Pearson
BTEC Level 3 Subsidiary Diploma, Diploma and Extended Diploma in Vehicle Technology

Specification

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Issue 4

Edexcel, BTEC and LCCI qualifications

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This specification is Issue 4. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on our website: qualifications.pearson.com

These qualifications were previously known as:

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology (QCF)

Pearson BTEC Level 3 Diploma in Vehicle Technology (QCF)

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology (QCF)

The QNs remain the same.

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BTEC Level 3 qualification titles covered by this specification

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology

Pearson BTEC Level 3 Diploma in Vehicle Technology

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology

These qualifications have been accredited to the national framework and are eligible for public funding as determined by the Department for Education (DfE) under Section 96 of the Learning and Skills Act 2000.

The qualification titles listed above feature in the funding lists published annually by the DfE and the regularly updated website www.education.gov.uk. The Qualification Number (QN) should be used by centres when they wish to seek public funding for their learners. As well as a QN, each unit within a qualification also has a unit reference number (URN).

The qualification title, QN and URNs will appear on learners' final certification documentation.	
The QNs for the qualifications in this publication are:	
Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology	600/4344/1
Pearson BTEC Level 3 Diploma in Vehicle Technology	600/4343/X
Pearson BTEC Level 3 Extended Diploma in Vehicle Technology	600/4328/3

These qualification titles will appear on a learners' certificates. Learners need to be made aware of this when they are recruited by the centre and registered with Pearson.

What are BTEC Level 3 qualifications?

BTEC Level 3 qualifications are undertaken in further education and sixth-form colleges, schools and other training providers. Their purpose, approaches to teaching, learning and assessment are established and understood by teaching professionals, employers and learners alike.

The BTEC Level 3 qualifications within this specification have been revised to fit the national framework. As such the revised titles are:

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology

Pearson BTEC Level 3 Diploma in Vehicle Technology

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology.

For clarity and continuity these qualifications are referred to within this specification and generically as BTEC Level 3 qualifications where appropriate. They maintain the same equivalences, benchmarks and other articulations (for example SCAAT points, UCAS Tariff points) as their predecessor qualifications. The following identifies the titling conventions and variations between the 'old' and 'new' specifications:

Predecessor BTEC Nationals (accredited 2007)	**BTEC Level 3 qualifications (for delivery from January 2012)**
Edexcel Level 3 BTEC National Award	Pearson BTEC Level 3 Subsidiary Diploma
Edexcel Level 3 BTEC National Certificate	Pearson BTEC Level 3 Diploma
Edexcel Level 3 BTEC National Diploma	Pearson BTEC Level 3 Extended Diploma

BTEC Level 3 qualifications are designed to provide highly specialist work-related qualifications in a range of vocational sectors. They give learners the knowledge, understanding and skills that they need to prepare for employment. The qualifications also provide career development opportunities for those already in work and through articulation to higher education, degree and professional development programmes provide progression opportunities within the same cognate or related areas of study within universities and other institutions. BTEC Level 3 qualifications accredit the achievement for courses and programmes of study for full-time or part-time learners in schools, colleges and other training provider organisations.

BTEC Level 3 qualifications provide much of the underpinning knowledge and understanding for the National Occupational Standards for the sector, where these are appropriate. They are supported by the relevant Sector Skills Councils (SSCs) and/or Standards Setting Bodies (SSBs). Certain BTEC Level 3 qualifications are recognised as Technical Certificates and form part of the Apprenticeship Framework. They attract UCAS points that equate to similar-sized general qualifications within education institutions within the UK.

On successful completion of a BTEC Level 3 qualification, a learner can progress to or within employment and/or continue their study in the same, or related vocational area.

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Total qualification time (TQT)

For all regulated qualifications, Pearson specifies a total number of hours that it is expected learners will be required to undertake in order 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 this, Pearson will also identify the number of Guided Learning Hours (GLH) that we expect a centre delivering the qualification will need to provide. Guided learning means activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, such as lessons, tutorials, online instruction and supervised study.

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.

Pearson consults with users of these qualifications in assigning TQT.

The TQT values for these qualifications are as follows:

Pearson BTEC Level 3 Subsidiary Diploma – TQT 600

Pearson BTEC Level 3 Diploma – TQT 1200

Pearson BTEC Level 3 Extended Diploma- TQT 1800

Pearson BTEC Level 3 Subsidiary Diploma — 60 credits

The 60-credit BTEC Level 3 Subsidiary Diploma extends the specialist work-related focus from the BTEC Level 3 Certificate and covers the key knowledge and practical skills required in the appropriate vocational sector. The BTEC Level 3 Subsidiary Diploma offers greater flexibility and a choice of emphasis through the optional units. It is broadly equivalent to one GCE A Level.

The BTEC Level 3 Subsidiary Diploma offers an engaging programme for those who are clear about the area of employment that they wish to enter. These learners may wish to extend their programme through the study of general qualifications such as GCE AS Levels, additional specialist learning (for example through another BTEC qualification) or a complementary NVQ. These learning programmes can be developed to allow learners to study related and complementary qualifications without duplication of content.

For adult learners the BTEC Level 3 Subsidiary Diploma can extend their experience of work in a particular sector. It may also be a suitable qualification for those wishing to change career or move into a particular area of employment following a career break.

The predecessor qualification to the BTEC Level 3 Subsidiary Diploma is the Edexcel Level 3 BTEC National Award which has the same equivalences, overall size and focus as the revised accredited qualification.

Pearson BTEC Level 3 Diploma — 120 credits

The 120-credit BTEC Level 3 Diploma broadens and expands the specialist work-related focus from the BTEC Level 3 Subsidiary Diploma. There is potential for the qualification to prepare learners for employment in the appropriate vocational sector and it is suitable for those who have decided that they wish to enter a particular area of work. It is broadly equivalent to two GCE A Levels.

Some learners may wish to gain the qualification in order to enter a specialist area of employment or to progress to the Level 3 Extended Diploma. Other learners may want to extend the specialism they studied on the BTEC Level 3 Certificate or the BTEC Level 3 Subsidiary Diploma programme.

The predecessor qualification to the BTEC Level 3 Diploma is the Edexcel Level 3 BTEC National Certificate, which has the same equivalences, overall size and focus as the revised qualification.

Pearson BTEC Level 3 Extended Diploma — 180 credits

The 180-credit BTEC Level 3 Extended Diploma extends and deepens the specialist work-related focus from the BTEC Level 3 Diploma. There is potential for the qualification to prepare learners for appropriate direct employment in the vocational sector and it is suitable for those who have decided that they clearly wish to enter a particular specialist area of work. It is broadly equivalent to three GCE A Levels.

Some learners may wish to gain the qualification in order to enter a specialist area of employment or to progress to a higher education foundation degree, HND or other professional development programme. Other learners may want to extend the specialist nature of the subjects they studied on the BTEC Level 3 Diploma or another programme of study.

The predecessor qualification to the BTEC Level 3 Extended Diploma is the Edexcel Level 3 BTEC National Diploma, which has the same equivalences, overall size and focus as the revised qualification.

Key features of the BTEC Level 3 qualifications in Vehicle Technology

The BTEC Level 3 qualifications in Vehicle Technology have been developed in the automotive sector to:

- provide education and training for vehicle technology employees
- provide employees working in the vehicle technology sector with opportunities to achieve a nationally recognised Level 3 vocationally-specific qualification
- provide full-time learners with the opportunity to enter employment in the Vehicle Technology sector or to progress to vocational qualifications such as the Pearson BTEC Higher Nationals in Automotive Engineering
- provide learners with the opportunity to develop a range of skills and techniques, personal skills and attributes essential for successful performance in working life.

National Occupational Standards

BTEC Level 3 qualifications are designed to provide much of the underpinning knowledge and understanding for the National Occupational Standards (NOS), as well as developing practical skills in preparation for work and possible achievement of NVQs in due course. NOS form the basis of National Vocational Qualifications (NVQs). BTEC Level 3 qualifications do not purport to deliver occupational competence in the sector, which should be demonstrated in a work context.

Each unit in the specification identifies links to elements of the NOS.

Rules of combination for Pearson BTEC Level 3 qualifications

The rules of combination specify the:

- total credit value of the qualification
- the minimum credit to be achieved at, or above, the level of the qualification
- the mandatory unit credit
- the optional unit credit
- the maximum credit that can come from other BTEC units.

When combining units for a BTEC Level 3 qualification, it is the centre's responsibility to ensure that the following rules of combination are adhered to.

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology

1. Qualification credit value: a minimum of 60 credits.
2. Minimum credit to be achieved at, or above, the level of the qualification: 60 credits.
3. Mandatory unit credit:
   - unendorsed pathway: 20 credits
   - motorsports endorsed pathway: 30 credits
4. Optional unit credits:
   - unendorsed pathway:40 credits
   - motorsports endorsed pathway: 30 credits

A maximum of **10 optional** credits may be imported from other BTEC units at Level 3 or above to meet local needs.

Pearson BTEC Level 3 Diploma in Vehicle Technology

1. Qualification credit value: a minimum of 120 credits.
2. Minimum credit to be achieved at, or above, the level of the qualification: 120 credits.
3. Mandatory unit credit:
   - unendorsed pathway: 50 credits
   - motorsports endorsed pathway: 40 credits
4. Optional unit credits:
   - unendorsed pathway: 70 credits
   - motorsports endorsed pathway: 80 credits

A maximum of **20 optional** credits may be imported from other BTEC units at Level 3 or above to meet local needs.

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology

1 Qualification credit value: a minimum of 180 credits.

2 Minimum credit to be achieved at, or above, the level of the qualification: 180 credits.

3 Mandatory unit credit:

- unendorsed pathway: 50 credits
- motorsports endorsed pathway: 60 credits

4 Optional unit credits:

- unendorsed pathway: 130 credits
- motorsports endorsed pathway: 120 credits

A maximum of **30 optional** credits may be imported from other BTEC units at Level 3 or above to meet local needs.

Centres should be aware that some BTEC units at level 3 or above are 'pass only' and therefore, may affect the learners overall grade.

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology

The Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology is a 60-credit and 360-guided-learning-hour (GLH) qualification.

To achieve the unendorsed pathway, learners must achieve 20 credits from the two mandatory units **and** a minimum of 40 credits from a minimum of four optional units.

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology			
Unendorsed pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
Unit	**Optional units**		
3	Vehicle System Fault Diagnosis and Rectification	10	3
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
10	Operation and Testing of Vehicle Electronic Ignition Systems	10	3
11	Vehicle Engine Management Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
13	Vehicle Electronic Ancillary and Information Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
16	Heavy Vehicle Transmission Systems	10	3
18	Mathematics for Engineering Technicians	10	3

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology (Motorsports)

The Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology (Motorsports) is a 60-credit and 360-guided-learning-hour (GLH) qualification.

To achieve the endorsed Motorsports pathway, learners must achieve 30 credits from the three mandatory units **and** a minimum of 30 credits from the endorsed motorsports pathway optional units.

Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology (Motorsports)			
Endorsed motorsports pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
24	Motorsport Workshop Practices	10	3
25	Motorsport Vehicle Preparation and Inspection	10	3
Unit	**Optional units**		
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
3	Vehicle System Fault Diagnosis and Rectification	10	3
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
7	Vehicle Electrical Charging and Starting Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
18	Mathematics for Engineering Technicians	10	3
23	Welding Technology	10	3
26	Professional Practice and Logistics for Motorsports	10	3

Pearson BTEC Level 3 Diploma in Vehicle Technology

The Pearson BTEC Level 3 Diploma in Vehicle Technology is a 120-credit and 720-guided-learning-hour (GLH) qualification.

To achieve the unendorsed pathway, learners must achieve 50 credits from the four mandatory units **and** minimum of 70 credits from the optional units.

Pearson BTEC Level 3 Diploma in Vehicle Technology			
Unendorsed pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
3	Vehicle System Fault Diagnosis and Rectification	10	3
4	Vehicle Project	20	3
Unit	**Optional units**		
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
7	Vehicle Electrical Charging and Starting Systems	10	3
8	Function and Operation of Vehicle Petrol Injection Systems	10	3
9	Diesel Fuel Injection Systems for Compression Ignition Engines	10	3
10	Operation and Testing of Vehicle Electronic Ignition Systems	10	3
11	Vehicle Engine Management Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
13	Vehicle Electronic Ancillary and Information Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
15	Heavy Vehicle Braking Systems	10	3
16	Heavy Vehicle Transmission Systems	10	3
17	Heavy Vehicle Steering and Suspension Systems, Wheels and Tyres	10	3
18	Mathematics for Engineering Technicians	10	3
19	Properties and Applications of Engineering Materials	10	3
20	Fabrication Processes and Technology	10	3
21	Engineering Design	10	3
22	Engineering Drawing for Technicians	10	3
23	Welding Technology	10	3

Pearson BTEC Level 3 Diploma in Vehicle Technology (Motorsports)

The Pearson BTEC Level 3 Diploma in Vehicle Technology (Motorsports) is a 120-credit and 720-guided-learning-hour (GLH) qualification.

To achieve the endorsed Motorsports pathway, learners must achieve 40 credits from the four mandatory units **and** a minimum of 80 credits from the endorsed motorsports pathways optional units.

Pearson BTEC Level 3 Diploma in Vehicle Technology (Motorsports)			
Endorsed motorsports pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
3	Vehicle System Fault Diagnosis and Rectification	10	3
24	Motorsport Workshop Practices	10	3
25	Motorsport Vehicle Preparation and Inspection	10	3
Unit	**Optional units**		
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
4	Vehicle Project	20	3
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
7	Vehicle Electrical Charging and Starting Systems	10	3
8	Function and Operation of Vehicle Petrol Injection Systems	10	3
10	Operation and Testing of Vehicle Electronic Ignition Systems	10	3
11	Vehicle Engine Management Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
13	Vehicle Electronic Ancillary and Information Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
18	Mathematics for Engineering Technicians	10	3
19	Properties and Applications of Engineering Materials	10	3
20	Fabrication Processes and Technology	10	3
21	Engineering Design	10	3
22	Engineering Drawing for technicians	10	3
23	Welding Technology	10	3
26	Professional Practice and Logistics for Motorsports	10	3

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology

The Pearson BTEC Level 3 Extended Diploma in Vehicle Technology is a 180-credit and 1080-guided-learning-hour (GLH) qualification.

To achieve the unendorsed pathway, learners must achieve 50 credits from the four mandatory units **and** a minimum of 130 credits from the optional units.

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology			
Unendorsed pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
3	Vehicle System Fault Diagnosis and Rectification	10	3
4	Vehicle Project	20	3
Unit	**Optional units**		
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
7	Vehicle Electrical Charging and Starting Systems	10	3
8	Function and Operation of Vehicle Petrol Injection Systems	10	3
9	Diesel Fuel Injection Systems for Compression Ignition Engines	10	3
10	Operation and Testing of Vehicle Electronic Ignition Systems	10	3
11	Vehicle Engine Management Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
13	Vehicle Electronic Ancillary and Information Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
15	Heavy Vehicle Braking Systems	10	3
16	Heavy Vehicle Transmission Systems	10	3
17	Heavy Vehicle Steering and Suspension Systems, Wheels and Tyres	10	3
18	Mathematics for Engineering Technicians	10	3
19	Properties and Applications of Engineering Materials	10	3
20	Fabrication Processes and Technology	10	3
21	Engineering Design	10	3
22	Engineering Drawing for Technicians	10	3
23	Welding Technology	10	3

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology (Motorsports)

The Pearson BTEC Level 3 Extended Diploma in Vehicle Technology (Motorsports) is a 180-credit and 1080-guided-learning-hour (GLH) qualification.

To achieve the endorsed motorsports pathway, learners must achieve 60 credits from the four mandatory units **and** a minimum of 120 credits from the endorsed motorsports pathway optional units.

Pearson BTEC Level 3 Extended Diploma in Vehicle Technology (Motorsports)			
Endorsed motorsports pathway			
Unit	**Mandatory units**	**Credit**	**Level**
1	Operation of Vehicle Chassis Systems	10	3
3	Vehicle System Fault Diagnosis and Rectification	10	3
4	Vehicle Project	20	3
24	Motorsport Workshop Practices	10	3
25	Motorsport Vehicle Preparation and Inspection	10	3
Unit	**Optional units**		
2	Vehicle Engine Principles, Operation, Service and Repair	10	3
5	Applications of Vehicle Science and Mathematics	10	3
6	Electrical and Electronic Principles for Vehicle Technology	10	3
7	Vehicle Electrical Charging and Starting Systems	10	3
8	Function and Operation of Vehicle Petrol Injection Systems	10	3
10	Operation and Testing of Vehicle Electronic Ignition Systems	10	3
11	Vehicle Engine Management Systems	10	3
12	Operation and Maintenance of Light Vehicle Transmission Systems	10	3
13	Vehicle Electronic Ancillary and Information Systems	10	3
14	Light Vehicle Suspension, Steering and Braking Systems	10	3
18	Mathematics for Engineering Technicians	10	3
19	Properties and Applications of Engineering Materials	10	3
20	Fabrication Processes and Technology	10	3
21	Engineering Design	10	3
22	Engineering Drawing for Technicians	10	3
23	Welding Technology	10	3
26	Professional Practice and Logistics for Motorsports	10	3

Assessment and grading

All assessment for BTEC Level 3 qualifications is criterion referenced, based on the achievement of specified learning outcomes. Each unit within the qualification has specified assessment and grading criteria which are to be used for grading purposes. A summative unit grade can be awarded at pass, merit or distinction:

- to achieve a 'pass' a learner must have satisfied **all** the pass assessment criteria
- to achieve a 'merit' a learner must additionally have satisfied **all** the merit grading criteria
- to achieve a 'distinction' a learner must additionally have satisfied **all** the distinction grading criteria.

Learners who complete the unit but who do not meet all the pass criteria are graded 'unclassified'.

Grading domains

The grading criteria are developed in relation to grading domains which are exemplified by a number of indicative characteristics at the level of the qualification.

There are four BTEC Level 3 qualification grading domains:

- application of knowledge and understanding
- development of practical and technical skills
- personal development for occupational roles
- application of generic skills.

Guidance

The purpose of assessment is to ensure that effective learning has taken place to give learners the opportunity to:

- meet the assessment and grading criteria and
- achieve the learning outcomes within the units.

All the assignments created by centres should be reliable and fit for purpose, and should build on the assessment and grading criteria. Assessment tasks and activities should enable learners to produce valid, sufficient and reliable evidence that relates directly to the specified criteria. Centres should enable learners to produce evidence in a variety of different forms and including, written reports, graphs and posters, along with projects, performance observation and time-constrained assessments.

Centres are encouraged to emphasise the practical application of the assessment and grading criteria, providing a realistic scenario for learners to adopt, and making maximum use of practical activities and work experience. The creation of assignments that are fit for purpose is vital to achievement and their importance cannot be over-emphasised.

The assessment and grading criteria must be clearly indicated in the fit-for-purpose assignments. This gives learners focus and helps with internal verification and standardisation processes. It will also help to ensure that learner feedback is specific to the assessment and grading criteria.

When looking at the assessment and grading grids and designing assignments, centres are encouraged to identify common topics and themes.

The units include guidance on appropriate assessment methodology. A central feature of vocational assessment is that it allows for assessment to be:

- current, ie to reflect the most recent developments and issues
- local, ie to reflect the employment context of the delivering centre
- flexible to reflect learner needs, ie at a time and in a way that matches the learner's requirements so that they can demonstrate achievement.

Calculation of the qualification grade

Pass qualification grade

Learners who achieve the minimum eligible credit value specified by the rule of combination will achieve the qualification at pass grade (see *Rules of combination for Pearson BTEC Level 3 National qualifications*).

Qualification grades above pass grade

Learners will be awarded a merit or distinction or distinction* qualification grade (or combination of these grades appropriate to the qualification) by the aggregation of points gained through the successful achievement of individual units. The number of points available is dependent on the unit level and grade achieved, and the credit size of the unit (as shown in the 'points available for credits achieved at different Levels and unit grades' below).

Points available for credits achieved at different Levels and unit grades

The table below shows the **number of points scored per credit** at the unit level and grade.

Unit level	**Points per credit**		
	Pass	**Merit**	**Distinction**
Level 2	5	6	7
Level 3	**7**	**8**	**9**
Level 4	9	10	11

Learners who achieve the correct number of points within the ranges shown in the 'qualification grade' table will achieve the qualification merit or distinction or distinction* grade (or combinations of these grades appropriate to the qualification).

Qualification grade

BTEC Level 3 Subsidiary Diploma

Points range above pass grade	Grade	
460-499	Merit	M
500-519	Distinction	D
520 and above	Distinction*	D*

BTEC Level 3 Diploma

Points range above pass grade	Grade
880-919	MP
920-959	MM
960-999	DM
1000-1029	DD
1030-1059	DD*
1060 and above	D*D*

BTEC Level 3 Extended Diploma

Points range above pass grade	Grade
1300-1339	MPP
1340-1379	MMP
1380-1419	MMM
1420-1459	DMM
1460-1499	DDM
1500-1529	DDD
1530-1559	DDD*
1560-1589	DD*D*
1590 and above	D*D*D*

Please refer to *Annexe D* for examples of calculation of qualification grade above pass grade.

Quality assurance of centres

Pearson's qualification specifications set out the standard to be achieved by each learner in order to be awarded the qualification. This is covered in the statement of learning outcomes, and assessment and grading criteria in each unit. Further guidance on delivery and assessment is given in the *Essential guidance for tutors* section in each unit. This section is designed to provide additional guidance and amplification related to the unit to support tutors, deliverers and assessors and to provide for a coherence of understanding and a consistency of delivery and assessment.

Approval

Centres that have not previously offered BTEC qualifications will first need to apply for, and be granted, centre approval before they can apply for approval to offer the programme.

When a centre applies for approval to offer a BTEC qualification they are required to enter into an approvals agreement.

The approvals agreement is a formal commitment by the head or principal of a centre to meet all the requirements of the specification and any linked codes or regulations. Sanctions and tariffs may be applied if centres do not comply with the agreement. Ultimately, this could result in the suspension of certification or withdrawal of approval.

Centres will be allowed 'accelerated approval' for a new programme where the centre already has approval for a programme that is being replaced by the new programme.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre and must have approval for programmes or groups of programmes that it is operating
- the centre agrees as part of gaining approval to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; it must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres a range of materials and opportunities intended to exemplify the processes required for effective assessment and examples of effective standards. Approved centres must use the materials and services to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers; planning, monitoring and recording of assessment processes; and for dealing with special circumstances, appeals and malpractice.

The approach of quality assured assessment is made through a partnership between an approved centre and Pearson. Pearson is committed to ensuring that it follows best practice and employs appropriate technology to support quality assurance processes where practicable. Therefore, the specific arrangements for working with centres will vary. Pearson seeks to ensure that the quality assurance processes that it uses do not place undue bureaucratic processes on centres and works to support centres in providing robust quality assurance processes.

Pearson monitors and supports centres in the effective operation of assessment and quality assurance. The methods which it uses to do this for BTEC First and National programmes include:

- ensuring that all centres have completed appropriate declarations at the time of approval undertaking approval visits to centres where necessary
- requiring all centres to appoint a Lead Internal Verifier for designated groups of programmes and to ensure that this person is trained and supported in carrying out that role
- requiring that the Lead Internal Verifier completes compulsory online standardisation related to assessment and verification decisions for the designated programme
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- overarching review and assessment of a centre's strategy for assessing and quality assuring its BTEC programmes.

Pearson Quality Assurance Handbook

Centres should refer to the *UK BTEC Quality Assurance Handbook*, issued annually, for detailed guidance.

An approved centre must make certification claims only when authorised by Pearson and strictly in accordance with requirements for reporting.

Centres that do not fully address and maintain rigorous approaches to quality assurance will be prevented from seeking certification for individual programmes or for all BTEC First and National programmes. Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

Programme design and delivery

BTEC Level 3 qualifications consist of mandatory units and optional units. Optional units are designed to provide a focus to the qualification and give more specialist opportunities in the sector.

In BTEC Level 3 qualifications each unit has a number of guided learning hours.

Guided learning hours are defined as all the times when a tutor, trainer or facilitator is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. It also includes time spent by staff assessing learner achievements. It does not include time spent by staff in day-to-day marking of assignments where the learner is not present.

Centres are advised to consider this definition when planning the programme of study associated with this specification.

Mode of delivery

Pearson does not define the mode of study for BTEC Level 3 qualifications. Centres are free to offer the qualifications using any mode of delivery (such as full-time, part-time, evening only, distance learning) that meets their learners' needs. Whichever mode of delivery is used, centres must ensure that learners have appropriate access to the resources identified in the specification and to the subject specialists delivering the units. This is particularly important for learners studying for the qualification through open or distance learning.

Learners studying for the qualification on a part-time basis bring with them a wealth of experience that should be utilised to maximum effect by tutors and assessors. The use of assessment evidence drawn from learners' work environments should be encouraged. Those planning the programme should aim to enhance the vocational nature of the qualification by:

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

Resources

BTEC Level 3 qualifications are designed to prepare learners for employment in specific occupational sectors. Physical resources need to support the delivery of the programme and the proper assessment of the learning outcomes and should, therefore, normally be of industry standard. Staff delivering programmes and conducting the assessments should be familiar with current practice and standards in the sector concerned. Centres will need to meet any specific resource requirements to gain approval from Pearson.

Where specific resources are required these have been indicated in individual units in the *Essential resources* sections.

Delivery approach

It is important that centres develop an approach to teaching and learning that supports the specialist vocational nature of BTEC Level 3 qualifications and the mode of delivery. Specifications give a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature. Tutors and assessors need to ensure that appropriate links are made between theory and practical application and that the knowledge base is applied to the sector. This requires the development of relevant and up-to-date teaching materials that allow learners to apply their learning to actual events and activity within the sector. Maximum use should be made of the learner's experience.

An outline learning plan is included in every unit as guidance which demonstrates one way in planning the delivery and assessment of the unit. The outline learning plan can be used in conjunction with the programme of suggested assignments.

Where the qualification has been designated and approved as a Technical Certificate and forms part of an apprenticeship scheme, particular care needs to be taken to build strong links between the learning and assessment for the BTEC Level 3 qualification and the related NVQs and Functional Skills that also contribute to the scheme.

Meeting local needs

These qualifications have been developed in consultation with centres and employers and the Sector Skills Councils or the Standards Setting Bodies for the relevant sector. Centres should make maximum use of the choice available to them within the optional units to meet the needs of their learners, and local skills and training needs.

In certain circumstances, units in this specification might not allow centres to meet a local need. In this situation, Pearson will ensure that the rule of combination allows centres to make use of units from other standard BTEC specifications. Centres are required to ensure that the coherence and purpose of the qualification is retained and to ensure that the vocational focus is not diluted.

See *Pearson BTEC Level 3 qualifications rules of combination* for information on meeting local needs.

These units cannot be used at the expense of the mandatory units in any qualification.

Functional Skills

BTEC Level 3 qualifications give learners opportunities to develop and apply Functional Skills.

Functional Skills are offered as stand-alone qualifications at Level 2. See individual units for opportunities to cover ICT, Mathematics and English Functional Skills.

Personal, learning and thinking skills

Opportunities are available to develop personal, learning and thinking skills (PLTS) within sector-related context. PLTS are identified in brackets after the unit pass criteria to which they are associated. Further opportunities for learners to demonstrate these skills may also be apparent as learners progress throughout their learning.

Access and recruitment

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

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

Centres are required to recruit learners to BTEC qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications and that the qualification will meet their needs. Centres should take appropriate steps to assess each applicant's potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the learner within the centre during their programme of study and any specific support that might be necessary to allow the learner to access the assessment for the qualification. Centres should consult Pearson's policy on learners with particular requirements.

Centres will need to review the entry profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a Level 3 qualification. For learners who have recently been in education, the profile is likely to include one of the following:

- a BTEC Level 2 qualification in Vehicle Technology or a related vocational area
- a standard of literacy and numeracy supported by a general education equivalent to four GCSEs at grade A*-C
- other related level 2 qualifications
- related work experience.

More mature learners may present a more varied profile of achievement that is likely to include experience of paid and/or unpaid employment.

Restrictions on learner entry

Most BTEC Level 3 qualifications are accredited for learners aged 16 years and over.

In particular sectors the restrictions on learner entry might also relate to any physical or legal barriers, for example people working in health, care or education are likely to be subject to police checks.

Access arrangements and special considerations

Equality and fairness are central to our work. Pearson's Equality Policy requires that all learners should 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.

Learners taking a qualification may be assessed in British sign language or Irish sign language where it is permitted for the purpose of reasonable adjustments.

Details on how to make adjustments for learners with protected characteristics are in the policy document Reasonable Adjustment and Special Considerations for BTEC and Pearson NVQ Qualifications, which are on our website, qualifications.pearson.com

Recognition of Prior Learning

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

Pearson encourages centres to recognise learners' previous achievements and experiences whether at work, home and at leisure, as well as in the classroom. RPL provides a route for the recognition of the achievements resulting from continuous learning.

RPL enables recognition of achievement from a range of activities using any valid assessment methodology. Provided that the assessment requirements of a given unit or qualification have been met, the use of RPL is acceptable for accrediting a unit, units or a whole qualification. Evidence of learning must be valid and reliable.

Unit format

All units in Pearson BTEC Level 3 qualifications have a standard format. The unit format is designed to give guidance on the requirements of the qualification for learners, tutors, assessors and those responsible for monitoring national standards.

Each unit has the following sections.

Unit title

The unit title will appear on the learner's Notification of Performance (NOP).

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.

Credit value

Each unit in BTEC Level 3 qualification has a credit value; learners will be awarded credits for the successful completion of whole units.

A credit value specifies the number of credits that will be awarded to a learner who has achieved all the learning outcomes of the unit.

Guided learning hours

Guided learning hours are defined on page 3.

Aim and purpose

The aim provides a clear summary of the purpose of the unit and is a succinct statement that summarises the learning outcomes of the unit.

Unit introduction

The unit introduction gives the reader an appreciation of the unit in the vocational setting of the qualification, as well as highlighting the focus of the unit. It gives the reader a snapshot of the unit and the key knowledge, skills and understanding gained while studying the unit. The unit introduction also highlights any links to the appropriate vocational sector by describing how the unit relates to that sector.

Learning outcomes

Learning outcomes state exactly what a learner should 'know, understand or be able to do' as a result of completing the unit.

Unit content

The unit content identifies the breadth of knowledge, skills and understanding needed to design and deliver a programme of learning to achieve each of the learning outcomes. This is informed by the underpinning knowledge and understanding requirements of the related NOS. The content provides the range of subject material for the programme of learning and specifies the skills, knowledge and understanding required for achievement of the pass, merit and distinction grading criteria.

Each learning outcome is stated in full and then the key phrases or concepts related to that learning outcome are listed in italics followed by the subsequent range of related topics.

Relationship between content and assessment criteria

The learner must have the opportunity within the delivery of the unit to cover all of the unit content.

It is not a requirement of the unit specification that all of the content is assessed. However, the indicative content will need to be covered in a programme of learning in order for learners to be able to meet the standard determined in the assessment and grading criteria. The merit and distinction grading criteria enable the learner to achieve higher levels of performance in acquisition of knowledge, understanding and skills.

Content structure and terminology

The information below shows how unit content is structured and gives the terminology used to explain the different components within the content.

- Learning outcome: this is given and in bold at the beginning of each section of content.
- Italicised sub-heading: it contains a key phrase or concept. This is content which must be covered in the delivery of the unit. Colons mark the end of an italicised sub-heading.
- Elements of content: the elements are in plain text and amplify the sub-heading. The elements must also be covered in the delivery of the unit. Semi-colons mark the end of an element.
- Brackets contain amplification of elements of content which must be covered in the delivery of the unit.
- 'eg' is a list of examples used for indicative amplification of an element (that is, the content specified in this amplification that could be covered or that could be replaced by other, similar material).

Assessment and grading grid

Each grading grid gives the assessment and grading criteria used to determine the evidence that each learner must produce in order to receive a pass, merit or distinction grade. It is important to note that the merit and distinction grading criteria require a qualitative improvement in a learner's evidence and not simply the production of more evidence at the same level.

Essential guidance for tutors

This section gives tutors additional guidance and amplification to aid understanding and a consistent level of delivery and assessment. It is divided into the following sections.

- *Delivery* – explains the content's relationship with the learning outcomes and offers guidance about possible approaches to delivery. This section is based on the more usual delivery modes but is not intended to rule out alternative approaches.
- *Outline learning plan* – the outline learning plan has been included in every unit as guidance and demonstrates one way in planning the delivery and assessment of a unit. The outline learning plan can be used in conjunction with the programme of suggested assignments.
- *Assessment* – gives amplification about the nature and type of evidence that learners need to produce in order to pass the unit or achieve the higher grades. This section should be read in conjunction with the grading criteria.
- *Suggested programme of assignments* – the table shows how the suggested assignments match and cover the assessment and grading criteria.

- *Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications* – sets out links with other units within the qualification. These links can be used to ensure that learners make connections between units, resulting in a coherent programme of learning. The links show opportunities for integration of learning, delivery and assessment.
- *Essential resources* – identifies any specialist resources needed to allow learners to generate the evidence required for each unit. The centre will be asked to ensure that any requirements are in place when it seeks approval from Pearson to offer the qualification.
- *Employer engagement and vocational contexts* – provides a short list of agencies, networks and other useful contacts for employer engagement and for sources of vocational contexts.
- *Indicative reading for learners* – gives a short list of learner resource material that benchmarks the level of study
- *Delivery of PLTS* - gives summary references where applicable of the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.
- *Functional Skills* - gives an indication of opportunities for developing functional skills at level two.

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Unit 1: Operation of Vehicle Chassis Systems

Unit code: M/503/7869

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the operation of the main chassis systems found in modern vehicles. This will include the vehicle transmission, steering, suspension and braking systems.

Unit introduction

Modern vehicles are highly developed machines that involve sophisticated and complex systems. Engines now provide more power, leading to higher torque and greater speeds than in the past, which drivers have to handle and control. This involves controlling power to the road wheels, stopping the vehicle when needed and directing it in a particular direction. In addition, the vehicle must be comfortable to travel in and be able to cope with the many forces that act on it.

This unit will introduce learners to the layout, function and operation of systems and components found in the main vehicle chassis systems. Learners will develop an understanding of the operating principles of a range of transmission, steering, suspension and braking systems.

The unit will also support further development of learner knowledge in areas such as fault diagnosis, specialised transmission systems, steering, suspension and brakes.

Learning outcomes

On completion of this unit a learner should:

1 Understand the layout and operation of a transmission system and its components

2 Understand the layout and operation of a steering system and its components

3 Understand the layout and operation of a suspension system and its components

4 Understand the layout and operation of a braking system and its components.

Unit content

1 **Understand the layout and operation of a transmission system and its components**

Transmission layout: drive method eg front-wheel drive, rear-wheel drive, four-wheel drive; power path eg flywheel, clutch, gearbox, drive/prop shafts

Transmission operation: function (clutch, gearbox, prop shaft, drive shaft, universal joint, final drive, differential); factors affecting torque transmitted by clutch eg number of plates, diameter, friction; gearing arrangements eg ratios, simple and compound gear trains

Transmission components: clutch eg single plate spring, diaphragm; release mechanisms eg linkage, cable, hydraulic, pneumatic, electrical; gearbox (input shaft, lay shaft, main shaft, idler); types of gear (straight cut, helical); universal joints eg Hooke's type, constant velocity type; final drive–crown wheel and pinion (bevel, hypoid and helical gears), differential (sun and planet gears); drive shafts (hollow and solid); axles eg semi, three quarter, fully floating; wheel hubs eg taper, roller bearings; transmission lubricant eg hypoid, multi-grade

2 **Understand the layout and operation of a steering system and its components**

Steering system layout: steering method eg rack and pinion, recirculating ball; position adjustment

Steering operation: Ackerman layout, toe out on turns, wheel alignment, camber, castor, swivel pin inclination, negative offset; oversteer and understeer behaviour; steering arrangement eg two-wheel steering, four-wheel steering systems

Steering components: steering wheel and steering column (bearings, bushes, mounting); universal joint (mounting methods, gaiters); steering linkage and joints for single steer vehicles eg track rod, drag link, drag link ends; steering arm, tie rod (bushes, joints); steering box (seals, bearing)

3 **Understand the layout and operation of a suspension system and its components**

Suspension systems layout: suspension method eg beam axle, independent front suspension (IFS), independent rear suspension (IRS); vibration and damping methods eg metal, rubber, hydraulic, hydro-pneumatic

Suspension operation: interaction of components eg vehicle loaded/unloaded, cornering, 'bump' reaction

Suspension components: spring systems eg leaf, coil, rubber, hydraulic; fittings and mounting eg shackles, U-bolts, saddle, tie bar; hydraulic/hydro-pneumatic systems eg fluid supply, storage, actuation, control; suspension damping eg oil, gas, friction; tyres eg type (radial, cross-ply, markings) and impact on vehicle suspension system

4 Understand the layout and operation of a braking system and its components

Layout: braking methods eg disc brakes, drum brakes; braking circuit eg hydraulic circuit, split braking circuits

Braking system operation: application of mechanical forces eg pedal force, transmission of force (fluid pressure, piston sizes); brake shoes/pads; heat dissipation eg mechanical to heat energy, vented brake arrangement; brake efficiency eg vehicle testing, axle efficiencies, brake balance; leading and trailing brake shoe action

Components: hydraulic circuit components eg single/tandem circuit, master/slave cylinders (machined surfaces, seals, pistons, springs), brake lines (fixed and flexible piping); brake servo eg diaphragm, spring, valve; pressure limiting valve eg seal, actuation; brake adjuster eg manual, automatic; brake discs/drums eg machined surface, vented, solid; callipers/actuators eg piston(s), seals, mounting; brake shoes (leading, trailing, springs); brake drums (machined surface, mounting); handbrake mechanism (actuation) eg mechanical linkage, cables, electronic control systems

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the layout of a vehicle's transmission	M1 compare two different types of transmission systems	D1 evaluate and justify the choice, in terms of layout and operation, of the transmission, steering, suspension and braking systems used for a current vehicle application.
P2 explain the operation of a transmission system and its components [IE1]	M2 compare two different types of steering systems	
P3 describe the layout of a vehicle's steering system	M3 compare two different types of suspension systems	
P4 explain the operation of a steering system and its components [IE1]	M4 compare two different types of braking systems.	
P5 describe the layout of a vehicle's suspension system		
P6 explain the operation of a suspension system and its components [IE1]		
P7 describe the layout of a vehicle's braking system		
P8 explain the operation of a braking system and its components [IE1].		

