation in each case. This would be an ideal practical/workshop activity as learners could provide a step-by-step commentary of how they used different work holding and tool holding techniques for turning, milling and mechanical assembly, using photographs to support their description. To complete the description of how the parts are manufactured, learners should outline basic screw thread forms and the basic methods of work assembly. The use of an engineering assembly drawing to indicate both how work is assembled and how thread forms are represented could be used. Learners would be expected to demonstrate knowledge of metric, imperial and international thread forms here.

Learners should complete their evidence with a consideration of methods of manufacture. They should describe the difference between traditional and CNC machining techniques and machine tools, using annotated photographs. These photographs should allow learners to describe at least three types of CNC machine indicating the key features and techniques of each. Finally, learners could present a series of drawing/photographs of components such as parts from engines, structural components etc. The different features of these parts could be identified with an outline of the CNC machine required to produce that specific feature.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know how to select engineering materials **Learning outcome 2** – Understand the properties of materials and the effects of heat treatment	Material selection	You have been asked to consider the suitability of a range of materials and heat treatment processes for a range of engineering applications and present your findings to a group of designers who are planning the new design of a new aircraft.	A presentation with annotated photographs Assessor observation record
Learning outcome 3 – Know forms of communication used within engineering	Engineering communication	You have been asked by your manager to give an overview, to a team of workshop technicians, of methods of engineering communication.	A presentation with annotated screenshots/ images Assessor observation record
Learning outcome 4 – Know the basic tools and techniques used in engineering **Learning outcome 5** – Know measurement and marking out techniques **Learning outcome 6** – Know about the types of Computer Numerical Control (CNC) machines and their uses	Engineering component manufacture	Your manager has asked you to visit a local company that produces specialist engineering parts. You are required to report on its manufacturing process.	A written log with annotated photographs/ drawings/ illustrations Completed logbook Assessor observation record

Suggested reading/resources

Books

Boyce et al. – *BTEC Level 2 First Engineering Student Book* (Pearson Education, 2010) ISBN 9781846907234

Clarke et al. – *Engineering BTEC First in Engineering Student Book (Level 2 BTEC First Engineering*) (Pearson Education, 2013) ISBN 9781446902431

Websites

BBC Bitesize – marking out	www.bbc.co.uk/schools/gcsebitesize/design/resistantmaterials/processtechniquesrev2.shtml
BBC Bitesize – materials	www.bbc.co.uk/schools/gcsebitesize/design/resistantmaterials/
Health and Safety Executive	www.HSE.gov.uk
The Institute of Mechanical Engineers	www.imeche.org/
Marking out	www.davidneat.wordpress.com/2014/01/31/tools-for-measuring-and-marking-out/
Roymech – drawing	www.roymech.co.uk/Useful_Tables/Drawing/Drawing.html#drawing
Technology student	www.technologystudent.com/

Unit 8: Principles of Aircraft Electrics and Systems

Level: 2

Unit type: Optional

Guided learning hours: 60

Assessment type: Internal

Unit introduction

It is important for engineers in the aerospace industry to have a knowledge of aircraft electrics and systems, for example navigation systems, aircraft control circuits and human comfort systems.

In this unit, you will gain an understanding of fundamental electrical concepts with regard to static electricity, electrical terms and circuitry, Ohm's and Kirchoff's Laws, and methods of producing and storing electricity by the use of batteries and capacitors. You will then develop your knowledge of direct current power sources and machines, magnetism, the electromagnetic effect and the principles of alternating current.

Learning outcomes

In this unit you will:

1. Understand electrical concepts
2. Know about direct current power sources and machines
3. Know the principles of alternating current
4. Know about aircraft electrical devices and data transmission.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Understand electrical concepts

Electron theory
• Structure and distribution of electrical charges within atoms, molecules, ions and compounds
• Molecular structure of conductors, semi-conductors and insulators
Static electricity and conduction
• Static electricity and distribution of electrical charges
• Electrostatic laws of attraction and repulsion
• Units of charge
• Coulomb's Law
• Conduction of electricity in solids, liquids and gases, and in a vacuum
Static charge
• Static build-up
• How to prevent static build-up, e.g.:
  ○ conductive tyres
  ○ static wick dischargers
Electrical terms
• Potential difference
• Electromotive force (EMF)
• Voltage
• Current
• Resistance
• Conductance
• Charge
• Conventional current flow
• Electron flow
Ohm's law
• Series, parallel and series-parallel circuits
• Resistance circuits calculations
Current division calculation
• Calculation for DC circuits with varying resistances in combination calculations

Voltage drop

- Kirchhoff calculations:
  - $V = I\,R$ = voltage drop across any resistor, R
  - $V = \frac{V\,\text{total} \times R}{\text{R total}}$ = voltage drop for resistor R in series
  - V total, total voltage, is equal to the sum of all the voltage drops in the circuit (is equal to zero)

Electricity production methods

- Heat
- Light
- Friction
- Pressure
- Chemical action
- Magnetism
- Motion

Capacitors

- Purposes:
  - charge storage
  - smoothing
  - emergency power
  - DC block
  - resonant circuits
- Construction – role played by:
  - conductors
  - dielectric
  - area
  - description of permittivity
- Operation:
  - charge/discharge cycle
  - relationship between Q, C & V
  - time constant ($t = CR$)

Learning outcome 2: Know about direct current power sources and machines

Chemical action of primary and secondary cells

- Construction and basic chemical action
- Dry cells
- Lead acid cells
- Nickel-cadmium cells
- Other alkaline cells

Internal resistance

- Basic explanation of internal resistance
- Effect on battery performance

Magnetic field of a bar magnet

- Flux lines
- Direction
- Density

Magnetic characteristics of soft and hard iron

- Hysteresis loop
- Remanence
- Coercive field
- Relative permeability
- Demagnetisation quadrant

Uses of magnetic materials

- Permanent magnets
- Magnetic shielding
- Electromagnet formers

Current-carrying conductor in a magnetic field

- Single conductor and one field:
  - direction of current and effect on field direction
  - strength of current and effect on field strength

EMF production

- Definition of electromagnetic induction
- Effect on the induced EMF of:
  - number of coils
  - relative speed and direction of movement

Key components

- DC generators:
  - armature
  - magnets
  - commutator
  - brushes
- DC motors:
  - armature
  - magnets
  - commutator
  - brushes

Learning outcome 3: Know the principles of alternating current

Alternating current

- Features:
  - position of coil relative to magnetic field
  - waveform
  - direction of flow on graph axis
- Terms:
  - cycle
  - periodic time
  - peak value
  - peak-to-peak value
  - magnitude or amplitude
  - frequency
  - average value
  - RMS value
  - phase

Single-phase AC generator components

- 2-pole machine
- Rotating armature
- Rotating field
- Armature
- Magnets
- Slip rings
- Brushes

Learning outcome 4: Know about aircraft electrical devices and data transmission

Thermocouples

- Materials
- Construction
- Operation
- Use

Aircraft applications and uses of

- Variable resistors
- Potentiometers
- Rheostats

Data bus uses

- Data redundancy
- Weight saving
- Need for a complex controller

Fibre optic cable light transmission

- Encode
- Transmit (including internal reflection)
- Boost
- Decode

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Understand electrical concepts		
P1 Explain the difference between a conductor and an insulator		
P2 Explain static electricity and conduction	M1 Explain the implications of static build-up on aircraft surfaces	D1 Evaluate the contribution of methods to prevent static build-up to the overall safety of an aircraft
P3 Explain the build-up of static charge on an aircraft surface		
P4 Explain electrical terms		
P5 Perform calculations involving Ohm's law		
P6 Calculate current division through series and parallel stages in a network		
P7 Calculate voltage drop across series and parallel stages in a network		
P8 Describe ways in which electricity can be produced	M2 Compare the ways in which electricity can be produced in terms of cost and efficiency	
P9 Explain the purpose of a capacitor		
P10 Describe the construction of a capacitor		
P11 Explain the operation of a capacitor		

Learning outcome 2: Know about direct current power sources and machines		
P12 Describe the chemical action of primary and secondary cells	M3 Explain the uses of primary and secondary cells and their suitability for designated devices	D2 Evaluate the characteristics of the DC power source used by a selected device
P13 Explain the connection of cells and batteries in series and in parallel		
P14 Explain the internal resistance of a battery		
P15 Describe the magnetic field of a bar magnet		
P16 Describe differences in the magnetic characteristics of soft and hard iron		
P17 Describe properties and uses of hard and soft magnetic materials		
P18 Describe the interaction of a current-carrying conductor in a magnetic field		
P19 Explain the production of an EMF by the interaction of a permanent magnet with a coil		
P20 Describe the function of the key components of DC generators		
P21 Describe the function of the key components of DC motors		
Learning outcome 3: Know the principles of alternating current		
P22 Explain the term 'alternating current'		
P23 Describe commonly used terms related to alternating current	M4 Explain the relationship between a minimum of two terms listed in P23	
P24 Describe the functions of the key components of a single-phase AC generator	M5 Explain how the components combine to produce alternating current	D3 Evaluate the differences between AC and DC generators
P25 Explain the difference between single-phase and 3-phase waveforms		

Learning outcome 4: Know about aircraft electrical devices and data transmission		
P26 Describe thermocouples	M6 Explain the uses of thermocouples and photo-cells in aircraft	
P27 Describe the construction and operation of a photo-cell		
P28 Describe the operation, application and common uses in aircraft of variable resistors, potentiometers, rheostats		
P29 Explain why data buses are used in aircraft		
P30 Explain how light can be transmitted along a fibre optic cable	M7 Explain the advantages and disadvantages of fibre optic data transmission	

Tutor guidance

Required resources

The resources needed for this unit are:

- a physics or general laboratory to carry out electrical demonstrations and practical work
- health and safety information
- the internet
- a learning centre/library.

Facilities to watch YouTube clips of electrical fundamental concepts would be beneficial. Visits to an aerospace assembly plant to see the use of electrical wiring and electrical applications would be also advantageous.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Understand electrical concepts

Assignment title: Electrical concepts

For distinction, learners will give reasons and present conclusions as to how effective methods are used to prevent static build-up on an aircraft in the air or on the ground. They will support their answers with reference to case studies of incidents and accidents. Learners should support their evaluation by the use of clear, appropriately labelled diagrams.

For merit, learners will need to give valid reasons why static build-up on aircraft when flying causes, for example, radiofrequency interference or damage to navigation equipment. Learners will need to compare different forms of energy used to create electricity, for example comparing solar (light) with nuclear fuel (chemical). They could consider efficiency of production and find the cost per unit/kWh of electricity created by the different methods. The comparative results could be displayed in a table.