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PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit should focus on developing learners' fundamental understanding of vehicle transmission, steering, suspension and braking systems. This will enable them to progress onto the specialist units with a greater appreciation of the layout, operation and components of these systems.

The unit would be best delivered early in the qualification, as many learners will have limited knowledge and understanding of the systems identified in the content. If this is the case, tutors may need to give learners 'hands-on' experience of identifying components and systems. This will enable them to appreciate the scale and complexity of components and systems.

The use of demonstration rigs in the classroom or workshop to reinforce understanding is recommended. In addition, the availability of separate components would strengthen the link between classroom work and the workshop. Learners would benefit from having access to a range of vehicles, to enable them to examine the different systems on various types, makes and models.

There are many ways to approach the delivery of the unit but its structure means that each of the systems can be covered separately, or a more integrated approach can be used. Integration would enable delivery of the underlying principles and interrelationships before dealing with the specific layout, operation and components of the individual systems. Centres will need to consider which method of delivery will enable coverage of the range of vocational contexts that may be of relevance to learners (for example to learners from specific dealerships, general repair workshops, private and commercial vehicles, motorsport). It is important that learners are made aware of the links between this unit and other relevant units in the learning programme.

To support delivery, centres should ensure that there are sufficient components (for example clutch plates, brake callipers, joints and fittings) available to enable a full understanding of the principles, function, layout and operation of the systems in each area. Learners should be encouraged to carry out their own research on different models to improve their understanding of a range of systems. This will help them develop and practice their skills of comparison and evaluation and therefore improve their chance of achieving the merit and distinction criteria.

Note the use of 'eg' in the unit content is to give an indication of the breadth and depth of the area or topic. As such not all content that follows an 'eg' needs to be taught or assessed.

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Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the layout of a vehicle transmission system and the function of transmission system components – explain the function and operation of a transmission system, including the factors affecting torque and gearing arrangements ***Practical workshop activities:*** – investigation of a transmission system and its components
Prepare for and complete Assignment 1: Transmission Systems (P1, P2, M1)
Whole-class teaching: – explain the layout of a vehicle steering system and the function of steering system components – explain the function and operation of a steering system ***Practical workshop activities:*** – investigation of a steering system and its components
Prepare for and complete Assignment 2: Steering Systems (P3, P4, M2)
Whole-class teaching: – explain the layout of a vehicle suspension system and the function of steering system components – explain the function and operation of a suspension system ***Practical workshop activities:*** – investigation of a suspension system and its components
Prepare for and complete Assignment 3: Suspension Systems (P5, P6, M3)
Whole-class teaching: – explain the layout of a vehicle braking system and the function of steering system components – explain the function and operation of a braking system ***Practical workshop activities:*** – investigation of a braking system and system components
Prepare for and complete Assignment 4: Braking Systems (P7, P8, M4)
Prepare for and complete Assignment 5: Evaluating Vehicle System Applications (D1)
Feedback to learners, unit evaluation and close

Assessment

Assessment of this unit might be best achieved through four separate assignments, each covering one of the listed systems (ie transmission, steering, suspension and brakes).

The assignments need to be constructed in such a way as to ensure sufficient coverage of the grading criteria and related unit content. Opportunities to meet the pass and merit criteria that relate to each system should be provided, for example to be able to describe a vehicle's transmission layout (P1), explain its operation and components (P2) and compare it with another different type of transmission (M1). The comparison for the merit criterion should also cover the different system's layout, operation and components.

The assignment could direct learners to investigate a given or chosen system (for example transmission) and then prepare their descriptions. Learners should be encouraged to research and use a range of resource materials during their investigation. Tutors should provide guidance on how such material can be referenced and used as part of learners' own work so as not to infringe guidelines on authentic evidence, for example annotation of images, diagrams used to support/clarify own text. Development of these research and presentation skills may also provide suitable evidence for functional skills attainment.

Guidance should be provided, during the early formative assessment period, on the type of evidence and amount of detail required, to ensure that it is sufficiently concise, clear and relevant to the unit criteria and content.

To achieve a pass, learners will need to produce a suitable description of each system's layout. This could be achieved through the production of drawings or sketches that illustrate the relevant aspects of the content (for example for P1, a transmission's drive method and power path). The drawings should then be suitably labelled and/or annotated to provide a sufficient description of the layout (for example to clearly identify the path taken by the power between the flywheel and the driven road wheels). In addition, for each system a suitable explanation of its operation and components is needed. Again, drawings or sketches can be used to good effect to support any written evidence (for example for P6, drawings that show the interaction of components during a 'bump' reaction of a suspension system, together with suitable labelling of the key components that play a part in the suspension of the vehicle under such conditions).

These could also be supplemented with evidence from practical activities carried out in other units or from work experience (for example steering geometry test report, braking efficiency tests). The use of such practical work would provide a vocational context to what could be seen as an overly theoretical unit.

To achieve the merit criteria, learners will need to compare two different types of system for each of those covered by the pass criteria (ie transmission, steering, suspension and brakes). One could be the system already examined for pass. The second could be chosen by the learner or set by the tutor, but it should be sufficiently different to provide scope for comparison. The comparison should consider the differences and similarities in terms of each system's layout, operation and components. It should also consider the differences in terms of how the components of each system interrelate with one another.

To achieve the distinction criterion, learners will need to choose, or be given, a current vehicle to investigate and evaluate in terms of the layout and operation of the four systems considered at pass level. It is expected that tutors will supervise the final choice of vehicle so that learners are exposed to systems different to those already covered through the pass and merit criteria (for example if two-wheel drives have been the main focus at pass/merit, then learners should consider a four-wheel drive vehicle for D1). This will give learners both variety in their study and exposure to a greater range of systems. The evaluation and justification should take into account the intended use and therefore design of the vehicle. It should also consider the interrelationships between the systems, for example the impact of the type of suspension on the steering and handling of the vehicle.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Transmission Systems	A vehicle technician needs to explain the layout and operation of a transmission system to a new apprentice	A written task supported by relevant drawings/sketches
P3, P4, M2	Steering Systems	A vehicle technician needs to explain the layout and operation of a steering system to a new apprentice	A written task supported by relevant drawings/sketches
P5, P6, M3	Suspension Systems	A vehicle technician needs to explain the layout and operation of a suspension system to a new apprentice	A written task supported by relevant drawings/sketches
P7, P8, M4	Braking Systems	A vehicle technician needs to explain the layout and operation of a braking system to a new apprentice	A written task supported by relevant drawings/sketches
D1	Evaluating Vehicle System Applications	A vehicle fleet operator has asked a technician to evaluate the suitability of a possible new fleet vehicle	A written report

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Vehicle System Fault Diagnosis
		Operation and Maintenance of Light Vehicle Transmission Systems

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair–Light Vehicle, particularly:

- Unit LV04: Remove and Replace Motor Vehicle Chassis Units and Components
- Unit LV08: Diagnose and Rectify Motor Vehicle Chassis System Faults
- Unit LV12: Remove and Replace Motor Vehicle Driveline Units and Components
- Unit LV13: Diagnose and Rectify Motor Vehicle Transmission and Driveline System Faults.

Essential resources

Centres need to provide learners with access to vehicle components (eg bevel, hypoid and helical gears), demonstration rigs (eg sectioned clutches, gearboxes, steering boxes) and vehicles. A range of suitable reference material (eg manuals and manufacturers' data) relating to the systems covered is also essential.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

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Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) ISBN 978-1408515181

Nunney, M — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to solve and explaining the operation of vehicle systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	asking questions to extend their thinking when researching the layout and operation of vehicle systems
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others to work towards common goals when researching the layout and operation of vehicle systems

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Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching the layout and function of vehicle systems
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	explaining the layout and function of vehicle systems
Present information in ways that are fit for purpose and audience	explaining the layout and function of vehicle systems
Mathematics	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	working with gear ratios and considering the application of forces on the vehicle due to the type of system being considered
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	explaining the layout and function of vehicle systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the layout and function of vehicle systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the layout and function of vehicle systems

Unit 2: Vehicle Engine Principles, Operation, Service and Repair

Unit code: L/602/1964

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the operating principles of vehicle engines, fuel supply systems and engine cooling and lubrication systems, and will enable them to carry out engine service and repair procedures.

Unit introduction

Although the technology used in modern vehicles is under constant development, the basic principles of the internal combustion engine (ICE) have remained the same for many years. However, advances in design have produced engines that are more efficient, powerful, environmentally friendly and, with the aid of electronics, much more responsive to the needs of the user.

Developments in engine design and materials technology have significantly increased the reliability and durability of engine components and systems and, therefore, minimised failure and the need for subsequent repairs. However, the modern motor vehicle technician still needs to have a working knowledge and understanding of the engine, and associated sub-systems, to enable them to carry out the necessary care, fault diagnosis and repair.

This unit will enable learners to develop an understanding of a range of engines in terms of their operating principles and processes, applications and service/repair. Two and four-stroke cycle spark and compression ignition engines will be considered together with their related sub-systems — fuel, cooling and lubrication. The unit also examines current and future developments in engine design that make use of alternative fuel and power systems.

Finally, the unit will give learners an opportunity to apply their understanding of engine principles by carrying out engine service and repair work in a vehicle workshop environment. Learners will gain practical experience of using a range of tools and equipment and will work to industry standards relating to vehicle service and repair.

Learning outcomes

On completion of this unit a learner should:

1 Understand the principles of operation of an internal combustion engine

2 Understand the principles of operation of fuel supply systems

3 Understand the principles of operation of engine cooling and lubrication systems

4 Be able to carry out engine service and repair procedures.

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Unit content

1 Understand the principles of operation of an internal combustion engine

Operating cycles: internal combustion engines (ICE) eg four-stroke spark ignition (SI) and compression ignition (CI) cycles, two-stroke cycle, Wankel (rotary); pressure-volume diagrams and engine performance diagrams (torque/power) eg the Otto cycle, identification of induction, compression, ignition, exhaust strokes, effects of bore, stroke, swept and clearance volume; engine efficiency eg engine timing, pressure charging, compression ratio

Engine configurations and layout: orientation (longitudinal/transverse); position of engine (front, mid and rear); cylinder arrangement eg single cylinder, multi cyclinder; cylinder configuration eg in-line, vee, horizontally opposed arrangements; vehicle design and performance eg space saving, arrangements for power transmission, vehicle function (passenger, people carrier, off-road, motorsport), cost, environmental issues

Engine assemblies: engine types eg four-stroke SI and CI, two-stroke cycle, Wankel (rotary); components eg cylinder block (piston, connecting rod, crankshaft and bearings), cylinder head (camshaft, inlet/exhaust valves, valve operating mechanisms such as overhead valve (OHV), single overhead cam (SOHC), double overhead cam (DOHC), variable valve timing); flywheel; inlet and exhaust manifolds

2 Understand the principles of operation of fuel supply systems

Petrol combustion process: fuel principles eg composition of petrol, characteristics of petrol, composition of air, air/fuel ratio, lambda ratio; combustion process eg mixing of fuel/air, flame spread, exhaust emissions; effects of pollutants/causes of undesirable emissions eg weak mixture, rich mixture, oil control problems; symptoms of incorrect combustion process eg detonation, pre-ignition; fuel supply method eg fuel injection, mechanical, electrical; fuel system components eg tank, petrol filter, air filter, supply/pressure pump, pressure regulator, injectors

Diesel combustion process: fuel principles eg composition of diesel, characteristics of diesel, air/fuel ratio; combustion process eg phases, delay, combustion/flame spread, spontaneous/direct burning, pressure/crank angle diagrams, diesel knock; exhaust emissions eg normal, excess air, excess fuel, effects of pollutants; fuel supply method eg rotary, inline, unit injector; fuel system components eg low pressure (tank, filter(s), supply pump), high pressure (in-line pump, governor, injector, cold start arrangements)

Alternative fuel/power: systems eg electric, liquefied petroleum gas (LPG), natural gas, hydrogen, hybrid; adapted/additional components eg batteries, fuel tank, additional modifications, cooling system, management control system, performance; legislation eg emissions, tax, health and safety

3 Understand the principles of operation of engine cooling and lubrication systems

Engine cooling systems: types of system eg air-cooled (cylinder construction, fan, shutters, thermostat), water-cooled (radiator, radiator cap, expansion tank, water pump, viscous/electric/mechanical fans, thermostat, hoses, types of coolant, level indication, anti-freeze protection, effects and prevention of corrosion); cooling control systems eg engine temperature sensor, ambient air temperature sensor, thermostatic control valves (mechanical and electrical), cooling air flow control (air flow control via flap for warm up); engine management system eg overheating, fuel cut-off

Engine lubrication system: system components eg wet/dry sumps, oil pump, pressure relief valve; engine oil types and filtration methods eg viscosity, Society of Automotive Engineers (SAE) rating, multi-grade oil; filters eg full flow or bypass; lubrication control systems eg sensors, level indicator (mechanical, electrical); pressure sensors eg absolute and gauge or lamp; low pressure safety system eg engine management system fuel cut-off

4 Be able to carry out engine service and repair procedures

Routine engine service: procedures eg changing engine lubricant, filters (air, lubricant, fuel), checking and adjusting engine timing (ignition, camshaft); working to instructions eg manufacturer's service schedules/data, dealership work schedules/job cards; use of tools and equipment eg hand tools, vehicle lift equipment, oil drainer, on-board service indicators; safe working procedures eg personal and vehicle protection (personal protective equipment, vehicle covers, mats); Control of Substances Hazardous to Health (COSHH) Regulations; safe disposal of waste products

Major engine repair: procedures eg strip and inspect bore and crankshaft journals for wear, cylinder head for distortion, valves for seating and damage; working to instructions eg manufacturer's repair manuals, web-based information, dealership work schedules/job cards/supervisor's instructions; use of tools and equipment eg engine crane, chains, slings, torque wrenches, micrometers, dial test indicators (DTI), timing tools, locking devices, cleaning equipment; safe working procedures eg personal and vehicle protection (personal protective equipment, vehicle covers, mats), manual handling, use of lifting and support equipment, use of cleaning solvents; safe disposal of waste products

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Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the operating cycles of two different internal combustion engines	M1 compare the advantages and disadvantages of the design and performance of two different engine configurations and layouts	D1 evaluate the suitability of an engine used for a current vehicle application, in terms of its layout, operation and performance
P2 explain the vehicle design and performance implications of an engine's configuration and layout	M2 compare the advantages and disadvantages of two different engines in terms of their fuel, cooling and lubrication systems	D2 compare a conventional fuel system with that of an alternative fuel/power source.
P3 explain the function, operation and construction of the components/ assemblies of one type of engine	M3 prepare a work schedule for a major engine repair procedure, carry out the repair and evaluate the effectiveness of the work schedule.	
P4 explain the effects of different air-fuel ratios on the petrol combustion process and exhaust emissions		
P5 explain the diesel combustion process		

Table continues on next page

Assessment and grading criteria		
P6 describe an application of an alternative fuel/power supply system		
P7 explain the principles of operation and difference between an air- and a water-cooled engine		
P8 explain the layout, system components and operation of two different engine lubrication systems		
P9 carry out a routine engine service by following given instructions [IE4, SM3, SM4]		
P10 carry out a major engine repair following given instructions [SM3, SM4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

The unit has been designed to enable learners with no previous experience of engines to gain an insight into the principles and applications of engine technology. Tutors will need to consider the best way to take learners through the basic principles of engine cycles, fuel supply, cooling and lubrication. This will need to be done in such a way that stretches those learners with some experience of engine technology but also provides sufficient support for those new to the topic. The method of delivery most likely to achieve this is using a practical/investigative approach supported by tutor-led sessions on the relevant theories (for example Otto cycle in relation to engine types, application of power and torque in engine performance). The unit should not be seen as purely theoretical with just one practical outcome and tutors should make delivery of the whole unit a 'hands-on' experience wherever possible.

Tutors may consider integrating this unit with others in the programme of study (for example *Unit 8: Function and Operation of Vehicle Petrol Injection Systems*, *Unit 9: Diesel Fuel Injection Systems for Compression Ignition Engines* and *Unit 11: Vehicle Engine Management Systems*). It may also be possible to integrate the delivery and/or assessment of this unit within a learner's work-based role/work placement. Both of these approaches will have the potential to increase the level of practical content and relevance for learners. However, it is critical that all vehicle workshop activities within the centre reflect and simulate current industry standards, practices and working environments. This includes dress, codes of practice, supervision and health and safety.

When planning for delivery, tutors will need to consider how much can be taught using 'live' vehicles and how much will need to be carried out using special training rigs or specialist models (for example engine, fuel/oil pump cut away sectioned models). The first three learning outcomes are likely to rely on a significant use of such rigs and models. However, it is expected that delivery of the final learning outcome will be carried out using 'live' vehicles and all work undertaken should replicate industry standards as far as possible. In particular, the routine engine service and major engine repair procedures undertaken (for example changing engine lubricant, filters, stripping/inspection of bore and crankshaft journals for wear) should follow typical vehicle workshop working instructions and use relevant industry standard tools and equipment.

Safe working procedures must always be followed. Tutors should ensure that safety is embedded within everything learners carry out in the vehicle workshop.

Note the use of 'eg' in the unit content is to give an indication of the breadth and depth of the area or topic. As such not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching/group work: – introduction to unit content, overview of activities and assessment methodology – group work on different cycles of operation in SI, CI and rotary engines – comparison and explanation of diagrams associated with pressure, volume, power and torque and subsequent effects of bore, stroke, swept and clearance volume – explanation of aspects relating to engine efficiency eg engine timing, pressure charging, compression ratio
Practical investigation and individual research: – strip out a variety of engine sub-assemblies to compile research of the components of a variety of engines types and variants clearly comparing the constructional details – working with a variety of configurations and layouts in a workshop, identify and research the vehicle design and performance implications of the vehicles
Prepare for and complete Assignment 1: Principles and Operation of Engines (P1, P2, P3, M1, D1)
Group investigation and individual research: – identify fuel supply components, operation and function along with a comparison of both CI and SI systems and variants – investigation of alternative fuel/power systems ***Whole- class teaching/group work:*** – explanation of the petrol combustion process aligned to content guidance – explanation of the diesel combustion process aligned to content guidance
Prepare for and complete Assignment 2: Fuel Systems (P4, P5, P6, D2)
Whole- class teaching: – explanation of the different types of cooling system and the differences between them – explanation of the different types of lubrication systems ***Individual learner work:*** – research air/water cooling systems and lubrication systems
Prepare for and complete Assignment 3: Cooling and Lubrication Systems (P7, P8, M2)

Topic and suggested assignments/activities and/assessment
Practical workshop activities: – tutor demonstration of routine engine service procedures – tutor demonstration of engine repair procedures – learners to practice carrying out engine service and repair procedures
Prepare for and complete Assignment 4: Routine Engine Servicing (P9)
Prepare for and complete Assignment 5: Major Engine Repair Procedures (P10, M3)
Feedback to learners, unit evaluation and close

Assessment

Tutors should design a varied assessment strategy that could include research and investigate tasks, set piece service/repair activities and technical reporting.

While assessment methods must reflect the unit content, they should also recognise the need to keep up to date with current components, systems, applications and working practices. The examples given in the unit content reflect current practice but could be replaced with more relevant and up-to-date examples as technology changes, without affecting content coverage. For example, the content for lubrication control systems has the examples 'sensors, level indicator (mechanical, electrical)' but advances in digital/computer-based engine management systems could make mechanical sensors obsolete in the not too distant future.

There are no fixed ways in which the unit should be assessed or the number of assessment instruments that might be used. The maximum number of assignments is likely to be five, one for each of the first three learning outcomes and two for the last. However, there are strong links between all the pass criteria and across the merit and distinction criteria. Tutors should endeavor to make the most of these links to keep the number of assessment instruments to a minimum.

One approach might be to design two project-style assignments that run in parallel to each other. Each project would focus on a particular engine and learners would study the engine's operating cycle, configuration and layout, combustion process, cooling and lubrication systems. They would then carry out a routine service on one engine and a major repair on the other.

To meet all the requirements of the criteria, one engine should use petrol combustion and the other diesel. One allowance on this would be to incorporate an alternative fuel such as LPG. Special considerations within the project brief would need to be applied to P2 and P3, which only need to be covered for one engine (although the configuration and layout of the second engine would need to be considered to achieve M1). Additional tasks would probably need to be included in the project brief to enable learners to achieve P6 (alternative fuel/power supply system), and P7 (differences in operation of an air- and a water-cooled engine). P6 could be achieved through a 'what if' scenario within one of the projects (for example consider an alternative fuel/power supply system for the vehicle being considered). P7 could be achieved by ensuring that one engine is air-cooled and the other water-cooled. However, as this situation is unlikely to occur, a 'what if' scenario could also be set within one of the projects (for example if the water-cooled engine had been air-cooled then explain the principles of operation and differences that would apply).

Running the two projects in parallel would ensure that assessment could follow delivery and also that the criteria would not need to be fragmented (ie visited twice at different times before they could be achieved). Opportunities to achieve the merit and distinction criteria could also be built into the projects with some imagination and careful planning.

Whatever form of assessment is used, the tasks set will need to ensure that for P1 learners are able to explain the operating cycles of two different internal combustion engines (ie selecting two from the list of examples in the unit content). For each engine, learners should explain the engine's operating cycle by using suitable diagrams to indicate pressure-volume within the cycle, engine performance (torque/power) and engine efficiencies (for example engine timing, pressure charging and applicable compression ratios).

For P2, learners must be able to explain the vehicle design and performance implications of an engine's configuration and layout. They need to take into account the orientation (longitudinal/transverse), position of engine (front, mid and rear), cylinder arrangement, cylinder configuration, the purpose for which the vehicle has been designed and its expected performance (see examples in the unit content). The key question for learners to address and consider is – why that engine for that vehicle?

To achieve P3 learners need to explain the function, operation and construction of the components/assemblies of one type of engine (for example a four-stroke SI engine or a four-stroke CI engine). Their explanation should include details of the engine's main components and assemblies (ie cylinder block, cylinder head, flywheel, inlet and exhaust manifolds).

Criteria P4, P5 and P6 focus on fuel systems. For P4, learners need to focus on a petrol engine and explain the effects of different air/fuel ratios on the petrol combustion process and exhaust emissions. This should include an introduction to fuel principles (for example composition of petrol, characteristics of petrol, composition of air, air/fuel ratio, lambda ratio) the combustion process, effects of pollutants and causes of undesirable symptoms. Learners should also consider the fuel supply method and fuel system components (for example tank, petrol filter, air filter). This could be set within the context of the particular petrol engine/vehicle being studied.

A similar approach is required for P5, but this time learners need to explain the diesel combustion process. Learners should explain diesel fuel principles, the combustion process, exhaust emissions, fuel supply method and fuel system components for either low pressure or high pressure diesel fuel systems.

For P6, learners must describe an application of an alternative fuel/power supply system. This can either be given by the tutor or chosen by the learner.

Learners should describe the system (for example LPG, natural gas, hydrogen, hybrid) and how traditional components have been adapted and/or any necessary additional components. They should also describe the relevant aspects of legislation that apply to these alternative fuel/power supplies. This should be set within the context of a particular vehicle.

P7 and P8 are closely linked and require learners to consider the fundamental differences between common cooling and lubrication systems. They can also be extended through to M2.

For P7, learners need to explain the principles of operation of and the differences between an air- and a water-cooled engine. Learners need to identify the types of system being considered (for example for an air cooled engine the cylinder construction, fan, shutters etc, for a water cooled engine the radiator, radiator cap, expansion tank etc). For each engine learners will need to consider the cooling control systems used and the relevant aspects of the engine management system with respect to engine cooling.

For P8, learners need to explain the system components, layout and operation of two different engine lubrication systems. This should include the respective system components (for example wet/dry sumps, oil pump, pressure relief valve), engine oil types and filtration methods, lubrication control systems, pressure sensors and low pressure safety system.

P9 and P10 form the focus of the practical assessment for this unit. Learners need to carry out a routine engine service and a major engine repair following given instructions. Examples of typical routine servicing and major repairs are given in the unit content, although these are not exclusive. Other service activities or repairs of an equivalent level of difficulty would be acceptable.

Assessment evidence for P9 and P10 is likely to be in the form of the learner's personal log/record of the work undertaken plus relevant tutor observation records. Learners may also wish to use suitably annotated photographic evidence to support both their log/record and tutor observation. The evidence must indicate the service and repair procedures carried out, the instructions followed, the tools and equipment used and the safe working procedures followed, including safe disposal of waste products.

To achieve M1, learners need to further consider the design and performance of two different engine configurations and layouts by comparing the advantages and disadvantages of each.

To achieve M2, learners need to build on their understanding of fuel, cooling and lubrication systems (P4 to P8) to compare the advantages and disadvantages of two engines with respect to these systems.

For M3, learners need to prepare a work schedule for a major engine repair procedure, carry out the repair and evaluate the effectiveness of the work schedule. Learners are expected to carry out a second (and different) major engine repair to achieve the merit criterion. It is not sufficient for learners just to prepare the work schedule and carry out a single repair in order to achieve P10 and M3. The object of the assessment at pass level is to establish whether learners can competently complete a given major repair under supervision/guidance. However, at merit level they are expected to demonstrate independence and reflection.

For D1, learners need to evaluate the suitability of an engine for a current vehicle application. This should be done in terms of the engine's layout, operation and performance. It is expected that the evidence presented will include a detailed evaluation of the particular vehicle's engine (for example type, power, layout, main components, fuel, lubrication systems). Having evaluated the engine in this way learners should then arrive at a reasoned justification for the manufacturer's choice based on their own findings.

Evidence for D1 is most likely to be in a written format but learners could also include diagrams, photographs or other visual means to illustrate their work. Where images are not learners' own work credit must be given to the originator. Learners should suitably annotate these images to indicate how they support their report.

For D2, learners must compare a conventional fuel system with that of an alternative fuel/power source. This can be linked with the work undertaken for P4, P5 and P6 and M2 (in part). The comparison should be in terms of the same aspects covered for the pass criteria (for example the fuel/power principles, combustion process, adapted/additional components, effects of pollutants/causes of undesirable emissions, fuel/power supply methods, fuel/power system components, relevant legislation). Again, evidence for this criterion is likely to be in the form of a written report and learners may make use of suitable images, as detailed for D1 above.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1, D1	Principles and Operation of Engines	A technician needs to explain to a new apprentice the different internal combustion cycles, the design and performance implications of an engine layout and the operation and construction of the components and sub-assemblies	A written report supported by relevant annotated diagrams
P4, P5, P6, D2	Fuel Systems	A technician needs to explain the differences between diesel, petrol and alternative fuel systems to an apprentice	A written report/presentation supported by relevant annotated diagrams
P7, P8, M2	Cooling and Lubrication Systems	An apprentice needs to investigate a vehicle’s cooling and lubrication systems	A written report supported by relevant annotated diagrams

Criteria covered	Assignment title	Scenario	Assessment method
P9	Routine Engine Servicing	A technician needs to carry out a routine engine service to give the opportunity of vocational tasks in employment	Workshop practical activity with associated documentary evidence to reflect industrial methods and standards. Observation Records and annotated photographs would also be suitable supporting evidence.
P10, M3	Major Engine Repair Procedures	A technician needs to carry out a major engine repair	Workshop practical activity with associated documentary evidence and a written evaluation to include data collation aligned to full list of tools and equipment utilised. Observation Records and annotated photographs would also be suitable supporting evidence.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Vehicle System and Fault Diagnosis and Rectification
		Vehicle Engine Management Systems

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit LV01: Carry out Routine Motor Vehicle Maintenance
- Unit LV05: Inspect Motor Vehicles Using Prescribed Methods
- Unit LV06: Inspect Vehicles.

Essential resources

Centres will need to provide learners with access to a suitable workshop, equipped to modern standards with live vehicles, test rigs and components that reflect current technology and working practices.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Nunney M — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information when researching vehicle engines
Self-managers	organising time and resources, anticipating and managing risks when carrying out vehicle engine servicing and repair

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work reviewing progress and acting on the outcomes
Team workers	collaborating with others when researching vehicle engines and when carrying out servicing and repairs

Functional Skills — Level 2

Skill	When learners are …
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	taking measurements of engine bore, strokes, swept and clearance volume, wear calculations
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching information on the principles of operation of an internal combustion engine, fuel, lubricating and servicing/repair procedures
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	preparing written evidence on the principles of operation of an internal combustion engine, fuel, lubricating and servicing/repair procedures

Unit 3: Vehicle System Fault Diagnosis and Rectification

Unit code: H/506/3191

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners the skills and knowledge needed to recognise fault symptoms, apply fault diagnosis and rectification procedures and confirm system integrity in a range of vehicle systems.

Unit introduction

Although technological advances have led to increasingly reliable mechanical, electrical and electronic vehicle systems, for a variety of reasons these systems still fail. When a fault develops it is more important than ever, from an operational, safety and often a legal standpoint, to carry out a quality repair.

Learners will be expected to diagnose and undertake work on faults in vehicle mechanical and electrical/electronic systems regardless of the manufacturer or vehicle type (for example light or heavy vehicle, passenger carrying vehicle, motorsport vehicles). Learners will identify, select and use a range of diagnostic tools and equipment, checking that they are in a safe and useable condition before use.

For the purpose of this unit, a fault may be considered to be a component failure or system malfunction relating to mechanical or electrical and electronic systems, individually or in combination.

When diagnosing faults, learners will need to work in a logical manner, working to instructions obtained from appropriate sources. Safe working practices and good housekeeping are a recurrent theme throughout the unit.

Learning outcomes

On completion of this unit a learner should:

1 Be able to identify vehicle system faults

2 Be able to prepare and use diagnostic equipment and procedures to identify and confirm faults

3 Know alternative rectification procedures

4 Be able to rectify faults and confirm system integrity.

Unit content

1 Be able to identify vehicle system faults

Mechanical system: systems eg engine (pistons, belts, chains, bearings, shafts), ancillary systems (fuel, lubrication, cooling), transmission (clutch, torque converter, gearbox, rear axle, differential), steering and suspension, braking; faults eg internal engine component failure, failed head gasket, failed seal, fuel blockage, contamination (oil, fuel, coolant, hydraulic and pneumatic fluid), non-starting, low/high oil pressure, faulty coolant system, clutch malfunction, damaged clutch linkages, bearing failure (engine, clutch, pump, rear axle/differential), selector mechanisms malfunction, gear selection difficult, faulty torque converter hydraulic components, worn gear, worn drive shaft/joint, misalignment (drive shafts, steering/suspension), defective steering/suspension components, inoperative braking system (faulty caliper, worn disc); symptoms eg unusual sounds, noisy bearings, leaks, smoke, metallic particles in lubricants, loss of power, exhaust gas contamination, misfire, engine overheating/overcooling, water contamination, clutch (slip, grab, judder, difficult selection), vibration, unusual tyre wear, poor brake efficiency, brake noise and judder, braking imbalance, excessive brake pedal travel, poor road handling, oversteer, understeer

Electrical/electronic system: systems eg starting, charging, ignition, lighting and auxiliary, control systems (electronic, instrumentation, engine); faults eg starting system sluggish or non-operational, battery faults, alternator malfunctioning, diode faults, electronic control not working, fuse problems, damaged or loose wire, inoperative ignition components, ignition timing faults, inoperative systems, headlamp misalignment, instrumentation malfunction, driver information malfunction, engine management malfunction, chassis control system malfunction (Anti-lock Braking System (ABS), stability control, transmission control), security and alarm systems failure; symptoms eg noisy operation, no charge, over charging, short circuit, open circuit, misfire, non-starting, incorrect information, inaccurate displays, confused control

2 Be able to prepare and use diagnostic equipment and procedures to identify and confirm faults

Preparation: adherence to regulations eg Provision and Use of Work Equipment Regulations (PUWER) 1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Electricity at Work Regulations 1989, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Health and Safety (First Aid) Regulations 1981, motorsport specific; positioning eg use of ramps, jacks, stands; vehicle protection eg covers, sheeting; component/system access eg removal of bodywork, fairings and covers, removal of excessive oil, dust, grease and dirt, competition/road debris

Diagnostic equipment: mechanical equipment eg dial gauges, micrometers, feeler gauges, pressure gauges, specialist equipment eg auto transmission test equipment, steering geometry and suspension alignment equipment, wheel balancing and brake testing equipment; electrical and electronic equipment eg meters, multimeters, oscilloscopes, diagnostic analysers, data logging/self-diagnosis equipment, emissions testers, computer systems

Diagnostic procedures: reference to considerations of safety and vehicle/system protection; procedures eg visual, aural, performance monitoring, road and roller tests, procedures used with electrical, electronic and systems diagnostic equipment; assessing vehicle information systems and data in a variety of formats eg workshop manuals, diagnostic information, CD ROMs, IT-based data retrieval systems and fault code analysers

3 Know alternative rectification procedures

Rectification procedures: eg

- dismantling, inspection and assessment: comparison against specifications (manufacturer, vehicle data, auto data, computer-based systems), factors influencing rectification choice (operational, cost, safety and legal requirements)
- adjustments: associated with the range of vehicle systems, manufacturers' specifications (tolerances, operational limits), safety, performance and legal considerations
- replacement: using new, overhauled and factory or third party reconditioned components and units
- repair: in-house or third-party specialist repair options, comparison of cost of replacement/repair including consideration of service life expectancy, reliability and warranty status
- substitution/alteration: use of adapted, redesigned or re-engineered components and/or units and effects of substitution (based on comparisons of specifications, manufacturers' bulletins, safety and service recommendations)

4 Be able to rectify faults and confirm system integrity

Rectify faults associated with mechanical systems: eg engine and ancillary systems, transmission, steering, wheels and tyres, suspension and braking systems

Rectify typical faults associated with electrical/electronic systems: eg starting, charging, ignition, lighting and auxiliary systems, vehicle instrumentation, driver information, engine management, chassis control (ABS, stability control, transmission control), security, driver information and alarm

Equipment: hand tools; MOT equipment; product specific equipment; for mechanical systems eg measuring equipment, analysers, on-board diagnostics, alignment equipment, balancing equipment; for electrical/electronic systems eg scanning equipment meters

Documentation to confirm system integrity: manufacturers' specifications and data; legal requirements; performance test data

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify two mechanical system faults on each of two different vehicles from given symptoms [IE1, IE4, SM3]	M1 justify the use of the equipment chosen to diagnose selected system faults with reference to the expected accuracy of the results obtained	D1 analyse a system's test results and recommend actions needed to rectify problems
P2 identify two electrical system faults on each of two different vehicles from given symptoms [IE1, IE4, SM3]	M2 compare the advantages and disadvantages of two diagnostic procedures including the use of dedicated test equipment	D2 review one vehicle diagnostic and rectification procedure carried out and make recommendations for improvement.
P3 prepare two vehicles for fault diagnosis [IE4, SM3]	M3 justify the selection of a rectification procedure in terms of safety, cost, performance and legal considerations.	
P4 use appropriate diagnostic equipment and procedures to diagnose faults on two different mechanical systems on each of two different vehicles [IE1, IE4, CT1, CT5, SM3]		

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Assessment and grading criteria		
P5 use appropriate diagnostic equipment and procedures to diagnose faults on two different electrical systems on each of two different vehicles [IE1, IE4, CT1, CT5, SM3]		
P6 describe an alternative rectification procedure for two faults on different mechanical systems		
P7 describe an alternative rectification procedure for two faults on different electrical/ electronic systems		
P8 carry out rectification procedures on two different faulty mechanical systems, conforming with manufacturers' specifications and safety and legal requirements [IE1, IE4, SM3, SM4]		
P9 carry out rectification procedures on two different faulty electrical/electronic systems, conforming with manufacturers' specifications and safety and legal requirements [IE1, IE4, SM3, SM4]		
P10 use appropriate equipment, procedures and documentation to confirm system integrity [IE1, IE4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Learners will need an understanding of the purpose, function, and principles of operation of specific vehicle components and systems before starting this unit. The delivery approach used should be sufficiently varied to provide learners with the underpinning knowledge and skills needed to assist with fault-finding operations on any vehicle type.

Learners should be given opportunities to compare the advantages and disadvantages of alternative diagnostic procedures and delivery should concentrate on developing practical diagnostic and rectification skills. Videos, simulations and rigs will be effective learning aids, since provision of 'live' examples across the range of system faults is likely to be impracticable.

The four learning outcomes are ordered logically and could be developed sequentially through practical demonstration and practice. This will help learners to understand the logic and routine behind effective fault-finding and rectification procedures before attempting to diagnose and rectify faults themselves.

The best way for learners to develop fault identification and diagnostic skills is to practise the procedures involved. Although knowledge of rectification procedures is needed for learning outcome 3 it may be best to develop this through practical activities. This may mean that the majority of time is devoted to the practical requirement of learning outcomes 1, 2 and 4.

Although the unit content attempts to range faults and symptoms it is appreciated that, in some cases, faults will actually be symptoms and in some cases symptoms will be faults. This should be explained during delivery so it occurs during assessment learners will feel confident about what they are doing.

The use of 'eg' is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments / activities and / assessment
Whole-class teaching / practical demonstration: – introduction to unit content, overview of activities and assessment methodology – using a mixture of live systems, training rigs and video materials, explain and demonstrate typical electrical and mechanical system faults and likely symptoms ***Practical workshop activities:*** - practical investigations of mechanical and electrical/electronic systems and system faults
Whole-class teaching / practical demonstration: – explain the relevant regulations that need to be considered before using diagnostic equipment – explain and demonstrate correct and safe methods of positioning a vehicle, means of vehicle protection and ensuring access to components and systems – explain and demonstrate use of mechanical and electrical and electronic diagnostic equipment – explain and demonstrate use of diagnostic procedures to identify and confirm faults ***Practical workshop activities:*** – practise using diagnostic equipment and procedures
Prepare for and carry out Assignment 1: Identifying and Diagnosing Faults (P1, P2, P3, P4, P5, M1, M2)
Whole-class teaching / practical demonstration: – explain and demonstrate a range of alternative rectification procedures ***Individual learner activities:*** – investigation of alternative rectification methods

Topic and suggested assignments/activities and/assessment
Prepare for and carry out Assignment 2: Alternative Rectification Procedures (P6, P7)
Whole-class teaching/practical demonstration: – explain and demonstrate use of equipment, procedures and documentation to rectify mechanical and electrical/electronic system faults – explain and demonstrate methods of confirming system integrity ***Practical workshop activities:*** – rectifying a range of vehicle system faults and using documentation to confirm system integrity
Prepare for and carry out Assignment 3: Rectifying Faults (P8, P9, P10, M3, D1, D2)
Feedback to learners, unit evaluation and close

Assessment

This unit is likely to be assessed through a combination of assignments and practical workshop investigations.

It is expected that learners will have carried out practical work on vehicles to support their underpinning knowledge. Evidence will include test data, printouts and records of diagnostic procedures carried out supported by witness statements/observation records supplemented by annotated photographs.

The emphasis of this unit is on developing practical fault diagnostic and rectification skills across a range of mechanical and electrical/electronic vehicle systems. Learners should be given opportunities to diagnose typical faults, recommend repair strategies and carry out fault rectification. This should be based on diagnostic information and other criteria such as safety, cost, operational and legal requirements. It is expected that learners will be given opportunities to use and compare alternative diagnostic procedures and equipment in practical situations.

To achieve the pass criteria associated with learning outcome 1 (P1 and P2) learners should identify faults on two mechanical and two electrical systems, on each of two different vehicles from given symptoms. This means there will be a total of eight faults to identify. It is likely that only one symptom for each fault will be sufficient. However it may be beneficial to learners if more symptoms can be given or arranged.

For P3, learners will need to prepare two vehicles for fault diagnostic checking. They will then need to diagnose faults on two mechanical systems (P4) and on two electrical systems (P5), on each of two different vehicles faults prior to rectification. Learners should be able to select and access sources of data to help with the fault diagnosis and also select, prepare and use the appropriate diagnostic equipment to carry out the tasks.

To achieve P6 and P7, learners need to describe an alternative rectification procedure for faults on two mechanical systems and two electrical/electronic systems. Although the rectification procedures described for the two electrical/electronic systems or two mechanical systems need to be different, procedures described for P6 can be used again in P7. The rectification strategies described could relate back to the different faults identified for P1 and P2.

For P8 and P9, learners will apply their knowledge by carrying out the rectification process, conforming with the manufacturer’s specifications, safety and legal requirements, for two different mechanical and two different electrical/electronic systems.

When confirming system integrity for P10, the equipment that could be used is listed within the unit content under learning outcome 4, although other equipment, such as that listed under learning outcome 2 as diagnostic equipment, is also appropriate. Confirmation of system integrity should include comparing results against manufacturers’ specifications and data, legal requirements and performance test data.

Throughout the assignments it is expected that each of the faults will be on different systems and may be on different vehicles at different times. The vehicles could, however, be of the same type (for example both goods vehicles or motorsports vehicles if this is appropriate) or different types. The intention is to give learners experience of a diverse range of vehicle system faults across different vehicles so that they have the opportunity to satisfy all the grading criteria with sufficient depth and rigour.

To achieve M1, learners should justify the use of the equipment selected to diagnose system faults, with reference to the expected accuracy of the results obtained.

This should demonstrate learners' ability to progress from knowing how to select and use the equipment to justifying the reasons for using the correct equipment and possible consequences of not doing so.

For M2, learners should compare the advantages and disadvantages of alternative diagnostic procedures, including the use of dedicated test equipment within the context of the fault diagnosis being carried out. Learners should also be able to justify the selection of a rectification procedure (M3) in terms of safety, cost, performance and legal considerations. All responses to tasks set for the merit criteria are likely to be in the form of written outcomes.

To achieve a distinction, learners should analyse test results and recommend actions to rectify the problems associated with systems and components (D1). Learners will also need to review a vehicle diagnostic and rectification procedure and make recommendations for improvement (D2).These criteria can be met through responses to written tasks after all pass criteria have been carried out and data obtained from the practical tasks for D1.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, P5, P7, M1, M2	Identifying and Diagnosing Faults	A vehicle technician needs to identify and diagnose vehicle system faults using diagnostic equipment	Practical work evidenced through records/log of work carried out and observation records
P6, P7	Alternative Rectification Procedures	A vehicle technician needs to propose alternative rectification procedures to be used for vehicle system faults	Written task
P8, P9, P10, M3, D1, D2	Rectifying Faults	A vehicle technician has to rectify faults and confirm system integrity	Practical work evidenced through records/log of work carried out and observation records

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Chassis Systems

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit AE06: Diagnose and Rectify Motor Electrical Unit and Component Faults
- Unit LV05: Inspect Motor Vehicles Using Prescribed Methods
- Unit LV06: Inspect Vehicles
- Unit LV07: Diagnose and Rectify Motor Vehicle Engine and Component Faults

- Unit LV08: Diagnose and Rectify Motor Vehicle Chassis System Faults
- Unit LV11: Overhaul Motor Mechanical Units
- Unit LV13: Diagnose and Rectify Motor Vehicle Transmission and Driveline System Faults.

Essential resources

A range of vehicle types and equipment is needed for delivery of this unit. This will include manufacturer/vehicle-specific equipment (eg for engine management, ABS, security and other advanced systems) and non-manufacturer/vehicle-specific equipment (eg meters, oscilloscopes). A variety of data sources will also be required to support the range of vehicles, systems, equipment and procedures used.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bonnick A — *Vehicle Electronic Systems and Fault Diagnosis* (Butterworth-Heinemann, 2004) ISBN 9780340706305

Hillier V — *Hillier's Fundamentals of Automotive Electronics Book 2, 6th Edition* (Nelson Thornes, 2012) ISBN 9781408515372

Nunney, M — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

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Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when locating, diagnosing and rectifying faults analysing and evaluating information relating to vehicle system faults, judging its relevance and value
Self-managers	organising time and resources and anticipating and managing risks when carrying out rectification procedures on vehicle systems
Creative thinkers	generating ideas, exploring possibilities and trying out new solutions when diagnosing and rectifying faults

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals for success criteria for their development and work
Team workers	collaborating with others to work towards common goals when carrying out rectification procedures on vehicle systems

Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Select and use a variety of sources of information independently for a complex task	accessing and using IT-based data retrieval systems and fault code analysers
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	using a variety of documentation and manufacturers' specifications when rectifying faults and confirming system integrity
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing different rectification procedures for vehicle system faults

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Unit 4: Vehicle Project

Unit code: K/502/7325

Level 3: BTEC Level 3 qualification

Credit value: 20

Guided learning hours: 120

Aim and purpose

The aim of this unit is to enable learners to specify, plan and implement a project in the vehicle technology sector and present its outcome.

Unit introduction

Vehicle technicians often find themselves in situations where problems need to be recognised and solutions found. These situations frequently lead to challenging and exciting opportunities and problems. Working on 'projects' gives the technician an opportunity to demonstrate what they know and put their skills to valuable use.

This unit will give learners opportunities to present their own solutions and should enable them to feel confident in carrying out project work in the vehicle technology sector.

The unit aims to integrate the knowledge and skills learners have gained throughout their programme of study, into a major piece of work that reflects the type of performance expected of a vehicle technician. The project is intended to develop learner ability to identify and plan a course of action and follow this through to produce a viable solution/outcome to an agreed specification and timescale.

The end result of the project could be the design, modification or testing of a vehicle system or product. As in the real world, the outcome of the project and its presentation are very important, although this unit is also about the skills of developing and carrying out a project. Throughout the project learners will apply the technical skills they have developed in other units of the qualification.

Learning outcomes

On completion of this unit a learner should:

1 Be able to specify a project, keep records, agree procedures and choose a solution

2 Be able to plan and monitor a project

3 Be able to implement the project plan within agreed procedures

4 Be able to present the project outcome.

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Unit content

1 **Be able to specify a project, keep records, agree procedures and choose a solution**

Project records: written eg notes, sketches, drawings; plans and modified plans; targets (setting, monitoring); use of planning tools eg paper based, electronic; recording initial concepts eg lists, notes, mind mapping, flow diagrams, sketches

Initial concepts: setting limits eg time, cost, feasibility, need; value–cost–benefit analysis; generating ideas eg group discussion, brainstorming, mind mapping; research techniques; lines of communication

Specification: type of project eg product/system design, modification, testing and evaluating or similar vehicle related topics; technical information eg functionality, reliability, operational conditions, process capability, scale of operation, size, capacity, cost, style, ergonomics, present and future trends; health and safety issues; environmental and sustainability issues; quality standards and legislation; timescales; physical and human resources implications

Procedures: roles and responsibilities eg decision making, budget planning and control; reporting methods; resource allocation and limits

Techniques: comparison methods eg statistical, graphical, quality and resource requirements/limitations, process capability, fitness-for-purpose; analysis eg cost–benefit, feasibility

2 **Be able to plan and monitor a project**

Planning: long-term planning eg planners, charts and scheduling techniques (flow charts, Gantt charts, critical path methods, software packages); setting priorities; useful resource information eg human and physical

Monitoring: monitor and record achievement eg use of logbook and/or diary for record keeping (names, addresses, telephone numbers, meeting dates, email and other correspondence lists); use of logbook eg for recording and analysing data or performance records, modifying/updating charts/planners, recording project goals and milestones, initial concepts, project solution technical decisions and information, use of specialist computer software packages to collate information and aligned timelines and record progress

3 **Be able to implement the project plan within agreed procedures**

Implement: proper use of resources eg equipment, tools, materials, within agreed timescale, use of appropriate techniques for generating solutions, adapting project plan where appropriate, maintaining appropriate records

Checking solutions: use of evaluative and analytical techniques eg graphs, matrix methods, statistics, Gantt charts, sequencing, scheduling, critical path methods, computer software packages

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4 **Be able to present the project outcome**

Presentation: deliver a presentation to a small group eg audience including known (peer group, tutors) and unknown (actual or simulated customer or client) participants; use of preparation techniques, presentation styles and techniques; preparation and use of visual aids eg software packages and projectors, charts, models, video/DVD clips

Project report: logbook/diary record of all events; computer based project management system; written/text-based technical report including relevant drawings/circuit diagrams, sketches, charts, graphs etc appropriate to the project solution; use of information and communication technology (ICT) as appropriate to present findings eg CAD, DTP, spreadsheets, databases, word processing software

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 prepare and maintain project records from initial concepts through to solution that take account of and record changing situations	M1 maintain detailed, concurrent records throughout the project that clearly show progress made and difficulties experienced	D1 independently manage the project development process, seeking support and guidance where necessary
P2 prepare a project specification [IE2, IE4, TW1, EP4]	M2 use a wide range of techniques and selection criteria to justify the chosen option	D2 evaluate the whole project development process, making recommendations for improvements.
P3 agree and prepare the procedures that will be followed when implementing the project [EP1]	M3 evaluate the project solution and suggest improvements	
P4 use appropriate techniques to evaluate three potential solutions and select the best option for development [CT1]	M4 present coherent and well-structured development records and final project report.	
P5 outline the project solution and plan its implementation [RL2]		
P6 monitor and record achievement over the lifecycle of the project		

Assessment and grading criteria		
P7 implement the plan and produce the project solution [RL2, SM1]		
P8 check the solution conforms to the project specification		
P9 prepare and deliver a presentation to a small group outlining the project specification and proposed solution [SM7]		
P10 present a written project report.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

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Essential guidance for tutors

Delivery

Centres will need to consider carefully how the unit content and required process skills are to be delivered. In particular, administrative, planning, implementation and presentation skills and knowledge need to be delivered before or in tandem with the time period allocated for the whole project. Some aspects of the content may be supported by other units in the programme and therefore may have already been covered. However, a large proportion of the process skills and knowledge will need to be delivered or reinforced during the early stages of project delivery. Ideally, learners should have developed the knowledge and skills associated with the content for learning outcomes 1, 2 and 3 before they start specifying, planning or implementing the project. Report writing and presentation skills could be left until later, but opportunities to gain, use and practise these skills may well have already occurred in earlier units.

Tutors could start delivery of the unit by giving learners an overview of the whole project process and identifying the major milestones that need to be met to satisfy the assessment criteria. Providing learners with a route map/overview of what is required, when it is required and the project assessment strategy enables learners to formulate clear objectives and will aid their planning and delivery of the project outcome. The use and importance of the logbook as a source of evidence and `living history' of the project should also be emphasised and learners should be encouraged to use logbooks to record events from the outset. This may be a computer based system that could aid the link up across units and aid the utilisation of modern software project systems. A portfolio of primary research material should also be introduced at this stage, where information collected from the internet, literature and journals may be used for assessment evidence and as a source of reference when producing the final written report. The unit requires learners to take a considerable amount of responsibility for their own work – it is important to recognise this and ensure that learners are aware of the need to organise and plan their work from the beginning.

Next, the process skills and knowledge may be delivered that enable learners to consider and select an appropriate project after carrying out a feasibility study. Learners should be encouraged to try and select their own suitable project, or obtain one from their place of work/external customer, in preference to being given one by their tutor. Learners who select their own project tend to have an interest in the subject and therefore require little encouragement to sustain their progress throughout the whole life of the project and so produce a worthwhile outcome.

The advantages/disadvantages of a group project should also be clearly spelled out to learners, before they make their choice, with strong recommendations for them to undertake an individual project. If learners really desire to work in a team all team members will need to agree the topic. It will also be essential to make sure that each team member has clear responsibilities and that everyone makes a contribution to the end result during every process/stage of the project. All individual team members must be clear about who is responsible and accountable for each aspect of the work. Each member of the team must produce their own evidence against all the criteria in the unit, as evidence cannot be shared. Regular progress meetings with the project supervisor (for example tutor and/or employer) are essential and a record must be kept of what is said and agreed. Each member of the team must be accountable for their own project outcome and solution.

The delivery of the skills and knowledge associated with producing a project specification and selecting a project option should then be delivered, with sufficient time being allocated for learners to produce their specification and select their most favourable option. Learners will require varying degrees of help at this stage and tutors should monitor individual learner progress and achievement carefully.

In order for learners to achieve learning outcome 2, tutors will need to introduce or recap on the planning and monitoring techniques required to implement the project solution and monitor and record achievement over the life cycle of the project. This learning outcome might best be delivered in a resource centre, where there is both library and computer access. Again, the amount of time spent with individual learners will vary according to their skill and proficiency in the use of planning and monitoring tools. Emphasis should be placed on the fact that the production of a long-term plan is not the end of the process and that there will need to be continual monitoring and modification/amendment of plans as events dictate.

The delivery of learning outcome 3, from the tutor's perspective, is mainly concerned with monitoring learner progress and acting as a point of reference for all things associated with the implementation and successful completion of the project solution. However, there is also a need to check with individual learners that they have planned their implementation process in accordance with agreed procedures, particularly with respect to budgetary constraints and resource/time limitations. Throughout the unit, but particularly during the implementation phase in workshops or laboratories, the tutor should ensure that learners are made aware of all relevant health and safety issues, both for the implementation process and the product solution. Learners should not use any equipment or process that they have not been trained to use, nor should they be allowed to use machinery without appropriate levels of supervision. To ensure a satisfactory outcome/solution, learners will need to liaise with the customer and/or the project tutor and, if appropriate, other members of the team throughout all stages of the project. As the project outcome and solution are assessed against the project specification it is important that the tutor guides each learner to ensure completion of their project. Learners should also be encouraged to consider the environmental impact/sustainability issues relating to their project solutions and the effect of national/international standards and legislation.

The development of the process skills and knowledge learners need to prepare and deliver a presentation and prepare and present a written report might best be started while learners are still engaged with the implementation of their project solution. Learners may already have been introduced to the use of presentation aids and the format and methodology of report writing, so again the amount of formal input required for individual learners will vary. Tutors need to be aware of both group and individual needs and offer help and advice accordingly. Learners should be able to use a range of computer software packages and electronic and manual equipment to prepare and present the presentation and final written report. Clear guidelines should be given to learners on the standards expected to meet the assessment criteria for learning outcome 4. Whether the presentation or the written report is presented first will depend on centre arrangements. It is often the case that the presentation is completed before the written report is submitted. This has the advantage of being able to inform the learner of any additional considerations that may need to be taken into account in order to improve the final project solution, as evidenced through the project report and any physical artefacts needed to demonstrate the solution. The importance of maintaining the logbook and having the logbook and other portfolio evidence ready for final scrutiny should also be emphasised before submission of the final report.

Choosing an appropriate project

The end result of the project should be a solution that is both relevant to the learner's field of study (for example heavy vehicle, light vehicle, motorsport) and that will draw on what they have learned while studying the other units of their programme. The solution may lead to some form of product, system or device. The end result could equally lead to a system of work, a process or a procedure or to a modification to an existing process or product. The best projects come from the initial identification of a genuine need or requirement.

Whatever type of project is undertaken, it is important to realise that the actual problem must be deliverable. Centres should allocate enough time to ensure that quality outcomes can be achieved against the project specification and be assessed. The project has to be feasible within the time available and, as project supervisor, the tutor should provide suitable guidance on this. Tutors may also need to help learners when they are in the process of finding a set of 'customer needs' for their project.

Some examples of a project outcome include:

- modifying an existing vehicle product or system
- designing and building a vehicle product or system
- testing and evaluating a vehicle product or system.

It is important to remember that learners are looking for a problem or task to be solved, not for a finished item as a starting point.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit – explain project milestones and assessment strategy – tour of access/use of centre library/learning centre/IT centre/workshops, throughout the life of the project – introduction to the nature and use of logbooks as source of evidence for the activities carried out throughout the life of the project. Use of diaries/computer diaries ***Learner activities:*** – open logbook and record what needs to be done, the project milestones and assessment strategy, possible research methods and record keeping methods
Prepare and complete Assignment 1: Prepare and maintain project records (P1, M1)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – present examples of past projects and/or project themes and outline advantages/disadvantages of group projects   – generation and stimulation of ideas – introduction to brainstorming and mind-mapping techniques. Learner participation in class brainstorming session   ***Individual learner activity:***   – produce a mind-map of their individual ideas for a project, or for a project idea they may have been given by their employer   ***Group activity:***   – participate in small brain storming groups, to develop individual ideas   ***Whole-class teaching:***   – initial concepts, feasibility of ideas
Prepare and complete Assignment 2: Project specification and selection (P2, P3, P4, M2)
Learner activity: – carry out a feasibility study of own/employer ideas/concepts for project subject and present findings   ***Whole-class teaching:***   – specification form and types according to project subject matter – technical, health and safety, environmental, legislative and resource considerations   ***Learner activity:***   – make first attempt at preparing own project specification   ***Whole-class teaching:***   – techniques/considerations for selecting best project solution option   – introduction to roles and responsibilities, reporting methods and resources that need to be considered when implementing project solution   ***Learner activity:***   – practise and use techniques and select best solution/s, from given scenarios   – produce and present an interim report containing the final project specification, the selected best option for the project solution and details of the procedures that will be adopted when implementing the project solution/outcome

Topic and suggested assignments/activities and/assessment
Whole-class teaching/individual tuition: – planning use of charts and scheduling techniques, software packages, setting priorities, resource planning, time planning ***Learner activity:*** – using planning techniques (both written and computer based) produce long-term plan (capable of modification) for implementation of own project solution/ outcome ***Whole-class teaching/individual tuition:*** – monitoring and modifying plans and recording achievement, use of logbooks as a means of monitoring, recording and providing evidence of achievement, computer diaries, etc
Prepare and complete Assignment 3: Production of project plan and monitor (P5, P6)
Learner activity: – implement plan and produce project solution/outcome in accordance with agreed specification, appropriate techniques for generating solutions and agreed procedures concerned with the scope of project – record and modify plans in the light of experience, re-evaluate progress and success on regular occasions and conscientiously record all necessary actions, changes of plan, technical and analytical aspects, findings and conclusions
Prepare and complete Assignment 4: Implement the project and produce project solution (P7, P8 M3)
Whole-class teaching/individual tuition: – tutor to act as facilitator, resource provider and point of reference for all problems associated with delivery of the project outcome/solution and for the regular monitoring and review of individual progress
Group teaching and demonstration: – presentation aids and techniques – use of audio-visual presentation aids. Techniques to consider when preparing notes/written material for presentation. Presentation of project report/deliverables. Written report style, protocols and structure. Use of IT/software packages for preparing report ***Learner activity:*** – practise preparation of presentation aids and, under supervision, practise use of a range of audio-visual equipment – prepare presentation and practise delivery to peers or self – prepare written report, seeking guidance from tutor, as necessary – deliver presentation to selected audience at time dictated by the centre – deliver project report and logbook and/or portfolio/artefacts as required for assessment by tutor

Topic and suggested assignments/activities and/assessment
Prepare for and complete Assignment 5: Present the project outcome (P9, P10, M4) **Prepare for and complete Assignment 6: Independently manage and critically evaluate the project (D1, D2)**
Feedback to learners, unit evaluation and close

Assessment

Assessment of this unit will be based primarily on the learner's logbook/diary and other evidence of the work carried out and the processes adopted. Use will also be made of the learner's specification document, presentation and technical project report.

It should be noted that the logbook/diary is intended to be a working document and should contain the learner's notes and records as they are made at the time. It does not need to be a well-presented/neat document, but should be an effective tool to capture events and information as and when they happen and provide a useful source of reference for the learner when preparing their presentation and final written report. The tutor/project supervisor could also annotate the logbook/diary to indicate and record their observations and interactions with the learner, for example use of ICT, the logical formulation of ideas, use of technical knowledge, analysis and the outcomes/recommendations from these meetings.

Learners will need to include, possibly as an annexe (under separate cover) to the technical report, their own sketches, drawings/circuit diagrams, notes, lists, charts, raw calculations etc to support their project report findings. Appropriate methods of presentation and management of the total evidence package should be discussed and used by the learner.

Learners will need guidance on how to write a formal technical report and this, together with other requirements of the unit, gives learners opportunities to practise and demonstrate their personal, learning and thinking skills (PLTS) and Functional Skills. Learners may be working closely with their own company/employer on their project and may be required to adopt the company's own 'house style' for the presentation of the report. This would of course be acceptable, since it will be in line with standard industry practice and report writing protocols and because it is the content of the report (ie its technical information, logical presentation methods and coherence) that is assessed, not its style.

Care should be taken to identify learners who may be genuinely terrified of standing in front of a group to make a presentation. The experience of making presentations is valuable and is recommended. However, as a minimum, learners only have to make an informal presentation to one or two people (which would reflect the typical minimum required in employment at this level) to achieve the unit. The presentation offers another opportunity for learners to generate evidence towards selected PLTS and Functional Skills.

As many of the activities undertaken by learners will be practical and skills-based, it is important to think about the method of capturing and presenting evidence for assessment purposes. Often, witness testimony or records of tutor observation will be necessary. Copies of these will need to be placed in the final portfolio of evidence.

To achieve P1, learners will need to prepare and maintain project records from initial concepts through to solution that take account of and record changing situations. Evidence could be collected by tutors from the learner's logbook. It is suggested that learners prepare and submit a written project specification for scrutiny in order to provide evidence for the achievement of P2 (ie that they have produced a specification to an acceptable standard). As part of the project specification learners could also include written evidence for the procedures (P3) that they have agreed to follow, after discussion with their tutor, when implementing their project solution. Particular emphasis should be placed on ensuring learners consider budgetary constraints and resource/time limitations. Evidence for P4, concerning the evaluation of potential solutions and the techniques used to select the best option, might best be obtained from the learner's logbook, or again form part of the written project specification/interim report.

To achieve learning outcome 2 learners will need to outline their chosen project solution and plan for its implementation (P5), in addition to monitoring and recording achievement over the life cycle of the project (P6). Evidence of achievement will again be through the logbook. Tutors may also wish to record some of this performance as an observation record or use witness statements. The observations might take place when learners are using computer-aided or manual planning tools in the learning centre. Additional evidence for P6 might come from the annotation of planning documentation or plans in the learner's logbook that show the changing situations.

Learning outcome 3 is concerned primarily with the implementation of the project solution while adhering to agreed procedures (P7) and checking throughout the implementation phase that the solution produced conforms with the project specification (P8). The type of project chosen by the learner will, to a degree, dictate the methods used to provide evidence of achievement. Learners who are engaged on design/build or physical testing/modification type projects on a system or component, will be spending most of their project implementation phase in workshops and/or laboratories. Therefore, tutors will need evidence from observation records and from the physical solution itself. Evidence of achievement of P7 for those learners engaged in the production of a modified procedure/service, will be via their logbook records, presentation and final written report.

No matter what type of project learners choose, the primary source of evidence for achieving P8 is likely to be their logbook, where comparisons can be made with the agreed procedures to see whether or not learners followed these procedures when producing their project solution.

In order to meet learning outcome 4, learners need to prepare and deliver a presentation outlining their project specification and proposed solution to a small group (P9) and present a written project report with supporting documentation (P10). Evidence for P9 will be obtained from a combination of hard copies of the presentation, such as handouts, slides etc and witness statements, together with the results of observation records from those present. Evidence for the achievement of P10 will come from the written report itself. Learners need clear guidelines as to what is expected well before the submission of their report.

To achieve M1, learners need to be able to work with greater autonomy and will have produced, and kept to, a workable plan. This will be demonstrated by their ability to maintain records throughout the project that are detailed, concurrent and clearly show progress made and the difficulties experienced. For M2, learners will need to have arrived at their project choice using a wide range of techniques and be able to justify their chosen option. The range of techniques used will need to show both statistical and graphical comparison methods for the potential solutions. Evidence will come from the learner's logbook and/or from the submitted written specification/interim report, (as was the case for achievement of P3).

Evidence for the achievement of M3, will come from observation records (particularly for design and build type solutions), scrutiny of logbook records and from the learner's reflections written in the final report. It is expected that having evaluated their solution against the specification and/or from field evaluation and customer feedback, learners will then be able to suggest improvements that genuinely enhance the value of their project solution. Learners will have to present coherent and well-structured development records and a final project report to achieve M4. The report structure is expected to adhere to standard technical report writing protocols. The development records are likely to be included as part of the learner's logbook and this should be submitted for final scrutiny at the same time as the report.

To achieve a distinction, learners will have been able to work consistently towards a successful outcome and in doing so they will have independently managed the project development process, seeking support and guidance where necessary (D1). They will have shown the ability to reflect on their work throughout the project. Through this, they will have been able to evaluate the whole of the project development process and provide suggestions as to what they would have done differently to make improvements (D2). The evidence for both criteria is likely to come from the logbook and portfolio notes with the addition of witness statements and observation records for D1 and a separate written statement or statement in the final report, clearly evaluating the project and making recommendations for improvements for D2.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Prepare and maintain project records	Tutor to scrutinise learner's project records and/or have completed observation record or have available independent witness testimony.	Through scrutiny of learner's logbook, observation records and/or witness testimony. Detailed and concurrent records need to be demonstrated to achieve M1.

Criteria covered	Assignment title	Scenario	Assessment method
P2, P3, P4, M2	Project specification and selection of best project option	Tutor to consider submitted work and scrutinise learner records and/or take account of observation records or witness testimony.	Marked submission of project specification to acceptable standard, including written procedures to be adopted and evidence for the evaluation of the solution. A wide range of statistical and graphical comparison methods demonstrated to meet M2.
P5, P6	Production of project plan and monitor project over its life cycle	Tutor to scrutinise project records and take account of observation records or witness testimony.	Scrutinise learner's long-term plans and logbook, identify and sanction achievement and changes made to plan, over the life of the project.
P7, P8, M3	Implement the project and produce the project solution	Tutor to observe leaner progress in implementing the project plan and in producing a project solution.	Through scrutiny of learner's logbook and observation records for implementation of project solution and written/observational evidence for evaluation of solution in order to meet M3
P9, P10, M4	Presenting the project outcome	Observation of oral presentation and consideration of written report and other project records and deliverables.	Through observation records and written oral presentation material and the marking of the final written report and consideration of all other project deliverables. Identification of well-structured and coherent development records and final report in

			order to meet M4.

Criteria covered	Assignment title	Scenario	Assessment method
D1, D2	Independently manage and critically evaluate the whole project	Tutor/supervisor observation records or independent witness statements and take account of learner's project records and written submissions.	Scrutinise learner's logbook and take account of observation records (D1) and mark written submission (D2).

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with the following unit titles in the Vehicle Technology suite:

Level 1	Level 2	Level 3
		Operation of Vehicle Chassis Systems
		Vehicle Engine Principles, Operation, Service and Repair
		Vehicle System Fault Diagnosis and Rectification

Essential resources

Learners will need access to a wide variety of physical resources, dependent on the type of project they pursue. Many of these resources are detailed within the other units in the qualification.

Employer engagement and vocational contexts

Employer-led vocational projects need to be encouraged as they bring a sense of realism and purpose to the whole project process and tend to motivate learners better. Awareness evenings, or similar, could usefully be arranged to encourage employer participation in setting suitable projects for learners. Additionally the topic of allocating employer driven projects to learners (employed or otherwise), could be raised at the faculties industrial focus committee meetings or at some other appropriate centre forum with employers.

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There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Lock D — *Project Management* (Gower Publishing, 2007) ISBN 0566087723

Melton T — *Project Management Toolkit, the Basics for Project Success* (Butterworth-Heinemann 2007) ISBN 9780750684408

Melton T — *Real Project Planning: Developing a Project Development Strategy* (Butterworth Heinemann 2007) ISBN 9780750684729

Project Management Institute — *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2008) ISBN 9781933890517

Smith N J — *Engineering Project Management* (Blackwell Publishing, 2007) ISBN 9781405168021

Tooley M and Dingle L — *BTEC National Engineering second edition* (Newnes, 2007) ISBN 9780750685214

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	carrying out research to produce a project solution analysing and evaluating information, when considering suitable project subject matter, on which to base a specification
Creative thinkers	generating ideas and exploring possibilities for a suitable project subject and solution
Reflective learners	setting goals and reviewing progress when planning their project and implementing their project solution
Team workers	collaborating with their project supervisor/client when producing their project technical specification
Self-managers	organising their time and resources to produce and present their project solution working towards goals and showing commitment, and managing their emotions, when preparing and presenting their oral presentation and written report
Effective participators	discussing issues of concern and seeking resolutions, when considering and agreeing procedures for the implementation of their project proposing practical ways forward, when having to adjust implementation plans in the light of experience

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Independent enquirers	analysing and evaluating information and supporting conclusions and arguments for the entire project process
Creative thinkers	trying out new solutions/alternatives when considering the best project solution
Reflective learners	evaluating their project solution and deciding on a modified implementation strategy
Team workers	engaged on group project work, where they need to collaborate on the apportionment of work, reach agreement on their own goals and objectives to satisfy the project assessment criteria and take responsibility for their own part of the group assignment

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Skill	When learners are …
Self-managers	engaged in implementing their project solution and having to overcome challenges and show flexibility when the implementation process does not go to plan
Effective participators	identifying improvements to their project solution that will be of benefit to their company/customer

Functional Skills — Level 2

Skill	When learners are …
ICT — Use ICT systems	
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	using computer-based techniques to plan a project
ICT — Find and select information	
Select and use a variety of sources of information independently for a complex task	using ICT to research, plan, monitor and implement a project
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	Possible use of a specialist software package and producing a report on the outcomes of the project ready for presentation.
Present information in ways that are fit for purpose and audience	producing a report on the outcomes of the project ready for presentation.
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	designing a solution to a problem.
Select and apply a range of skills to find solutions	designing a solution to a problem.

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Skill	**When learners are …**
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	working in a group when planning, monitoring and implementing a project solution. presenting a final project solution.
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the project and possible solutions.
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing a report on the outcomes of the project ready for presentation.

Unit 5: Applications of Vehicle Science and Mathematics

Unit code: R/503/1367

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the mathematical and scientific principles that are an inherent part of many areas of motor vehicle technology.

Unit introduction

This unit will develop learner knowledge of mathematical and scientific principles and their application in the vehicle technology environment. This can be in a variety of vocational areas, such as the fine detail needed in the calculations in motorsport or the crucial calculations required when working with large commercial vehicles.

Learners will carry out data collection and manipulation in vehicle-related areas such as speed, acceleration and power. They will also complete a variety of practical activities including carrying out an engine performance test and comparing the outcomes to scientific calculations.

Learning outcomes

On completion of this unit a learner should:

1. Be able to apply mathematical and statistical methods to vehicle-related tasks
2. Be able to apply fundamental algebraic laws and trigonometric ratios to solve vehicle-related tasks
3. Be able to apply scientific principles related to heat, force and machines to solve vehicle-related tasks
4. Be able to carry out engine testing and apply scientific principles to determine vehicle and engine performance.