For pass, learners will, using diagrams, give appropriate reasons and features explaining why certain materials are conductors, semi-conductors and insulators in a solid, liquid or gaseous phase or in a vacuum. Explanations should include the structure and distribution of electrical charges within the atomic, ionic and molecular materials, for example metals, graphite, silicon/germanium, plastics and dry air. This can be expanded to include an explanation of static electricity, and how the charge builds on an aircraft's surface due to friction, when moving through the air at a high altitude. Learners should support their explanations by the use clear, appropriately labelled diagrams.

Learners may use the functions of electrical components and circuits to give valid explanations of common electrical terms such as potential difference, electromotive force and conventional current flow . This should be supported by the use of appropriately labelled circuit diagrams. This task can be expanded to include calculations involving Ohm's Law and Kirchoff's Laws. Learners will need to describe the features of, for example, transferring chemical energy into electricity using a battery or using the electromagnetic effect in wind turbines. Learners will need to provide clear details of the purpose of different types of capacitor from charge storage, by smoothing or evening out fluctuations, or for emergency power situations. They will also need to provide appropriately labelled diagrams to show how capacitors are constructed, giving the functions of the parts that make up the capacitor. This can be expanded to include how a capacitor operates using its capacitance C, the charge on each conductor and the voltage across the device.

Learning outcome 2: Know about direct current power sources and machines

Assignment title: Direct current power sources and machines

For distinction, learners will draw conclusions about the characteristics of a DC power source used by an aerospace device.

For merit, learners will need to give valid reasons why the functions of primary or secondary cells make them suitable for designated devices, using relevant labelled diagrams.

For pass, learners will need to describe the chemical actions at the anode and cathode in a primary and secondary cell. These descriptions should be supported by appropriately labelled diagrams. Learners will need to give clear details showing the connection of cells and batteries in a circuit when they are in series and when they are in parallel. To support their explanations learners will need to show the connection of cells and batteries using valid circuit diagrams and include calculations of the total voltage produced from the numbers of cells or batteries. This can be expanded to explain the appropriate factors that cause internal resistance in batteries. Learners should use the properties of hard and soft magnetic materials to give valid reasons as to what makes them suitable for appropriate applications in the aerospace industry. This can be expanded to show the differences in soft and hard iron characteristics and the uses of soft and hard irons. Learners should use labelled diagrams of a bar magnet to show the flux lines, their direction and density. Learners will use diagrams of the thumb and hand rules to describe the effect of current-carrying conductors in a magnetic field. They will need to define the electromagnetic effect and explain the effect of the number of coils and relative speed and direction of movement. Learners will then use this theory in describing the function of the key components in DC motors and generators, which will be supported by appropriately labelled diagrams.

Learning outcome 3: Know the principles of alternating current

Assignment title: Alternating current

For distinction, learners will use the features of AC and DC generators to draw up a table showing valid differences. Learners should use appropriate diagrams to support their evaluation.

For merit, learners will use their knowledge from the pass criteria to produce an appropriately labelled graph to show features of a relationship between two of the AC terms. Learners will show how the functions of the different components produce an alternating current.

For pass, learners will use a suitably labelled graph to explain alternating current and its features. Learners should use appropriately labelled diagrams to support their descriptions of the functions of the components of a single-phase AC generator and give reasons for the difference between a single-phase and three-phase waveform.

Learning outcome 4: Know about aircraft electrical devices and data transmission

Assignment title: Aircraft electrical devices and data transmission

For merit, learners will use the features and functions of thermocouples and photocells to explain their uses in the aerospace industry. Learners should use an appropriate table to detail the advantages and disadvantages of fibre optic data transmission.

For pass, learners will need to describe the features and operation of thermocouples and photo-cells, including appropriate uses such as a temperature sensor and producer of DC electricity. Learners need to use appropriately labelled circuit diagrams and/or diagrams to show features of variable resistors, rheostats and potentiometers, and their uses in aircraft such as in lighting and audio equipment. Learners will give valid reasons why data buses are used in the aerospace industry, such as the transferring of data between two computers. Learners will use an appropriately labelled diagram to show how light is transmitted down optic fibres and how this can be used for communication, including, for example, coding and decoding information.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Understand electrical concepts	Electrical concepts	You have been asked to prepare some materials to help new team members with basic electrical concepts and how they apply to aerospace.	A technical written report supported by annotated diagrams, circuit diagrams, flow charts, tables and problem-solving calculations.
Learning outcome 2 – Know about direct current power sources and machines	Direct current power sources and machines	As an electrical technician working on new aerospace projects you have been asked to produce a report on DC power sources and machines, to support new employees.	A technical written report supported by annotated diagrams, magnetic flux diagrams, flow charts and tables.
Learning outcome 3 – Know the principles of alternating current	Alternating current	You work as part of the electrical/ electronic team in an aerospace company and have been asked to give an update to employees on alternating current.	A technical report supported by AC single and three phase waveforms, graphs, tables and annotated diagrams.
Learning outcome 4 – Know about aircraft electrical devices and data transmission	Aircraft electrical devices and data transmission	You have been asked to prepare materials about aircraft electrical devices and data transmission, for the training department.	A technical report supported by annotated diagrams and tables.

Suggested reading/resources

Books

Bird J O – *Electrical and Electronic Principles and Technology* (Routledge, 2013) ISBN 9780415662857

Bolton W – *Engineering Science Sixth Edition* (Routledge, 2015) ISBN 9781138828933

Boyce A, Clarke A, Derbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book*, (Pearson, 2010) ISBN 9781846907234

Websites

Association of Science Education	www.ase.org.uk/
BBC GCSE bitesize – electronics	www.bbc.co.uk/schools/gcsebitesize/design/electronics/
How Stuff Works	www.howstuffworks.com
Institute of Electrical Engineers	www.4rfv.co.uk/c/14721/institution-of-electrical-engineers-iee
Institute of Physics	www.iop.org/
Maplin electronics	www.maplin.co.uk/
National Physics Laboratory	www.npl.co.uk/
National STEM Centre – electricity	www.nationalstemcentre.org.uk/elibrary/search?term=electricity&filter=R&order=score
National STEM Centre – electricity in engineering	www.nationalstemcentre.org.uk/elibrary/engineering/search?term=electricity&filter=R&order=score&facet%5B0%5D=age_range%3A%2214-16%22&facet%5B1%5D=type%3A%22Experiment%22
YouTube – electricity and circuits (plus batteries and static)	www.youtube.com/watch?v=D2monVkCkX4
YouTube – generators and motors	www.youtube.com/watch?v=d_aTC0iKO68

Unit 9: Principles of Welding and Fabrication

Level: 2

Unit type: Optional

Guided learning hours: 60

Assessment type: Internal

Unit introduction

Welding and joining techniques play a fundamental role in both the manufacture and in-service repair of aerospace structures and components. These techniques become more advanced as new, complex materials are developed. Welding and joining of aerospace materials provides a detailed review of different techniques for joining metallic and non-metallic aerospace materials.

In this unit, you will investigate and gain knowledge of the key welding and fixing techniques that make them suitable for applications within the aerospace industry. You will also learn about the range of welding symbols and how they are displayed to allow engineers to carry out specific welding applications. It is also important that you know the causes and effects of a range of weld faults. You will learn how these can be prevented to ensure that weld quality is maintained and, above all, that components are fabricated to meet the exacting safety standards of the aerospace industry. You will also develop knowledge of a range of tools and machinery associated with welding and be able to determine the most appropriate use for the range of techniques and processes covered in this unit.

Learning outcomes

In this unit you will:

1. Know different welding and fixing techniques
2. Know the terminology and symbols used within welding
3. Know the effects of welding
4. Know common materials used in fabrication
5. Know the different types and application of fabrication tools.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know different welding and fixing techniques
Welding and fixing techniques, e.g. • Temporary fixings (tack welding) • Soldering • Brazing • Spot welding • Riveting • Adhesive bonding, e.g. composite bonding films, epoxy resins • Mechanical fastenings (bolts, screws) • Self-securing joints (knocked up, panned down, grooved seam, swaged and joggled joints) **Non-fusion joining processes, e.g.** • Soldering (hard/soft) • Brazing **Fusion welding processes, e.g.** • Arc welding (MMA) • Oxyacetylene • Spot welding • MIG • MAG • TIG
Learning outcome 2: Know the terminology and symbols used within welding
Types of weld joint • Butt welds • Tee welds • Corner welds • Lap weld • Edge weld • Fillet welds

Symbols

- To include relevant additional information, i.e.
- Supplementary symbols
- Complementary indication
- Dimensions

Learning outcome 3: Know the effects of welding

Types of distortion, e.g.

- Longitudinal shrinkage
- Transverse shrinkage
- Angular distortion
- Bowing and dishing
- Buckling
- Twisting

Types of defect

- Porosity weld defect
- Omitted weld defect
- Biased weld defect
- Burn through weld defect
- Missed weld defect

Methods

- Testing, e.g. destructive, non-destructive
- Checking, e.g. dimensional, visual, quality standards

Learning outcome 4: Know common materials used in fabrication

Materials

- Ferrous (low carbon, medium carbon high carbon and stainless steels)
- Non-ferrous (aluminium/aluminium alloys, brass, copper, titanium/titanium alloys, zinc/zinc alloys)
- Non-metallic, e.g. plastics, rubbers, composites

Learning outcome 5: Know the different types and application of fabrication tools

Hand tools

- Hammers
- Mallets
- Bench stakes and mandrels
- Files
- Chisels
- Clamps and grips
- Spanners
- Cutting tools
- Screwdrivers
- Pliers
- Saws
- Formers

Machinery and machine tools

- Drills
- Saws
- Grinders
- Bending equipment
- Folding machines
- Guillotines
- Up and down stroking press brakes
- Shears
- Punches
- Nibbling machines
- Steel working tools
- CNC variations

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the apprentice is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the apprentice is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the apprentice is able to:
Learning outcome 1: Know different welding and fixing techniques		
P1 Describe different types of welding and fixing techniques	M1 Explain the benefits of mechanical, fusion and non-fusion welding and fixing techniques, including examples of when each would be used	D1 Compare different types of welding and fixing techniques and justify their use for specific applications
P2 Describe the principles and applications of non-fusion joining processes		
P3 Describe the principles and applications of the fusion welding processes		
Learning outcome 2: Know the terminology and symbols used within welding		
P4 Describe the features and joint preparation of different types of weld joints	M2 Explain the advantages and disadvantages of using different types of weld joints	
P5 Identify elementary symbols commonly used in accordance with current industry standards		
Learning outcome 3: Know the effects of welding		
P6 Describe types of distortion which can occur when welding and their causes	M3 Explain how to prevent distortion when welding	D2 Evaluate the possible consequences of a minimum of three different weld faults
P7 Describe different types of weld defect which can occur when welding and their causes	M4 Explain how weld defects can be prevented	
P8 Describe methods used to identify weld distortion and defects		

Learning outcome 4: Know common materials used in fabrication		
P9 Describe the different materials and their forms that can be used in fabrication		
P10 Outline possible fabrication applications for different types of materials	M5 Explain the benefits of using different materials for different applications	D3 Compare different materials and justify their use for specific applications
Learning outcome 5: Know the different types and application of fabrication tools		
P11 Describe the use of hand tools within fabrication applications		
P12 Describe the use of machinery and machine tools within fabrication applications	M6 Justify the use of different machine tools for specific applications	

Tutor guidance

Required resources

The resources needed for this unit are:

- a welding workshop
- appropriate welding equipment, consumables, tools and materials as outlined in the unit content.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know different welding and fixing techniques

Learning outcome 2: Know the terminology and symbols used within welding

Assignment title: Welding and fixing techniques and associated terminology and symbols

For distinction, learners will need to compare at least four different types of welding and fixing technique, describing their features and identifying their relevant advantages and disadvantages. This could be presented as an illustrative report.