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Unit content

1 **Be able to apply mathematical and statistical methods to vehicle-related tasks**

Data for vehicle-related tasks: data eg engine speed, stopping distance, miles per gallon, brake pad life, vehicle speed, acceleration, wheel bearing life; sources eg manufacturers, workshop experiments, publicly available figures,(such as media, internet); considerations eg types of error, accuracy, representation

Mathematical methods: methods eg addition, subtraction, multiplication, division, use of brackets, order, estimation techniques, use of calculators, expressing numbers using standard form and scientific notation eg 5.6 x 10^5, 12 x 10^3 W, 12 kW; features eg ratio and proportion, percentage, real and integer numbers, binary systems, vulgar and decimal fractions, ratios, direct and inverse proportion, roots and powers (such as $v = \sqrt{2gh}$, $I = \sqrt{\frac{P}{R}}$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$, $\frac{1}{2}mv^2 = mgh$ find v, $\frac{1}{2}QV = \frac{1}{2}CV^2$ find V)

Data manipulation and graphical representation: data represented in graphical format eg bar charts, pie charts, frequency distributions, class boundaries and class width, frequency table, variables (discrete and continuous); histogram (continuous and discrete variants); cumulative frequency curves

Statistical information: arithmetic mean; median; mode; discrete and grouped data

2 **Be able to apply fundamental algebraic laws and trigonometric ratios to solve vehicle-related tasks**

Linear equations and straight line graphs: linear equations eg $y = mx + c$; straight line graph (coordinates on a pair of labelled Cartesian axes, positive or negative gradient, intercept, plot of a straight line)

Factorisation and quadratics: multiply expressions in brackets by a number, symbol or by another expression in a bracket; by extraction of a common factor eg $\boldsymbol{ax} + \boldsymbol{ay}, \boldsymbol{a}(\boldsymbol{x} + 2) + \boldsymbol{b}(\boldsymbol{x} + 2)$; by grouping eg $\boldsymbol{ax} - \boldsymbol{ay} + \boldsymbol{bx} - \boldsymbol{by}$; quadratic expressions eg $\boldsymbol{a}^2 + 2\boldsymbol{ab} + \boldsymbol{b}^2$; roots of an equation eg quadratic equations with real roots by factorisation, and by the use of formula

Trigonometric ratios: basic ratios eg sine, cosine, tangent; $\text{Sin}\theta/\text{Cos}\theta = \text{Tan}\theta$

Vehicle-related tasks: algebraic application eg Ohm’s law, pair of simultaneous linear equations in two unknowns, acceleration 30 to 50 mph, time taken to cover a given distance when subjected to constant acceleration, volume and area of combined shapes eg swept, clearance volume, loading capacity, workshop areas; trigonometric application eg steering and suspension angles, valve timing, wiper motion angles

3 Be able to apply scientific principles related to heat, force and machines to solve vehicle-related tasks

Force: laws of friction; friction in a clutch; stress and strain; Young's modulus; forces in tension/compression; vehicle component subjected to tension/compression eg tie rod, cylinder head bolt, push rod, valve stem, piston, connecting rod, braking components

Heat: gas laws eg Boyle's law, Charles' law, general gas equation $pV/T = C$, ideal gas equation $pV = \mathrm{m}RT$; change of dimension eg linear, superficial, cubical, heat dissipation; pressure eg hydraulic, gas; gauge pressure, atmospheric pressure

Machines: ratios eg steering box, gear ratio, final drive ratio, compression ratio; vehicle mechanism eg alternator and power steering, pulleys, winches, levers, brake operation, cylinder, gearbox

4 Be able to carry out engine testing and apply scientific principles to determine vehicle and engine performance

Vehicle performance: equations of motion; Newton's laws; performance eg work, power, velocity, acceleration, retardation

Engine testing: safe use of equipment eg rolling road, dynamometer rig, engine analyser; collection of data eg torque, power (indicated and brake), fuel consumption

Engine performance: performance to report on eg torque, power (indicated and brake), mechanical efficiency, thermal efficiency, volumetric efficiency, specific fuel consumption, brake mean effective pressure, indicated mean effective pressure; presentation within report eg engine indicator diagrams, calculations using data (such as efficiency, frictional loss, temperature variations)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain what should be considered before using data gathered from different sources [IE4]	M1 solve a pair of simultaneous linear equations in two unknowns	D1 compare actual data and calculated data for engine or vehicle performance.
P2 use mathematical methods for different features to manipulate collected data and present statistical information in a graphical format	M2 solve a quadratic equation by factorisation and one by the formula method	
P3 solve a linear equation by plotting a straight line graph, using given experimental data, and use it to deduce the gradient, intercept and equation of the line for a vehicle-related task [IE4]	M3 explain, with examples, the importance of the accuracy of data that is used to solve a range of problems related to engine and vehicle performance.	
P4 factorise by extraction and grouping of a common factor from expressions with two, three and four terms respectively		

Assessment and grading criteria		
P5 use trigonometric ratios to solve two vehicle-related tasks		
P6 use the laws of friction to find the friction in a clutch		
P7 determine Young's modulus for a given tension/compression on a given vehicle component		
P8 use a gas law to determine the change in dimensions of the gas		
P9 describe how ratios help a given vehicle mechanism function properly		
P10 calculate vehicle performance using Newton's laws and the equations of motion		
P11 carry out engine testing to obtain data and report on engine performance.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

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Essential guidance for tutors

Delivery

This unit would be best delivered at an early stage in the qualification. It should be linked with other technical units to demonstrate the practical application of science and mathematics within vehicle technology.

Before starting the unit, learners should be able to demonstrate proficiency in basic mathematical concepts and in the use of an electronic scientific calculator to carry out a variety of functions.

It is essential that the unit content is delivered in a vehicle context. Ideally, this will be achieved through integration with other units which will also help to reduce the assessment burden on learners. There are natural links with other units in the qualification. For example, electrical units that use algebraic application of Ohm's law, units involving calculation of engine ratios and volumes or trigonometric applications to do with steering and suspension. For example when studying *Unit 14: Light Vehicle Suspension, Steering and Braking Systems*, learners could investigate specific components, tyres, wheels or ride height. They could then use the data collected during their investigation for the mathematical content of this unit.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching:
– introduction to unit content, scheme of work and method of assessment
– explain what needs to be considered when using vehicle data
– explain and demonstrate the use of a range of mathematical methods for different features
Individual learner activities:
– tutor-led solution of vehicle- related problems using mathematical methods
Whole-class teaching:
– explain and demonstrate how statistical information can be displayed
– explain and demonstrate evaluation of mean, median and mode for discrete data
– explain and demonstrate evaluation of mean, median and mode for grouped data.

Topic and suggested assignments/activities and/assessment
Individual learner activities: – tutor-led solution of problems on data collection – tutor-led evaluation of problems involving mean, median and mode for discrete data – tutor-led evaluation of problems involving mean, median and mode for grouped data
Prepare for and carry out Assignment 1: Mathematical and Statistical Methods (P1, P2)
Whole-class teaching: – recall the basic rules of transposition and explain how to solve simple linear equations before showing how a linear equation can be represented by a straight graph – explain the significance of the gradient (negative and positive) and intercept for the straight line law and then lead the class in the choice of suitable scales and plotting graphs from given data – explain the use of trigonometric ratios ***Individual learner activity:*** – tutor-led exercises in plotting straight line graphs – tutor-led exercises in solving vehicle- related tasks using trigonometric ratios
Prepare for and carry out Assignment 2: Algebraic Laws and Trigonometric Ratios (P3, P4, P5, M1, M2)
Whole-class teaching: – explain the laws of friction and their application in terms of vehicle clutch and/or brake linings – explain Young's modulus and its application to vehicle components involving tension/compression – explain the use of the gas laws to determine changes in gas dimensions – explain the application of ratios in different vehicle mechanisms ***Individual learner activity:*** – tutor-led exercises in the use of the laws of friction and Young's modulus – tutor-led exercises in the use of the gas laws – investigation of ratios in vehicle mechanisms
Prepare for and carry out Assignment 3: Heat, Force and Machines Ratios (P6, P7, P8, P9)

Topic and suggested assignments/activities and/assessment
Whole-class teaching:
– explain the equations of motion and Newton's laws and their use when calculating vehicle performance
– explain and demonstrate the safe use of testing equipment and its use in the collection of relevant data
– explain the reporting and presentation of engine performance
Individual learner activity:
– obtaining data from engine testing
Prepare for and carry out Assignment 4: Vehicle and Engine Performance (P10, P11, M3, D1)
Feedback to learners, unit evaluation and close

Assessment

For P1, the collation of data should be made vocationally relevant by using vehicle-related subject areas such as engine power to stroke or fuel consumption to capacity. A variety of sources should be used, for example manufacturers' or internet sites. An explanation of the considerations to be taken into account before using the data should be included.

For P2, the methods (for example add, subtract etc) and features (for example ratio or percentages etc) need to be completed prior to graphical presentation. This can be in a variety of formats (for example bar and pie charts, frequency distribution tables). This could be achieved by using computer-based software packages, although care must be taken to ensure authenticity of the evidence provided. Learners need to calculate mean, median and mode for discrete and grouped data. The graphical format used must include at least one from bar charts, pie charts, frequency distributions, and frequency table. It should also include a histogram (continuous and discrete variants) and a cumulative frequency curve.

The evidence for P3 could be generated using vehicle speed and timing and the task set should ensure that gradient, intercept and the equation of the line can be presented in the evidence. P4 should also use vehicle-related formulae where possible.

Assessment of M1 and M2 can be linked to that for P3 and P4. If a vehicle context is difficult to apply, then P4, M1 and M2 could be achieved through a purely mathematical context. However, P4 will require a range of tasks that allows expressions with two, three and four terms. Each task is therefore likely to have a different vehicle-related algebraic application or mathematical scenario.

For P5, the use of steering geometry or piston displacement could give vocational relevance when using one basic ratio and $\text{Sin}\theta/\text{Cos}\theta = \text{Tan}\theta$ to calculate angles and length of steering components. This could be integrated with other units that cover vehicle componentry applications.

The evidence for P6 and P7 would naturally link to clutch or brake linings and the use of components for applying loads, such as handbrake cables, to determine Young's modulus.

Assessment of P8 could be integrated with that of other units. The task used should focus on vocational gas applications, such as within engine technology, suspension or brake systems. The task should enable learners to use one of the gas laws outlined in the unit content and must include data on pressure.

Using a system application such as the handbrake, complete with its lever mechanism, would enable learners to generate evidence for P9. There needs to be clear direction to ensure that responses include a description of how mechanical ratios help the system function.

For P10, learners will need to produce evidence of calculating vehicle performance using Newton's laws and the equations of motion. This should be contextualised to their intended vocational area (for example light vehicle, heavy vehicle, motorsport).

For P11, learners will need to complete engine testing to obtain a range of performance data, as set out in the unit content. Assessment of P11 could be linked to that for M3 and D1 and would need to be completed after achievement of P1.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2	Mathematical and Statistical Methods	A vehicle technician needs to use mathematical methods and gather and manipulate data	Written responses to set tasks
P3, P4, P5, M1, M2	Algebraic Laws and Trigonometric Ratios	A vehicle technician needs to use algebraic laws and trigonometry	Written responses to set tasks
P6, P7, P8, P9	Heat, Force and Machines	A vehicle technician needs to use the laws of friction, gas laws and ratios	Written responses to set tasks
P10, P11, M3, D1	Vehicle and Engine Performance	A vehicle technician needs to calculate vehicle performance and carry out engine testing	Written responses to set tasks and a report of engine performance based on practical engine testing

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Mathematics for Engineering Technicians
		Vehicle System and Fault Diagnosis and Rectification
		Electrical and Electronic Principles for Vehicle Technology

Essential resources

As a minimum, centres will need to provide learners with access to workshop facilities to enable practical investigation and assessment of friction, Young's modulus, ratios, measuring bores and complete calculations linked to gas laws etc.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bonnick, A — *Automotive Science and Mathematics* (Butterworth-Heinemann, 2008) ISBN 0750685220

Greer A, Fuller A and Taylor GW — *BTEC National Mathematics for Technicians* (Nelson Thornes, 2004) ISBN 0748779493

Twigg P — *Science for Motor Vehicle Engineers* (Butterworth-Heinemann, 1995) ISBN 034064527X

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information and data, judging its relevance and value

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	trying out alternative or new solutions to mathematical problems and following ideas through
Reflective learners	reviewing progress when solving problems and acting on the outcomes to make corrections to understanding

Functional Skills — Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine and non-routine vehicle- related problems
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant laws, calculations and formulae to be applied to vehicle-related problems
Select and apply a range of skills to find solutions	selecting and applying relevant laws, calculations and formulae to be applied to vehicle-related problems
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to vehicle-related problems
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of vehicle-related mathematical concepts
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate mathematical data
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	solving vehicle-related problems and communicating accurate solutions effectively

Unit 6: Electrical and Electronic Principles for Vehicle Technology

Unit code: Y/503/1368

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of the underlying principles that govern the operation of electrical and electronic devices and circuits used within a modern motor vehicle.

Unit introduction

In this unit learners will gain an understanding of electrical and electronic principles through the analysis of direct current (DC) motor vehicle electrical circuits. Learners will also be introduced to the principles and properties of magnetism as applied to motor vehicle circuit devices.

Learners will then examine the concepts of digital electronic principles and microprocessor applications in motor vehicles. Finally, learners will be introduced to single-phase alternating current (AC) theory as applied to vehicle alternators. They will consider waveform characteristics and determine the values (using phasor and algebraic representation and actual waveform measurements using an oscilloscope) of alternating quantities.

This unit has been designed to encourage learners to take an investigative approach through practical construction, measurement and testing of circuits and, where applicable, the use of computer-based circuit analysis and simulation.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use circuit theory to determine voltage, current and resistance in direct current (DC) motor vehicle circuits

2 Understand the principles, properties and applications of magnetism in motor vehicle technology

3 Know the concepts of digital principles and applications of microprocessors in motor vehicles

4 Be able to use single-phase alternating current (AC) theory to determine vehicle alternator performance.

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Unit content

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1 Be able to use circuit theory to determine voltage, current and resistance in direct current (DC) motor vehicle circuits

DC circuit theory: voltage eg potential difference, electromotive force (emf); resistance eg conductors and insulators, resistivity, temperature coefficient, internal resistance of a DC source; circuit components (power source eg battery, stabilised power supply; resistors eg function, types, values, colour coding; diodes eg types, characteristics, forward and reverse bias modes); circuit layout (DC power source, resistors in series, resistors in parallel, series and parallel combinations); Ohm's law, power and energy formulae eg V = IR, P = IV, W = Pt; application of Kirchoff's voltage and current laws

DC motor vehicle circuits: circuits to include a DC power source, four components including circuit protection and switching arrangement; vehicle applications eg lighting circuits (side and rear lamp, main and dip headlamp, front and rear fog lamps, stop lamp, reverse lamp, indicator and hazard warning system), auxiliary circuits (horn, window winding, central locking, interior heater, rear screen heater), vehicle security systems, air-conditioning, use of relays, circuit protection devices (DC power source circuit protection fuse and resistors (series/parallel)), operating component(s) such as motor assembly; diode resistor circuit with DC power source, series resistors and diodes eg bulb failure circuit, low oil pressure circuits, alternator rectifier

Measurements in DC motor vehicle circuits: safe use of a multimeter eg setting, handling, health and safety; measurements (circuit current, voltage, resistance, internal resistance of a DC power source); testing a diode's forward and reverse bias

2 Understand the principles, properties and applications of magnetism in motor vehicle technology

Characteristics of magnetic field: field patterns (flux, flux density (B), magnetomotive force (mmf) and field strength (H), permeability, B/H curves and loops); ferromagnetic materials; reluctance; magnetic screening; hysteresis

Electromagnetic induction: principles eg induced emf, eddy currents, self and mutual inductance; motor vehicle applications (electric motor/generator eg series and shunt motor/generator, transformer eg primary and secondary current and voltage ratios); motor vehicle applications of Faraday and Lenz's laws eg electrical induction in an alternator, electromagnetic coil

3 Know the concepts of digital principles and applications of microprocessors in motor vehicles

Digital principles: binary system eg binary notation and algebra, bits and bytes, input/output (I/O) voltage levels; logic system eg AND, OR, NOT NAND and NOR gates; truth tables, memory circuits, sequential and clocked circuits, flip flops, read only memory (ROM)/random access memory (RAM) structures and organisation; timers; digital to analogue (D/A) and analogue to digital (A/D) converters; types of integrated circuits eg classification, operation, performance characteristics and identification; vehicle applications eg fault diagnosis, code readers, data logging, visual/audio output, speed sensor processing, engine timing control, satellite navigation

Microprocessors: microprocessor system eg programmes, language, I/O interface, memory; construction of microprocessor eg control section, arithmetic and logic sections, register section, memory, I/O section buses, fetch and execute cycle, control by clock pulses; motor vehicle application of microprocessors eg engine management, antilock braking systems (ABS), climate control, suspension settings, transmission modes

4 Be able to use single-phase alternating current (AC) theory to determine vehicle alternator performance

Single-phase AC circuit theory: waveform characteristics eg sinusoidal and non-sinusoidal waveforms, amplitude, period time, frequency, instantaneous, peak/peak-to-peak, root mean square (rms), average values, form factor; determination of values using phasor and algebraic representation of alternating quantities eg graphical and phasor addition of two sinusoidal voltages, reactance and impedance of pure resistor (R), inductor (L) and capacitor (C) components

Alternator performance: safe use of an oscilloscope eg setting, handling, health and safety; measurements (periodic time, frequency, amplitude, peak/peak-to-peak, rms and average values)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 use DC circuit theory to calculate current, voltage and resistance in three motor vehicle circuits [IE1]	M1 use Kirchoff's laws to determine voltage and current in a motor vehicle circuit that has at least five nodes and the power dissipated in a load resistor containing two voltage sources	D1 analyse the operation and the effects of varying component parameters of a motor vehicle power supply circuit that includes at least a transformer, diode and resistor
P2 use a multimeter to carry out circuit measurements in DC motor vehicle circuits [SM3]	M2 compare the function and principles of operation of two different vehicle applications of microprocessors	D2 evaluate the performance of a motor and a generator used within a motor vehicle system by reference to electrical and electronic theory.
P3 compare the forward and reverse characteristics of two different types of semi-conductor diode	M3 compare the results of adding and subtracting two sinusoidal AC waveforms graphically and by phasor diagram.	
P4 describe the characteristics of a magnetic field		
P5 explain the relationship between flux density (B) and field strength (H)		
P6 explain how the principles of electromagnetic induction apply to a given motor vehicle application		

Assessment and grading criteria		
P7 describe two different vehicle system applications of digital principles		
P8 describe the function and operation of two vehicle system integrated circuits		
P9 describe the function and operation of a vehicle system microprocessor		
P10 use single-phase AC circuit theory to explain and determine the characteristics of a sinusoidal AC waveform [IE3]		
P11 use an oscilloscope to measure and determine the performance of a vehicle alternator [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

It is important that learners receive the appropriate induction, development and support whilst working on this unit. They may also need to develop a certain level of computer skills in order to use computer-based software for circuit simulation.

The four learning outcomes of this unit are linked and the delivery strategy should ensure that these links are maintained.

Learning outcome 1 is the most likely starting point for delivery, as it will establish much of the underpinning knowledge and skills required for the remaining learning outcomes. The unit could be delivered through a combination of theory lessons and demonstrations, reinforced through practical work in a vehicle workshop. It is important that learners have a thorough understanding of circuit theory if they are to be able to recognise, understand and apply their knowledge to the relevant components.

Initially, delivery could use paper-based or computer-based exercises (for example calculating the required value of a second resistance in a series circuit to give a current flow of 2A with a 12V DC power source). However, even at this stage it may be beneficial to introduce learners to real circuit components. A task that requires learners to practise theoretical calculations and then check a vehicle circuit in a practical environment would stimulate the learning process, aid development and reinforce relevance.

The ability of learners to lay out circuits is an important part of learning outcome 1 and will support the other learning outcomes. Most tutors might start with paper-based methods of drawing simple circuits (for example power source and series/parallel combination of resistors such as voltage and current divider circuits). It is likely that they will move on to computer simulation and the use of real circuits/components, using either bread boarding techniques or soldered circuits. It would be appropriate at this time to use vehicle wiring diagrams.

Learners should be given the opportunity to practise using the formulae identified in the unit content, although they are not required to memorise them. However, they should be expected to select the most appropriate formulae to determine the required circuit values of current, voltage or resistance. In addition, learners should have the confidence to transpose equations to meet their needs (for example use Ohm's law $V = IR$ and the power equation $P = IV$ to arrive at $P = I^2R$, use $R = R_1+R_2$ to arrive at $R_1 = R - R_2$). Because the ability to transpose formulae is a mathematical skill tutors will need to ensure that appropriate support is provided during both the delivery of this learning outcome and the unit as a whole. Centres should consider carefully how best to integrate the learning that takes place in this and other mathematical/science- based units.

During delivery of this unit, learners should be given the opportunity to experience as wide a range of measurement and computer-based simulation software as possible. However, it would not be appropriate to use computer-based simulation packages without any actual practical use or development of vehicle electrical and electronic circuits and components. Tutors are therefore encouraged to relate theory to real vehicle engineering applications wherever possible. Industrial visits or work experience could be used to support learning and give learners an appreciation of the industrial applications of electrical and electronic principles.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, scheme of work and method of assessment – explain the terminology used to describe the parameters of direct current circuit theory and the associated symbols and units – demonstration of simple circuit layouts using components or computer simulation, together with representation of components using circuit symbols and explanation of resistor colour coding
Whole-class teaching: – explain the application of Ohm's law in the calculation of resistance, current and voltage in direct current circuits and the use of formulae to evaluate power and energy – explain the application of Kirchhoff's voltage and current laws together with a demonstration of potential and current division using circuit simulation software ***Individual learner activities:*** – tutor-led exercises on solution of problems involving direct current circuit theory ***Whole-class teaching:*** – explain the technique involved in the solution of problems involving voltage current and resistance in motor vehicle circuits ***Individual learner activities:*** – tutor-led solution of problems on vehicle circuits
Prepare for and carry out Assignment 1: DC Circuit Theory, Resistors and Kirchhoff's Laws (P1, M1)
Whole-class teaching: – practical activity to introduce and demonstrate the safe use of a multimeter, setting the various ranges and using them to measure the internal resistance of a DC voltage source – explain the characteristics of diodes followed by a demonstration to show how they operate in forward and reverse bias modes, and the function of resistors and diodes in a diode resistor circuit with a DC power source
Prepare for and carry out Assignment 2: DC Circuit Theory, Measurement and Diodes (P2, P3)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – discuss the idea of magnetic fields generated by permanent magnets, together with the concept of magnetic flux and the laws of attraction and repulsion – explain the relationship between flux density, magnetic flux and cross-sectional area followed by a demonstration of the flux density meter – explain and discuss the concepts of magneto-motive force, field strength and reluctance ***Individual learner activities:*** – tutor-led solution of problems on flux density – tutor-led solution of problems on magneto-motive force, field strength and reluctance
Whole-class teaching: – explain and demonstrate the concept of Electromagnetic induction, explain the occurrence of eddy currents and how to minimise them followed by a discussion and explanation of self and mutual inductance – explain and discuss the magnetic field produced by a current – tutor demonstration showing the force acting on a current carrying conductor in a magnetic field and the associated formula ($F = BI\ell$) followed by a demonstration of Fleming's rules – tutor introduction to the concept of induced emf due to motion ($e=B\ell v$) ***Individual learner activities:*** – tutor-led solution of simple problems on self and mutual inductance – tutor-led solution of problems on force on a conductor and induced emf due to motion ***Whole-class teaching:*** – describe the construction and operation of DC motors and generators with particular reference to the previous week's work – explain and discuss the transformer principle, the idea of an ideal transformer and the transformation ratios ***Individual learner activities:*** – tutor-led solution of problems on DC motors and generators – tutor-led solution of simple problems involving the transformation ratios
Prepare for and carry out Assignment 3: Magnetism, Transformers and Motor/Generators (P4, P5, P6, D2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain principles of binary and logic systems – describe the purpose and function of truth tables, memory circuits, sequential and clocked circuits, flip flops, ROM and RAM – explain the use of timers and D/A and A/D converters – explain vehicle applications of digital principles and discuss the different types of vehicle integrated circuits ***Individual learner activities:*** – investigation and research of vehicle system applications of digital principles and integrated circuits – investigation and research of vehicle system microprocessors
Prepare for and carry out Assignment 4: Digital Principles and Microprocessors (P7, P8, P9, M2)
Whole-class teaching: – discuss the generation of a sinusoidal waveform and define relevant terms such as amplitude, periodic time, frequency etc – explain the characteristics of non-sinusoidal waveforms and form-factor – solve problems involving waveform characteristics – explain phasor and algebraic representation of alternating quantities and demonstrate the methods of phasor addition ***Individual learner activities:*** – tutor-led solution of problems on phasor addition ***Whole-class teaching:*** – explain and discuss the calculation of capacitive and inductive reactance, and the calculation of impedance from circuits containing pure R, L and C – tutor demonstration to explain the safe use and setting up of an oscilloscope – practical work to measure the characteristics of sinusoidal waveforms and complete worksheets – tutor demonstration of the use of an oscilloscope and multimeter to investigate half and full wave rectification ***Individual learner activities:*** – tutor-led exercises on solution of problems involving circuit reactance and impedance ***Whole-class teaching:*** – group practical work to compare measured and theoretical results – tutor-led investigation of primary and secondary current and voltage ratios – tutor demonstration of the operation of a simple power supply and the function of the individual components

Topic and suggested assignments/activities and/assessment
Individual learner activities: – recording results and comparing measured findings with theoretical results
Prepare for and complete Assignment 5: Single-Phase AC Theory (P10, P11, M3, D1)
Feedback to learners, unit evaluation and close

Assessment

Much of the evidence for the pass criteria could be generated through practical experimentation and investigation with real components and circuits and computer-based software packages.

It is likely that at least five assessment instruments will be needed for this unit. If practical work and tests are also used then the total number of pieces of assessed work could be more. This should be considered carefully so as to not place an unduly high assessment burden on learners or the tutor.

Wherever possible, practical work should lead to a final product that can be handed in for assessment at the end of the session without further need for report writing. Alternatively, practical work could be observed by the tutor/witness and a record of observation used for assessment evidence. Both of these methods will help in ensuring authenticity of evidence and also keep the assessment activities short, sharp and relevant.

Evidence of the use of DC circuit theory to calculate current, voltage and resistance in three motor vehicle circuits (P1) could be produced by using paper- or computer-based methods. Between them, the three motor vehicle circuits need to be chosen to cover the required aspects of the unit content. However, it is essential that centres combine any testing of this sort with practical hands-on experience of real circuits and components. This could be achieved by prototyping circuits using simulation software to establish theoretical circuit values, followed by learners building the circuit and physically checking theory against actual results by measurement. Whichever method is used, tutors need to ensure that there is sufficient product evidence of the circuit being used/developed and the formulae selected to determine the required current, voltage or resistance values. This is particularly important where computer software is used that does not have a facility to print results or where printouts do not show sufficient detail to meet the criterion.

The ability to use a multimeter to carry out circuit measurements in DC motor vehicle circuits (P2) will require process evidence (ie it will need to be observed by the tutor or assessor during relevant practical activities on motor vehicle applications). This could be the end product measurement of circuits being assessed for P1.Tutors could capture this evidence by using an appropriate record of observation and oral questioning of each learner during the practical activities used for delivery.

The comparison of the forward and reverse characteristics of two different types of semiconductor diode (P3) will require the use of a multimeter, power supply, ammeter with shunt, and a switch resistor box. This could be a progression from P1/P2 and could be set up on a vehicle for learners to build, test and compare against data and detail provided.

The characteristics of magnetic fields (P4) could be demonstrated on an OHP by using magnets and iron filings. Learners could sketch or be provided with a handout of the results and then make appropriate comparisons with expected theoretical results. The relationship between flux density and field strength (P5), may be set within the context and use of different materials such as silicon iron and mild steel in vehicle examples such as coil, relay and starter operation.

Evidence for P6 will be descriptive and learners will need to consider the movement of a conductor within a magnetic field in vehicle examples such as alternators, starters and solenoids.

For P7, learners need to describe two different vehicle system applications of digital principles. It is expected that one of these will involve the application of a binary system and the other a logic system including D/A and A/D converters, as appropriate to the particular vehicle application. There is a strong link between P7 and P8, which could be used to good effect if the vehicle system applications of digital principles (P7) enables learners to describe the function and operation of two vehicle system integrated circuits (P8).

For P9, a practical investigation of a microprocessor application for a selected vehicle system, combined with a descriptive task, could be used. The investigation and report needs to focus on the microprocessor system being applied and its construction. Typical motor vehicle applications of microprocessors could be engine management, anti-lock braking systems, climate control, suspension settings or transmission modes.

P10 requires learners to use single phase AC circuit theory to explain and determine the characteristics of a sinusoidal AC waveform. This should include waveform characteristics and the determination of values using phasor and algebraic representation of alternating quantities. There is a useful link here with P11 and an assignment could be structured to provide a relevant link between the theory and application of AC to a vehicle.

All the merit and distinction criteria have close links with the pass criteria and tutors should try to design their assignments around these links.

M1 relates to the use of Kirchoff's laws and naturally follows on from learners' use of DC circuit theory to calculate current, voltage and resistance in P1. To achieve M1, learners need to be able use Kirchoff's laws to determine voltage and current in a motor vehicle circuit that has at least five nodes, and the power dissipated in a load resistor containing two voltage sources. Learners should be encouraged to use computer-based simulation to check their calculations.

M2 links to P9 and is designed to encourage learners to taker a wider and deeper look at the application of microprocessors in motor vehicles. It is important to keep in mind that the comparison should be based on the original findings for P8 (ie the microprocessor system being applied and its construction).

M3 is an extension of P10 and P11, for which learners will have demonstrated an ability to work with a single sinusoidal AC waveform. To achieve M3 learners need to compare the results of adding and subtracting two sinusoidal AC waveforms graphically and by phasor diagram. There are possible links outside of this unit, for example to *Unit 5: Applications of Vehicle Science and Mathematics*.

For D1, learners must analyse the operation and the effects of varying component parameters of a motor vehicle power supply circuit that includes at least a transformer, diode and a resistor. To achieve this, a basic power supply could be simulated to allow all the respective properties to be investigated without the hazards of damaging a vehicle’s system. This could be achieved using a function generator, alternating voltage or variable power source, along with a small isolating transformer, diode rectifiers (half wave and bridge) and load resistors in circuits such as alternator applications, bulb failure warning systems or data input devices.

D2 requires learners to evaluate the performance of a motor and a generator used within a motor vehicle system by reference to electrical and electronic theory. This can be achieved practically using appropriate experimental rigs that allow learners to compare their results with known characteristics for specific machines for example alternator output, motor applications such as door or window operating systems.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	DC Circuit Theory, Resistors and Kirchhoff’s Laws	A technician needs to evaluate current, voltage and resistance in a DC network and usie Kirchhoff’s laws to determine the current and power dissipated in a load resistor	Written responses to set tasks, carried out under controlled conditions
P2, P3	DC Circuit Theory, Measurement and Diodes	A technician needs to complete measurements using a multimeter in a DC network and compare the characteristics of two different types of semi-conductor diode	Practical assignment evidenced by learner records and tutor observation records
P4, P5, P6, D2	Magnetism, Transformers and Motor/Generators	A technician needs to explain to a new apprentice the characteristics of magnetism and help them evaluate the performance of a motor and generator	A written report containing diagrams, graphs and calculations

Criteria covered	Assignment title	Scenario	Assessment method
P7, P8, P9, M2	Digital Principles and Microprocessors	A technician needs to describe the vehicle system applications of digital principles, integrated circuits and microprocessors	Written responses to set tasks, carried out under controlled conditions
P10, P11, M3, D1	Single-Phase AC Theory	A technician needs to consider the characteristics of a sinusoidal AC waveform and use an oscilloscope to determine the performance of an alternator	A written report based on practical investigations

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Applications of Vehicle Science and Mathematics
		Mathematics for Engineering Technicians
		Vehicle System and Fault Diagnosis and Rectification

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Auto-Electrical and Mobile Electrical Installation, particularly:

- Unit AE04: Diagnose and Rectify Motor Vehicle Engine Electrical Faults
- Unit AE06: Diagnose and Rectify Motor Vehicle Electrical Unit and Component Faults.

Essential resources

It is essential that learners have access to a vehicle workshop equipped with test rigs, vehicles and current electrical/electronic instruments such as digital and analogue multimeters, function generators and oscilloscopes. Centres will also need to provide appropriate circuit components, as identified in the unit content, together with the means to physically construct circuits. With the increased use of computer-based methods for circuit design and simulation, centres are strongly advised to consider the provision of suitable hardware and software for computer-based circuit simulation and analysis.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bird J O — *Electrical and Electronic Principles and Technology* (Newnes, 2007) ISBN 9780750685566

Bird J O — *Electrical Circuit Theory and Technology* (Newnes, 2010) ISBN 9781856177702

Denton T — *Automobile Electrical and Electronic Systems* (Butterworth-Heinemann, 2004) ISBN 9780750662192

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when using circuit theory to calculate current, voltage and resistance in motor vehicle circuits
Self-managers	organising time and resources and prioritising actions when using multimeters and oscilloscopes

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	trying out alternative or new solutions to vehicle-related electrical and electronic problems
Reflective learners	reviewing progress when solving problems and acting on the outcomes to make corrections to understanding

Functional Skills — Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving vehicle-related electrical and electronic problems
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant laws and formulae to be applied to vehicle-related problems
Select and apply a range of skills to find solutions	selecting and applying relevant laws and formulae to be applied to vehicle-related problems
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to vehicle-related problems
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of electrical and electronic principles and concepts
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate electrical and electronic data
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	solving vehicle-related problems and communicating accurate solutions effectively

Unit 7: Vehicle Electrical Charging and Starting Systems

Unit code: F/602/1962

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the processes and technology that support engine electrical charging and starting systems, enabling them to diagnose and rectify faults on these systems.

Unit introduction

The application of electrical technology in modern motor vehicle systems is under constant development. This has resulted in an ever-increasing electrical load being placed on a vehicle's charging and starting systems. The unit will give learners the opportunity to determine faults in a vehicle's battery, charging and starting systems, identify and confirm the specific component that has failed and undertake suitable rectification procedures.

Learners will investigate the chemical process within a battery and understand how to specify a battery for a particular vehicle. They will also gain an understanding of the operation and conversion of energy within the charging and starting systems of a modern motor vehicle. The unit will enable them to apply this knowledge to both charging and starting systems and undertake diagnostic and rectification work on a range of vehicles.

Learning outcomes

On completion of this unit a learner should:

1 Be able to specify a battery for a given motor vehicle application

2 Understand a vehicle's starting system

3 Understand a vehicle's electrical charging system

4 Be able to diagnose and rectify electrical system faults on a vehicle's charging and starting systems.

Unit content

1 **Be able to specify a battery for a given motor vehicle application**

Chemical processes of lead acid batteries: chemical to electrical conversion, water to electrolyte process eg charge and discharge cycles, use of chemical symbols, changes to specific gravity and components chemical state; health and safety eg gases produced, acid content

Battery performance and construction: performance eg cold cranking amperage, amp/hour rating (10/20 rating); construction eg casing, plates (lead dioxide and spongy lead), separators; connections eg series/parallel, vehicle earthing, corrosion protection; electrolyte eg sulphuric acid, distilled water; battery calculations eg amp/hour system requirement, cold cranking usage, plate area, maximum load; battery specification eg manufacturer's recommendations, type, make, performance; specify battery by comparing system calculations/performance tests to battery capabilities

2 **Understand a vehicle's starting system**

Starting system: energy conversion eg electrical to mechanical rotation, rotational to linear translation; starter solenoid eg provide mechanical movement by use of Electromagnetic application; ignition key/push button switch eg provide timely electrical supply to starting system; principles of starter motor eg conversion of electrical energy to mechanical movement, creation and use of magnetic effect to create mechanical movement (Fleming's left hand rule)

Starting system components: electrical supply (battery); circuit protection methods eg fuse, immobiliser, key recognition, relay; ignition switch eg key or manual operation; wiring looms; warning system eg visual and audible; solenoid; starter motor assembly eg casing, magnets, armature, brush box, gear, roller clutch drive

Circuit diagrams: switched supply system; permanent feed system; recognition of circuit components/circuit symbols; types of circuit diagrams eg use of workshop manuals, manufacturer's diagrams, wiring diagrams and schematics

3 **Understand a vehicle's electrical charging system**

Voltage generation, rectification and regulation: function of generator eg alternator to create electro-motive-force using Fleming's right hand rule; system components eg stator, rotor, rectifier, voltage regulator, slip ring, brushes, bearings, cooling fan; warning device; bridge rectifier; drive belts eg single- or multi- 'V' design

Multi-phase electrical output: principles of three-phase electricity eg excitation, magnetic inductance, sinusoidal pattern, full wave rectification; use of oscilloscope to observe wave patterns; AC-DC voltage conversion

4 Be able to diagnose and rectify electrical system faults on a vehicle's charging and starting systems

Battery tests and faults: testing eg relative density, battery capacity, condition testing; equipment eg hydrometer, multimeter, dedicated test equipment, inductive amp clamp; typical battery faults eg dead cell, shorting out, low specific density, failing under heavy discharge, physical damage (overcharged causing heat distortion, corrosion/degradation, mechanical damage/defects)

Starting system tests and faults: system operation; circuit testing eg continuity, feed, voltage drop; component test eg ignition switch, solenoid operation, starter motor operation and internal components (armature, brushes, windings, circuit protection eg relays, overload relay, immobiliser); use of test equipment eg multimeter, dedicated test equipment, oscilloscope, inductive amp clamp; typical starting system faults eg internal short on armature, failed solenoid operation, inhibitor switch failed

Charging system tests and faults: system operation; circuit testing eg continuity, feed, voltage drop; component test eg diodes, bearings, rotor, windings; output test eg voltage, current, waveform; typical charging system faults eg diode failure (indicator light on), faulty voltage control (overcharging), bearing fault (noisy or excessive free play), faulty brush box/rotor (no charge); use of test equipment eg multimeter, dedicated test equipment, oscilloscope, inductive amp clamp

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Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the chemical processes of a lead acid battery	M1 compare the performance characteristics of two different batteries	D1 evaluate the engine electrical systems of two different vehicles in terms of the ease of carrying out diagnostic and rectification procedures.
P2 perform calculations to select a battery, based on performance and construction, for a given motor vehicle application [IE1]	M2 justify the choice of starting system diagnostic tests and rectification methods	
P3 explain the operation of a vehicle's starting system and the function of its components	M3 justify the choice of charging system diagnostic tests and rectification methods.	
P4 use a circuit diagram to identify the electrical components of a vehicle's starting system		
P5 explain the process of voltage generation and regulation for a given vehicle application		

Assessment and grading criteria		
P6 explain the application of multi-phase electrical output in relationship to a vehicle's charging system		
P7 carry out diagnostic tests to identify two different vehicle battery faults [SM3, SM4]		
P8 diagnose and rectify two different vehicle starting system faults [SM3, SM4]		
P9 diagnose and rectify two different vehicle charging system faults [SM3, SM4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Before starting this unit learners should, ideally, have an understanding of the fundamentals of each system to be considered. This may have come from previous study or hands-on experience within the industry. Learners should at least be able to identify the components of the systems covered (battery, starting system, charging system) and have an appreciation of the need to carry out diagnostic and repair procedures to rectify system faults. Where learners do not have this level of understanding centres will need to ensure that sufficient underpinning knowledge is provided before delivering the unit content.

The unit would be best delivered using a practical, hands-on approach. For example, a laboratory demonstration of the chemical processes within a battery for learning outcome 1 and the evaluation of changes in the electrolyte and the state of charge within each cell. Most of the delivery of the unit will rely on the use of rigs or vehicles to aid learner understanding of both starting and charging systems. This is particularly important with concepts such as mechanical movement created by magnetic influence on components, commutation applications and flawed actuation as a direct result of a failed component.

All practical work should reflect both current industry practice and consider the benefits of covering a range of industry applications (for example 6/12/24 volt systems) for specific groups.

Learners will be required to apply some mathematical and scientific skills throughout the unit. Therefore when planning delivery of this unit, tutors may need to consider the timing of delivery in relation to other units that support development of the required skills.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – using laboratory demonstration equipment, explain the chemical processes that occur within a lead acid battery – describe the health and safety considerations that need to be taken into account when handling batteries – explain the performance and construction of a vehicle battery – explain use of calculations for a selection of batteries ***Individual learner activities:*** – carry out battery calculations and specify a battery by comparing system calculations/performance tests to battery capabilities

Topic and suggested assignments/activities and/assessment
Prepare for and complete Assignment 1: Vehicle Batteries (P1, P2, M1)
Whole-class teaching: – explain the process of energy conversion in a starting system – explain the function and operation of a starter solenoid and the ignition switch – explain the principles of a starter motor – identify and explain the function and operation of starting system components – explain the use of different types of circuit diagrams ***Individual learner activities:*** – practical investigation of starting systems and components – use of circuit diagrams to identify components
Prepare for and complete Assignment 2: Vehicle Starting Systems (P3, P4)
Whole-class teaching: – explain the function of a generator and system components – explain the function and operation of bridge rectifiers, drive belts and warning systems – explain the principles of three-phase electricity and AC to DC voltage conversion – demonstrate use of an oscilloscope ***Individual learner activities:*** – practical investigation of vehicle electrical charging systems and components – use of oscilloscope to observe wave patterns
Prepare for and complete Assignment 3: Vehicle Electrical Charging Systems (P5, P6)
Whole-class teaching: – demonstrate use of equipment to test batteries and rectify typical battery faults – demonstrate use of equipment to test circuits and components and rectify typical starting system faults – demonstrate use of equipment to test circuits and components and rectify typical charging system faults ***Practical workshop activities:*** – use of test equipment to diagnose and rectify system faults
Prepare for and complete Assignment 4: Diagnosing and Rectifying Faults (P7, P8, P9, M2, M3, D1)
Feedback to learners, unit evaluation and close

Assessment

Assessment evidence is most likely to be gathered from practical work on vehicles and test rigs. Tutors will need to provide or simulate a range of system faults on vehicles to ensure authenticity of individual evidence for large groups of learners. Work-based evidence of the application of theory and fault-finding skills would also be acceptable.

P1 and P2 are linked and should be assessed together. For P1, learners will need to explain the chemical processes of a lead acid battery. In particular they should consider the chemical to electrical conversion, water to electrolyte process and relevant health and safety issues when working with a battery.

P2 requires learners to be able to consider the performance and construction of a battery for a given or chosen vehicle application. When considering performance, learners should typically look at the impact of cold cranking, other draws on the power of the battery (for example the demand from modern computer and security systems when the vehicle is idle) and issues such as amp/hour rating. When looking at construction, learners should be considering the battery's casing, plates and separators. They will also need to include how connections are achieved and electrolyte is used. The essential aspect of this criterion will be the learner's ability to perform the required battery calculations and establish the required battery specification for the application. It is expected that learners will draw from and make suitable references (for example manufacturer's recommendations, types, makes and performance capabilities) when specifying the battery and use their system calculations/performance tests to determine battery capabilities.

The assignment used for P1 and P2 could be extended to cover M1. This will require learners to compare the performance characteristics of two different batteries. One of the batteries used could be the one already dealt with for P2 and compared against another (completely different) battery.

A second assignment could be used to cover P3 and P4. This will require learners to explain the function of the components and operating principles of a vehicle's starting system (P3). The components to be covered include the battery, circuit protection methods, ignition switch, wiring looms, warning system, solenoid, starter and motor assembly. The explanation should consider the relevant energy conversion methods (for example electrical to mechanical rotation, rotational to linear translation), the operation of the starter solenoid and ignition key/push button switch and the operating principles of the starter motor. In explaining the function of components learners could also identify them using a circuit diagram in order to achieve P4.

P5 and P6 can also be linked, with learners covering the processes involved in voltage generation, rectification and regulation and the application of multiphase output. For P5, learners will need to provide suitable explanations of the function of a generator, relevant system components and the related drive belts. P6 requires learners to explain the application of multi-phase electrical output in relationship to a vehicle's charging system. This should include the general principles of multi-phase electrical output, the use of an oscilloscope to observe wave patterns (screenshots or sketches may be used to evidence the patterns observed under specific conditions), and the application of AC-DC voltage conversion in a vehicle setting.

P7, P8 and P9 will require learners to demonstrate their practical skills with respect to diagnostic tests and rectification for batteries, starter and charging systems. P7 requires learners to carry out diagnostic tests to identify two different vehicle battery faults. Assessment of rectification is not required as this would simply mean replacing the faulty battery. However P8 and P9 will require learners to carry out both diagnostic tests and rectification of two different vehicle starting system faults and two different vehicle charging systems.

The assessment of P7 could be linked back to P1 and P2. Typical battery faults might include dead cell(s), shorting out, low specific density, failing under heavy discharge or physical damage. Learners will need to select and use suitable equipment when carrying out the diagnostic tests.

For P8 and P9, the diagnostics tests should consider the respective system operation, appropriate circuit testing and component tests. The rectification procedures should be completed and systems checked to confirm integrity. Appropriate work records should also be completed.

It is likely that relevant observation records/witness statements will form the evidence of learners using a range of equipment for each system to confirm diagnosis before undertaking rectification. A short report (or logbook entry) outlining the details of the diagnostic procedures carried out would also be expected. The report does not have to be a full technical report but should reflect industry practice of reporting back to supervisor/customer. To ensure authenticity centres will need to provide a variety of faults so that each learner is able to carry out a series of diagnostic and rectification procedures unique to them.

The practical activities carried out for P8 and P9 will link directly with M2, M3 and D1.

To achieve M2 and M3, learners must be able to justify the choice of starting and charging system diagnostic tests and rectification methods used (on each of the two different vehicle system faults for each criterion), respectively.

For D1, learners should be able to evaluate the engine electrical systems of two different vehicles in terms of the ease of carrying out diagnostic and rectification procedures. The systems considered could be the same ones used for P8 and P9.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Vehicle Batteries	A technician needs to select a suitable battery for a vehicle application	Written report including calculations
P3, P4	Vehicle Starting Systems	A vehicle technician needs to explain to an apprentice the function and operation of a vehicle's starting system	Written report

Criteria covered	Assignment title	Scenario	Assessment method
P5, P6	Vehicle Electrical Charging Systems	A vehicle technician needs to explain to an apprentice the operation of a vehicle's electrical charging system	Written report
P7, P8, P9, M2, M3, D1	Diagnosing and Rectifying Faults	A vehicle technician needs to diagnose and rectify faults on a vehicle's battery, charging and starting system	Practical activities evidenced by record sheets and observation records.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Systems
		Electrical and Electronic Principles for Vehicle Technology

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit AE06: Diagnose and Rectify Motor Electrical Unit and Component Faults
- Unit LV06: Inspect Motor Vehicles
- Unit LV11: Overhaul Motor Mechanical Units.

Essential resources

Learners will need access to suitable motor vehicle workshop facilities. This should include equipment for working with dangerous acids, voltage generation equipment and test equipment including oscilloscopes. A range of components and vehicles should be provided as well as a variety of data sources and technical information.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Denton T — *Automobile Electrical and Electronic Systems* (Butterworth-Heinemann, 2004) ISBN 9780750662192

Hillier V and Coombes P — *Hillier's Fundamentals of Motor Vehicle Technology* (Nelson Thornes, 2010) ISBN 9781408515181

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when selecting a battery for a given motor vehicle application
Self-managers	organising time and resources, prioritising actions and anticipating, taking and managing risks when carrying out fault diagnosis on vehicle starting and charging systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	asking questions to extend their thinking
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others when researching vehicle starting and charging systems

Functional Skills — Level 2

Skill	**When learners are …**
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching information (eg safety, maintenance and diagnostic data)
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining operating principles and functions of vehicle electrical systems and components

Unit 8: Function and Operation of Vehicle Petrol Injection Systems

Unit code: R/502/5908

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of the function and operation of petrol injection systems and the methods used to test, maintain and repair them.

Unit introduction

Most modern vehicles are fitted with fuel injection systems that enable the engine to work more efficiently and usually result in greater power and cleaner exhaust emissions. These systems work by forcing pressurised fuel through a tiny nozzle that atomises the fuel, allowing it to burn more quickly when mixed with air.

In this unit learners will study a variety of fuel injection systems in order to understand their operation and the differences between systems. Learners will develop an understanding of the air and fuel supply systems and will gain knowledge of the operation of the engine control systems and components. Learners will also develop knowledge of the equipment and methods used to test, maintain and repair petrol fuel injection systems.

Learning outcomes

On completion of this unit a learner should:

1 Understand the operational differences of petrol injection systems

2 Understand the function and operation of air and fuel supply components and systems

3 Understand the operation of electronic control systems and components

4 Know the methods used to test, maintain and repair petrol fuel injection systems.

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Unit content

1 **Understand the operational differences of petrol injection systems**

Petrol injection system: principles of fuel combustion eg composition of atmospheric air, calorific value of fuel, mixture strength and the range of combustibility, influence of air/fuel ratio on engine power output; vaporisation of fuel and cooling effects on charge density; injector layout (single point, multi-point, phased and continuous injection); mechanical and electronic control (open and closed loop systems); specification eg technical improvements relative to performance, emissions and costs

Fuel injector positioning: single/multi-point/common rail/direct injectors; positioning of injector within the induction manifold eg up-stream, down-stream or direct into the cylinder; quality of the homogeny of the charge and volumetric efficiency eg requirements for compensatory enrichment, effects of fuel condensation on manifolds walls

Stoichiometric and lean burn technology: phasing of injection eg induction cycle injection (stoichiometric cycle), compression stroke injection (direct injection, stratified engine operation); fuel injection strategies eg continuous injection, intermittent injection, semi sequential and sequential injection, asynchronous and grouped injection; operational conditions eg cold starting, idling, maximum power; thermal efficiency and the formation of pollutants; exhaust gas composition eg composition of the exhaust gases under rich, lean and stoichiometric conditions, legal requirements

2 **Understand the function and operation of air and fuel supply components and systems**

Air supply system components: air intake tract; air cleaner; air throttle valve (butterfly valve); throttle body; use of an electric throttle; induction manifold and plenum chamber; variable geometry induction manifolds

Fuel supply components: fuel tank construction eg steel with soldered joints, welded joints, moulded plastic, use of internal baffles and swirl pots; electric fuel pump eg vane, roller gear, plunger; valves eg pressure relief, non-return; fuel lines eg accumulator, pipelines, fuel pipe connections, fuel filter; continuous injection mechanical systems; pressure regulator with induction manifold pressure correction; common fuel rail injection (direct injection) eg low pressure supply pump, low pressure sensor, high pressure pump, high pressure injectors, high pressure sensor; methods employed to reduce fuel vapour escape eg charcoal canister, purge control valve

3 Understand the operation of electronic control systems and components

Sensors, switches and actuators: sensors eg crankshaft position, camshaft position, coolant temperature, ambient air temperature, fuel temperature, mass air flow (vane type, thermal type (hot wire and hot chip), manifold pressure sensors (manifold absolute pressure (MAP) sensor, exhaust gas oxygen sensor (step response lambda, broad band lambda), engine speed and throttle position sensor; switches eg thermo-time switch, idle speed switch, inertia switch; actuators eg solenoid injectors, variable manifold butterfly actuators, electrical throttle valve actuator

Electronic control unit (ECU): input and output processes; injector driver circuits; fuel mapping; basic programming theory eg use of input parameters to enable the software to calculate correct fuel quantity for injection; software updating eg use of specialised software to change fuel map setting at varying engine/operational conditions; software self- diagnostics; controller area network (CAN) data bus eg single wire, twin wire, fibre optic

Emission control principles and components: exhaust gas oxygen sensing; catalytic converter eg reduction, oxidising, nitrogen oxides (NOx); exhaust gas recirculation (EGR) and components eg outline of the process to reduce NOx formation, operation strategies, EGR valve, vacuum modulator, vacuum sensing valve; air injection and components eg air pump, air injector, pulse air injection, electronic control of EGR and air injection systems; effect of engine operating conditions eg cranking, cold start enrichment, hot start enrichment, cold idle, hot idle, light load, full load, acceleration, deceleration, engine speed limitation

4 Know the methods used to test, maintain and repair petrol fuel injection systems

Diagnostic equipment and tests: exhaust gas analysis eg use of exhaust gas analysers, lambda values, air/fuel ratio, idle speed adjustments; on-board diagnostics (OBD) eg fault code reading, data logging, use of break out box to locate faults, data link connection to dedicated code readers; vacuum pump eg induction system leakage, simulation of manifold depression to check fuel pressure regulator; multimeter eg system voltage and circuit tests, circuit resistance, circuit integrity; pressure gauge eg fuel line pressure and regulator settings; injector delivery and spray pattern eg injection quantity, spray pattern and leakage; oscilloscope eg engine/camshaft speed sensor patterns, injection duration, lambda sensor output

Injection systems faults and symptoms: eg throttle position sensor, mass air flow sensor, coolant sensor, crankshaft/camshaft speed/position sensor, exhaust oxygen sensor, idle speed control valve

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the operation of two different petrol injection systems used on modern fuel injected engines [IE1, IE4]	M1 compare the relative advantages and disadvantages of port injection and direct injection with reference to timing of the injection process	D1 evaluate two typical modern petrol injection systems in terms of their legal, environmental and operational requirements
P2 describe the methods used to position the fuel injector for an induction port injection and a direct injection into the cylinder [IE1, IE4]	M2 compare the injection, combustion cycle and exhaust emissions within a stoichiometric air fuel ratio engine and a lean burn stratified charge engine	D2 evaluate the use of diagnostic tests using standard workshop equipment in comparison to dedicated on board diagnostic facilities, equipment and software used with modern petrol injection systems.
P3 describe the principles of stoichiometric and lean burn technology with reference to petrol injection engines [IE1, IE4]	M3 compare the diagnostic tests and repair strategies that can be performed on two different modern petrol injection systems, including the equipment that may be used.	
P4 explain the function and operation of the air and fuel supply components of a given fuel injection system [IE1, IE4]		

Assessment and grading criteria		
P5 describe the function and operation of four major input sensors, their related switches and actuators and how the electronic control unit uses feedback from these devices to calculate quantity of fuel injected [IE1]		
P6 explain the emission control measures and associated components used for a given fuel injected engine system		
P7 describe the diagnostic equipment required and tests that need to be carried out to check the satisfactory operation of two different fuel injection systems		
P8 describe the symptoms associated with three different injection system faults found in modern engines and the repair strategy for each.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using a balance of theoretical and practical study. Where possible the function, operation and principles of injection systems should be demonstrated through investigations using rigs, units, vehicles, components and equipment.

The learning outcomes could be delivered in order. This will enable learners to develop an overall understanding of the operational differences of a range of systems before going into too much detail. Learners would then understand the design principles and requirements of petrol injection systems before targeting the complexities of specific components, testing, maintenance and repair.

Although the unit does not require the use of diagnostic equipment to carry out tests and fault diagnosis, it would be good practice to provide learners with an opportunity to do so where this equipment is available.

Formative assessment, with effective feedback and support, will play an important part in learner development throughout this unit, particularly for their achievement of the merit and distinction grades. Learners should be encouraged to compare and consider relative advantages and disadvantages of stoichiometric and lean burn technology. In particular, they should consider how current and proposed changes in emission requirements will impact on fuel injection technology. Learners should also consider the interrelationship of all components that contribute to mixture correction and hence the emission control process.

Note that the use of 'eg' in the content is to give an indication of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the principles of fuel combustion and the composition of petrol fuels – explain the operation of conventional petrol fuel injection systems and the operational factors that can affect performance and emissions – explain the different types of fuel supply pumps and means of fuel supply operation

Topic and suggested assignments/activities and/assessment
– explain the operation of pressure regulating valves, heaters and coolers and fuel injection system settings – explain methods of venting petrol fuel injection systems ***Individual learner activities:*** – investigation/case study of different types of petrol fuel injection system
Whole-class teaching: – explain function and operation of air supply components – explain function and operation of fuel supply components ***Practical workshop activities:*** – practical investigation of a range of air and petrol fuel supply components
Prepare for and complete Assignment 1: Petrol Injection and Air and Fuel Supply Systems (P1, P2, P3, P4, M1, M2, D1)
Whole-class teaching: – explain function and operation of sensors and actuators – explain the operation of common rail, electronically controlled low pressure and high pressure systems – explain the operation of petrol fuel injection cold start devices – explain single, two and variable speed governing and the operation of hydraulic and electrical governors – explain the function and operation of an ECU – explain emission control methods, legal requirements for emissions and effects on emissions of different operating conditions ***Individual learner activities:*** – investigation/case study of petrol engine control systems and components
Prepare for and complete Assignment 2: Electronic Control Systems (P5, P6)
Whole-class teaching: – explain and demonstrate the use of equipment for exhaust gas analysis – explain the operation of on-board diagnostic equipment – explain the procedures for checking common rail pressures and the effects of low rail pressure – explain induction system leakage, the effects of changes in boost pressure on turbocharged engines, effects of fuel injection quantities of changes in boost pressure – explain and demonstrate use of multimeter, pressure gauge and oscilloscope – explain typical injection system faults and their symptoms – explain methods of testing and servicing injection fuel systems

Topic and suggested assignments/activities and/assessment
Practical workshop activities: – use of diagnostic equipment to carry out tests and fault diagnosis on petrol fuel systems
Prepare for and complete Assignment 3: Maintenance and Repair of Petrol Fuel Injection Systems (P7, P8, M3, D2)
Feedback to learners, unit evaluation and close

Assessment

A variety of evidence could be used to support assessment. For example, a mixture of written tests and practical investigative assignments could be used requiring learners to explain, describe, identify, compare and evaluate as required by the criteria.

For P1, learners need to explain the operation of two different petrol injection systems used on modern fuel injected engines. A task could be developed requiring learners to inspect two different types of system (selected from those outlined in the unit content) in a practical environment. The task should ensure the learner explains principles of combustion, vaporisation of fuel and cooling effects on charge density, injector layout, mechanical and electronic control and consider the specifications of each where appropriate. P2 requires learners to describe the methods used to position the fuel injector for an induction port injection and a direct injection into the cylinder. The task should ensure the learner considers the quality of the homogeny of the charge and volumetric efficiency. P1 and P2 are closely linked and could be assessed together. The same vehicles could then be used for both criteria.

There are similar close links between P3 and P4. For P3, learners need to explain the principles of stoichiometric and lean burn technology with reference to petrol injection engines. This should include phasing of injection, fuel injection strategies, operational conditions, thermal efficiency and the formation of pollutants including exhaust gas composition. It is expected that learners will refer to more than one type of petrol injected engine to cover the requirements of the unit content. They will need to demonstrate an understanding of the combustion of fuel within an engine and the differences between the homogenous/stoichiometric charge and the stratified, overall lean mixtures associated with modern direct injected engines. To achieve P4, learners need to explain the function and operation of the air and fuel supply components of a given fuel injection system. The operation and function of all components listed in the content under "Air Supply System components" should be explained. The fuel supply components should include the tank, pump, valves, fuel lines etc where applicable in the given system. Learners will, by necessity, need to refer to open and closed loop control methods and their relevance to the function, operation and fundamental principles affecting fuel delivery.

For P5, learners need to describe the function and operation of four major input sensors, their related switches and actuators and how the electronic control unit uses feedback from these devices to calculate quantity of fuel injected. This criterion should not be fragmented into sensors, switches, actuators and ECU. One activity should be designed to enable the whole criterion to be covered at the same time. Learners should include, for each major input sensor considered, suitable references to the interrelationships between each of the components within the systems.

P6 requires learners to explain the emission control measures and associated components used for a given fuel injected engine system. Learners should consider exhaust gas sensing, catalytic converter, EGR and associated components and the effect of engine operating conditions on emissions.

P7 and P8 focus on system defects, symptoms and the necessary testing procedures used in maintenance and repair processes. It is likely, although not essential, that the three faults in P8 will be associated with the two systems considered for P7. It is expected that faults associated with more than one system will be considered. Wherever possible the descriptions associated with P7 and P8 should be the product of a practical investigation undertaken by the learner and should give consideration to exhaust gas analysis, OBD, vacuum pump, multimeter, pressure guage, injection delivery and oscilloscope. Where centres do not have the equipment to do this they may wish to consider work-based evidence if practicable.

For M1, learners will need to compare the relative attributes of port injection and direct cylinder injection. They should also clearly define the point at which injection commences relative to the engine cycle.

M2 is linked to P3, P4, P5 and P6 in as much as learners need to explore in more detail the differences in combustion strategy to meet the close limits set by environmental legislation. It is expected that learners will refer to the use of closed loop control and the use of step response and/or broadband (or both) oxygen sensors to enable accurate reduction and oxidation to occur within the catalytic converter.

M3 is linked to P7 and P8. Learners need to compare the effectiveness of the tests that can be used to locate faults and the appropriate repair strategies. This should draw on and bring together the understanding gained at pass level enabling them to demonstrate a coherent understanding of testing and fault finding methods.

For D1, learners need to evaluate two typical modern petrol injection systems in terms of their legal, environmental and operational requirements. For D2, they will need to evaluate the use of diagnostic tests. Emphasis should be placed on the comparison with diagnostic algorithms using standard workshop test equipment and on-board diagnosis (OBD) which require dedicated test equipment. Learners should cite examples of actual testing.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1, M2, D1	Petrol Injection and Air and Fuel Supply Systems	A vehicle technician has been asked to explain the operational differences of petrol injection systems and the function and operation of air and fuel supply systems	Written responses to set tasks
P5, P6	Electronic Control Systems	A vehicle technician needs to describe the function and operation of sensors, switches and actuators and emission control measures	Written responses to set tasks
P7, P8, M3, D2	Maintenance and Repair of Petrol Fuel Injection Systems	A vehicle technician needs to describe the methods used to test, maintain and repair petrol fuel injection systems	A written report based on practical investigations

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Systems
		Vehicle System Fault Diagnosis and Rectification

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- LV06: Inspect Motor Vehicles
- LV07: Diagnose and Rectify Light Vehicle Engine and Component Faults.

Essential resources

Learners will need access to a range of components, assemblies and rigs and, wherever possible, access to the diagnostic equipment identified in the unit content. Access to suitable vehicles and tools will need to be provided along with a range of relevant information sources and operational manuals.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bonnick, A — *Vehicle Electronic Systems and Fault Diagnosis* (Butterworth-Heinemann, 1998) ISBN 9780340706305

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) ISBN 978-1408515181

Hillier V — *Hillier's Fundamentals of Automotive Electronics* Book 2, 6th Edition (Nelson Thornes, 2012) ISBN 9781408515372

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and analysing and evaluating information when comparing petrol injection systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others to work towards common goals when researching petrol injection systems
Self-managers	organising time and resources and prioritising actions

Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching petrol injection systems, diagnostic equipment and fault- finding/repair methods
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and explaining petrol injection systems, diagnostic equipment and fault-finding/repair methods
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching petrol injection systems, diagnostic equipment and fault- finding/repair methods
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining and describing petrol injection systems, diagnostic equipment and fault-finding/repair methods

Unit 9: Diesel Fuel Injection Systems for Compression Ignition Engines

Unit code: K/503/1441

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of the operation of different types of light and heavy vehicle diesel fuel injection systems and the methods used to test, maintain and repair them.

Unit introduction

Advances in technology and a tightening of exhaust emissions requirements have led to a considerable improvement in the performance of diesel engines. Once exclusively used in large heavy vehicles, plant or marine applications, diesel engines are now an acceptable alternative to petrol engines in light vehicles. To compete effectively as an alternative, the light diesel engine must have similar attributes to the petrol engine. Modern fuel injection systems in diesel engines enable improved engine performance and economy and control of emissions, enabling parity with the petrol engine.

In this unit learners will study a variety of fuel injection systems in order to appreciate their function, their operation and the differences between systems. The unit will develop learner understanding of air and fuel supply systems and the operation of the engine control systems and components. Learners will also develop their knowledge of the equipment and methods used to test, maintain and repair diesel fuel injection systems.

Learning outcomes

On completion of this unit a learner should:

1 Understand the operational differences of diesel fuel injection systems

2 Understand the function and operation of air and diesel fuel supply components and systems

3 Understand the operation of diesel engine control systems and components

4 Know the methods used to test, maintain and repair diesel fuel injection systems.

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Unit content

1 **Understand the operational differences of diesel fuel injection systems**

Diesel injection system: principles of diesel fuel combustion, combustion phases, turbulence and the compression of induced air, composition of fuels used in diesel engines, abnormal combustion and its causes; conventional diesel fuel injection systems eg in line, rotary fuel injection pump, high pressure common rail injection system using electronic injector control, low pressure common rail injection system using combined pump and injector, electronic diesel control using conventional fuel injection pump; operational factors eg technical improvements relative to performance and emissions

Diesel fuel supply: fuel supply pumps eg types (diaphragm, gear vane and plunger), multi-stage pressure development, provision for hand priming, single and double pumping action; means of operation eg fuel pump camshaft, engine camshaft auxiliary drives, electrical drives; fuel supply pressure regulating valves (control of fuel flow rates in high-pressure systems); fuel heaters and coolers eg waxing prevention methods, cooling of returned fuel before entering fuel tank; procedures for venting diesel fuel injection systems eg requirements to bleed air from the system, self- venting systems, faults associated with entrapment of air in the fuel injection system; fuel injection system settings requirements to set maximum fuel and maximum speed(mechanical or electronic), methods used to identify injection timing marks/position for refitting to engine, adjustment of plunger travel or torque methods on combined pump and injector types

2 **Understand the function and operation of air and diesel fuel supply components and systems**

Air supply system components: air cleaners; induction manifold design; use of resonance chambers to improve engine volumetric efficiency; variable geometry induction manifolds and variable geometry turbo chargers

Diesel fuel supply components: fuel tank eg construction, methods used to minimise aeration of the fuel; filtration of the fuel eg requirements to filter the fuel, effects of low temperature wax formation on fine filters, filter placement, effects of water ingress, methods used to trap and remove water, construction and position of primary and secondary filters, effect of blocked filtration system (loss of power, misfire, engine shut down); control valves eg delivery valves with anti-dribble control, manual shut down, solenoid shut down valves and reverse flow valves (used on electronically governed inline pumps to ensure engine shut down), application of electronic control; injector nozzles eg single hole, multi-hole, pintle, pintaux; fuel injection pump eg in-line fuel injection pumps, single and multi-cylinder, drive couplings, mechanical advance/retard system, electronic control of injection timing, firing order control, anti-reverse cams, methods used to meter quantity of fuel injected; high and low pressure pipes eg high pressure injection pipes, factors that govern internal and external diameter, length of high pressure pipes, factors that affect injection timing, size and effects on volume flow rates (low pressure pipes), need for adequate clamping of pipes

3 Understand the operation of diesel engine control systems and components

Sensors and actuators: sensors eg engine speed, air mass, coolant temperature, throttle position, fuel pressure intake manifold pressure, intake manifold temperature, governor control rod position, throttle position; actuators eg electrical/hydraulic servo units, glow plugs (methods to reduce diesel knock), injectors, fuel pressure regulating valve, rotary injection pumps (distributor type injection pumps, drive methods and engine timing), method to ensure correct firing order

Control systems: common rail, electronically controlled, low pressure systems eg combined pump and injector, drive mechanism for injector, control strategies, operation of the injector on its cycle, fuel supply pump operation pump drive and timing arrangements; common rail electronically controlled high-pressure system eg fuel supply circuitry, operation of the supply pump, fuel rail pressure sensors, pressure limiting valve, construction and operation of the injector, pre-injection phase, main injection phase; diesel fuel injection cold start devices eg retardation of injection timing, excess fuel device (including the legal implications of its use), manifold combustion heaters, heater plugs, ether injection, decompression devices; single, two and variable speed governing eg governor cut in/cut out, maximum speed over-run, hysteresis, over-shoot, speed droop; hydraulic and electronic governors eg components and operation under idling, maximum speed (legal requirement), over-run and variable speed

Electronic control unit (ECU): input and output processes; injector driver circuits; fuel mapping; basic programming theory eg use of input parameters to enable the software to calculate correct fuel quantity for injection; software updating eg use of specialised software to change fuel map setting at varying engine/operational conditions; software self- diagnostics; controller area network (CAN) data bus eg single wire, twin wire, fibre optic

Emission control measures and components: exhaust gas emissions under normal and abnormal running conditions eg methods employed to reduce emissions (exhaust gas recirculation (EGR), urea injection into exhaust using selective catalytic reduction); legal requirements for emissions (EURO specification); effect of diesel engine operating conditions eg cranking, cold/hot start, cold idle, hot idle, light load, full load, acceleration, deceleration, engine speed limitation

4 Know the methods used to test, maintain and repair diesel fuel injection systems

Diagnostic equipment and tests: exhaust gas analysis eg use of smoke meters for exhaust gas opacity, idle speed adjustments and maximum speed settings; on-board diagnostics (OBD) eg fault code reading, data logging, use of break out box to locate faults, data link connection to dedicated code readers; checking common rail operational pressures, effects of low rail pressure on starting and performance; induction system leakage, effects of changes in boost pressure on turbocharged engines, effects of fuel injection quantities of changes in boost pressure; use of multimeter eg system voltage and circuit tests on injector control solenoids, circuit resistance, circuit integrity; pressure gauge eg fuel line pressure and regulator settings; oscilloscope eg engine/camshaft speed sensor patterns and injection duration

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Injection system faults and symptoms: removal and refitting of main fuel injection system components eg removal and refitting of injectors including common rail, removal and refitting of a fuel injection pump; servicing of fuel system eg fuel filters, bleeding and rectification of leaks; checking the operation of the fuel injection system eg in situ adjustments of fuel quantities injected and speed, checking of injection timing, producing fault finding algorithms; testing of injectors eg safety factors associated with high pressure fluids and vapour, spray patterns, setting pressures, nozzle back leakage, nozzle tip leakage, specialised equipment to test combined pump and injector types; maintenance of fuel systems eg fuel filter condition, condition of pipes and securing clamps, leaks, checking the condition and security of fuel injection pumps and drive couplings, security of maximum fuel and speed seals, check indication of visible vapour from the exhaust; test rectification techniques eg location of misfire on conventional injection system and/or on common rail using dedicated software, poor performance through lack of power, excess exhaust gas opacity, fuel leaks, air ingress, probable causes of black, blue and white smoke; legal implications of defects on diesel fuel injection systems eg excessive smoke, loss of power weight ratio and fuel leaks onto the road surface

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the operation of two different diesel fuel injection systems used on modern diesel engines [IE4]	M1 compare the relative advantages and disadvantages of a conventional fuel injection system with a high pressure common rail system	D1 evaluate two typical modern diesel injection systems in terms of their legal, environmental and operational requirements
P2 describe two different types of diesel fuel supply methods [IE4]	M2 compare two governor types used on modern automotive diesel engines in terms of their modes of operation and levels of sensitivity	D2 evaluate the use of diagnostic tests using standard workshop equipment in comparison to dedicated on board diagnostic facilities, equipment and software used with modern diesel injection systems.
P3 explain the function and operation of the air and diesel fuel supply components of a given diesel fuel injection system	M3 compare the diagnostic tests and repair strategies that can be performed on two different modern diesel injection systems, including the equipment that may be used.	

Table continues on next page

Assessment and grading criteria		
P4 describe the function and operation of four major diesel injection system input sensors, the related actuators and their relationship with the engine electronic control unit		
P5 explain the emission control measures and associated components used for a given diesel fuel injected engine system		
P6 describe the diagnostic equipment required and the tests that need to be carried out to check the satisfactory operation of two different diesel fuel injection systems		
P7 describe the symptoms associated with three different diesel fuel injection system faults found in modern engines and the repair strategy for each.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	
	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using a balance of theoretical and practical study. Where possible the function, operation and principles of injection systems should be demonstrated through investigations using demonstration rigs, vehicles, components and equipment.

The learning outcomes could be delivered in order. This will enable learners to develop an overall understanding of the operational differences of a range of systems before going into too much detail. Learners would then understand the design principles and requirements of diesel injection and combustion principles before targeting the complexities of specific components, testing, maintenance and repair.

Although the unit does not require the use of diagnostic equipment to carry out tests and fault diagnosis, it would be good practice to provide learners with opportunities to do so where this equipment is available.

Formative assessment, with effective feedback and support, will play an important part in learner development throughout this unit, particularly for their achievement of the merit and distinction grades. Learners should be encouraged to compare and consider relative advantages and disadvantages of conventional injection systems with the high pressure and electronically controlled common rail system. In particular, they should consider how current and proposed changes in emission requirements will impact on fuel injection technology. Learners should also consider the interrelationship of all components that contribute to mixture correction and hence the emission control process.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching:
– introduction to unit content, overview of activities and assessment methodology
– explain the principles of diesel fuel combustion and the composition of diesel fuels
– explain the operation of conventional diesel fuel injection systems and the operational factors that can affect performance and emissions

Topic and suggested assignments/activities and/assessment
– explain the different types of fuel supply pump and means of fuel supply operation – explain the operation of pressure regulating valves, heaters and coolers and fuel injection system settings – explain methods of venting diesel fuel injection systems ***Individual learner activities:*** – investigation/case study of different types of diesel fuel injection system
Prepare for and carry out Assignment 1: Diesel Fuel Injection Systems (P1, P2, M1, D1)
Whole-class teaching: – explain function and operation of air supply components – explain function and operation of fuel supply components ***Practical workshop activities:*** – practical investigation of a range of air and diesel fuel supply components
Whole-class teaching: – explain function and operation of sensors and actuators – explain the operation of common rail, electronically controlled low pressure and high pressure systems – explain the operation of diesel fuel injection cold start devices – explain single, two and variable speed governing and the operation of hydraulic and electrical governors – explain the function and operation of an ECU – explain emission control methods, legal requirements for emissions and effects on emissions of different operating conditions ***Individual learner activities:*** – investigation/case study of diesel engine control systems and components
Prepare for and carry out Assignment 2: Air and Diesel Fuel Supply and Engine Control Systems (P3, P4, P5, M2)
Whole-class teaching: – explain and demonstrate the use of equipment for exhaust gas analysis – explain the operation of on-board diagnostic equipment – explain the procedures for checking common rail pressures and the effects of low rail pressure – explain induction system leakage, the effects of changes in boost pressure on turbocharged engines, effects of fuel injection quantities of changes in boost pressure – explain and demonstrate use of multimeter, pressure gauge and oscilloscope

Topic and suggested assignments/activities and/assessment
– explain typical injection system faults and their symptoms – explain methods of testing and servicing injection fuel systems ***Practical workshop activities:*** – use of diagnostic equipment to carry out tests and fault diagnosis on diesel fuel systems
Prepare for and carry out Assignment 3: Testing and Maintenance of Diesel Fuel Injection Systems (P6, P7, M3, D2)
Feedback to learners, unit evaluation and close

Assessment

Assessment of this unit could be through a mixture of written tests and practical investigative assignments.