For merit, learners will need to explain the benefits of mechanical, fusion and non-fusion welding and fixing techniques. Learners should give examples of when each technique would be used, taking into account the material, the environment and type of technique being performed. Learners should also consider the advantages and disadvantages of using different types of weld joint in a range of situations to ensure each joint is fit for purpose.

For pass, learners will need to describe at least six different types of welding and fixing technique when joining materials. These descriptions should be supported by appropriately labelled diagrams showing how each technique is carried out and giving valid reasons for using each technique when welding. Learners need to describe the principles and applications of both non-fusion joining processes, i.e. soldering and brazing. They will also need to describe the principles and applications of at least four fusion welding processes. The descriptions for both non-fusion and fusion processes should include how each type of weld is used to join materials together, along with appropriate examples of where each technique could be used. Learners will need to describe the features and joint preparation of a minimum of four different types of weld joint. There should also be examples of at least five different welding symbols that will include a range of additional information, as specified in the unit content.

Learning outcome 3: Know the effects of welding

Assignment title: Welding effects

For distinction, learners will examine three different weld faults and draw valid conclusions about the issues that could arise from such faults.

For merit, learners will need to explain preventative measures for both distortion and defects, considering the material type and thickness, weld temperature and technique used.

For pass, learners will need to describe a minimum of four types of distortion that can occur when welding and examine what the causes are for each. Learners will also need to describe a minimum of three different types of weld defect that can occur during welding and examine what the causes are for each. Learners will need to describe methods used to identify weld distortion and defects. This could be presented as a poster or presentation, which could include diagrams identifying the type of distortion and weld defect.

Learning outcome 4: Know common materials used in fabrication

Learning outcome 5: Know the different types and application of fabrication tools

Assignment title: Welding materials and tools

For distinction, learners will need to compare a minimum of three different materials, looking at the advantages and disadvantages of each material and drawing valid conclusions as to why each material is suitable for a specific application.

For merit, learners will need to determine why certain materials are best suited for a range of applications. Learners could identify a particular application that is appropriate to their workplace and justify the use of a particular material and the machine tools that could be used to produce an appropriate fabrication.

For pass, learners will need to know about the common materials that are used in fabrication. They should describe a ferrous, non-ferrous and non-metallic material and consider their form of supply, such as flat bar, angle or tube when looking to create a welded joint. This will enable learners to determine appropriate fabrication applications when using different types of material. There is a wide range of tools used when fabricating and learners should describe a minimum of five hand tools. Likewise, learners should describe a minimum of five pieces of machinery and machine tools across the range in the unit content. This could be presented using labelled diagrams supported by annotations of how each hand tool, machinery and machine tool is used during fabrication applications.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know different welding and fixing techniques **Learning outcome 2** – Know the terminology and symbols used within welding	Welding and fixing techniques and associated terminology and symbols	As an aerospace engineering technician you have been asked to produce some introductory exemplar training materials about welding and fixing techniques and associated terminology and symbols for new engineering apprentices.	An illustrated technical report showing a range of welding and fixing techniques, including features and preparation of a range of weld joints. A poster displaying a range of common welding symbols used with current industry standards.
Learning outcome 3 – Know the effects of welding	Welding effects	You work as part of the quality standards team in an aerospace company and have been asked to give an update to employees with respect to a range of distortion and weld defects that can occur during fabrication.	A written technical report with annotated diagrams/images showing a range of distortion and weld defects that includes references to methods used to identify weld faults. A poster displaying ways to prevent/minimise weld faults.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 4 – Know common materials used in fabrication **Learning outcome 5** – Know the different types and application of fabrication tools	Welding materials and tools	You have been asked to produce some technical information about the materials, tools and machinery used when fabricating products at your company.	A written technical report examining a range of materials used in fabrication along with diagrams/illustrations of a range of forms of supply of materials. A poster displaying a range of hand/machine tools and machinery used during specific applications at your place of work.

Suggested reading/resources

Books

Clarke S, et al.– *BTEC First in Engineering Student Book*, Harlow (Pearson Education, 2013) ISBN: 9781446902431

Jeffus L – *Welding: Principles and Applications Seventh Edition* (Delmar Cengage Learning, 2011) ISBN 9781111039172

Livesey A, Robinson A – *The Repair of Vehicle Bodies* (Routledge, 2013) ISBN 9780415534451

Raj B, Shankar V and Bhaduri A – *Welding Technology for Engineers* (Alpha Science International Ltd, 2006) ISBN 9781842651940

Timings R – *Fabrication and Welding Engineering* (Routledge, 2008) ISBN 9780750666916

Weman K – *Welding Processes Handbook* (Woodhead Publishing, 2003) ISBN 9780849317736

Zhang H – *Resistance Welding* (CRC Press, 2005) ISBN 9780849323461

Websites

Basic welding information	www.rqriley.com/welding-new.html
Basic welding information	www.youtube.com/watch?v=B4jqkbKqS0s
BOC group: suppliers of industrial gases	www.boconline.co.uk
Different welding techniques	www.youtube.com/watch?v=qZv6DCxTfXI
Further welding information	www.weldinginfocenter.org/basics/ba_02.html
Health and Safety Executive (welding health and safety)	www.hse.gov.uk/welding/index.htm
MIG Welding	www.youtube.com/watch?v=7r437J7EO5A
The Welding Institute	www.twi.co.uk
Welding defects	www.weldersuniverse.com/weld_defects.pdf
Welding techniques	www.gowelding.org

Unit 10: Principles of Aerospace Composite Materials

Level:	**2**
Unit type:	**Optional**
Guided learning hours:	**60**
Assessment type:	**Internal**

Unit introduction

Scientists and engineers are constantly carrying out research to develop new composite materials that will bring technological advances to the aerospace industry. Composite materials are used, for example, for their strength and corrosion resistance, and play an important part in the manufacture of components and in aircraft assembly plants.

In this unit, you will investigate and gain an understanding of the key materials that make up composites and the vital properties that make them suitable for their applications, for example carbon fibre is used for building aeroplane wing covers because of its strength to weight ratio. You will gain an understanding of how fibres are produced, the importance of their arrangement to form a matrix and the key processes in forming the composite structure. It is also important that you develop your knowledge of the health and safety procedures involved in producing composite materials, the risks and hazards associated with handling them and the health and safety precautions that need to be taken.

Learning outcomes

In this unit you will:

1. Understand the composition, properties and application of aerospace composite materials
2. Understand how fibres are produced and used to form aerospace composite structures
3. Know health and safety procedures associated with composite materials in aerospace applications.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Understand the composition, properties and application of aerospace composite materials
Key materials • Carbon fibre • Glass fibre • Aramid fibre • Quartz fibre • Sandwich materials • Laminate materials **Properties** • Strength/weight ratio • Fatigue life • Corrosion resistance • Conductivity • Strength • Impact resistance • Rapid temperature change **Application** • Wing covers • Fairings • Floorboards • Vertical/horizontal stabiliser • Spars • Ribs
Learning outcome 2: Understand how fibres are produced and used to form aerospace composite structures
Uses • Filament • Tow • Strand • Mat • Woven fabric • Lamina • Matrix

Fibre arrangement

- Random fibre arrangement
- Unidirectional stack
- Woven (plain weave, basket weave)

Bonding materials

- Epoxy resin
- Polyester
- Phenolic
- Vinyl esters
- Use of hardeners

Key processes

- Wet hand lay-up
- Pre-preg lay-up
- Resin film infusion
- Resin transfer moulding
- Carbon fibre moulding
- Automatic tape laying

Learning outcome 3: Know health and safety procedures associated with composite materials in aerospace applications

Hazards and risks

- Composite material potential hazards, e.g. corrosive, flammable, toxic, carcinogenic, irritant
- Processing:
  - personal risk, e.g. ingestion, inhalation, skin damage, allergies, burns
  - risk to materials, e.g. contaminants, foreign object damage
  - risk to materials, water, chemicals
  - risks to environment, e.g. fire and explosion, contamination
- Handling:
  - personal risk, e.g. dust, particulates and fibres, splinters, burns
  - risks to components, e.g. impact damage, contaminants

Safety precautions and procedures

- Health and safety legislation, manufacturers' information, codes of practice, COSHH
- Use of personal protective equipment (PPE), e.g. fume/dust extraction
- Safe disposal of waste
- Safe transport
- Storage
- Hazard signs

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Understand the composition, properties and application of aerospace composite materials		
P1 Describe key materials for composites	M1 Compare the advantages and disadvantages of different aerospace composites	D1 Evaluate the properties of aerospace composites that makes them suitable for specific applications
P2 Explain the properties of aerospace composite materials		
P3 Describe the application of aerospace composite materials		
Learning outcome 2: Understand how fibres are produced and used to form aerospace composite structures		
P4 Describe how composite fibre materials are used to produce finished components	M2 Explain the differences, advantages and disadvantages of composite fibre materials	
P5 Outline the importance of fibre arrangement within composite structures		
P6 Describe bonding materials used to form matrices	M3 Explain the properties that make these bonding materials suitable for forming matrices	
P7 Explain key processes used to form composite structures		

Learning outcome 3: Know health and safety procedures associated with composite materials in aerospace applications		
P8 Describe potential hazards and risks associated with the processing of composite materials		
P9 Describe potential hazards and risks associated with handling composite materials		
P10 Describe safety precautions and procedures used when processing and handling composite materials	M4 Explain the importance of safety precautions and procedures used when processing and handling composite materials	D2 Assess the possible consequences if safety precautions and procedures are not properly applied and maintained

Tutor guidance

Required resources

The resources needed for this unit are:

- example composite materials and their constituents for demonstration purposes
- example components made up of composite materials
- health and safety information
- the internet.