P1 and P2 are closely linked and could be assessed together, using the same vehicles for both criteria. For P1, learners need to explain the operation of two different diesel fuel injection systems used on modern diesel engines. A task could be developed requiring learners to inspect two different types of systems (selected from those outlined in the unit content) in a practical environment. P2 requires learners to describe two different types of diesel fuel supply methods. Ideally, one will be a conventional fuel lift pump with hand priming and the other a two-stage high-pressure pump and flow control valve for a common rail system.

For P3, learners need to explain the function and operation of the air and diesel fuel supply components of a given diesel fuel injection system. This should include an explanation of the principles of induction system design used to improve engine volumetric efficiency. Specifically this should be the use of acoustic design on normally aspirated engines to aid the induction ram effect and the use of geometrical variable manifolds and turbochargers to improve engine performance characteristics. Learners should also consider the effects of turbo charger boost pressure on fuel quantities injected and emissions which would enable learners to appreciate the control strategies involved.

For P4, learners need to describe the function and operation of four major diesel injection system input sensors and related actuators used to monitor engine parameters and enable the fuel and timing of injection to be controlled with accuracy through the ECU. P5, for which learners need to explain emission control measures and associated components can be linked with P3 and P4.

P6 and P7 can be linked through a practical assessment during a workshop session or at the learner’s own place of work. If work-based evidence is used care must be taken to ensure may its validity and authenticity.

For M1, learners need to compare the relative advantages and disadvantages of a conventional fuel injection system and the high-pressure common rail system. This is closely linked to P1, P2, P4 and P5.

For M2, the learner is required to compare two different engine governing systems such as speed for heavy goods vehicle against performance limitations/ expectations for light vehicles. It is important that the related operational characteristics of these governors are analysed and compared in relation to their operation and levels of sensitivity.

M3 requires learners to compare the diagnostic tests and repair strategies performed on two different diesel injection systems. This builds on the knowledge gained through P6 and P7 and could be built in to the same practical assignment.

For D1, learners need to evaluate two modern diesel injection systems in terms of their legal, environmental and operational requirements.

D2 requires them to evaluate the use of diagnostic tests using standard workshop equipment in comparison to dedicated on board diagnostic facilities, equipment and software used with modern diesel injection systems. Emphasis should be placed on the comparisons with diagnostic algorithms using standard workshop test equipment and on-board diagnosis (OBD), which require dedicated test equipment. Learners will need to give examples of actual testing.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Diesel Fuel Injection Systems	A vehicle technician has been asked to investigate and compare two diesel fuel injection systems	A written report
P3, P4, P5, M2	Air and Diesel Fuel Supply and Engine Control Systems	A vehicle technician needs to explain the function and operation of air and diesel fuel supply and diesel engine control systems to a new apprentice	A written report
P6, P7, M3, D2	Testing and Maintenance of Diesel Fuel Injection Systems	A technician needs to explain to an apprentice how to carry out testing and maintenance of a diesel fuel injection system	A written report

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Vehicle Engine Principles, Operation, Service and Repair
		Vehicle System Fault Diagnosis

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit LV06: Inspect Motor Vehicles
- Unit LV07: Diagnose and Rectify Motor Vehicle Engine and Component Faults.

Essential resources

Learners will need access to a range of components, assemblies and rigs and, wherever possible, access to the diagnostic equipment identified in the unit content. Access to suitable vehicles and tools will need to be provided along with a range of relevant information sources and operational manuals.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University .of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Nunney, M — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to different diesel fuel injection systems and fuel supply methods, judging its relevance and value

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work

Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and explaining the operation of diesel fuel injection systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the operation of diesel fuel injection systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the operation of diesel fuel injection systems

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Unit 10: Operation and Testing of Vehicle Electronic Ignition Systems

Unit code: R/503/1398

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of the function and operation of vehicle electronic ignition systems and will enable them to test these systems to verify faults.

Unit introduction

Electronic ignition systems have developed in line with the advancement of engine technology and engine management systems. Modern electronic ignition systems have improved vehicle reliability, performance and efficiency of operation. Recent advances in spark plug design, manufacture, operation and longer working life have also improved electronic ignition systems.

It is important that all motor vehicle technicians are aware of these systems and are able to recognise and confirm faults. This unit will enable learners to understand the fundamental operating principles of electronic ignition systems and will give them the knowledge and understanding needed to carry out accurate diagnosis and repair. Learners will develop an understanding of the main components of vehicle electronic ignition systems and their relationship to the efficient operation of the engine unit and sub-systems.

Learning outcomes

On completion of this unit a learner should:

1 Understand the function and operation of conventional ignition systems and their components

2 Understand the operation of programmed electronic ignition and distributorless ignition systems

3 Know about the function and operation of pulse generators and control modules

4 Be able to undertake tests on electronic ignition system to verify system faults.

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Unit content

1 Understand the function and operation of conventional ignition systems and their components

Ignition system operation: ignition timing (static and dynamic); dwell (angle, time, variation); ignition scope patterns eg spark kV, primary circuit, secondary circuit, dwell, coil output

Ignition system components: circuits (diagrams, primary, secondary); contact breaker; coil; leads; distributor and cap; rotor arm; spark plugs; mechanisms (mechanical advance, retard, vacuum advance)

2 Understand the operation of programmed electronic ignition and distributorless ignition systems

Programmed electronic ignition: components, functions and operation; electronic control unit; sensors eg manifold absolute pressure, crankshaft, camshaft, engine temperature, knock, air temperature; ignition coil; distributor; ignition switch; reluctor disc; discharge eg capacitor, inductive

Distributor less ignition system: components, functions and operation; transformer; capacitor; ignition coil(s) eg waste spark, direct acting; spark plug; sensor eg manifold pressure, crankshaft, camshaft, knock; primary current switching modules, waste spark, direct acting

3 Know about the function and operation of pulse generators and control modules

Generators: Hall effect eg Hall voltage, Hall integrated circuit (IC), vanes, magnet, control module; inductive pick-up eg permanent magnet, inductive windings, trigger wheel; optical pulse eg light emitting diode, phototransistor

Transistor assisted contacts: transistor operation; Darlington pair; advantages of breakerless systems

Control modules: eg pulse shaping, dwell period control, voltage stabilisation, primary switching, pulse processing, secondary output control, ignition amplifier, air gap, electronic spark advance, spark advance map, read-only memory (ROM), erasable programmable read-only memory (EPROM), knock control

4 **Be able to undertake tests on electronic ignition system to verify system faults**

Testing: equipment eg on-board diagnostics, test instruments, voltage drop tester, electronic control unit tester; spark advance and retard tester; safe working practice; components and circuits eg fuses, wiring, connectors, coil, spark plug, leads, rotor arm, distributor cap, pulse generator, sensors (such as crankshaft, camshaft, knock), break out box, ignition switch, reluctor air gap; checking for faults eg moisture, dirt, corrosion, fault code reading, gap, data link connection, output and resistance, spark plug leads condition and resistance, rotor arm condition and leakage, distributor cap condition and leakage, dwell angle, spark plug condition, pulse generator module resistance, ignition timing, sensor output, sensor operation

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain, with the aid of appropriate diagrams, the operation of a typical conventional ignition system and the function of its main components	M1 compare the relative advantages and disadvantages of a typical conventional ignition system, a programmed electronic ignition and a distributor less ignition system	D1 explain how the conventional ignition system, programmed electronic ignition system and distributor less ignition system operate in a variety of cold start and acceleration situations
P2 distinguish between dwell angle, dwell time and dwell variation	M2 suggest methods for dealing with typical faults on the electronic ignition system.	D2 analyse test results to diagnose defects, wear and maladjustment in the ignition system from given data and symptoms.
P3 explain the operation of a programmed electronic ignition system and the function of its main components		
P4 explain the operation of a distributor less ignition system and the function of its main components		
P5 describe the function and operation of a pulse generator		

Assessment and grading criteria		
P6 describe the advantages of transistor assisted contacts		
P7 describe the use of two control modules		
P8 use appropriate equipment to carry out tests on five components/circuits to verify faults in an ignition system [IE1, SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit should ensure that learners gain a thorough understanding of conventional and electronic ignition system components and their interrelationship with each other. A balance of theoretical and practical study is recommended and systems and operating principles should be demonstrated using rigs, units and components.

Safe working practices should be followed in any practical activities, which should also reflect current commercial practice within learners' vocational areas.

The learning outcomes are ordered in a logical way and could therefore be delivered sequentially. Learning outcome 4 requires practical investigation and learners will need the underpinning knowledge and understanding obtained through studying learning outcomes 1, 2 and 3 before they carry out this practical activity.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the operation of a typical conventional ignition system including ignition timing, dwell and ignition scope patterns – explain the function of conventional ignition system circuits and components ***Individual learner investigation:*** – investigation of conventional ignition system circuits and components
Prepare for and complete Assignment 1: Conventional Ignition Systems (P1, P2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the function and operation of a programmed ignition system, an ECU and ignition system sensors – explain the function of an ignition coil, the distributor, ignition switch and a reluctor disc in a programmed ignition system – explain the function and operation of a distributor less ignition system, including transformer, capacitor, ignition coils, sensors and switching modules ***Individual learner investigation:*** – investigation of programmed electronic ignition and distributor less ignition system circuits and components
Whole-class teaching: – explain the function and operation of a generator, including the Hall effect, inductive pick-up and optical pulse – explain the operation of a transistor, a Darlington pair and the advantages of breaker less systems – explain the function and applications of control modules ***Individual learner investigation:*** – investigation of pulse generators and control modules
Prepare for and complete Assignment 2: Programmed Electronic Ignition, Distributor less Ignition Systems and Pulse Generators (P3, P4, P5, P6, M1, D1)
Prepare for and complete Assignment 3: Control Modules (P7)
Whole-class teaching: – explain the safe working practices to be followed when testing an electronic ignition system – explain and demonstrate the use of test equipment – demonstrate methods of checking components and circuits for faults ***Practical workshop activities:*** – testing of electronic ignition system components and circuits for satisfactory operation
Prepare for and complete Assignment 4: Testing Electronic Ignition Systems (P8, M2, D2)
Feedback to learners, unit evaluation and close

Assessment

Assessment of this unit will normally be carried out through a combination of assignments, projects, and practical investigations. The unit can be linked to other units such as *Unit 5: Applications of Vehicle Science and Mathematics* and *Unit 6: Electrical and Electronic Principles for Vehicle Technology* and it would be appropriate, where possible, to combine assessment. Alternatively, this unit could be assessed using four assignments.

The first assignment could assess P1 and P2, with written tasks for each criterion. For P1 the use of diagrams is essential in the assessment process, and learners should explain both the function and operation of the main components of a typical conventional ignition system. This should include the type of circuit, contact breaker, coil, leads, distributor and cap and rotor arm. For P2, a simple description including the differences between the indicated elements could be assessed at the same time.

A second assignment could cover P3, P4, P5, P6 and M1. This could also provide an opportunity to direct learners to D1. Separate written tasks could be given for each criterion and learner responses are likely to be in the form of a report.

P7 could be assessed independently in a third assignment, or could be linked to the second assignment.

A final assignment covering P8, M2 and D2 could be assessed with the aid of task sheets that track authenticated, reliable and current practical activities on five components/circuits. The structure of this assignment is critical and tutors should ensure that learners have opportunities to diagnose faults (P8), suggest methods for dealing with faults (M2), and analyse test results on defects, wear and maladjustment (D2). The data and symptoms should be given to each learner. The evidence provided must include the test results involved and would typically incorporate printouts from test equipment. A witness statement/observation record would be a suitable form of evidence to show what the learner did and the equipment they used when carrying out tests.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2	Conventional Ignition Systems	A vehicle technician working on historic racing cars needs to report on the operation of a conventional ignition system	A written report supported by relevant diagrams
P3, P4, P5, P6, M1, D1	Programmed Electronic Ignition, Distributor less Ignition Systems and Pulse Generators	A technician needs to explain the function and operation of programmed and distributor less ignition systems and pulse generators to a new apprentice	A written report
P7	Control Modules	A vehicle technician needs to describe the use of control modules to a mature technician	A written report
P8, M2, D2	Testing Electronic Ignition Systems	A technician needs to carry out tests on ignition system components and circuits as part of professional development	Practical activities evidenced by record sheets and observation records.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Vehicle System and Fault Diagnosis and Rectification
		Electrical and Electronic Principles for Vehicle Technology

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit LV01: Carry out Routine Motor Vehicle Maintenance
- Unit LV06: Inspect Motor Vehicles
- Unit AE04: Diagnose and Rectify Motor Vehicle Engine Electrical Faults.

Essential resources

Learners will need access to vehicle workshops equipped with modern vehicles, rigs, components and appropriate test equipment.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bosch R — *Automotive Electrics/Automotive Electronics* (Professional Engineering Publishing, 2007) ISBN 9780470519370

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when verifying faults in an ignition system
Self-managers	organising time and resources and anticipating and managing risks when carrying out tests on electronic ignition system components/circuits

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work

Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	explaining the operation of electronic ignition systems and the function of their components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the operation of electronic ignition systems and the function of their components writing up results after testing for faults

Unit 11: Vehicle Engine Management Systems

Unit code: R/602/1951

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the operating principles and characteristics of engine management systems and will enable them to test and locate engine management system faults.

Unit introduction

Modern motor vehicles continue to make use of the rapid advances in electronics technology in a wide range of vehicle applications. This unit considers how electronics are used in engine management systems (EMS) and, in particular, the use of engine control units (ECU) which control different aspects of an engine's operation.

As a minimum, a simple ECU may just control the quantity of fuel injected into each cylinder during each engine cycle. However, advanced ECUs also control the ignition timing, variable valve timing, the level of boost maintained by a turbocharger and may also control a range of other engine system peripherals. Increasingly, the EMS also plays an important part in maintaining environmental controls, fuel economy and safety and in ensuring compliance with the various legislative requirements placed on modern engines.

This unit will enable learners to gain an understanding of the systems and operating principles of an engine management system. Learners will also consider the interaction between the engine management system and the functions and performance of a modern motor vehicle engine. They will also carry out a series of engine management system tests and will select and use equipment to carry out a diagnostic test to determine EMS faults.

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Learning outcomes

On completion of this unit a learner should:

1 Understand the operating principles and characteristics of an engine management system

2 Understand the operating principles of engine management system sensors and actuators

3 Understand the interrelationships and interaction of engine management systems and components

4 Be able to carry out tests on an engine management system to locate a system fault.

Unit content

1 **Understand the operating principles and characteristics of an engine management system**

Operating principles and characteristics: systems modelling eg diagrammatic representation of system input/process/output, characteristics of open and closed-loop system control strategies used in engine management systems; control systems eg analogue, digital, programmable, non-programmable; main elements of a digital processing system eg central processing unit (CPU), memory devices (such as volatile, non-volatile), buses, input/output ports; principal functions of a digital processing system eg multiplexing, controller area network (CAN) systems; characteristics eg purpose and applications of the system, operating conditions (conditions in which the system is operative or inoperative, 'fail-safe' features), system features (benefits, cost, performance, safety, convenience, efficiency)

Engine management systems: integration developments eg fuel, mechanical to full electronic; interaction between other vehicle systems eg sport mode on gearbox selection; fuel management (spark and combustion ignition) systems; ignition control and combined fuel/ignition control; emission control eg active to reactive such as use of lambda system and knock sensor control; vehicle performance monitoring eg throttle position, driver selection

2 **Understand the operating principles of engine management system sensors and actuators**

Operating principles of sensors: types eg Electromagnetic , Hall effect, photo-electric, resistive, inductive, piezo-electric element effect, capacitive; factors affecting performance and application eg sensitivity, accuracy, linearity and stability; influence of environmental factors eg heat, vibration, moisture, contaminants

Operating principles of actuators: eg ignition components such as coils, high tension (HT) components (individual coils, spark generators), fuel components (idle control valves, cold start devices, electronic injectors), variable valve timing control

3 **Understand the interrelationships and interaction of engine management systems and components**

Interfacing and signal processing: compatibility between components and systems eg temperature and speed sensors, throttle position/drive by wire actuators; characteristics of devices which give rise to the need for signal processing (inductive pick-ups, analogue to digital (AD) and digital to analogue (DA) conversion); control of output devices eg energy transfer, power output stages, buffer circuits

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Functional interrelationships: location eg units and components within the vehicle, position/location of components relative to others in the system; functional relationships between the elements of the system eg data input from sensors and electronic control unit (ECU) process to affect actuation; impact of a component's failure on other components within the system, the operation of the system and on external systems eg the effect of speed sensor failure, Lambda sensor fault

System interactions: eg integration fuel and emission control and/or vehicle performance control, achieved by common data sources and actuator responses

4 **Be able to carry out tests on an engine management system to locate a system fault**

Test components/circuits for satisfactory operation: test equipment eg on-board diagnostics, test instruments, voltage drop tester, ECU tester, spark advance and retard tester; safe working practice eg common rail fuel pressures, working with ECU, HT voltage; components and circuits eg fuses, wiring, connectors, injector, coil, ECU, pulse generator, sensors/transducers (such as crankshaft, camshaft, knock), actuators, pressure check (fuel pump), break out box; checking for faults eg moisture, dirt, corrosion, fault code reading, gap, data link connection, output and resistance, condition, ignition timing, sensor output, sensor operation

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the operating principles and characteristics associated with an engine management system	M1 compare the relative advantages and disadvantages of two different engine management systems	D1 justify the comparative benefits of dedicated diagnostic equipment and procedures employed with engine management systems
P2 explain the operating principles and application of three different types of engine management system sensor	M2 compare the performance of three engine management system sensors in terms of their sensitivity, accuracy, linearity and stability	D2 evaluate an engine management system diagnostic procedure and recommend possible improvements.
P3 explain the operating principles and application of three different types of engine management system actuator	M3 explain the benefits of an integrated control system on engine performance.	
P4 describe the interfacing and signal processing requirements of two engine management system components		
P5 explain the functional interrelationships and system interactions of engine management system units and components		

Table continues on next page

Assessment and grading criteria		
P6 explain the effect of different engine management functions during fuel, emission and performance control		
P7 use appropriate equipment to carry out tests on five different engine management system components/circuits to establish their serviceability [IE1, SM3]		
P8 carry out a diagnostic check to locate an engine management system fault [IE1, SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

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Essential guidance for tutors

Delivery

When delivering this unit tutors should focus on giving learners opportunities to explore the operating principles and characteristics of as wide a range of engine management systems and components as possible. Learners should be shown how to use block diagrams and should be encouraged to use them to represent system inputs/outputs and characteristics, and to break complex systems down into their sub-systems and components.

Videos, pictures and actual system components can be used to help explain the function and operation of sensors, actuators and circuits.

Block diagrams, circuit diagrams and simulation software can be used to give learners an appreciation of the digital principles used for engine systems. The conversion of circuit signals (ie AC to DC, DC to AC) should form an integral part of this explanation.

The use of 2D and 3D engine maps can help to explain the relevance of the different scales/comparisons used. Fault recording can be explained with fault codes and the use of dedicated equipment (for example scanner).

The operation of the engine management system can be demonstrated using engine rigs, appropriate vehicles or simulation equipment/software (for example signal interface unit).

When covering system integration, emphasis should be placed on the effect that other systems have on the engine management system. Although it is not expected that the operation of other associated systems (for example anti-lock braking systems) is covered in detail, it is advisable to cover how a speed sensor could be utilised across different systems.

The importance of working safely should be emphasised throughout the practical activities used for diagnosis and routine maintenance. Maintenance and diagnostic procedures will need to be undertaken on vehicles incorporating the relevant systems and should be completed to relevant standards.

Learners should be given opportunities to compare the characteristics of integrated systems with other designs (ie SI and CI). It may be advantageous to design investigative exercises around separate elements of the systems (for example investigating and comparing the characteristics and operation of various types of sensors for a particular application). Similarly, learners should have opportunities to compare associated diagnostic techniques and test equipment available for a particular system.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain and demonstrate use of systems modelling – explain the function of control systems and the main elements and functions of a digital processing system – explain the characteristics, purpose and applications of an engine management system – explain integration developments and interaction between other vehicle systems – explain fuel management systems, ignition and emission control and vehicle performance monitoring ***Individual learner activities:*** – investigation of operating principles and characteristics of engine management systems – use of block diagrams to represent systems and system inputs/outputs
Whole-class teaching: – explain the types, performance and application of engine management system sensors and transducers – explain the performance and application of engine management system actuators ***Practical workshop activities:*** – practical investigation of system sensors and actuators
Prepare for and complete Assignment 1: Engine Management Systems, Sensors and Actuators (P1, P2, P3, M1, M2)
Whole-class teaching: – explain the interfacing and compatibility of components and systems – explain principles of signal processing and characteristics of related components – identify the location of components and systems and describe their position in relation to each other – explain the relationships between the different parts of the system and describe how one component's failure can impact on other parts of the system – explain system interactions

Topic and suggested assignments/activities and/assessment
Group activities: investigation of digital principles and conversion of circuit signals in engine systems
Prepare for and complete Assignment 2: Interrelationships and Interaction of Engine Management Systems (P4, P5, P6, M3)
Whole-class teaching: – explain the safe working practices that need to be followed when testing engine management systems – demonstrate the use of equipment to test a range of components and circuits for satisfactory operation and to locate faults ***Practical workshop activities:*** – testing engine management systems to locate system faults
Prepare for and complete Assignment 3: Engine Management System Testing and Fault Location (P7, P8, D1, D2)
Feedback to learners, unit evaluation and close

Assessment

This unit could be assessed using three assignments and evidence is likely to be in the form of written work and tutor observation of practical work.

The first assignment could be designed to cover the requirements of P1, P2, P3, M1 and M2. Evidence should show that learners can explain both the operating principles and characteristics associated with an engine management system. The task should ensure inclusion of systems modelling, the control system used and their principle functions and characteristics. The evidence should also show that learners have understood the relevant aspects of the engine management system being considered. This should include integration developments, the interaction between other vehicle systems, fuel management systems, ignition control and combined fuel/ignition control, emission control and vehicle performance monitoring. The assessment task could also include a natural link to M1, by asking learners to consider two different engine management systems.

Learners could then consider relevant engine management system sensors to cover P2 (engine sensors/transducers such as engine temperature, speed and position) and actuators to cover P3 (such as idle control or ignition components). It would be natural to put the sensors/transducers (input) and actuators (output) within three different vehicle contexts (possibly across the two different engine management systems). Learner evidence should identify, for each specific application, the type of sensor/transducer being used (for example Electromagnetic, Hall-effect, photo-electric, resistive, inductive, piezo-electric element effect, capacitive), the factors that may affect its performance and application and the influence of environmental factors. It would be possible to generate evidence for P2 and P3 through a practical investigation of the outputs and inputs from sensors/transducers and actuators using scanner/oscilloscopes or other dedicated equipment. For the actuators, learners must show an understanding of the principles of how individual actuators operate, such as spark generation and idle control valve (for example, include how the electromagnetic effect is used to create linear movement). Learners should be given opportunities to link the work carried out for P2 with the requirements of M2.

A second assignment could be used to cover P4, P5, P6 and M3. This will need to include a task requiring learners to describe the interfacing and signal processing requirements of two engine management systems (P4) and explain the functional interrelationship and system interaction of one of these (P5). A separate task could then require learners to explain the effect of different engine management functions during fuel, emission and performance control (P6). Finally, a task to explain the benefits of an integrated control system on engine performance would cover M3.

The third assignment will require learners to carry out practical activities to cover P7 and P8. It would also provide the best opportunity to cover D1 and D2.

For P7, learners will need to use appropriate equipment to carry out tests on five different engine management system components/circuits to establish their serviceability. The evidence for this criterion should be gathered over time and collected together in a portfolio/report, including results of the tests, relevant descriptive work and tutor observation/oral questioning records. The evidence should include the results of tests on both components and circuits, and clearly identify which system(s) and components are affected and are serviceable.

The evidence for P8 may also be used for some (or all if appropriate) of the testing carried out for P7. Although this would be ideal in terms of integration, it would need to be managed carefully to ensure full coverage of both criteria. An additional task could be included to give learners an opportunity to work towards D1 and D2 during the testing/diagnostic activities. This should result in a separate written report including the justification and evaluation required by these two criteria.

It is expected that all the tests and procedures are completed to relevant standards and within health and safety guidelines.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1, M2	Engine Management Systems, Sensors and Actuators	A vehicle technician has been asked to explain the characteristics and operation of an engine management system and its sensors and actuators to a new apprentice	A written report

Criteria covered	Assignment title	Scenario	Assessment method
P4, P5, P6, M3	Interrelationships and Interaction of Engine Management Systems	A vehicle technician has been asked to explain the interrelationships and interaction of engine management systems and components to a new apprentice	A written report
P7, P8, D1, D2	Engine Management System Testing and Fault Location	A vehicle technician needs to locate an engine management system fault to aid work-based development	A practical assignment evidenced through learners' portfolio and tutor observation records

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Function and Operation of Petrol Injection Systems
		Electrical and Electronic Principles for Vehicle Technology

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- LV01: Carry Out Routine Motor Vehicle Maintenance
- LV02: Remove and Replace Motor Engine Units and Components
- LV07: Diagnose and Rectify Motor Vehicle Engine and Component Faults.

Essential resources

A range of components, vehicles, diagnostic equipment and software will be required for delivery of this unit. This will need to include manufacturer/vehicle specific maintenance and test equipment and non-specific equipment such as measuring instruments, meters and pressure gauges. A variety of data sources will also be required for the vehicles, systems and procedures used.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bonnick, A — *Automotive Computer Controlled Systems* (Butterworth-Heinemann, 2001) ISBN 9780750650892

Bonnick, A — *Vehicle Electronic Systems and Fault Diagnosis* (Butterworth-Heinemann, 1998) ISBN 9780340706305

Denton, T — *Advanced Automotive Fault Diagnosis* (Butterworth-Heinemann, 2006) ISBN 9780750669917

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when carrying out tests and checks on engine management systems
Self-managers	organising time and resources and prioritising actions when carrying out tests and checks on engine management systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others to work towards common goals when working in small groups

Functional Skills — Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and selecting information about engine management operating systems and principles
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining engine management operating systems and principles

Unit 12: Operation and Maintenance of Light Vehicle Transmission Systems

Unit code: H/503/8212

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this is to provide learners with an understanding of the construction and operating principles of light vehicle transmission systems and will enable them to inspect and maintain these systems.

Unit introduction

This unit covers the conventional aspects of light vehicle transmission systems, their function, principal components and operating principles. This will include a detailed examination of the three major systems — a vehicle's clutch mechanism, gearbox and the driveline and final drive systems.

Learners will be introduced to the most recent developments in the use of electronics for the control and operation of transmissions systems in both standard production vehicles and motorsport applications. These developments are now frequently integrated into the overall electronic management of the vehicle and can provide significant improvements in terms of driveability, economy and performance. Learners will appreciate the fundamental operating principles of these developments, their integration within transmission systems and their significance in the maintenance of a vehicle's transmission system.

Finally, learners will carry out specific tests and checks to identify transmission system faults such as clutch slip, gearbox linkage problems and failing constant velocity joints. Learners will use these tests and checks, together with on-board diagnostic equipment, to maintain a vehicle's transmission system. This will include the maintenance requirements relating to driver/passenger safety and component reliability.

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Learning outcomes

On completion of this unit a learner should:

1. Understand the operation of a vehicle clutch mechanism and the function of its principal components
2. Understand the operation of a vehicle gearbox and the function of its principal components
3. Understand the operation of a vehicle driveline system and final drive and the function of its principal components
4. Be able to maintain a vehicle's transmission system.

Unit content

1 **Understand the operation of a vehicle clutch mechanism and the function of its principal components**

Principal clutch components: pressure plate, disc, flywheel (including bearings and bushes); release bearings; release systems eg production vehicles (hydraulic, mechanical and cable), motorsport vehicles (push/pull and electro-hydraulic actuating mechanisms)

Types of clutch mechanisms: eg production clutches (coil and diaphragm spring, single plate, wet and dry types), automatic clutches (torque converter, fluid flywheel, one way clutch), motorsport clutches (paddle, slipper and multi-plate)

Operating principles of clutch: constructional design and use of materials (linings, drive plates and friction surfaces, springs); engagement and disengagement of clutch (single and multiplate, one way clutches and automatic clutches); provision for adjustment/self-adjustment; torque calculations and coefficient of friction; power flow; common faults eg wear, misalignment; fault symptoms (slip, drag, judder, overheating); fluid flywheels

2 **Understand the operation of a vehicle gearbox and the function of its principal components**

Principal gearbox components: gear design (spur and helical); bearings, shafts, casing, selector and sealing arrangements; gear locking and interlock mechanisms; gear speed synchronisation and engagement mechanisms eg sliding mesh, synchromesh and dog type

Types of gearboxes: eg manual (single stage, double stage, sliding mesh, constant mesh), automatic (epicyclic gear train, hydraulic control systems); layout eg transverse, longitudinal and transaxle

Operating principles of gearbox: manual gearbox - gear ratios, power flow eg constant mesh single and double stage; torque and speed calculations; gear ratio characteristics and number of available gears; selection and engagement methods eg synchromesh and dog type, selector forks, interlocks and linkages, remote control mechanisms, motorsport (sequential, electro-hydraulic); automatic gearbox - torque converters (lock-up mechanism); epicyclic gear trains (simple and compound); brake bands; multi-plate and unidirectional clutches; power flow paths; function of key hydraulic components (pump, governor, actuators, servos, regulator and shift valves); electronic control system including mode selection; electronic selection of conventional gear arrangements; lubrication eg method (splash and pump assisted); oil requirements and types (mineral, synthetic); seals and sealing arrangements (static and dynamic types)

3 Understand the operation of a vehicle driveline system and final drive and the function of its principal components

Principal components of driveline system: propeller shaft arrangement eg single, divided; driveline arrangements eg front, rear and four wheel; universal joints eg Hooke type and rubber; constant velocity joints, sliding joints; drive systems eg two-wheel, four-wheel (transfer box, centre differentials, viscous couplings, differential locks, automatic and manual)

Principal components of final drive: axle types and support arrangements eg transaxles, live and independent; final drives eg bevel, spiral and hypoid; differentials eg sun and planetary gears, crown wheel and pinion, limited slip systems; axle types eg semi, three quarter and fully floating; bearings

Operating principles of driveline: universal joints (Hooke type and rubber); constant velocity joints (angular limitations and conditions required to achieve constant velocity, basic consideration of balance requirements, alignment and torque capacity of hollow and solid shafts); suspension and transmission characteristics giving rise to the requirement for sliding joints and centre propshaft bearings

Operating principles of final drive: gear ratio, speed reduction and torque multiplication in the final drive; final drive arrangements for transaxles; driving thrust and torque reaction; differential (effects on torque/speed at the driven wheels, limited-slip differentials); lubrication methods (final drive and rear axles); oil requirements and types (mineral, synthetic); oil seals and sealing arrangements (static and dynamic)

4 Be able to maintain a vehicle's transmission system

Transmission system faults: eg clutch (slip, drag, judder, loss of drive, excessive noise, wear, misalignment, operating mechanism faults), gearbox (gear selection, oil leaks, linkages and fittings), driveline and finals drives (prop/drive shafts, universal and CV joints, bearings, gaiters and seals), use of on-board diagnostic (OBD) equipment, reporting methods (inspection records, oral report to supervisor)

Maintenance operations: working to manufacturers' maintenance and service procedures eg manuals, job cards, direct supervision; maintenance operations eg clutch adjustments/alignment, gearbox oil change, gear selection linkage repair, driveshaft gaiter condition check/replacement, security of mountings and fittings; context of the maintenance operations eg routine maintenance, repair or adjustment due to a system failure, alternative service procedures for adverse condition (vehicles operating in dry, dusty environments, race/rally vehicles and vehicles working in extreme temperature environments)

Critical safety considerations: procedures relating to maintenance operations carried out eg materials handling (protection against dust, oil and chemical exposure), vehicle and system protection (application of four-wheel drive diff locks, lifting and supporting vehicles), personal protective equipment (PPE), Control of Substances Hazardous to Health (COSHH) Regulations, component and environmental waste disposal.

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the function of the principal components of two different types of clutch mechanism	M1 compare two different vehicle clutch types in terms of their principal components and operating principles	D1 justify the use of a specific clutch type for two different vehicle applications in terms of purpose, function and performance
P2 explain the operating principles of one type of clutch	M2 explain the advantages and disadvantages of increasing the number of available gears in a gearbox	D2 justify the use of a specific type of driveline and final drive arrangement for two different vehicle applications in terms of purpose, function and performance.
P3 describe the function of the principal components of one type of gearbox	M3 compare two different vehicle driveline and final drive arrangements.	
P4 explain the operating principles of two different types of vehicle gearbox		
P5 describe the function of the principal components in a vehicle driveline and final drive		

Table continues on next page

Assessment and grading criteria		
P6 explain the operating principles of a vehicle's driveline and final drive arrangement		
P7 inspect a vehicle's transmission system [SM3, SM4]		
P8 report faults and attribute symptoms to the faults identified [SM3, SM4]		
P9 carry out a maintenance operation on a vehicle's transmission system [SM3, SM4]		
P10 follow relevant safety procedures when inspecting and maintaining a vehicle's transmission system [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered in the context of learners' chosen areas (for example light vehicle, motorsport), although a generic approach is also suitable. The term 'maintenance' in this unit is used in a generic way and can be taken to mean either routine maintenance (a regular service) or less routine work (a repair due to a component failure or adjustment to correct a misalignment).

Delivery of this unit would ideally include a balance of theoretical and practical study. Whatever approach is taken, learners' experience should be sufficiently varied to give them the knowledge and skills needed to perform routine motor vehicle workshop operations. In addition, learners need to develop the skills and understanding to diagnose transmission system faults in an industrial setting. Health and safety should be emphasised when learners are undertaking practical activities.

The learning outcomes could be delivered in the order in which they are listed. In this way, learners will begin to understand the function and operating principles of the relevant parts of the power train from the clutch to the gearbox and through the driveline to the final drive.

Learners should be introduced to the range of clutches – production, automatic and motorsport variations. However, centres may wish to focus on a specific clutch type to meet local needs and cover the others in a more general way. The approach taken with clutches could be replicated with gearboxes, the driveline and final drive. However, tutors should ensure that learners gain sufficient understanding of all types and delivery should not be limited to the one or two required to meet the assessment criteria.

For the final learning outcome learners will need access to vehicles and workshop facilities. The delivery of this part of the unit could consist of lectures to introduce the transmission system and likely faults, learner-led research into the maintenance requirements followed by practical application on vehicles in the workshop. Again, learners should experience a range of routine maintenance operations in line with those suggested in the unit content.

During practical work, the critical safety aspects of each operation need to be emphasised. Learners should be encouraged to recognise and explain these aspects of safety during their practical workshop activities to reinforce the importance to themselves and others.

The use of a record of the practical work carried out should be standard practice. This is likely to be in the form of a workshop logbook. This will enable learners to capture and reflect on their experience and will provide support and guidance during the activities chosen for the final assessment.

Note that the use of 'eg' in the content is to give an indication and an illustration of the breadth and depth of the area of topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the function of the principal clutch components – explain the construction, layout and differences between production clutches, automatic clutches and motorsport clutches – explain the operating principles of a vehicle clutch mechanism and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of clutch components
Prepare for and complete Assignment 1: Vehicle Clutch Operation (P1, P2, M1, D1)
Whole-class teaching: – explain the function of the principal gearbox components – explain the construction, layout and differences between types of gearbox – explain the operating principles of a vehicle gearbox and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of gearboxes and gearbox components
Prepare for and complete Assignment 2: Vehicle Gearbox Operation (P3, P4, M2)
Whole-class teaching: – explain the function of the principal driveline and final drive components – explain the operating principles of a vehicle driveline and final drive and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of gearbox components
Prepare for and complete Assignment 3: Vehicle Driveline and Final Drive Operation (P5, P6, M3, D2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the health and safety considerations that must be taken into account when carrying out maintenance on a vehicle transmission system ***Practical workshop activities:*** – tutor-led inspection and maintenance of vehicle transmission systems
Prepare for and complete Assignment 4: Maintaining Vehicle Transmission Systems (P7, P8, P9, P10)
Feedback to learners, unit evaluation and close

Assessment

This unit provides opportunities for assessment evidence to be generated from a combination of assignments, projects and practical work. Although most of the pass criteria require descriptive evidence it is not expected that tutors only use tests to achieve this. The unit lends itself to an investigative, practical approach and this should be reflected in the assessment strategy wherever possible. The range of evidence presented could include notes, diagrams, investigative test data and the records of the maintenance and diagnostic procedures carried out.

To achieve a pass, learners will need to describe the function of the principal components of two types of clutch mechanism (P1), one gearbox (P3) and a vehicle's driveline and final drive (P5). In addition, learners need to explain the operating principles of one of the clutches (P2), two types of gearbox (P4) and one vehicle's driveline and final drive arrangement (P6). The unit content for each of these areas provides a range of choices through the examples listed. For clutches, this includes production, automatic and motorsport, and within these groupings there are further examples. Tutors are expected to cover as wide a range of these as possible during delivery but need only select one or two of these, as indicated by the criteria, for assessment purposes. This will enable tutors to concentrate on a specific specialisation as the main focus of assessment (for example motorsport paddle clutch).

Where a criterion requires learners to consider two types this is to ensure that coverage is sufficiently varied so as not to limit learners' employment potential. For example, whilst a centre may specialise in motorsport it is important that learners are equally aware of a production vehicle's clutch or vice-versa. The range of choices available could mean that each learner could be considering the function of the principle components for a different type of vehicle and clutch. This can be beneficial when considering the authenticity of learner evidence.

At pass level, learners should also be able to inspect a vehicle's transmission system (P7), identify and report faults aligned to the symptoms that are attributed to the findings (P8), and carry out a routine maintenance operation (P9) whilst following relevant safety procedures (P10). P7, P8, P9 and P10 would be best assessed through investigation and practical examination of a live vehicle layout and configuration. P10 should be an integral part of the assessment for P7 and P9.

A suitable transmission system fault may need to be simulated for P7 and P8 and learners given the typical symptoms of the fault, as would be reported by a driver of the faulty vehicle. Assessment is likely to consist of a written inspection record completed by learners at the time of the inspection, a verbal report back to the supervisor/customer (tutor record of oral questioning/observation) and tutor observation of the process (for example use of logical and efficient diagnostic techniques, safe working).

The main assessment evidence for P9 would be the final product - the completed maintenance task. However, tutor observation will also be necessary to cover the process aspects of the task (for example working to the manufacturer's procedures, correct and safe working). The final link is with P10 and the safety procedures relating to the maintenance operation being carried out. For example, tutors will need to observe learners handling materials correctly, using relevant system protection, using appropriate PPE, working to COSHH regulations and correctly disposing of waste, as required by the task being undertaken.

To achieve a merit, learners need to compare the constructional differences of two different clutch types (for example production diaphragm spring versus motorsport paddle or production wet versus production dry types). The two clutches could be the same as those considered for P1, or if tutors wish to encourage learners to have wider experience then one or two completely different clutches could be used. The focus of the comparison should be based on the understanding developed through P1 and P2. Learners must also explain the advantages and disadvantages of multiple gear ratio applications (for example 3 speed versus 4 speed, 5 speed versus 6 speed). Finally, they need to compare two different vehicle driveline and final drive arrangements (for example longitudinal, in line versus transverse or rear engine, rear wheel drive versus rear engine four wheel-drive). Again, one of these could be the driveline and final drive considered for P5 and P6.

To achieve a distinction, learners need to justify the use of two different clutch types and two different types of driveline and final drive arrangements for differing applications (for example production, fast road, motorsport track, motorsport rally), in terms of purpose, function and performance. Once again, these could be the same clutches, driveline and final drives that learners have been working with through the pass and merit criteria.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Vehicle Clutch Operation	A vehicle technician has been asked to explain the operation of a vehicle clutch to a new apprentice	A written task under controlled conditions or oral questioning

Criteria covered	Assignment title	Scenario	Assessment method
P3, P4, M2	Vehicle Gearbox Operation	A vehicle technician has been asked to explain the operation of a vehicle gearbox to a new apprentice	A written task under controlled conditions or oral questioning
P5, P6, M3, D2	Vehicle Driveline and Final Drive Operation	A vehicle technician has been asked to explain the operation of a vehicle driveline and final drive a new apprentice	A written task under controlled conditions or oral questioning
P7, P8, P9, P10	Maintaining Vehicle Transmission Systems	A vehicle technician has to safely inspect, diagnose and repair a transmission system	A practical maintenance task supported by observation records and a written inspection record

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Systems
		Vehicle System Fault Diagnosis and Rectification

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit LV12: Remove and Replace Motor Vehicle Driveline Units and Components
- Unit LV13: Diagnose and Rectify Motor Vehicle Transmission and Driveline System Faults.

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Essential resources

Learners will need access to a range of transmission types (clutches, gearboxes and driveline/final drives) and their components. A variety of information and data sources specific to the transmission systems will also be required. The necessary special tools and equipment will be needed for investigation and routine maintenance of the selected transmission systems as defined in the unit content and grading criteria.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Denton T — *Advanced Automotive Fault Diagnosis* (Butterworth-Heinemann, 2006) ISBN 9780750669917

Heisler H — *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002) ISBN 0750651318

Hillier V and Coombes, P — *Hillier's Fundamentals of Motor Vehicle Technology: 6th Edition Book 1* (Nelson Thornes, 2010) ISBN 9780748780822

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Self-managers	organising time and resources and prioritising actions when inspecting and carrying out maintenance on vehicle transmission systems anticipating and managing risks relating to the inspection and maintenance of a vehicle's transmission system

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to vehicle transmission systems
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others when carrying out inspection and maintenance of vehicle transmission systems

Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	searching for information on specific vehicle transmission systems
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	preparing and presenting technical reports on the various aspects of vehicle transmission systems and their components and arrangements completing maintenance documents and records
Present information in ways that are fit for purpose and audience	presenting technical reports on the various aspects of vehicle transmission systems and their components and arrangements
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting materials and researching information on vehicle transmission systems (eg safety, maintenance and diagnostic data)
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the operating principles of vehicle clutches, gearboxes, drivelines and final drives.

Unit 13: Vehicle Electronic Ancillary and Information Systems

Unit code: D/503/1419

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of vehicle electronic ancillary and information systems and will enable them to inspect these systems to confirm system operation and integrity.

Unit introduction

Significant technological developments within the motor vehicle industry have resulted in modern vehicles being equipped with a vast array of additional ancillary and information systems. From anti-lock braking systems (ABS) and stability control, to condition monitoring computers and satellite navigation and information, these systems contribute to the overall safety and comfort of the vehicle's occupants.

Through practical investigation, learners will gain an understanding of the function of these systems and their key components. The unit will also focus on how ancillary and information systems interrelate with each other and how they interact with a vehicle's driver or passengers.

Learners will carry out inspections on different vehicle ancillary and information systems to confirm their correct operation and system integrity.

Learning outcomes

On completion of this unit a learner should:

1 Understand the operating principles and characteristics of vehicle electronic ancillary and information systems

2 Know about the function of key units and components of vehicle electronic ancillary and information systems

3 Know the interrelationships and interaction of vehicle electronic ancillary and information systems

4 Be able to inspect vehicle electronic ancillary and information systems.

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Unit content

1 **Understand the operating principles and characteristics of vehicle electronic ancillary and information systems**

Systems model: use of systems model (input – process – output); characteristics of control strategies employed eg open-loop, closed-loop

Operating principles and characteristics: control systems eg analogue, digital, programmable, non-programmable; main elements of a digital processing system and principal functions eg central processing unit (CPU), memory devices (such as volatile, non-volatile), buses, input/output ports, multiplexing, controller area network (CAN) systems; characteristics eg purpose and applications of the system, operating conditions (such as conditions in which the system is operative or inoperative, 'fail-safe' features), system evaluation to identify benefits, comparative cost, performance, safety, convenience, efficiency

Vehicle electronic ancillary and information systems: electronic ancillary systems eg anti-lock braking systems (ABS), vehicle stability control systems, security and alarm systems, central body electronic systems (such as seat positioning, seatbelt tensioning, secondary restraint systems, cargo/cabin compartment climate control); information systems eg driver information (condition monitoring and trip computers), navigation – global positioning system (GPS), communication systems, entertainment systems, proximity (reversing) sensors and road positioning

Operating principles of sensors and actuators: transducers used in vehicle ancillary and information systems eg electromagnetic, Hall-effect, photoelectric, resistive, inductive, capacitive; factors affecting performance and application eg sensitivity, accuracy, linearity and stability; influence of environmental factors eg heat, vibration, moisture, contaminants

2 **Know about the function of key units and components of vehicle electronic ancillary and information systems**

Key units and components of vehicle ancillary systems: input data eg temperature, speed, position; process data eg mapping to input; output data eg electronic/mechanical actuation; key units and components eg sensors (temperature, speed, position), processors (ABS, electronic climate control unit), actuators (switches, inductive, capacitive, direct current (DC) motors, stepper motors when used for throttle poisoning or ventilation control), solenoids when used on ABS, air conditioning or for multi-position; legal considerations eg modifications to vehicle specification that may affect sensor/system performance (fitment of larger wheels/tyres effect on speedometer accuracy, fitment of passenger airbag isolation switches)

Key units and components of vehicle information systems: input data eg temperature, speed, position, levels, electrical values; process data; visual output eg lights, display screen, gauges; audible output eg buzzer, speaker; key units and components eg sensors (temperature, fluid level, speed, GPS); processors eg satellite navigation, on-board diagnostics when used as comfort computing; output units eg display screen, speakers, buzzers, gauges, lights; legal considerations eg fitment of radar detectors

3 Know the interrelationships and interaction of vehicle electronic ancillary and information systems

Interfacing and signal processing: compatibility between components and systems; characteristics of devices which give rise to the need for signal processing (inductive pick-ups, analogue to digital (AD), digital to analogue (DA)); control of output devices eg energy transfer, power output stages, buffer circuits

Representational methods: diagrams eg circuit, flow, block, systems; circuit type eg electrical, electronic, hydraulic, pneumatic; connections

Functional interrelationships: location eg units and components within the vehicle, position/location of components relative to others in the system; functional relationships between the elements of the system; effects eg failures on other components within the system, the operation of the system and on external systems (such as effect of speed sensor failure)

System interaction: ways in which the system under consideration interacts with other vehicle systems and functions eg integration of anti-lock braking and stability control (anti-skid), systems, stability control system obtains information from the steering system, ABS system components interacts with the braking and engine control systems

Driver/passenger interaction: driver/passenger influence on the operation and characteristics of the system (such as seat pad recognition); effects of the system on the driver’s/passengers’ behaviour, comfort and safety (such as temperature effect on stress levels)

Vehicle interaction: ways in which the system affects the vehicle in relation to other vehicles eg proximity detection; external factors influencing the operation/function of the system eg satellite navigation, ground positioning systems

4 Be able to inspect vehicle electronic ancillary and information systems

Inspections: location of systems and key components; means of identification; testing and diagnostic procedures as appropriate to the system under consideration

Safety: relating to the operation, inspection, maintenance and testing of the system

Practical confirmation of system operation and characteristics: observation of the system in operation; examination of system responses to external conditions as appropriate to the system under consideration

Testing considerations: factors affecting performance/reliability and application eg sensitivity, accuracy, linearity and stability; influence of environmental factors eg heat, vibration, moisture, contaminants

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 with the aid of a systems model, explain the operating principles and characteristics associated with the vehicle electronic ancillary and information systems	M1 explain how the malfunction of key units and components can influence the operation of a vehicle electronic ancillary and information system	D1 compare two different sensors, with respect to position and environment control
P2 describe the operating principles of sensors and actuators	M2 describe the benefits of the interaction of vehicle ancillary and information systems for a chosen application.	D2 analyse characteristics of two vehicle electronic ancillary and information systems in terms of function, performance, safety and cost.
P3 describe the function of the key units and components of two vehicle ancillary systems		
P4 describe the function of the key units and components of two vehicle information systems		
P5 describe interfacing and signal processing in ancillary and information systems		

Assessment and grading criteria		
P6 use representational methods to help describe the functional interrelationship and interaction between systems		
P7 describe driver/passenger and vehicle interactions for one ancillary and one information system		
P8 safely inspect an electronic ancillary system to confirm system operation and integrity [SM3, SM4]		
P9 safely inspect an information system to confirm system operation and integrity [SM3, SM4]		
P10 identify the testing considerations to make when carrying out a practical investigation into inspecting vehicle electronic ancillary and information systems.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

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Essential guidance for tutors

Delivery

Delivery of this unit should be designed to give learners an understanding of the operating principles and characteristics of vehicle electronic ancillary and information systems. They should then progress on to a representative selection of the electronic ancillary and information systems found in current vehicles.

Detailed investigation (including function/operation at component level) is likely to only be possible for a limited number of systems (for example ABS, central body systems). For more complex systems a 'black-box' approach (with the emphasis on functions) will be more appropriate (for example GPS navigation systems).

A balance of theoretical study and practical investigation is likely to give learners maximum opportunity to understand systems of this complexity. Video materials, simulations and rigs will be effective aids to learning, since 'live' demonstrations of the operation of some of the systems (for example vehicle stability control) could be impractical. Practical investigation should reflect industry processes and procedures and should be linked to other units wherever possible.

The learning outcomes are ordered in a logical way and could therefore be delivered sequentially. Learning outcome 4 requires practical investigation and learners will need the underpinning knowledge and understanding obtained through studying learning outcomes 1, 2 and 3 before carrying out any practical activities.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the use of a systems model and the characteristics of control strategies used – explain the operation and characteristics of sensors and actuators – explain and demonstrate the operation and characteristics associated with key ancillary and information systems ***Individual learner activities:*** – investigation of the operation of vehicle electronic ancillary systems, information systems, sensors and actuators

Whole-class teaching: – explain the function of ancillary system key units and components including the possible legal implications of making modifications to the vehicle – explain the function of information system key units and components including the possible legal implications of making modifications to the vehicle ***Individual learner activities:*** – investigation of system components
Prepare for and carry out Assignment 1: Function and Operation of Ancillary and Information Systems and Components (P1, P2, P3, P4, M1 (in part), D1)
Whole-class teaching: – explain interfacing and signal processing including compatibility between systems and the control of output devices – demonstrate use of representational methods to describe functional relationships and interaction between units, components and systems – explain interaction between driver and vehicle ***Individual learner activities:*** – investigation of the interrelationships and interaction of vehicle electronic ancillary and information systems
Whole-class teaching: – explain the safety requirements linked to the inspection, testing and maintenance of electronic ancillary and information systems – explain and demonstrate identifying and testing vehicle electronic ancillary and information systems – explain and demonstrate observation and examination of systems to confirm operation – explain the factors that need to be considered when testing systems
Prepare for and carry out Assignment 2: Interrelationship and Interaction of Ancillary and Information System Components (P5, P6, P7, M1 (in part), M2, D2)
Prepare for and complete Assignment 3: Inspecting and Testing Electronic Ancillary and Information Systems (P8, P9, P10)
Feedback to learners, unit evaluation and close

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Assessment

This unit could be assessed using three assignments.

The first assignment could cover P1, P2, P3, the ancillary part of M1 and D1. Learners will need to generate evidence of using a systems model to explain the operating principles and characteristics (P1) and describe the function of two ancillary systems (P3). Learners will also need to describe the operating principles of sensors and actuators (P2) relating to the two identified ancillary systems, comparing different sensors in respect of position and environment (D1). This could be combined with a task for attaining the part of M1 explaining ancillary system malfunction. All evidence for this first assignment is likely to be in written form and may include diagrams and sketches.

The second assignment could cover P4, P5, P6 and P7. Learners would need to describe the function of key units and components of two vehicle information systems (P4). To meet P5 the description of interfacing and signal processing should include compatibility, inductive pick-ups, processing, and the control of output devices. The inclusion of an appropriate circuit diagram for each system would meet P6 and would need to include the description of the functional interrelationship and interaction of systems.

Learners could then be asked to describe driver/passenger and vehicle interactions (P7). Further tasks could be set to extend to the information system element of M1, M2 and D2.

The third assignment will need to be based on practical sessions, with learners carrying out inspections on both ancillary (P8) and information systems (P9) to industry standards. A written task could ask learners to identify testing considerations for both types of system (P10).

Evidence should include notes, diagrams, test data, and records of the maintenance and diagnostic procedures carried out. Witness statements/ observation records, supplemented by annotated photographs, could also form part of the evidence for these practical elements.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1 (in part), D1	Function and Operation of Ancillary and Information Systems and Components	A technician needs to investigate vehicle ancillary systems, sensors and actuators prior to system testing	A written report
P5, P6, P7, M1 (in part), M2, D2	Interrelationship and Interaction of Ancillary and Information System Components	A technician needs to investigate the vehicle information systems, system interfacing and signal processing and the interaction between systems	A written report

Criteria covered	Assignment title	Scenario	Assessment method
P8, P9, P10	Inspecting and Testing Electronic Ancillary and Information Systems	A technician needs to inspect vehicle electronic ancillary and information systems to confirm their operation	A practical assignment evidenced through learners' portfolio and tutor observation records

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Chassis Systems
		Electrical and Electronic Principles for Vehicle Technology

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit AE06: Diagnose and Rectify Motor Electrical Unit and Component Faults
- Unit LV06: Inspect Motor Vehicles.

Essential resources

A range of components, vehicles and equipment will be required for practical investigation, along with an accompanying variety of data sources.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Denton Tom — *Automobile Electrical and Electronic Systems* (Butterworth-Heinemann, 2004) ISBN 0750662190

Hillier V — *Hillier's Fundamentals of Automotive Electronics* Book 2, 6th Edition (Nelson Thornes, 2012) ISBN 9781408515372

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve analysing and evaluating information relating to legal considerations, judging its relevance and value
Self-managers	organising time and resources and prioritising actions when carrying out inspections on vehicle ancillary and information systems anticipating, taking and managing risks when carrying out inspections on vehicle ancillary and information systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others when working in groups to inspect ancillary and information systems

Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and explaining the function and operation of vehicle electronic ancillary and information systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching vehicle electronic ancillary and information systems and related legal considerations
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	using a systems model to help explain the operating principles and characteristics associated with vehicle electronic ancillary and information systems explaining the operating principles of sensors and actuators describing the function of key units and components of vehicle ancillary and information systems, including legal considerations using representational methods to help describe the functional interrelationship and interaction between systems

Unit 14: Light Vehicle Suspension, Steering and Braking Systems

Unit code: J/503/1415

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to give learners knowledge of the operating principles of light vehicle suspension, steering and braking systems, enabling them to carry out fault-finding on these systems.

Unit introduction

Advances in engine and transmission design mean that modern vehicles have an increased need for suspension, steering and braking technology that can cope with the forces associated with modern vehicle performance.

Some suspension systems have different modes for the driver to select according to personal demands or those of the terrain. The most sophisticated suspension systems can self-level, have yaw control and adjust to the type of terrain being encountered.

Steering systems are now mostly power-assisted, in some cases to counter the effects of wider tyres and suspension that have been set to enhance the vehicle's road holding. Most tyres are now low profile in order to ensure that performance, control and stability are maximised.

Sports vehicles, family saloons, multi-purpose vehicles, off-road vehicles, passenger service vehicles and haulage vehicles all require different things from these systems in order to perform well in the environment for which they are intended. It is vital that these systems interrelate with, and complement, each other to ensure maximum comfort and safety of the driver and passengers.

This unit will develop learners' knowledge of the function and operation of the main suspension, steering and braking system components and their relationship to the efficient operation of the vehicle. Learners will then carry out a range of practical inspection and fault-finding techniques on these systems.

Learning outcomes

On completion of this unit a learner should:

1 Know the function and operation of different types of suspension system

2 Know the function and operation of steering system components

3 Know the function and operation of braking system components

4 Be able to carry out fault-finding procedures on steering, braking and suspension systems.

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Unit content

1 Know the function and operation of different types of suspension system

Suspension systems: types of independent front suspension eg unequal length wishbones, transverse link and strut; types of independent rear suspension eg trailing arm, pure and semi, unequal transverse links, transverse link and strut, air suspension; dampers (construction, operation and typical faults); suspension requirements eg sprung weight, unsprung weight; impact of chassis design on suspension type eg ladder, monocoque, space frame, welded shell constructions

Adaptive suspension system main components: Electronic Control Unit (ECU); regulator; solenoid valve; sensors; dampers; system operation

2 Know the function and operation of steering system components

Power-assisted steering main components: hydraulic pump; control valve; power cylinder; reservoir; filter; pressure relief valve; pipes; steering gear; types eg integral, semi-integral, rack and pinion, worm and follower, speed sensitive

Steering characteristics: understeer; oversteer; neutral steer; roll axis; roll centre; centre of gravity

Road wheels: wheel type eg alloy (cast or forged), steel, well based, specialist (such as wire spoke, flat-edge, double hump, divided, detachable flange); rim codes; wheel retention methods

Tyres: types eg belt and brace construction, ply construction; tyre profile and tyre markings eg width, aspect ratio, type of construction, load index, speed index, ply ratings, direction indicators; applications eg high performance, light/heavy vehicles, motorcycle, agriculture, industrial; valve types

3 Know the function and operation of braking system components

Main components: types of system eg single piston disc brakes, multi-piston disc brakes; brake fluid characteristics; brake bleeding componentry; brake pad warning systems; types of brake circuits (construction and operation) eg tandem master cylinders, vacuum servo units, pressure apportioning valves

Anti-lock braking system (ABS) components: wheel speed sensors; ECU; system modulator; reservoir; electronic control system

4 Be able to carry out fault-finding procedures on steering, braking and suspension systems

Fault-finding: identification of typical faults and corrective action to be taken for each system; adjustment and servicing of the main components for each of the systems; protection of units against the usual hazards during use or fault-finding; safe working practice

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the function and operation of two independent front and two independent rear vehicle suspension systems, including suspension requirements and the impact of chassis design	M1 compare the relative advantages and disadvantages of an adaptive suspension system and one other type of suspension system	D1 evaluate two different braking system applications for efficiency and safety when used in conjunction with an anti-lock braking system.
P2 describe the function and operation of the main components of an adaptive suspension system	M2 explain the effect of understeer, oversteer and neutral steering characteristics, vehicle roll axis, roll centre and centre of gravity on wheel/tyre function and operation.	
P3 describe the function and operation of the main components of power assisted steering		
P4 distinguish the range of steering characteristics		
P5 describe the functional differences between two different wheel and tyre combinations		

Assessment and grading criteria		
P6 describe the function and operation of the components found in a given type of braking system		
P7 describe the function and operation of the components found in an anti-lock braking system		
P8 carry out fault-finding on a suspension system to check for satisfactory operation [IE1, SM3, SM4]		
P9 carry out fault-finding on a steering system to check for satisfactory operation [IE1, SM3, SM4]		
P10 carry out fault-finding on a braking system to check for satisfactory operation [IE1, SM3, SM4]		
P11 state the corrective action to be taken for each of the faults found.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit should ensure that learners have a thorough understanding of steering, suspension and braking system components and their interrelationship with each other.

Wherever possible, learners should carry out practical investigations of components, and a balance of theoretical and practical study is recommended. Systems and operating principles should be demonstrated using rigs, units and components. Safe working practices should be emphasised during any practical activities. Learners should have access to appropriate information sources (for example manufacturer's manuals and data books, CD ROM-based technical data, online sources) and tools and equipment.

There is no defined order of delivery but it is recommended that learning outcomes 1, 2 and 3 are delivered before learning outcome 4, as learners need to apply knowledge gained within the first three learning outcomes when carrying out the practical activities for learning outcome 4.

While a detailed understanding of the main types of suspension systems is required for learning outcome 1, emphasis should be placed on the adaptive system and its main components.

Similarly for learning outcome 2, where a detailed understanding of road wheel and tyre characteristics is required, emphasis should be placed on power-assisted steering components and the characteristics of steering such as understeer and oversteer.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the different types of independent front and rear suspension – explain the construction and operation of dampers – explain sprung and unsprung weight and the impact of chassis design on suspension – identify and describe the main components of an adaptive suspension system

Topic and suggested assignments/activities and/assessment
Practical workshop activities: – investigation of front, rear and adaptive suspension systems and components
Prepare for and carry out Assignment 1: Suspension Systems (P1, P2, M1)
Whole-class teaching: – explain the function and operation of the main components within a power-assisted steering system – explain the range of steering characteristics and their effects – describe the different types of road wheels and tyres ***Practical workshop activities:*** – investigation of power assisted steering system components – investigation of wheel and tyre construction
Prepare for and carry out Assignment 2: Steering System Components (P3, P4, P5, M2)
Whole-class teaching: – explain the differences between the different types of brake system – explain the function and operation of the main components within a braking system – explain the function and operation of the main components within an anti-lock braking system ***Practical workshop activities:*** – investigation of braking system components
Prepare for and carry out Assignment 3: Braking System Components (P6, P7, D1)
Whole-class teaching: – explain and demonstrate the techniques used for inspecting steering, braking and suspension systems – explain and demonstrate the methods used for adjustment and servicing of steering, braking and suspension system components ***Practical workshop activities:*** – inspecting and fault-finding on steering, braking and suspension systems
Prepare for and carry out Assignment 4: Fault-finding of Steering, Braking and Suspension Systems (P7, P8, P9, P10, P11)
Feedback to learners, unit evaluation and close

Assessment

This unit could be assessed through three written assignments and one practical assignment.

The first written assignment could give learners opportunities to meet the requirements of P1, P2 and M1. A task could be set asking learners to describe the function and operation of two main types of independent front and two types of independent rear vehicle suspension design (P1). Different types of rear suspension could be given to different learners from the range listed within the unit content. The task should ensure that learners cover dampers, the suspension requirements and the impact of chassis design.

For P2, a task should be given asking learners to describe the function and operation of the main components of an adaptive suspension system. The main components that need to be covered are listed within the unit content. A further written task could be set asking learners to compare the relative advantages and disadvantages of an adaptive suspension system and one other suspension system (M1).

A second assignment could be given to meet the requirements of P3, P4, P5 and M2.

An initial task, covering P3, could require learners to describe the function and operations of the main components in a power-assisted steering system. Tutors can give different types of steering system to different learners.

A second task in this assignment could ask learners to distinguish between understeer, oversteer and neutral steering characteristics, vehicle roll axis, roll centre and centre of gravity, to achieve P4.

A third task, covering P5, would again give tutors the opportunity to give different wheel and tyre combinations to different learners. Consideration should be given to wheel types, rim codes and retention methods, valve and tyre types including profile and markings and applications. A further task could be set asking learners to explain the effect of steering characteristics on wheel/tyre function and operation (M2).

A third written assignment could be used to meet the requirements of P6, P7 and D1. Initially, learners could describe the function and operation of the components found in braking systems (P6) and anti-lock braking systems (P7). A further task could then be set asking them to evaluate two braking system applications when used in conjunction with an anti-lock braking system (D1). Although the components used in the anti-lock braking system are clearly listed within the unit content tutors can vary what is given to each learner. It is important that the type of system is fully explored and that brake bleeding componentry and brake pad warning systems are considered in the descriptions.

A final practical assignment could be set to meet the requirements of P8, P9, P10 and P11. Learners would need to be given a particular vehicle to carry out a fault-finding exercise on its suspension, steering and braking systems. In doing so learners will need to establish which components are operating satisfactorily and which are not. At least one fault in each system must be present to allow corrective action to be identified. A record of hazard protection and safe working needs to be made.

Depending on the resources available different learners could work on different vehicles. Evidence for this practical assignment is likely to be in the form of a witness statement/observation record, supplemented by annotated photographs and a list of the faults found and suggested corrective action for each.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Suspension Systems	A vehicle technician needs to describe the function and operation of suspension systems to a new apprentice	Written report
P3, P4, P5, M2	Steering System Components	A vehicle technician needs to describe the function and operation of steering systems to a new apprentice	Written report
P6, P7, D1	Braking System Components	A vehicle technician needs to describe the function and operation of braking system components to a new apprentice	Written report
P8, P9, P10, P11	Fault-finding of Steering, Braking and Suspension Systems	A vehicle technician needs to inspect a vehicle's steering, braking and suspension systems	Practical activities evidenced by learner record sheets and observation records.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Chassis Systems
		Vehicle System Fault Diagnosis and Rectification

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit LV05: Inspect Motor Vehicles Using Prescribed Methods
- Unit LV06: Inspect Motor Vehicles
- Unit LV08: Diagnose and Rectify Motor Vehicle Chassis System Faults.

Essential resources

A range of suspension, steering and braking components and equipment will be required for delivery of this unit. Learners will need access to vehicles in order to carry out fault-finding on the different systems.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Killingsworth J, Godfrey E and Haynes J — Suspension, Steering and Driveline Manual (Haynes, 1998) ISBN 1563922932

Nunney N J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 0750680377

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Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when carrying out fault-finding on steering, braking and suspension systems
Self-managers	organising time and resources and prioritising actions when carrying out fault-finding on steering, braking and suspension systems anticipating, taking and managing risks when carrying out fault-finding on steering, braking and suspension systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with other when working as a group during fault-finding activities

Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and describing the function and operation of vehicle suspension, steering and braking systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching vehicle suspension, steering and braking systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the function and operation of vehicle suspension, steering and braking systems

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Unit 15: Heavy Vehicle Braking Systems

Unit code: L/503/1416

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge and understanding of heavy vehicle braking systems and will enable them to carry out maintenance procedures on these systems.

Unit introduction

The unit will develop learner knowledge and understanding of the specialist braking systems found on heavy vehicles, public service vehicles and plant.

Learning outcome 1 will introduce learners to air compression and storage for heavy vehicle braking systems. This will include the operation of the air supply and storage components, together with the function and operation of pressure protection devices such as pressure regulating valves, switches and sensors.

Learning outcomes 2 and 3 will introduce learners to the actuation, control and operation of heavy vehicle braking and auxiliary braking systems.

The final learning outcome will provide hands-on experience of maintaining a heavy vehicle's braking system in accordance with safety and legal requirements. This will include familiarising learners with relevant safety precautions such as braking efficiency, brake balance and pressure build-up time. Learners will also be introduced to the legislation and regulations that apply to heavy vehicle braking systems.

Learners will apply maintenance procedures including drum/disc brake adjustment, brake tests, leakage tests, pressure monitoring and the maintenance of appropriate maintenance records.

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Learning outcomes

On completion of this unit a learner should:

1 Know the function and operation of air compression and storage components in a heavy vehicle braking system

2 Know the function and operation of actuation and control systems used on heavy vehicle air brakes

3 Understand the operation and application of a heavy vehicle auxiliary braking system

4 Be able to maintain the safety of a heavy vehicle's braking system in accordance with legal requirements.

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Unit content

1 **Know the function and operation of air compression and storage components in a heavy vehicle braking system**

Air supply: air filter eg induction manifold, inlet filter; air compressor eg method of drive, single/twin cylinder, liquid/air cooled air compressor, internal unloading mechanisms; air drier eg single/twin tower air drier, purge tanks; electronic air processing system (APS) eg integrated air driers, multi-circuit protection valves, electronic control to adjust reservoir charge pressures; antifreeze system eg alcohol evaporator/injector, heater units on air drier components; safety valve eg location and reasons for fitting; pressure control system eg governor valve and integral un-loader mechanisms in compressor and air drier units, remote un-loader valve

Air storage: number and size of air reservoirs; testing and inspection; factors that affect serviceability

Pressure protection: circuit pressure control and monitoring valves eg single and double check valves, pressure regulating valve, pressure protection valve (single and multi), automatic drain valves; warning devices eg low pressure warning devices, pressure gauges, pressure switches and pressure sensors

2 **Know the function and operation of actuation and control systems used on heavy vehicle air brakes**

Actuation system: air brake actuators eg single, double and spring brake units (diaphragm and piston types), methods used to release spring tension in the absence of air pressure; parking brake systems eg remote and integrated spring brake units, application with drum and disc brake units; brake clearance adjustment eg slack adjuster (manual and automatic), foundation brake expander mechanisms (wedge, S-cam, strut (Z-cam), disc brake); auxiliary air valves eg quick release valves, solenoid valves, test couplings, manual release valves, exhaust silencing devices; safety precautions and procedures eg risks associated with compressed gas, trapping hands in actuation mechanisms

Control system: foot valve eg single and dual units, position within the pneumatic circuit; hand control valve eg up-right and inverse pressure types, position within pneumatic circuit; relay valve eg function and operation, single and multi-input relay valves, trailer control valve, trailer emergency relay valve, supply dump valve; pressure protection systems eg brake protection valve (for use with vehicles using load sensing and air suspension); interlock valve eg spring brake-parking protection in the event of parking brake lever set in OFF position on the air pressure build up causing the brakes to release; electronic control of air braking eg principles associated with electronic braking systems (EBS), anti-lock braking system (ABS), electronic stability programmes (ESP) and traction control (anti-spin regulation (ASR))

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Full air and air/hydraulic braking systems: full air system eg service and secondary circuits; split and dual braking systems employing upright and inverse air pressure, differential protection systems for drum brakes employing spring brake units; load sensing valves eg mechanically and pneumatically actuated, adjustment and testing; spring brakes applied to trailers (parking brake circuits); anti-jack knife devices eg causes of jack-knifing, methods to reduce the occurrence, controlled fifth wheel coupling, use of anti-lock braking on tractor drive axle; vehicle configuration eg two-axle and multi-axle layouts (including air suspension, pneumatic circuits, convention for port labelling), 2-line drawbar and articulated vehicle systems

Air over hydraulic braking systems: eg hydraulic circuit interfaced with air pressure circuits, hydraulically operated expander mechanism, hydraulic tandem master cylinder with air assistance, hydraulic load sensing valves, arrangement of parking brake, use of remote spring brake and application compliance with trailers using full air braking systems

3 Understand the operation and application of a heavy vehicle auxiliary braking system

Engine auxiliary brake: exhaust manifold and engine compression types; operational cycle, construction (method used to cut fuel injected), effectiveness

Transmission auxiliary brake: hydraulic retarder eg remote and integral construction with gearbox, control system, arrangements for cooling; friction retarder and provision for cooling; electric retarder eg principles (using eddy current braking with reference to Lenz's law), control system, effects of heat generation on the operational efficiency, method used to dissipate heat energy

4 Be able to maintain the safety of a heavy vehicle's braking system in accordance with legal requirements

Safety precautions: braking efficiency eg definition, calculation of braking efficiency from data (service, secondary and parking brake test); brake balance eg definition from testers' manual, calculation of brake balance from data obtained under test; pressure build-up time eg definition, test procedure, likely causes of poor build-up performance

Legal requirements: major legal documents affecting heavy vehicle braking standards eg Motor Vehicles (Construction and Use) Regulations (including community directives), Goods Vehicles (Plating and Testing) Regulations, Public Service Vehicles (Condition of Fitness, Equipment, Use and Certification) Regulations

Maintenance: drum/disc brake adjustment; brake test eg roller brake testers, use of retardation meter under road test conditions; leakage test eg pressure loss over set time, use of leak detection device/fluids; pressure monitoring eg checking load sensing valve settings, pressure balance on dual footbrake valves, operation of the trailer control valve dump function, trailer relay emergency valve operation; maintenance records eg legal requirements to keep and store records, paper-based records, use of wall charts, service sheets, defect notices, prohibitions, computer-based service and maintenance logging

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the function and operation of the air supply and storage components of a heavy vehicle high pressure braking system	M1 explain the construction of the air supply and storage components of a high pressure braking system for a heavy vehicle	D1 evaluate data derived from a braking system test and identify the required maintenance procedure
P2 describe the function and operation of the pressure protection components within a heavy vehicle's pressure storage system	M2 compare the construction, operation and application of a heavy vehicle full air braking system with that of an air/hydraulic system	D2 explain the effect that two different types of wear or maladjustment may have on the effectiveness and legality of a heavy vehicle's braking system.
P3 describe the function and operation of the components used for the actuation and control of a full air braking system	M3 compare the application and effectiveness of an engine-activated auxiliary braking system with that of a transmission type auxiliary braking system.	
P4 describe the function and operation of a braking system using air/hydraulic control		
P5 explain the operation of an engine auxiliary braking system		

Table continues on next page

Assessment and grading criteria		
P6 explain the operation of a transmission auxiliary braking system		
P7 describe the safety precautions and legal requirements for a heavy vehicle brake system [IE4]		
P8 describe the main requirements for heavy vehicle braking systems maintenance		
P9 carry out and record the results of a drum/disc brake adjustment [SM3, SM4]		
P10 carry out and record the results of one other heavy vehicle braking system maintenance procedure [SM3, SM4]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

It is expected that learners will have a working knowledge of general vehicle systems, such as the theory associated with vehicle braking and various foundation brake configurations including leading, trailing, twin leading and disc brakes. It is important that learners understand the methods used to operate the major braking systems used on vehicles. They also need an understanding of heavy vehicle suspension and steering systems so that they appreciate the connection between the applications of air braking technology and air suspension.