Visits to composite manufacturing plants would be advantageous and/or a specialist visiting speaker would be useful. Facilities to watch YouTube clips of producing composite materials would also be beneficial.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Understand the composition, properties and application of aerospace composite materials

Assignment title: Aerospace composite materials, their properties and applications

For distinction, learners will need to include valid reasons for how the advantageous properties of four different composite materials make them suitable for their specific aerospace applications. The use of relevant labelled diagrams, data and technical information would support learner evidence where appropriate.

For merit, learners need to compare at least four different composite materials, using their properties to identify their relevant advantages and disadvantages. This could be presented in a table.

For pass, learners need to describe how the relevant features of at least four key materials are used to make composites for the aerospace industry. Their choice needs to include a sandwich and a laminate material. Learners need to give clear details about the properties of the four materials chosen and give valid reasons how and why they are used in the aerospace industry, such as the use of carbon fibre reinforced polymer for its strength to weight ratio.

Learning outcome 2: Understand how fibres are produced and used to form aerospace composite structures

Learning outcome 3: Know health and safety procedures associated with composite materials in aerospace applications

Assignment title: The production and use of aerospace composite materials

For distinction, learners need to give careful consideration of the possible consequences, for example to personnel and the environment, and the possible legal consequences that can occur when safety precautions and procedures are not applied and maintained accurately, consistently and properly.

For merit, learners should use appropriately labelled diagrams and give valid reasons to support the comparisons of five different aerospace composites. Learners need to explain how at least three different bonding materials are used to form effective matrices for different purposes, such as resistance to UV light and degradation. Learners need to explain why safety precautions and following procedures appropriately prevent incidents and accidents occurring when processing and handling composite materials.

For pass, learners need to describe how at least five different fibre materials are used in composite materials. This description should be supported by labelled diagrams. Learners should use labelled diagrams and give valid reasons to support the importance of having fibre arrangements in composite structure, for example using different fibre laminates to give varying properties such as stiffness, strength and thermal expansion. Learners need to describe the properties of at least three different bonding materials, for example high melting point, boiling point, speed of adhesion and a description of the use of hardeners, if appropriate. Learners will need to explain how at least four different processes, including a lay-up process and a moulding process, are used to form composite structures. This could be supported by labelled diagrams and flow charts. Learners should use relevant health and safety sources of information, such as health and safety legislation and COSHH, to support their descriptions of safety precautions and procedures, and the hazards and risks associated with preparing and handling composite materials.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Understand the composition, properties and application of aerospace composite materials	Aerospace composite materials, their properties and applications	As an aerospace engineering technician you have been asked to produce some introductory exemplar training materials about composites for new engineering learners.	An illustrated technical report based on a range of case studies of specific aerospace composite material applications.
Learning outcome 2 – Understand how fibres are produced and used to form aerospace composite structures **Learning outcome 3** – Know health and safety procedures associated with composite materials in aerospace applications	The production and use of aerospace composite materials	You have been asked to produce technical information for the company's technical guide, including health and safety features.	An illustrated technical report showing, for example diagrams, flow charts, annotated photographs, with information on how aerospace composite structures are produced safely.

Suggested reading/resources

Books

Black B – *Workshop Processes, Practices and Material* (Routledge, 2015) ISBN 9781138784727

Boyce A, Clarke A, Derbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book* (Pearson, 2010) ISBN 9781846907234

Websites

Composites in Aviation	www.youtube.com/watch?v=wXxn-8OA8Ac
COSHH	www.hse.gov.uk/coshh/
BBC iPlayer – elemental business carbon materials	www.bbc.co.uk/programmes/p01pz6yx
BBC iPlayer – elements: carbon(C) – materials	www.bbc.co.uk/programmes/p02rnvcm
The British Composites Society	www.iom3.org/british-composites-society
Health and Safety Executive	www.HSE.gov.uk
The Institute of Materials – minerals and mining	www.iom3.org/
Introduction to composites	www.youtube.com/watch?v=WYqCnEvTRUQ
Making a carbon fibre mould	www.youtube.com/watch?v=IAdVO8Rkv6c
Materials World magazine	www.iom3.org/materials-world-magazine
National STEM Centre – designing Materials for the future	www.nationalstemcentre.org.uk/elibrary/resource/2383/composites-designing-materials-for-the-future
National STEM Centre – it is a materials world	www.nationalstemcentre.org.uk/elibrary/resource/2726/it-s-a-material-world
National STEM Centre– future in composite technologies	www.nationalstemcentre.org.uk/elibrary/resource/4192/future-in-composite-technologies
The Royal Society of Chemistry – composite materials	www.rsc.org/search-results/?q=composite%20materials
Self-healing airplane wings 'to fix tiny cracks'	www.bbc.co.uk/news/technology-33047859
Wet hand lay-up	www.youtube.com/watch?v=7FVO9WqKqB8

Unit 11: Principles of Mechanical Assembly and Fitting

Level: 2

Unit type: Optional

Guided learning hours: 60

Assessment type: Internal

Unit introduction

It is important for engineers to have knowledge of the methods and techniques used to assemble and fit components to engineering equipment and the quality checks that need to be carried out.

In this unit, you will gain knowledge of the engineering drawings, specifications and processes that support mechanical assembly and fitting components. You will also gain knowledge of electrical/electronic and hydraulic power components, and how to fit them safely to engineering equipment using different tools and assembly techniques. It is important that you have knowledge of compliance and the quality-checking process for a mechanical assembly against relevant standards. You will learn about the tools, equipment and measuring instruments used to carry this out safely. It is also important that you have an awareness of how to identify defects in engineering equipment and their components.

As an engineer of the future, you will need to have a knowledge of the role of mechanical assembly and fitting in your industry.

Learning outcomes

In this unit you will:

1. Know the processes that support the mechanical assembly and fitting of engineering components
2. Know about assembling and fitting components safely to engineering equipment
3. Know about the safe use of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know the processes that support the mechanical assembly and fitting of engineering components
• Engineering drawing uses, e.g. visual perspective, technical details, illustrates engineering components accurately • Supportive processes, e.g. support documentation, specifications, standards documentation
Learning outcome 2: Know about assembling and fitting components safely to engineering equipment
Electrical/electronic components • Components, e.g. conduit, trunking, tray type table enclosures, plugs and sockets, sensors, motors, transformers, relays, solenoids, switches, electronic modular units, instrumentation units • Techniques, e.g. routing cables and wires, mounting/securing components, cable fixings and fasteners, terminating and joining cables/wires using screwed/clamped/soldered/crimped connections • Use of cable protection devices, e.g. sleeving, grommets **Hydraulic power components** • Components, e.g. motors, pumps, compressors, intensifiers, filters, lubricators, separation units, reservoirs, accumulators, sensors, meters, gauges, indicators • Pipework and connection devices, e.g. manifolds, couplings, pipework, cabling, wires • Control components, e.g. valves, actuators, cylinders, regulators **Tools and relevant assembly methods and techniques** • Fitting, e.g. filing, scraping, lapping, polishing, blue bedding of components, shimming, packing, use of expansion/contraction methods • Securing, e.g. fasteners, threaded devices, bolt locking methods, riveting, soldering, brazing, sealants, adhesives • Use of tools, e.g. drilling, soldering irons, reaming, press tools, hacksaws, files, spanners, screwdrivers, wrenches, sockets, crimping tools, torque wrench, alignment tools • Use of assembly aids and equipment, e.g. work holding devices, jigs, fixtures, supports, lifting and moving equipment, rollers, wedges • Working within specified timeframes, e.g. estimation time to complete task, working to set times • Maintaining safe working environment, e.g. appropriate and approved assembly techniques used at all times, work area housekeeping, risk assessments • Assembly tasks (sub-assemblies or assemblies), e.g. panel, support framework, casings, hydraulic power, simple electrical circuit, component kits

Standards and instructions

- Quality checks, e.g. setting working clearance, torque settings, alignment, balancing
- National standards, e.g. British Standards (BS), International Organization for Standardisation (ISO)
- Design standards, e.g. customer standards and requirements, company standards and procedures
- Specified instructions, e.g. specific system requirements, operational manuals, manufacturers' instructions

Learning outcome 3: Know about the safe use of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment

Fit for purpose

- Appropriateness to assembly task
- Health and safety considerations
- Relevant regulations and guidance
- Permitted operating range

Tools, equipment and measuring instruments

- Hand tools, e.g. hacksaws, files, spanners, screwdrivers, wrenches, sockets, crimping tools
- Power tools, e.g. drills, soldering irons, air tools
- Equipment: personal protective equipment (PPE); other, e.g. for lifting and moving, jigs, fixtures, supports, wire looms
- Measuring instruments, e.g. rule, tape measure, micrometers, gauges, dial test indicators, multimeters, pressure meters
- Quality checks, e.g. completeness, alignment, size, positional accuracy, component security, damage or foreign objects
- Engineering equipment that has a range of components, e.g.:
    - electrical/electronic – correct inputs/outputs, electrical continuity
    - hydraulic power – function, leak and pressure testing, electrical continuity, pipework free from ripples or creases
    - sub-assemblies – function, freedom of movement, orientation, operating/working clearances, bearing end float

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Know the processes that support the mechanical assembly and fitting of engineering components		
P1 Describe the uses of engineering drawings and specifications in mechanical assembly and fitting	M1 Explain the differences between engineering drawings and specifications in mechanical assembly and fitting	
P2 Describe the processes that support the mechanical assembly and fitting of engineering components		
Learning outcome 2: Know about assembling and fitting components safely to engineering equipment		
P3 Describe how to safely connect/fit given components to engineering equipment		
P4 Describe how to safely use tools and relevant assembly methods and techniques to carry out different assembly tasks safely		
P5 Describe how to use relevant standards and instructions to check the compliance of an assembly for quality and accuracy	M2 Explain the importance of using relevant standards and instructions when checking the compliance of an assembly	D1 Evaluate the standards and instructions used to carry out an assembly task

Learning outcome 3: Know about the safe use of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment			
P6 Describe how hand and power tools, equipment and measuring instruments are fit for purpose	M3 Explain the action to be taken before use if tools, equipment and measuring instruments are found not to be fit for purpose	D2 Assess the risks involved during the use of tools, equipment and measuring instruments when checking the quality of assembled engineering equipment
P7 Describe how to safely use tools, equipment and measuring instruments to carry out quality checks on different types of assembled engineering equipment		
P8 Describe how to safely carry out quality checks on given engineering equipment and their components	M4 Explain how defects in engineering equipment and their components are identified	

Tutor guidance

Required resources

The resources needed for this unit are:

- a workshop with relevant equipment, components, measuring instruments, hand and power tools
- relevant standards and manufacturers' information
- health and safety information and PPE
- a learning centre/library
- the internet.

Visits to assembly and fitting plants would be advantageous and/or a specialist visiting speaker would be useful.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know the processes that support the mechanical assembly and fitting of engineering components

Learning outcome 2: Know about assembling and fitting components safely to engineering equipment

Assignment title: Mechanical assembly and fitting components safely

For distinction, learner evidence will include a detailed evaluation of why complying with standards and assembly instructions is important when carrying out mechanical assembly and fitting. Learners will consider, in a general way, the effectiveness and usefulness of using supportive material, and will then present an example of its application to a specific assembly operation, for example fitting pipe connectors to a hydraulic manifold or assembling an electro-mechanical actuator.

For merit, learners will refer to exemplar engineering drawings and specifications when explaining the differences between them. Learners can use a table to explain the differences provided that it contains explanations and is not a simple list of difference statements. A drawing communicates information in a visual way, whereas a specification will consist of text statements and numerical data; learners will discuss the merits and limitations of both methods. Learners will also present reasons why it is necessary to refer to standards and assembly instructions when checking an assembly for compliance, for example testing the torque setting of a bolt and seeing if its value is as stated in the assembly instructions.

For pass, learner evidence will contain accurate descriptions of how engineering drawings and specifications support mechanical assembly and fitting, such as the use of specifications to find all the detailed requirements of the task. Learners will also present information about other documentation used to support mechanical assembly and fitting, for example manufacturers' data sheets and industry standards. Learners will use pre- and post-fitting labelled diagrams with technical notes to support their descriptions of how to safely connect/fit at least five electrical/electronic components and at least five hydraulic power components to engineering equipment. Learners will present accurate descriptions of the relevant assembly methods and techniques associated with at least two different assembly tasks, including relevant fitting and securing, use of tools and assembly aids and equipment. Learners will refer to the quality and accuracy checks that would be carried out to ensure the compliance of a completed assembly/fitting operation with the relevant standards and assembly instructions.

Learning outcome 3: Know about the safe use of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment

Assignment title: Carrying out quality checks safely on assembled engineering equipment

For distinction, learners will carry out a detailed review of the possible risks involved when performing quality checks on engineering assemblies. Learners will weigh up the significance of risks by taking account of factors such as the impact on self and others if things go wrong, for example assessing the risks to personal safety when pressure checking a hydraulic actuator assembly. If there is a leakage of hydraulic fluid from the seals or sudden extension of the actuator rod, this could cause personal injury. Learner evidence should cover the risks posed when quality checking a mechanical piece of equipment, a hydraulic power assembly and an electrical/electronic assembly. Learners should propose ways of reducing the impact if things go wrong, for example wearing the correct personal protective equipment (PPE) or having a safety circuit breaker when testing electrical assemblies.

For merit, learners will provide accurate and clear details about the actions to be taken if a tool, piece of equipment or measuring instrument is found not to be fit for purpose when inspected prior to use, for example a multimeter with a faulty battery or damaged test leads that need to be replaced; a spanner with a damaged head that is not repairable. Learner evidence will include detailed explanations about the options available to an assembly technician faced with using equipment that they consider not to be fit for purpose, for example replace, repair or recalibrate.

Learner evidence will include strategies for identifying defects in tools and equipment that are used in assembly and fitting operations, for example visual inspection, internal inspection using ultra-sound and calibration checks.

For pass, learners will reference given examples of tools, equipment and measuring instruments when they are describing how to check that equipment is fit for purpose when used to carry out assembly or fitting operations. For tools and equipment, they will check they are appropriate to the assembly task, are in a good state of repair and free from any defects. For the measuring instruments, they will ensure that they are the correct model, are working properly and capable of producing consistent, accurate results, for example having access to an up-to-date calibration certificate for a pressure gauge.

Learners will also include examples of how to handle and use instruments safely to ensure that measured data is accurate and consistent. For example, how quality checks, such as function, leak and pressure testing on hydraulic power components are carried out safely; safe checking of an electrical assembly using a digital multimeter when high voltages are present.

Learners will then consider, for two different types of assembled engineering equipment and their components, how tools, equipment and measuring instruments are used to check that the assemblies have been built to specification.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know the processes that support the mechanical assembly and fitting of engineering components **Learning outcome 2** – Know about assembling and fitting components safely to engineering equipment	Mechanical assembly and fitting components safely	You have been asked to produce materials for the company's technical catalogue on examples of mechanical assembly and fitting tasks.	An illustrated technical report showing examples of support processes, components, tools, assembly techniques/methods, equipment and reference to standards and instructions.
Learning outcome 3 – Know about the safe use of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment	Carrying out quality checks safely on assembled engineering equipment	You work as part of the quality standards team in an engineering company and have been asked to give an update to employees in the assembly plant on carrying out quality checks safely.	A written technical report with annotated diagrams with reference to preparation and carrying out quality checks safely.

Suggested reading/resources

Books

Boyce A, Clarke A, Derbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book*, (Pearson 2010) ISBN 9781846907234

Darbyshire A – *Mechanical Engineering* (Taylor & Francis Ltd, 2010) ISBN 9780080965772

Timings R L –*Engineering Fundamentals* (Routledge, 2002) ISBN 9780750656092

Websites

BBC Bitesize – hydraulics	www.bbc.co.uk/schools/gcsebitesize/science/triple_aqa/using_physics_make_things_work/hydraulics/revision/1/
COSHH	www.hse.gov.uk/coshh/
Health and Safety Executive	www.HSE.gov.uk
The Institute of Mechanical Engineers	www.imeche.org/
National STEM Centre – design system presentation	www.nationalstemcentre.org.uk/elibrary/engineering/resource/1544/workshop-4-key-stage-five-resources
National STEM Centre – wind turbine project – component parts	www.nationalstemcentre.org.uk/elibrary/engineering/resource/3772/wind-turbine-project-component-parts
National STEM Centre – fuel systems components	www.nationalstemcentre.org.uk/elibrary/engineering/resource/1753/activity-case-study-6-andrew-keen
National STEM centre – Technology Enhancement Programme	www.nationalstemcentre.org.uk/elibrary/engineering/search?term=technology+enhancement+programme&filter=R&order=score
YouTube Hydraulics	www.youtube.com/watch?v=g0asnTBLVqg

Unit 12: Principles of Computer Aided Design (CAD)

Level:	**2**
Unit type:	**Optional**
Guided learning hours:	**60**
Assessment type:	**Internal**

Unit introduction

Computers and bespoke software are used for a wide range of applications in engineering. They can be used for simulation, stress analysis, computer aided manufacture and for Computer Aided Design (CAD).

In this unit, you will learn how to set up a CAD system and use the software to produce a range of engineering drawings. You will learn how to use national and international standards to ensure that, wherever the drawings produced are viewed, they will be clearly understood. You will learn about the appropriate health and safety requirements and investigate some of the more advanced features of the software, ensuring that you comply with industry standard practice.

Learning outcomes

In this unit you will:

1. Know the risks to health and safety associated with the use of computer equipment and associated peripheral devices
2. Know how to configure the CAD system to suit drawing requirements
3. Know the requirement to comply with national and international drawing standards
4. Know how to use CAD software for the production of 2D industry standard engineering drawings
5. Know how to use layers, copy, modify and manipulate drawn entities to maintain drawing efficiency.

Learning outcomes and unit content

What needs to be learnt
Learning outcome 1: Know the risks to health and safety associated with the use of computer equipment and associated peripheral devices
Hazards • Electrical hazard • Repetitive work • Screen glare • Excessive VDU use **Requirements** • Working position • Lighting • Environment
Learning outcome 2: Know how to configure the CAD system to suit drawing requirements
Drawing parameters, e.g. • Drawing templates • Sheet sizes • Drawing lines and limits • Scales • Line types • Text and dimension styles • Screen display • Drawing origin and datum • Drawing layers • Peripheral devices input and output procedures • Customised menus • Units • Toolbars

Benefits and limitations, e.g.

- Productivity and speed of drawing creation
- Accuracy of drawing components
- Uniformity of production
- Modification/editing
- Storage space required
- Standardised parts, symbols etc.
- Working practices
- Electronic data exchange and transfer
- Finite element analysis
- Set-up cost
- Data storage
- Training

Learning outcome 3: Know the requirement to comply with national and international drawing standards

Features, e.g.

- Drawing sheet sizes and layouts
- Projection – First and Third angle
- Types of line
- Lettering and numbering
- Dimensioning
- Symbols
- Section cross hatching
- Units
- Abbreviations
- Representation of common features

Symbols, e.g.

- Weld symbols
- Electrical/electronic symbols
- Fluid power symbols
- Mechanical symbols

Standard representations, e.g.

- Sketches
- Schematic diagrams
- Flow charts
- Physical layout diagrams
- Illustrations from manufacturers' manuals

Learning outcome 4: Know how to use CAD software for the production of 2D industry standard engineering drawings

Requirements

- Reference point
- Ease of use
- Compatibility

Co-ordinate input methods

- Absolute
- Relative/incremental
- Polar

Geometry, e.g.

- Lines
- Circles
- Arcs
- Ellipses

Drawing aids, e.g.

- Coordinate grids and snaps
- Object snaps
- Viewing features, e.g. zoom, previous, pan

Dimensions

- Linear dimensions
- Radial dimensions
- Angular dimensions
- Leaders dimensions
- Text dimensions
- Tolerances dimensions

Text

- Text location, font type, size and orientation

Learning outcome 5: Know how to use layers, copy, modify and manipulate drawn entities to maintain drawing efficiency

Layers

- Layer definition
- Layer management

Attributes

- Size
- Position
- Orientation

Drawing commands

- Scaling
- Mirroring
- Rotating
- Trimming
- Moving/translating
- Corner filleting/chamfering
- Exploding
- Copying
- Arrays/patterns
- Extending
- Stretching
- Erasing

Assessment and grading criteria		
Pass To achieve a pass grade the evidence must show that the learner is able to:	**Merit** To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	**Distinction** To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
Learning outcome 1: Know the risks to health and safety associated with the use of computer equipment and associated peripheral devices		
P1 Describe the hazards and possible risks associated with the use of Visual Display Unit (VDU) equipment and peripheral devices	M1 Explain the responsibilities of both the employer and employee under the relevant health and safety legislation that relates to the use of VDUs and peripheral devices	D1 Evaluate the steps that can be taken to ensure that any hazards related to working with VDUs and peripheral devices can be minimised
P2 Describe the requirements of a suitable working environment relating to the safe use of computer equipment		
P3 Outline the requirements of the current Health and Safety (Display Screen Equipment) Regulations		
Learning outcome 2: Know how to configure the CAD system to suit drawing requirements		
P4 Outline drawing parameters that can be set by the user during system configuration	M2 Explain how to configure a CAD system for a defined drawing specification	D2 Justify a selected configuration for a defined drawing specification
P5 State the benefits and limitations of the use of CAD software in comparison to conventional drawing methods		

Learning outcome 3: Know the requirement to comply with national and international drawing standards		
P6 Outline the national and international standards and conventions that relate to engineering drawing practice	M3 Explain the reasons for using standards and conventions in engineering drawing practice and how national and international standards are sourced	
P7 Outline features of a CAD drawing that need to comply with national and international standards		
P8 Describe the use of standard symbols and representations used within CAD drawings		
Learning outcome 4: Know how to use CAD software for the production of 2D industry standard engineering drawings		
P9 Describe the requirements of drawing datum selection	M4 Explain the consequences of not establishing and identifying datums on engineering drawings	
P10 Describe the different co-ordinate input methods and their uses		
P11 Outline types of geometry that can be drawn	M5 Explain how the different types of geometry are used to create engineering drawings and the drawing aids used	
P12 Describe the use of drawing aids that are commonly used		
P13 Describe methods of adding dimensions and text to drawn geometry to create a working drawing	M6 Explain what sort of information needs to be included in drawing templates	D3 Justify the use of different dimensions and text within a drawing template
P14 Outline the benefits of using drawing templates		
P15 Describe the types of device available to produce hard copy of the completed drawing		
P16 Outline the importance of saving partial or completed drawings at appropriate intervals	M7 Explain the importance of maintaining version control when saving drawings	D4 Compare the different methods of version control used in saving drawings

Learning outcome 5: Know how to use layers, copy, modify and manipulate drawn entities to maintain drawing efficiency		
P17 Describe how to set-up different layers and typical uses	M8 Explain the reasons for using different layers in drawings	
P18 Describe the attributes of entities that can be edited or modified		
P19 Outline drawing commands by which entities can be modified/manipulated to aid drawing efficiency		

Tutor guidance

Required resources

The resources needed for this unit are:

- computers equipped with appropriate peripheral and installed with CAD software
- relevant standards and manufacturers' information
- a learning centre/library
- the internet.

Visits from local HSE representatives would be helpful in guiding learners with regard to current legislation related to the use of computer equipment.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 9 Internal assessment*.

Learning outcome 1: Know the risks to health and safety associated with the use of computer equipment and associated peripheral devices

Learning outcome 2: Know how to configure the CAD system to suit drawing requirements

Learning outcome 3: Know the requirement to comply with national and international drawing standards

Assignment title*:* Setting up for CAD

For distinction, learners should develop their discussion of hazards and risks to produce an evaluation of the steps that can be taken to minimise hazards. A consideration of the advantages, disadvantages and alternatives would be expected here. Learners could balance the cost of specialist equipment against the cost of time lost due to ill health for example. Similarly, they should justify a drawing configuration for a specific engineering/aerospace application. Typically, this could be the use of a specific template being used with a range of pre-set layers, units etc.

For merit, learners could feature comments in each section of their presentation, clearly explaining the responsibilities of both employer and employee when considering the use of VDU equipment and peripherals in the first section. For example, chair setup, lighting etc. The learner could link this to the Health and Safety at Work etc Act and related legislation. This could be followed with a detailed explanation of how a CAD system can be individually configured for a defined engineering/aerospace specification in the second section, showing how features such as templates and units are configured for example. The use of screenshots to illustrate this would be expected here. The reasons for using standards and conventions could include an explanation incorporating engineers working for a multi-national company in different parts of the world and using standard designs and drawings. Finally, a description of where these standards can be sourced could

be researched. CAD drawings produced by the learner could be used to support all of the above. The drawings could be added to a portfolio of evidence, with appropriate cross-referencing.

For pass, learners could base their evidence on a series of photographs/screenshots; with appropriate annotations. By producing an appropriate presentation learners can give verbal descriptions/outlines to meet the evidence requirements for these outcomes. Learners could display images of poor computer workstation set up (for example trailling cables) and detail the hazards and risks associated with VDU and peripheral equipment. This could be linked to a description of a suitable working environment portraying safe use of equipment with appropriate annotated photographs. Guidelines from the HSE website could form a presentation slide allowing learners to outline Display Screen Equipment (DSE) requirements.

The second part of the presentation could once again make use of annotated screen shots or embedded video clips, indicating the drawing parameters that can be set by the user during system configuration; at least ten drawing parameters should be covered here. This could be followed by more slides, contrasting CAD images and conventional hand drawn images and stating the benefits and limitations of the use of CAD software in comparison to conventional drawing techniques; a minimum of six benefits and six limitations are required here.

The final part of the presentation could focus on examples from national and international standards outlining their use in engineering drawing practice. By illustrating their use in CAD images learners will be able to provide a brief overview of the features of a CAD drawing that need to comply with national and international standards and describe their use.

Learning outcome 4: Know how to use CAD software for the production of 2D industry standard engineering drawings

Learning outcome 5: Know how to use layers, copy, modify and manipulate drawn entities to maintain drawing efficiency

Assignment title: Using CAD

For distinction, learners should ensure that when considering dimensioning techniques they fully justify the use of different dimensions and text. This could be evidenced, in a demonstration, by adding appropriate notes and dimensioning different features of the aerospace component the learner has drawn. A verbal commentary explaining their reasoning for the use of these tools would also be useful. In addition, whilst demonstrating the saving of drawings, learners should demonstrate and hence compare the different methods of version control used, indicating the positive and negative effects throughout.

For merit, learners could extend their verbal responses to ensure they clearly demonstrate the consequences of not establishing datums. Examples of good and bad practice could be explained and used here. Three different types of geometry and the use of drawing aids in engineering drawings should be demonstrated with comments by the learner clearly indicating how these are used. Learners should use the templates presented on screen to demonstrate the sort of information anticipated, including version control and its importance. Finally, a practical demonstration of the reasons for using different layers would be anticipated, with a full verbal explanation accompanying this.

For pass, learners could set up a large monitor or projector to allow a demonstration of CAD techniques to be viewed by colleagues/assessors. The learner could verbally describe the requirements of drawing datum selection while using the software to select appropriate datum position/s. This could be followed by a demonstration and description of different co-ordinate input methods and types of geometry that can be created (at least five) and drawing aids (at least three). The learner could then describe and apply text and different dimensions to their drawing (at least three different types of dimension). All of the above should be used to produce a recognisable aerospace component/part, which should also be placed on a template with the learner outlining the benefits using drawing templates. The finished drawing/s should then be printed/plotted with the learner indicating and hence describing the types of device that are available for producing hard copies. Throughout the exercises the learner should regularly save the drawing file and outline verbally the importance of doing this. Learners should then extend their demonstration, using their drawing/s, to describe how to set up layers and describe their uses. Attributes that can be edited/modified should also be identified and described and the commands that allow modification/manipulation should also be demonstrated and outlined verbally (at least six commands would be required). All of this could be recorded and an observation record used to capture the evidence (by the assessor).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Learning outcomes and assessment criteria	Assignment title	Scenario	Assessment method
Learning outcome 1 – Know the risks to health and safety associated with the use of computer equipment and associated peripheral devices **Learning outcome 2** – Know how to configure the CAD system to suit drawing requirements **Learning outcome 3** – Know the requirement to comply with national and international drawing standards	Setting up for CAD	You have been asked by your manager to prepare a presentation on how to set up and prepare a workstation for CAD technicians when they first start with your company.	A presentation with annotated photographs Assessor observation record
Learning outcome 4 – Know how to use CAD software for the production of 2D industry standard engineering drawings **Learning outcome 5** – Know how to use layers, copy, modify and manipulate drawn entities to maintain drawing efficiency	Using CAD	You have been asked by your manager to provide a demonstration of the use of CAD software to members of the production team.	A practical demonstration of CAD techniques/drawing with a verbal explanation/commentary. Assessor observation record. Video.

Suggested reading/resources

Books

CADFolks – *AutoCAD 2015 For Beginners* (CreateSpace Independent Publishing Platform, 2014) ISBN 9781502322814

Tran P – *SolidWorks 2014 – Basic Tools* (SDC Publications, 2014) ISBN 9781585038534

Websites

BBC Bitesize – CAD	www.bbc.co.uk/schools/gcsebitesize/design/electronics/industrial_designrev4.shtml
Ellenfinkelstein – AutoCAD Tips	www.ellenfinkelstein.com/AutoCAD_tips.html
Solidworks tutorials	www.solidworkstutorials.com/
Technology student – CAD	www.technologystudent.com/cam/twod1.htm

14 Further information and useful publications

To get in touch with us visit our 'Contact us' pages:

- Edexcel, BTEC and Pearson Work Based Learning contact details: qualifications.pearson.com/en/support/contact-us.html
- books, software and online resources for UK schools and colleges: www.pearsonschoolsandfecolleges.co.uk

Key publications:

- Adjustments for candidates with disabilities and learning difficulties – Access and Arrangements and Reasonable Adjustments, General and Vocational qualifications (Joint Council for Qualifications (JCQ))
- Equality Policy (Pearson)
- Recognition of Prior Learning Policy and Process (Pearson)
- UK Information Manual (Pearson)
- UK Quality Vocational Assurance Handbook (Pearson).

All of these publications are available on our website.

Publications on the quality assurance of BTEC qualifications are available on our website.

Our publications catalogue lists all the material available to support our qualifications. To access the catalogue and order publications, please visit our website.

Additional resources

If you need further learning and teaching materials to support planning and delivery for your learners, there is a wide range of BTEC resources available.

Any publisher can seek endorsement for their resources, and, if they are successful, we will list their BTEC resources on our website, qualifications.pearson.com

15 Professional development and training

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- Ask the Expert: submit your question online to our Ask the Expert online service and we will make sure your query is handled by a subject specialist
- Please visit, qualifications.pearson.com/en/support/contact-us.html

Apprenticeship Standards in the

Aerospace and Aviation Sector

Employer Occupational Brief

Occupational Competence and Technical Knowledge Qualifications

Assessment Strategy for

Employers, Training Providers and Awarding Organisations

Version 3

Table of contents

Introduction

Employers in the Aerospace and Aviation Sectors have produced this Qualification Assessment Strategy to:

- support the implementation and delivery of the Apprenticeship Standard in a way that is appropriate, relevant, feasible, manageable and affordable in a wide range of employer contexts
- provide clarity for Awarding Organisations on what constitutes competent performance
- encourage and promote consistent assessment of Competence and Technical Knowledge requirements
- promote cost-effective delivery and assessment plans
- motivate apprentices to always maintain a high level of skills, knowledge and behaviours throughout the apprenticeship and not just to do enough to satisfy the minimum requirements, in the knowledge that they will be continually assessed leading to a final end point assessment with a technical interview (viva) and supported by the achievement of competence and technical knowledge qualifications coupled portfolio of evidence
- add value to both the apprentice and the employer, by complementing and building on normal company performance management and development tools including regular performance reviews
- enable and encourage progression and continuing professional development by being linked to professional recognition
- position the apprenticeship not just as a job, but as the starting point for a career in the sector – assessment at the end marks a clear recognition of achievements, on which the individual can build
- select assessment methods that will ensure relevance and consistency, irrespective of the specific job role of the apprentice
- ensure costs and practicalities will be appropriate and proportionate to large as well as SME employers
- including those with large or small numbers of apprentices.

This document also provides definitions for:

- the qualifications and experience required for Assessors/Trainers/Teachers and Verifiers
- the assessment environment for the Foundation and Development Phase Occupational Competence Qualifications
- access to assessment

and requirements relating to:

- carrying out occupational competence assessments
- performance evidence requirements for occupational competence
- assessing knowledge and understanding
- use of witness testimonies
- continuing professional development
- quality control of assessment.

Section 1

Occupational Competence Qualifications (Foundation and Development Phase)

Assessor Requirements to Demonstrate Effective Assessment Practice

Assessment must be carried out by competent Assessors that, as a minimum, must hold the QCF Level 3 Award in Assessing Competence in the Work Environment. Current and operational Assessors that hold units D32 and/or D33 or A1 and/or A2 as appropriate to the assessment being carried out will not be required to achieve the QCF Level 3 Award as they are still appropriate for the assessment requirements set out in this Assessment Strategy. However, they will be expected to regularly review their skills, knowledge and understanding and, where applicable, undertake continuing professional development to ensure that they are carrying out workplace assessment to the most up-to-date Employer Units of Competence.

Assessor Technical Requirements

Assessors must be able to demonstrate that they have verifiable, relevant and sufficient technical competence to evaluate and judge performance and knowledge evidence requirements as set out in the relevant outcomes in the Employer Units of Competence.

This will be demonstrated either by holding a relevant technical qualification or by proven industrial experience of the technical areas to be assessed. The assessor's competence must, at the very least, be at the same level as that required of the Apprentice in the units being assessed.

Assessors must also be fully conversant with the Awarding Organisation's assessment recording documentation used for the Employer Units of Competence against which the assessments and verification are to be carried out, plus any other relevant documentation and system and procedures to support the Quality Assurance (QA) process.

Verifier Requirements (internal and external)

Internal QA (Internal Verification) must be carried out by competent Verifiers that, as a minimum, must hold the QCF Level 4 Award in the Internal Quality Assurance of Assessment Processes and Practices.

Current and operational Internal Verifiers that hold internal verification units V1 or D34 will not be required to achieve the QCF Level 4 Award, as they are still appropriate for the verification requirements set out in this Assessment Strategy. Verifiers must be familiar with, and preferably hold, either the nationally recognised Assessor units D32 and/or D33 or A1 and/or A2 or the QCF Level 3 Award in Assessing Competence in the Work Environment.

External QA (External Verification) must be carried out by competent External Verifiers that as a minimum must hold the QCF Level 4 Award in the External Quality Assurance of Assessment Processes and Practices.

Current and operational External Verifiers that hold external verification units V2 or D35 will not be required to achieve the QCF Level 4 Award as they are still appropriate for the verification requirements set out in this Assessment Strategy. Verifiers must be familiar with, and preferably hold, either the nationally recognised Assessor units D32 and/or D33 or A1 and/or A2 or the QCF Level 3 Award in Assessing Competence in the Work Environment.

External and Internal Verifiers will be expected to regularly review their skills, knowledge and understanding and where applicable undertake continuing professional development to ensure that they are carrying out workplace Quality Assurance (verification) of Assessment Processes and Practices to the most up-to-date Employer Units of Competence.

Verifiers, both Internal and External, will also be expected to be fully conversant with the terminology used in the Employer Units of Competence against which the assessments and verification are to be carried out, the appropriate Regulatory Body's systems and procedures and the relevant Awarding Organisation's documentation, systems and procedures within which the assessment and verification is taking place.

Specific technical requirements for internal and external verifiers

Internal and external Verifiers for the Employer Units of Competence must be able to demonstrate that have verifiable, sufficient and relevant industrial experience, and must have a working knowledge of the processes, techniques and procedures that are used in the engineering industry.

The table overleaf and on the following page show the recommended levels of technical competence for Assessors, Internal Verifiers and External Verifiers.

Technical Requirements for Assessors and Verifiers

Position	Prime activity requirements	Support activity requirements	Technical requirements (see Notes section below)
Assessor	Assessment Skills	IV Systems	Technical *competence* in the areas covered by the Employer Units of Competence being assessed
Internal Verifier	Verification Skills	Assessment Knowledge	Technical *understanding* of the areas covered by the Employer Units of Competence being verified
External Verifier	Verification skills	Assessment Understanding	Technical *awareness* of the areas covered by the Employer Units Competence being verified

Notes

1. Technical competence is defined here as a combination of practical skills and knowledge, as well as the ability to apply both of these in familiar and new situations, within a real working environment.
2. Technical understanding is defined here as having a good understanding of the technical activities being assessed, together with knowledge of relevant Health and Safety implications and requirements of the assessments.
3. Technical awareness is defined here as a general overview of the subject area, sufficient to ensure that assessment and evidence are reliable and that relevant Health and Safety requirements have been complied with.
4. The competence required by the Assessor, Internal Verifier and External verifier roles, in the occupational area being assessed, is likely to exist at three levels as indicated by the shaded zones in the table overleaf.

Technical Competence / Required by:	An ability to *discuss* the general principles of the competences being assessed	An ability to *describe* the practical aspects of the competence being assessed	An ability to *demonstrate* the practical competences being assessed
Assessor			
Internal Verifier			
External Verifier			

Assessment Environment of the Employer Units of Competence in the Foundation Phase of the Apprenticeship

The Employer Units of Competence are intended to have a wide application throughout the Aerospace and Aviation Sector. It is therefore necessary to have a flexible approach to the environment in which the Employer Units of Competence are delivered and assessed during the Foundation Phase of the Apprenticeship.

Therefore, there is much to be gained by acquiring the basic engineering competencies required in the **Foundation Phase** of the Apprenticeship whilst working in a sheltered but realistic environment such as in a Training Centre or College. This is due to an ongoing emphasis on safety critical work activities and the need to ensure flexibility of assessment opportunities to both maintain and enhance the provision of competent personnel within the Aerospace and Aviation industry. These assessment conditions will allow a minimum safe level of skills, knowledge and understanding to be achieved and demonstrated by the Apprentice prior to being exposed to the hazards of the industrial environment, thus minimising the risk of injury to themselves and other employees.

For the above reasons, the assessment of the Apprentices competence in a sheltered but realistic environment **is acceptable** for the Employer Units of Competence included the **Foundation Phase** of the Apprenticeship, where the environment replicates that expected in industry.

Where applicable, the machinery, tools, materials, equipment and resources used must be representative of industry standards and there must be sufficient equipment/resources available for each Apprentice to demonstrate their competence on an individual basis. Workpieces or work outcomes assessed must be the Apprentice's own work and should be actual work examples that combine the skills and techniques required by the Employer Units of Competence so that achievement will properly reflect the Apprentice's capabilities.

Assessors must therefore ensure that the competency assessed in a simulated environment is fully transferable to the workplace. Other aspects that should be considered could include:

- environmental conditions, such as lighting conditions, noise levels and the presence of hazards
- pressure of work, such as time constraints and repetitive activities
- producing actual workpieces or work outcomes, the consequences of making mistakes and the effect these have on customer, supplier and departmental relationships.

Assessment Environment of the Employer Units of Competence in the Development Phase of the Apprenticeship

The evidence put forward for the Employer Units of Competence can **only** be regarded valid, reliable, sufficient and authentic if achieved and obtained in the working environment where the Apprentice is employed and be clearly attributable to the Apprentice. However, in certain circumstances, simulation/replication of work activities may be acceptable, but must be kept to an absolute minimum.

The use of high quality, realistic simulations/replication, which impose pressures consistent with workplace expectations, should only be used in relation to the assessment of the following:

- rare or dangerous occurrences, such as those associated with health, safety and the environment issues, emergency scenarios and rare operations at work
- the response to faults and problems for which no opportunity has presented for the use of naturally occurring workplace evidence of learners competence
- aspects of working relationships and communications for which no opportunity has presented for the use of naturally occurring workplace evidence of learners competence.
- Simulations/replications will require prior approval from the specific Awarding Organisation and should be designed in accordance with the following parameters:
- the environment in which simulations take place must be designed to match the characteristics of the working environment
- competencies achieved via simulation/replication must be transferable to the working environment
- simulations which are designed to assess competence in dealing with emergencies, accidents and incidents must be verified as complying with relevant health, safety and environmental legislation by a competent health and safety/environmental control officer before being used
- simulated activities should place Apprentices under the same pressures of time, access to resources and access to information as would be expected if the activity was real
- simulated activities should require Apprentices to demonstrate their competence using plant and/or equipment used in the working environment
- simulated activities which require interaction with colleagues and contacts should require the Apprentice to use the communication media that would be expected at the workplace
- for health and safety reasons simulations need not involve the use of genuine substances/materials. Any simulations which require the Apprentice to handle or otherwise deal with materials substances/should ensure that the substitute takes the same form as in the workplace.

Access to Assessment

There are no entry requirements required for the Employer Units of Competence, unless this is a legal requirement of the process or the environment in which the Apprentice is working in. Assessment is open to any Apprentice who has the potential to reach the assessment requirements set out in the relevant units.

Aids or appliances, which are designed to alleviate disability, may be used during assessment, providing they do not compromise the standard required.

Carrying Out Assessments of the Occupational Competence Qualifications

The Employer Units of Competence have been specifically developed to cover a wide range of activities. The evidence produced for the units will, therefore, depend on the skills and knowledge required by employers and specified in the Apprentices Training Plan. The Skills section of the Employer Units of Competence makes reference to a number of optional items listed in the Skills section of the units (**for example 'any three from five'**). This is the minimum standard set by employers.

Where the unit requirements give a choice of optional areas, assessors should note that Apprentices do not need to provide evidence of the other areas to complete the unit (in the example above, two items), unless specified by the employer, particularly where these additional items may relate to other activities or methods that are not part of the Apprentices normal workplace activities or are not required by the employer.

Performance Evidence Requirements of the Occupational Competence Qualifications

Performance evidence must be the main form of evidence gathered. In order to demonstrate consistent competent performance for a unit, a minimum of three different examples of performance of the unit activity will be required. Items of performance evidence often contain features that apply to more than one unit, and **can be used as evidence in any unit** where they are suitable.

Performance evidence must be:

- products of the Apprentices work, such as items that have been produced or worked on, plans, charts, reports, standard operating procedures, documents produced as part of a work activity, records or photographs of the completed activity

together with:

- evidence of the way the Apprentice carried out the activities, such as witness testimonies, assessor observations or authenticated Apprentice reports of the activity undertaken.

Competent performance is more than just carrying out a series of individual set tasks. Many of the units in the Foundation Phase contain statements that require the Apprentice to provide evidence that proves they are capable of combining various features and techniques. Where this is the case, separate fragments of evidence would not provide this combination of features and techniques and, therefore, will not be acceptable as demonstrating competent performance.

If there is any doubt as to what constitutes suitable evidence the Internal/External Verifier should be consulted.

Example:

Foundation Unit 10: Preparing aircraft detail assemblies

Unit specific additional assessment requirements:

Specific Unit Requirements

In order to prove their ability to combine different aircraft detail assembly operations, at least one of the assemblies produced must be of a significant nature, and must contain a minimum of **four** of the components listed in the skills section, paragraph 2.

Assessing Knowledge and Understanding requirements in the Occupational Competence Qualifications

Knowledge and understanding are key components of competent performance, but it is unlikely that performance evidence alone will provide enough evidence in this area. Where the Apprentice's knowledge and understanding are not apparent from performance evidence, they must be assessed by other means and be supported by suitable evidence.

Knowledge and understanding can be demonstrated in a number of different ways. It is recommended that oral questioning and practical demonstrations are used perhaps whilst observing the apprentice undertake specific tasks, as these are considered the most appropriate for these units. Assessors should ask enough questions to make sure that the Apprentice has an appropriate level of knowledge and understanding, as required by the unit.

Evidence of knowledge and understanding will not be required for those items in the skills section of the Employer Units of Competence that have not been selected by the Employer.

The achievement of the specific knowledge and understanding requirements in the units may not simply be inferred by the results of tests, exams or assignments from other units such as in the technical knowledge qualifications or other training programmes. Where evidence is submitted from these sources, the assessor must, as with any assessment, make sure the evidence is valid, reliable, authentic, directly attributable to the Apprentice, and meets the full knowledge and understanding requirements of the unit.

Where oral questioning is used, the assessor must retain a record of the questions asked, together with the Apprentices answers.

Witness testimony

Where observation is used to obtain performance evidence, this must be carried out against the unit assessment criteria. Best practice would require that such observation is carried out by a qualified Assessor. If this is not practicable, then alternative sources of evidence may be used.

For example, the observation may be carried out against the assessment criteria by someone else that is in close contact with the Apprentice. This could be a team leader, supervisor, mentor or line manager who may be regarded as a suitable witness to the Apprentices competency. However, the witness must be technically competent in the process or skills that they are providing testimony for, to at least the same level of expertise as that required of the Apprentice. It will be the responsibility of the assessor to make sure that any witness testimonies accepted as evidence of the Apprentices competency are reliable, auditable and technically valid.

Maximising opportunities to use assessment evidence

One of the critical factors required in order to make this Assessment Strategy as efficient and effective as possible and to ease the burden of assessment, is the Assessor's ability and expertise to work in partnership with the apprentice and their employer to provide advice and guidance on how to maximise opportunities to cross-reference performance and knowledge evidence to all relevant Employer Units of Competence. For example, if a knowledge statement is repeated in a number of separate Employer Units of Competence and the expected evidence/response to that statement is the same including the context, then the same piece of evidence should be cross referenced to the appropriate units.

Section 2

Technical Knowledge Qualifications (Foundation and Development Phase)

Teacher/Trainer/Lecturer/Assessor requirements

Staff must:

- have relevant experience in teaching/training/assessing

or

- hold or are working towards an appropriate teaching/training/assessing qualification

and

- be technically knowledgeable in the area(s) for which they are delivering training/assessing, with appropriate qualifications
- be familiar with the Engineering Technician (UK spec) requirements where delivering/assessing Level 3, they will be required to provide a signed declaration confirming they have read and understood the Engineering Technician UK spec and the evidence requirements to meet the engineering technician (UK spec) criteria.

Internal Quality Assurance requirements

Staff must:

- have experience in quality management/internal verification

or

- hold or be working towards an appropriate internal quality assurance qualification

and

- be familiar with the occupation and technical content covered within the qualification
- be familiar with the Engineering Technician (UK spec) requirements where delivering/assessing Level 3, they will be required to provide a signed declaration confirming they have read and understood the Engineering Technician UK spec and the evidence requirements to meet the engineering technician (UK spec) criteria.

External Quality Assurance requirements

Staff must:

- have experience in quality management/external verification
- hold or be working towards an appropriate external quality assurance qualification
- be familiar with the occupation and technical content covered within the qualifications
- be familiar with the Engineering Technician (UK spec) requirements for Level 3 and understand the evidence requirements to meet the engineering technician (UK spec) criteria.

Assessments

The qualifications will include both internal and external assessments, which could include a range of different methods such as:

- Practical assessments
- Short-answer Questions
- Written or Multiple choice tests
- Paper-based or online assessments
- Other appropriate assessment methods

The assessments methods to be used will be agreed across all Awarding Organisations (AOs) involved in the development of the units.

Grading

The knowledge qualifications will be graded pass, merit or distinction in line with the grading criteria to be agreed across all AOs involved in the development of the units.

The agreed grading criteria will be made available to providers, teachers, assessors and learners to ensure they are fully aware of the achievement requirements for each grade. Please refer to the specifications from the individual AOs.

Section 3

General Requirements

Continuing Professional Development (CPD)

Centres must support their staff to ensure that they have current technical knowledge of the occupational area, that delivery, mentoring, training, assessment and verification are in line with best practice, technical advancements and that they will take account of any national or legislative developments.

There must be an auditable individual CPD plan in place for all staff assessing and verifying the qualifications within the Aerospace and Aviation Foundation and Development phases, the plan must meet the relevant provider and Aerospace and Aviation employer requirements.

Assessors/Teachers/Trainers/Lecturers (as applicable):

- must understand the Engineering Technician (UK spec) requirements when providing guidance to assessors. They will be required to provide a signed declaration confirming they have read and understood the Engineering Technician UK spec and the evidence requirements to meet the engineering technician (UK spec) criteria as it a mandatory requirement that all Apprentices complete the Aerospace and Aviation Apprenticeship Standard – Engineering Technician Performance Indicators Recording Document (currently in development). The engineering technician (UK spec) can be found at www.engc.org.uk
- must understand the requirements of the Aerospace and Aviation Apprenticeship Standard – End of Scheme Assessment Recording Document (currently in development).

Quality Control of Assessment

General

There are two major points where an Awarding Organisation interacts with the Centre in relation to the External Quality Control of Assessment and these are:

- approval – when a Centre takes on new qualifications/units, the Awarding Organisation, normally through an External Verifier (EV) ensures that the Centre is suitably equipped and prepared to deliver the new units/qualification
- monitoring – throughout the ongoing delivery of the qualification/units the Awarding Organisation, through EV monitoring and other mechanisms must maintain the quality and consistency of assessment of the units/qualification.

Approval

In granting Approval, the Awarding Organisation, normally through its External Verifiers (EV) must ensure that the prospective Centre:

- meets the requirements of the Qualification Regulator
- has sufficient and appropriate physical and staff resources
- meets relevant health and safety and/or equality and access requirements
- has a robust plan for the delivery of the qualification/units.

The Awarding Organisation may visit the Centre to view evidence or may undertake this via other means.

The Awarding Organisation must have a clear rationale for the method(s) deployed.

Monitoring

Each AO, through EV monitoring and other mechanisms, must ensure:

- that a strategy is developed and deployed for the ongoing AO monitoring of the Centre. This strategy must be based on an active risk assessment of the Centre. In particular, the strategy must identify the Apprentice, assessors and Internal Verifier sampling strategy to be deployed and the rationale behind this
- that the Centre's internal QA processes are effective in assessment
- that sanctions are applied to a Centre where necessary and that corrective actions are taken by the Centre and monitored by the AO/EV
- that reviews of the AO's external auditing arrangements are undertaken.

Notes:

a) It is recognised that each AO will have its own guidance and procedure on the internal and external QA process applied to these qualifications. See individual AO websites for further information.

b) This Assessment Strategy is 'work in progress' and will be amended and re- issued as the Competence and Technical Knowledge Qualifications and assessment methodologies are developed and modified. i.e. it is hoped that it will be adapted to meet the requirements of the Aerospace MRO Sector as their Standards and qualification requirements are developed.

c) The Aerospace and Aviation Sector is mindful that its Apprenticeships are and **must** be available across all four Nations in the UK. Therefore the Sector has ensured that the Employer Occupational Brief (EOB) and the associated Employer Units of Competence are directly aligned to the existing format and content of the Sectors National Occupational Standards (NOS).

November 2017

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