It is recommended that this unit is delivered using a balance of theoretical and practical study. Learners should have access to manufacturers' technical information that uses the current port numbering convention. Systems and operating principles are best demonstrated using a combination of vehicles, air brake demonstration rigs and components.

Tutors will need to ensure that learners appreciate the safety and legal aspects relevant to compressed air braking systems.

Practical workshop sessions should develop learners' ability to carry out accurate brake testing and to deal with combinations of system faults which may affect more than one system on the same vehicle. More complex system faults, including air-braking systems that use electronic control and computer-based fault diagnosis, could be introduced where practical, or possibly be demonstrated with the support of a vehicle manufacturer or main dealer.

The order in which the learning outcomes are delivered depends largely on the level of prerequisite knowledge of the various related topics. However, most centres are likely to consider the compression and storage of air first, including aspects of air brake technology associated with servicing and maintenance. Examples include air driers, alcohol injection systems, reservoir charging times and predominant charging of specific circuits. The legal requirements imposed on heavy vehicle systems can also be covered in part.

It is anticipated that most learners will have access to live heavy vehicles to work with or to at least observe the basic charging process. Where centres do not have access to running vehicles then it may be possible to organise a group demonstration with a local vehicle dealer or operator.

Actuation and control of air braking systems are best covered using an integrated approach of theory and practice. Testing of individual valves and components on training rigs will help learners identify the main characteristics. Integrated theory and practice sessions will enable for learners to assemble complete air braking circuits using a step-by-step approach.

The use of training rigs, where learners have to connect valves and pipes to assemble the circuit, is probably the most effective method to assimilate the circuit and valve configuration. During these practice sessions it would be appropriate to demonstrate simple faults and fault-finding techniques that relate closely to basic servicing and maintenance. For example, air leaks from pipes and unions or air leaks from exhaust ports on an operating valve.

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Factors that affect vehicle stability and control (such as jack-knifing) can be demonstrated by using simple vehicle models, locking axles or individual wheels and observing their behaviour when rolling down a slight gradient. The task can be made into a simple exercise which reinforces the more abstract concepts associated with stability of rigid and articulated vehicles.

An introduction to the operating principles of vehicle retarders, such as the eddy current type, can be covered by practical observation of the effects of eddy current formation on a non-ferrous disc rotating within an electromagnetic field. This can be extended to observe the effects of increasing the current flowing through the electromagnet. Learners should then progress onto an actual retarder, relating the theory associated with Lenz's law and the retarder's operation. Engine braking, hydraulic and friction retarders can similarly be explained in terms of the principles providing the retarding forces and the requirements to dissipate substantial heat energy once in operation.

Where centres do not have access to a roller vehicle brake tester then they are advised to arrange a visit to a test station, local vehicle dealer or operator for a demonstration. This will significantly help to reinforce the concept of vehicle braking efficiency to stated minimum legal limits.

Note that the use of 'eg' in the content is to give an indication and an illustration of the breadth and depth of the area of topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – describe the function and operation of an air supply system and its components – describe the function and operation of an air storage system and its components – explain the function and operation of circuit pressure control and monitoring valves and pressure warning devices – explain the legal requirements that relate to air supply and storage ***Practical workshop activities:*** – practical investigation of operation of air supply and storage system and components, including reservoir charging
Prepare for and complete Assignment 1: Air Compression and Storage Systems and Components (P1, P2, M1)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the function and operation of an actuation system and its components, including related safety precautions and procedures – explain the function and operation of a control system and its components – explain the actuation and control of full air braking systems and air/hydraulic braking systems and the differences between – describe the causes of jack-knifing and devices used to reduce the risk of it occurring ***Practical workshop activities:*** – investigation and testing of valves and components – assembly of air braking circuits
Prepare for and complete Assignment 2: Actuation and Control Systems (P3, P4, M2)
Whole-class teaching: – explain the operation, construction and effectiveness of engine auxiliary brakes – explain the principles of operation of hydraulic retarders, friction retarders and electric retarders and relevant methods of cooling/heat dissipation ***Practical workshop activities:*** – investigation of engine braking and retarders using roller testing facilities
Prepare for and complete Assignment 3: Auxiliary Braking Systems (P5, P6, M3)
Whole-class teaching: – explain the safety requirements for braking efficiency, brake balancing and pressure build-up time – explain the legal documentation relating to heavy vehicle braking – explain and demonstrate methods of adjusting brake drums/discs – explain and demonstrate brake testing, pressure monitoring and leakage testing procedures – explain the use of maintenance records ***Practical workshop activities:*** – practise and use of a range of heavy vehicle maintenance procedures
Prepare for and complete Assignment 4: Heavy Vehicle Braking Systems Maintenance (P7, P8, P9, P10, D1, D2)
Feedback to learners, unit evaluation and close

Assessment

A range of assessment methods can be used and it likely that evidence will be collected from a combination of activities/assignments, investigative projects and practical work.

Assignments and projects should be designed to develop learners' basic knowledge of braking systems and provide opportunities to assess their understanding of system testing. Centres may also consider the use of periodic short tests. These could comprise short- answer questions or set-piece workshop tasks that enable learners to demonstrate specific aspects of the required practical skills. A variety of assessment strategies should be used to give learners the opportunity to demonstrate their full ability and to add diversity to the subject.

Learners should be encouraged to carry out research and use a range of resource materials during their investigations. Tutors should provide guidance on how material can be referenced and used as part of learners' own work so as not to infringe guidelines on authenticity of evidence.

For P1, learners should describe the function and operation of the main components used for the compression and storage of air. This can be achieved with the aid of suitably labelled circuit/component diagrams and/or copies of manufacturers' diagrams (whether redrawn/sketched by the learner or electronically copied). Electronically copied diagrams are acceptable provided learners have annotated the work adequately, the source of the information is acknowledged and they are used to aid learners' own description.

Having achieved P1 learners could extend their description of the operation of a high pressure braking system to include an explanation of the system's construction to meet the requirements of M1.

P2 can be linked with P1, as learners need to describe the function and operation of the pressure protection components within a heavy vehicle's pressure storage system. The braking/storage system could be the same for both criteria. Learners should describe the circuit pressure control, monitoring valves and warning devices that apply to the system being considered. The description should include a clear indication that learners have understood the need to use a pressure protection system. In particular, learners must appreciate that failure of one circuit or device might result in the loss of pressure and so adversely affect the level of vehicle safety.

P3, P4, P5 and P6 relate to the different heavy vehicle braking systems. This section is likely to form the core of the unit assessment strategy and provide most of the underpinning knowledge and understanding needed for the other criteria.

For P3, learners need to describe the function and operation of the components used for the actuation and control of a full air braking system (service and secondary circuits). Learners should make use of circuit and component diagrams to support their description of full air braking systems (including trailers). They should also draw from the actuation and control system components listed in the unit content, as appropriate to the system being considered. The operation of the major control valves should include reference to how the progressive control of braking is obtained. Descriptions of multi-function valves should include both normal operation and situations where failure of individual circuit(s) may occur.

For P4, learners need to describe the function and operation of an air/hydraulic control braking system. This should include a clear description of how air pressure is used to generate large hydraulic pressure at the wheel cylinders plus the operation of the parking brake using air/hydraulic systems.

To achieve M2, learners need to use their understanding from P3 (a full air braking system) and P4 (an air/hydraulic system) to compare the construction, operation and application of the two systems as used on heavy vehicles. The comparison should consider aspects such as the types of compressor, internal and external unloading methods, air driers including the electronic controlled air processing systems (APS) and the storage arrangements for each system.

For P5, learners need to explain the operation of an engine auxiliary braking system. It is expected that they will be able to comment on the manner in which the vehicle energy of motion is converted by the engine to provide a retarding force.

To achieve P6 learners need to explain the operation of a transmission auxiliary braking system, including the method of energy absorption and dissipation. Learners should provide an explanation of a system's hydraulic retarder, friction retarder or electric retarder and any related provision for cooling/heat dissipation for a given or chosen system.

Learners could extend the work for P5 and P6 by comparing the application and effectiveness of an engine-activated auxiliary braking system with that of a transmission type auxiliary braking system, in order to meet the requirements of M3.

For P7, learners need to describe the safety precautions and legal requirements for a heavy vehicle braking system. They must identify the major legal documents affecting the vehicle which relate to the braking system being considered. It is expected that the work for this criterion will be linked to that undertaken when considering the braking systems in P3, P4, P5 and P6.

It is expected that P8, P9 and P10 will be linked. Learners should first describe the requirements for heavy vehicle braking systems maintenance, before carrying out and recording the results of a drum/disc brake adjustment and one other braking system maintenance procedure. The second procedure should be selected from those listed in the unit content - a brake test, leakage test or pressure monitoring.

Evidence for both criteria is likely to be the learner's log of the procedures carried out together with a description of the system's maintenance requirements. The work will also require verification by a competent assessor, whether carried out in the learner's workplace or the centre's workshop. This verification will provide further evidence of learner achievement and is likely to be in the form of a record of observation. Annotated photographic evidence can also be used to record the stages of the maintenance procedure, and the use of tools, environment, etc.

Both distinction criteria link with the last three pass criteria, particularly the practical aspects of P9. However, learners will need to draw on their understanding of all the pass criteria to achieve D1 and D2. Learners should evaluate data derived from a braking system test and identify the required maintenance procedure to meet the requirements of D1.

For D2, learners must explain the effects that two different maladjustments or excessive wear faults can have on the effectiveness and legality of a heavy vehicle braking system.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Air Compression and Storage Systems and Components	A technician needs to report on the construction and operation of a heavy vehicle's high pressure braking system	A written report
P3, P4, M2	Actuation and Control Systems	A technician needs to report on the function and operation of actuation and control systems	A written report
P5, P6, M3	Auxiliary Braking Systems	A technician needs to report on the function and operation of an auxiliary braking system	A written report
P7, P8, P9, D1, D2	Heavy Vehicle Braking Systems Maintenance	A technician needs to carry out maintenance on a heavy vehicle braking system	A practical maintenance task supported by observation records and a written inspection record

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Vehicle Technology sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Vehicle Systems Fault Diagnosis and Rectification
		Heavy Vehicle Steering and Suspension Systems

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Heavy Vehicle, particularly:

- Unit HV06: Inspect Motor Vehicles
- Unit HV08: Diagnose and Rectify Motor Vehicle Chassis System Faults.

Essential resources

Learners will need access to vehicle workshop facilities equipped to deal with heavy vehicles. A range of heavy vehicle braking components and rigs will also need to be available.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Heisler H — *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002) ISBN 9780750651318

Nunney M J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to safety and legal requirements, judging its relevance and value
Self-managers	organising time and resources and prioritising actions when carrying out heavy vehicle braking systems maintenance anticipating, taking and managing risks when carrying out heavy vehicle braking systems maintenance

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others when working in groups to carry out heavy vehicle braking systems maintenance

Functional Skills — Level 2

Skill	**When learners are …**
Mathematics	
Select and apply a range of skills to find solutions	carrying out calculations to determine braking efficiency and brake balance
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	interpreting and present braking efficiency and brake balance data.
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and describing the function and operation of heavy vehicle braking systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the function and operation of heavy vehicle braking systems and the safety and legal requirements associated with their maintenance
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the function and operation of heavy vehicle braking systems recording the results of brake tests, maintenance procedures and reporting findings.

Unit 16: Heavy Vehicle Transmission Systems

Unit code: Y/503/1421

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to give learners an understanding of the construction and operating principles of heavy vehicle transmission systems and will enable them to inspect and maintain these systems.

Unit introduction

The unit covers the conventional aspects of heavy vehicle transmission systems, their function, principal components and operating principles. This will include a detailed examination of a heavy vehicle's clutch mechanism, its gearbox and the driveline and final drive systems.

Learners will be introduced to recent developments in the use of electronics for the control and operation of transmission systems in a range of heavy vehicles. These developments are frequently integrated into the overall electronic management of vehicles and can provide significant improvements in terms of driveability, economy and performance. Learners will develop an understanding of the fundamental operating principles of these electronic systems, their integration within transmission systems and their significance in the maintenance of a vehicle's transmission system.

Learners will carry out specific tests and checks to identify transmission system faults such as clutch slip, gearbox linkage problems and failing universal joints. They will use these tests and checks, together with the use of on-board diagnostic equipment, to maintain a vehicle's transmission system. This will include maintenance requirements relating to driver/passenger safety and component reliability.

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Learning outcomes

On completion of this unit a learner should:

1 Understand the operation of a heavy vehicle clutch mechanism and the function of its principal components

2 Understand the operation of a heavy vehicle gearbox and the function of its principal components

3 Understand the operation of a heavy vehicle driveline system and final drive and the function of its principal components

4 Be able to maintain a heavy vehicle's transmission system.

Unit content

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1 **Understand the operation of a heavy vehicle clutch mechanism and the function of its principal components**

Principal clutch components: pressure plate, disc, flywheel (including bearings and bushes); release bearings; release systems eg production vehicle servo mechanisms, air assisted clutch release mechanism

Types of clutch mechanisms: eg production clutches (coil and diaphragm spring, single plate, multi-plate wet and dry types), automatic clutches (torque converter, fluid flywheel, one way clutch)

Operating principles of clutch: constructional design and use of materials (linings, drive plates and friction surfaces, springs); engagement and disengagement of clutch (single and multi-plate, one way clutches, clutch brakes and automatic clutches); provision for adjustment/self-adjustment; torque calculations and coefficient of friction; power flow; common faults eg wear, misalignment; fault symptoms (slip, drag, judder, overheating); fluid flywheels

2 **Understand the operation of a heavy vehicle gearbox and the function of its principal components**

Principal gearbox components: gear design (spur and helical); bearings, shafts, casing, selector and sealing arrangements; gear locking and interlock mechanisms; gear speed synchronisation and engagement mechanisms eg sliding mesh, synchromesh and dog type

Types of gearboxes: eg manual (single stage, double stage, sliding mesh, constant mesh, twin layshaft), auxiliary gearbox (splitter gearboxes, range change gearboxes), automatic and semi-automatic (epicyclic gear train, hydraulic control systems)

Operating principles of gearbox: manual gearbox – gear ratios, power flow eg constant mesh single and double stage; torque and speed calculations; gear characteristics eg ratio, number of available gears, suitable gear ratios to enable hill climbing ability; gear selection and engagement methods eg synchromesh and dog type, selector forks, interlocks and linkages, remote control mechanisms, automatic gearbox - torque converters (lock-up mechanism); epicyclic gear trains (simple and compound); brake bands; multi-plate and unidirectional clutches; power flow paths; function of key hydraulic components (pump, governor, actuators, servos, regulator and shift valves); electronic control system including mode selection; electronic selection of conventional gear arrangements; lubrication eg method (splash and pump assisted); oil requirements and types (mineral, synthetic); seals and sealing arrangements (static and dynamic types)

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3 Understand the operation of a heavy vehicle driveline system and final drive and the function of its principal components

Principal components of driveline systems: propeller shaft arrangement eg single, divided (use of centre bearings); driveline arrangements eg front, rear twin and all wheel drives; universal joints eg Hooke type and rubber; constant velocity joints, sliding joints; drive systems eg two-wheel, four-wheel (transfer box, centre differentials, viscous couplings, differential locks, automatic and manual)

Principal components of final drive: axle types and support arrangements eg live and independent, single and twin-drive axles; final drives eg bevel, spiral, worm and wheel, hypoid and double reduction; differentials eg sun and planetary gears, crown wheel and pinion; axle types eg three quarter, fully floating and double reduction hub arrangements; bearings and drive shaft loadings

Operating principles of driveline: universal joints ; constant velocity joints (angular limitations and conditions required to achieve constant velocity, basic consideration of balance requirements, alignment and torque capacity of hollow and solid shafts); suspension and transmission characteristics giving rise to the requirement for sliding joints and centre propshaft bearings

Operating principles of final drive: gear ratio, speed reduction and torque multiplication in the final drive; final drive arrangements for transaxles; driving thrust and torque reaction; differential (effects on torque/speed at the driven wheels, limited-slip differentials); lubrication methods (final drive and rear axles); oil requirements and types (mineral, synthetic); oil seals and sealing arrangements (static and dynamic)

4 Be able to maintain a heavy vehicle's transmission system

Transmission system faults: eg clutch (slip, drag, judder, loss of drive, excessive noise, wear, misalignment, operating mechanism faults), gearbox (gear selection, oil leaks, linkages and fittings), driveline and finals drives (prop/drive shafts, universal and constant velocity (CV) joints, bearings, gaiters and seals), use of on-board diagnostic (OBD) equipment, reporting methods (inspection records, oral report to supervisor)

Maintenance operations: working to manufacturers' maintenance and service procedures eg manuals, job cards, direct supervision; maintenance operations eg clutch adjustments/alignment, gearbox oil change, gear selection linkage repair, driveshaft gaiter condition check/replacement, security of mountings and fittings; context of the maintenance operations eg routine maintenance, repair or adjustment due to a system failure, alternative service procedures for adverse condition (vehicles operating in dry, dusty environments and vehicles working in extreme temperature environments)

Safety procedures: procedures relating to maintenance operations carried out eg materials handling (protection against dust, oil and chemical exposure), vehicle and system protection (application of four-wheel drive diff locks, lifting and supporting vehicles), personal protective equipment (PPE), Control of Substances Hazardous to Health (COSHH) Regulations, component and environmental waste disposal

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the function of the principal components of two different types of heavy vehicle clutch mechanism	M1 compare two different heavy vehicle clutch types in terms of their principal components and operating principles	D1 justify the use of a specific clutch type for two different heavy vehicle applications in terms of purpose, function and performance
P2 explain the operating principles of one type of heavy vehicle clutch	M2 explain the advantages and disadvantages of increasing the number of available gears in a heavy vehicle's gearbox	D2 justify the use of a specific type of driveline and final drive arrangement for two different heavy vehicle applications in terms of purpose, function and performance.
P3 describe the function of the principal components of one type of heavy vehicle gearbox	M3 compare two different heavy vehicle driveline and final drive arrangements.	
P4 explain the operating principles of two different types of heavy vehicle gearbox		
P5 describe the function of the principal components in a heavy vehicle driveline and final drive		

Table continues on next page

Assessment and grading criteria		
P6 explain the operating principles of a heavy vehicle's driveline and final drive arrangement		
P7 inspect a heavy vehicle's transmission system [SM3, SM4]		
P8 report faults and attribute symptoms to the faults identified		
P9 carry out a maintenance operation on a heavy vehicle's transmission system [SM3, SM4]		
P10 follow relevant safety procedures when inspecting and maintaining a heavy vehicle's transmission system [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered in the context of learners' chosen areas (for example heavy vehicle or passenger vehicle), although a generic approach would be equally suitable. The term 'maintenance' in this unit is used in a generic way and can be taken to mean either routine maintenance (a regular service) or less routine work (a repair due to a component failure or adjustment to correct a misalignment).

Delivery of this unit would ideally be a balance of theoretical and practical study. Whatever approach is taken, learners' experience should be sufficiently varied to provide them with the knowledge and skills needed to carry out routine heavy vehicle workshop operations. In addition, learners need to develop the skills and understanding to diagnose transmission system faults in an industrial setting. Health and safety should be emphasised whenever learners undertake practical activities.

The learning outcomes could be delivered in the order in which they are listed. In this way, learners will gain a progressive understanding of the function and operating principles of the relevant parts of the power train from the clutch (through the gearbox and driveline) to the final drive.

Learners should be introduced to a range of clutches used on modern heavy and passenger carrying vehicles. However, centres may wish to focus on a specific clutch type to meet local needs and cover the others in a more general way. The approach taken with clutches could be replicated with gearboxes, driveline and the final drive. However, centres should ensure that learners gain a sufficient understanding of all types and delivery should not be limited to the one or two required to meet the assessment criteria.

For the final learning outcome learners will need access to heavy vehicles and workshop facilities. Delivery of this part of the unit could consist of lectures to introduce the transmission system and likely faults, learner-led research into the maintenance requirements followed by practical application on vehicles in the workshop. Again, learners should experience a range of routine maintenance operations in line with those suggested in the unit content.

During practical work, the critical safety aspects of each operation should be emphasised. Learners should be encouraged to recognise and explain these aspects of safety during their practical workshop activities to reinforce the importance to themselves and to others.

The use of a record of practical work carried out should be standard practice. This is likely to be in the form of a workshop logbook. This will enable learners to capture and reflect on their experience and will provide support and guidance during the activities chosen for the final assessment.

Note that the use of 'eg' in the content is to give an indication and an illustration of the breadth and depth of the area of topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the function of the principal clutch components – explain the construction, layout and differences between production clutches and automatic clutches – explain the operating principles of a heavy vehicle clutch mechanism and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of clutch components
Prepare for and complete Assignment 1: Heavy Vehicle Clutch Operation (P1, P2, M1, D1)
Whole-class teaching: – explain the function of the principal gearbox components – explain the construction, layout and differences between types of gearbox – explain the operating principles of a heavy vehicle gearbox and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of heavy vehicle gearboxes and gearbox components
Prepare for and complete Assignment 2: Heavy Vehicle Gearbox Operation (P3, P4, M2)
Whole-class teaching: – explain the function of the principal driveline and final drive components – explain the operating principles of a vehicle driveline and final drive and common faults that can occur ***Individual learner investigation:*** – investigate the function and operation of a range of gearbox components
Prepare for and complete Assignment 3: Heavy Vehicle Driveline and Final Drive Operation (P5, P6, M3, D2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the health and safety considerations that must be taken into account when carrying out maintenance on a vehicle transmission system ***Practical workshop activities:*** – tutor-led inspection and maintenance of vehicle transmission systems
Prepare for and complete Assignment 4: Inspection and Maintenance of Heavy Vehicle Transmission Systems (P7, P8, P9, P10)
Feedback to learners, unit evaluation and close

Assessment

This unit provides opportunities for evidence to be generated from a combination of assignments, projects and practical work. Although most of the pass criteria require descriptive evidence it is not expected that centres will only use tests to generate this evidence. The unit lends itself to an investigative, practical approach and this should be reflected in the assessment strategy wherever possible. The range of evidence presented could include notes, diagrams, investigative test data and the records of the maintenance and diagnostic procedures carried out.

Proving authenticity and guarding against plagiarism can be a problem, particularly with open, written assignments. Assessment of P1 to P6 is particularly suited to, and could be carried out through, either 'on-the-job' oral questioning/observation, or through a written time constrained assessment. Both of these methods can assure high levels of authenticity. P7, P8, P9 and P10 require individual practical work and are less problematic when it comes to authenticity. Centres should note however, that whichever method is chosen, they will need to ensure that each criterion and its related content is met in full.

To achieve a pass, learners will need to describe the function of the principal components of two different types of heavy vehicle clutch mechanisms (P1), one type of gearbox (P3) and a heavy vehicle's driveline and final drive (P5). In addition, learners need to explain the operating principles of one of the clutches (P2), two types of gearbox (P4) and one heavy vehicle's driveline and final drive (P6).

The unit content for each of these areas (clutches, gearboxes, driveline/final drives) provides a range of choices through the examples listed. For clutches, this includes production single and multi-plate and automatic, and within these groupings there are further examples. Centres are expected to cover as wide a range as possible during delivery of the unit but need only select one or two of these, as indicated by the criteria, for assessment purposes. This will enable centres to concentrate on a specific specialisation as the main focus of assessment (for example computer-aided gear changing).

Where a criterion identifies that learners must consider two types this is to ensure that the learning process is sufficiently wide. For example, whilst a centre may specialise in goods vehicles it is important that learners are equally aware of a light commercial vehicle's clutch. The purpose is to make sure that learners' employment potential is not limited. The range of choices available should mean that for any one group, each learner could be considering the function of the principal components for a different type of vehicle and clutch type. This can be beneficial when considering the issues that surround authenticity of evidence.

P7, P8, P9 and P10 would be best assessed through investigation and practical examination of a live vehicle layout and configuration. P10 should be an integral part of the assessment for P7 and P9.

A suitable transmission system fault may need to be simulated for P7 and P8 and learners given the typical symptoms of the fault, as would be reported by a driver of the faulty vehicle. Evidence is likely to a written inspection record that learners complete at the time of the inspection, a verbal report back to the supervisor/customer (tutor record of oral questioning/observation) and tutor observation of the process (for example use of logical and efficient diagnostic techniques, safe working).

The main assessment evidence for P9 is the final product - the completed maintenance task. However, a record of tutor observations will be necessary to cover the process aspects of the task (for example working to the manufacturer's procedures, correct and safe working). The final link is with P10 and the safety procedures relating to the maintenance operation being carried out. For example, tutors will need to observe the learner handling materials correctly, using relevant system protection, using appropriate PPE, working to COSHH regulations and correctly disposing of waste, as required by the task being carried out.

To achieve a merit, learners need to compare the constructional differences of two different clutch types (for example production diaphragm spring and a coil spring type). The two clutches could be the same as those considered for P1, or if centres wish to encourage learners to have a wider experience then one or two completely different clutches could be used. The focus of the comparison should be based on the understanding developed through the work carried out for P1 and P2. Learners must also be able to explain the requirement of multiple gear ratio applications (for example splitter gearbox and range change gearboxes giving multiple ratios, 8 speed versus 10 speed) to provide the necessary hill climbing ability. Finally, they need to compare two different heavy vehicle driveline and final drive arrangements (for example longitudinal, in line versus transverse or rear engine, rear wheel drive versus rear engine four-wheel drive). Again, one of these could be the driveline and final drive considered for P5 and P6.

To achieve a distinction, learners need to justify the use of a specific clutch type (D1) and justify the use of a specific type of driveline and final drive arrangement (D2) for two different heavy vehicle applications in terms of purpose, function and performance. Once again, these could be the same clutches, driveline and final drives that learners worked with through the pass and merit criteria.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Heavy Vehicle Clutch Operation	A technician needs to explain the function and operation of clutch mechanisms to a new apprentice	A written task under controlled conditions or oral questioning
P3, P4, M2	Heavy Vehicle Gearbox Operation	A technician needs to explain the function and operation of gearboxes to a new apprentice	A written task under controlled conditions or oral questioning
P5, P6, M3, D2	Heavy Vehicle Driveline and Final Drive Operation	A technician needs to explain the function and operation of a driveline and final drive to a new apprentice	A written task under controlled conditions or oral questioning
P7, P8, P9	Inspection and Maintenance of Heavy Vehicle Transmission Systems	A technician needs to safely inspect, diagnose and repair a heavy vehicle transmission system	A practical maintenance task supported by observation records and a written inspection record

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Operation of Vehicle Chassis Systems
		Vehicle System Fault Diagnosis and Rectification

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Heavy Vehicle, particularly:

- Unit HV06: Inspect Motor Vehicles
- Unit HV13: Diagnose and Rectify Motor Vehicle Transmission and Driveline System Faults.

Essential resources

Learners will need access to a range of transmission types (clutches, gearboxes and driveline/final drives) and their components for this unit. A variety of information and data sources specific to transmission systems will also be required. The necessary special tools and equipment will be needed for learners to carry out the investigations and routine maintenance operations on the selected transmission systems as defined in the unit content and grading criteria.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Denton T — *Advanced Automotive Fault Diagnosis* (Butterworth-Heinemann, 2006) ISBN 9780750669917

Heisler H — *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002) ISBN 9780750651318

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Nunney M J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Self-managers	organising time and resources and prioritising actions when inspecting and carrying out maintenance on vehicle transmission systems anticipating and managing risks relating to the inspection and maintenance of a vehicle's transmission system

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to vehicle transmission systems
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others when carrying out inspection and maintenance of vehicle transmission systems

Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	explaining the function and operation of heavy vehicle transmission systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and interpreting manufacturers' maintenance and service procedures
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the function and operation of heavy vehicle transmission systems

Unit 17: Heavy Vehicle Steering and Suspension Systems, Wheels and Tyres

Unit code: Y/502/5909

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to give learners knowledge of the construction and operation of a range of heavy vehicle steering systems, suspension layouts, wheels and tyres, enabling them to carry out inspection and fault finding on these systems.

Unit introduction

This unit covers vehicle steering and suspension systems, their principal components and operating principles. This includes a detailed examination of the steering system including hydraulic power assistance, a variety of suspension layouts currently used on heavy vehicles, such as the leaf, rubber and pneumatic suspension systems.

Learners will be introduced to the range of heavy vehicle body designs and types used to meet the diverse and varying operational conditions experienced by goods vehicles and passenger carrying vehicles.

Finally, learners will carry out tests and checks to identify steering and suspension system faults such as failure of power assistance or excessive tyre wear. Learners will use these tests and checks, together with the legal requirements relating to the class of vehicle, to identify the means of maintaining the vehicle’s roadworthiness, including the maintenance requirements relating to driver/passenger safety and component reliability.

Learning outcomes

On completion of this unit a learner should:

1 Know the construction and operation of heavy vehicle manual and power-assisted steering systems

2 Know the types of heavy vehicle body design and suspension systems

3 Understand the construction, design and legal requirements for heavy vehicle wheels and tyres

4 Be able to carry out maintenance procedures on a heavy vehicle’s steering and suspension systems.

Unit content

1 **Know the construction and operation of heavy vehicle manual and power-assisted steering systems**

Manual steering system operation: single and twin steer axles eg all connective linkage and geometry to obtain true rolling when cornering; rear axle steering systems applied to large heavy vehicles; steering systems on articulated passenger vehicles; application of Ackerman steering principles to large vehicles; effects of imposed loads on the steering compliance when cornering; effects of load on the accuracy of steering settings

Manual steering components: steering boxes eg recirculating ball, hour glass worm and roller; steering linkage on single and twin steering systems eg drag links, track rods, drop arms, ball joints, king pins and bushes; steering wheels and columns eg use of universal joint to facilitate cab tilting, ergonomic and anthropometrical factors of steering wheel position with or without power-assisted steering

Power-assisted steering system operation: single and twin steer vehicles; integral type power-assisted steering boxes; externally fitted power rams and strut type reaction member; methods employed to apportion assistance eg torsion bar and rotary hydraulic valve, shuttle type, principles underpinning the method of obtaining assistance

Power-assisted steering components: hydraulic pump (position and operation); drive arrangements; pump reservoir; pressure control valves eg pressure relief, flow control; pipes, hoses, seals and gaiters; integral and external power servo rams; filtration; prevention of moisture and dirt ingress eg fluid cleanliness, checking fluid filters and reservoir condition, periodic replacement of hydraulic fluid, bleeding of the system

Steering geometry: non-steer eg wheel alignment requirements of single- and twin-drive axles; steering geometry eg caster, camber, king pin inclination, positive and negative off-set; wheel alignment checks on single and twin steer eg methods used to measure correct alignment between twin steer axles, effects of vehicle loads on the accuracy of the settings

2 Know the types of heavy vehicle body design and suspension systems

Chassis and cab design: rigid and articulated vehicles; trailer systems eg semi and draw bar trailers; axle layouts eg two, three and four axle vehicles; drive arrangements eg twin drive and all wheel drive; body types eg flat bed tankers, refrigerated, box, municipal waste disposal, bus/coach; ergonomics of cab design eg vibration control, instrument positioning, driver controls and facilities

Leaf spring suspension system: springs eg fixed and variable rate, helper springs; centre bolt; bump stops; shackles eg fixed, swinging, shackle pins and bushes; load compensation mechanisms eg balance beam, interactive linkages; transmission of torque; axle location eg use of torque rods, A-frames, Panhard rods, trunnion bearing assemblies; vibration dampers eg function and location, single and double acting telescopic hydraulic dampers; trailing arm suspension; independent suspension eg double wishbone, anti-roll bars; forces acting on suspension members eg reactive and non-reactive systems

Rubber suspension: layout eg configuration of suspension unit to provide energy absorption (positioning in compression and shear); single and multi-axle; methods employed to enable the transmission of braking and driving torque; hub arrangements eg fully floating showing bearing arrangements, pre-packed bearing cassettes; lubrication eg type of lubricants and properties, means to ensure adequate lubricant at the contact faces; sealing methods eg use of lip seals, O-rings, sealing compounds

Pneumatic suspension system: axle layout eg two, three, four or more axles; components eg levelling valves, mechanically and pneumatically operated, air suspension pneumatic circuit components (air springs using involute and rolling diaphragm); axle-lifting equipment eg suspension layout to enable dead axle to be lifted from the road surface, overweight protection, adjustment of trim height; electronic levelling control (ELC) eg electronic levelling sensors, control unit, self-diagnosis

3 Understand the construction, design and legal requirements for heavy vehicle wheels and tyres

Construction of heavy vehicle wheels: wheel rims eg two-piece, three-piece, one-piece (well-based) rims

Tyre construction: tyre type eg radial ply, cross ply, super single tyres, re-cut tyres; tyre inflation valves eg types, remote sensors, position of the valves when fitted to the vehicle; causes and symptoms of defects eg irregular wear patterns, damage to tread, wall and bead region

Design features: operational factors eg ply ratings, load carrying capacities and load rating index, tubed/tubeless tyres, tread patterns and application, tread depths, aspect ratios, inflation pressures

Legal requirements: eg prescribed mixing of tyre construction on large vehicles, fitness for purpose, general condition as prescribed in the legislative source and the vehicle tester's manual

4 Be able to carry out maintenance procedures on a heavy vehicle's steering and suspension systems

Maintenance : removal and refitting of main components; adjustment of main components eg alignment of axles, checking of suspension geometry; servicing/lubrication of main units eg using manufacturers' inspection sheets, awareness of the effects of harsh working environments on the service intervals; personal safety and protection of units against usual hazards during use or repair eg dangers associated with working on air suspension units, overstressing power steering systems during pressure tests; performance tests for the systems eg undertake a manufacturer's test of air suspension or power steering unit; completing report documentation; interpretation of results eg from given data make an interpretation of the systems condition; identification of symptoms and probable causes eg axle mal-alignment, excessive internal leakage in power steering box, failure to self- trim on air suspension, poor handling under load, excessive tyre wear

Repair cycles: preventative and corrective action eg inspection procedures for the different systems (manufacturers' inspection sheets, tester's manual); statutory requirements eg for large goods vehicles (LGV), passenger carrying vehicle (PCV); annual tests eg appreciation of the wear limits imposed on components and systems as stated in the tester's manual, inspection of tyres/wheels and the effects of ply/load index on the plated vehicle weights

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the operation and components of a manual heavy vehicle steering system	M1 compare the constructional details of two different heavy vehicle steering systems	D1 diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's steering system, including wheels and tyres, from given symptoms and data
P2 describe the operation and components of a power-assisted heavy vehicle steering system	M2 compare the constructional details of two different heavy vehicle suspension systems	D2 diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's suspension system, including wheels and tyres, from given symptoms and data.
P3 describe the steering geometry and wheel alignments checks for single and twin steer system	M3 compare two different types of heavy vehicle body construction and layout.	
P4 describe two different types of heavy vehicle chassis and cab designs		

Table continues on next page

Assessment and grading criteria		
P5 describe the principles of operation and components of a heavy vehicle leaf spring suspension system		
P6 describe the principles of operation and components of a heavy vehicle rubber suspension system		
P7 describe the operation and components of a heavy vehicle pneumatic suspension system		
P8 explain the construction, design features and legal requirements of a heavy vehicle wheel and tyre [IE4]		
P9 carry out a maintenance procedure on a heavy vehicle's steering system [SM3, SM4]		
P10 carry out a maintenance procedure on a heavy vehicle's suspension system [SM3, SM4]		
P11 describe a typical repair cycle for each of the systems inspected.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered in the context of learners' chosen areas (for example heavy goods vehicle or passenger vehicle), although a generic approach is also suitable. The term 'maintenance' in this unit is used in a generic way and can be taken to mean either routine maintenance (a regular service) or less routine work (a repair due to a component failure or adjustment to correct a misalignment).

Delivery of this unit would ideally be a balance of theoretical and practical study. Whatever approach is taken should enable learners to develop the knowledge and skills needed to carry out routine heavy vehicle workshop operations and diagnose steering and suspension system faults in an industrial setting. Health and safety should be emphasised whenever learners undertake practical activities.

The learning outcomes could be delivered in the order in which they are listed. In this way, learners will gain knowledge of the function and operating principles of the relevant parts of steering systems, the configuration of heavy vehicle chassis and suspension types and layouts.

For the final learning outcome learners will need access to heavy vehicles and workshop facilities. Delivery of this part of the unit could consist of lectures to introduce the steering/suspension system and likely faults, learner-led research into the maintenance requirements followed by practical application on vehicles in the workshop. Learners should be given opportunities to experience a range of routine maintenance operations in line with those suggested in the unit content.

During practical work, the critical health and safety procedures of each operation need to be emphasised. Learners should be encouraged to recognise and explain these safety aspects during their practical workshop activities to reinforce the importance to themselves and to others.

The use of a record of practical work carried out should be standard practice. This is likely to be in the form of a workshop logbook. This will enable learners to capture and reflect on their experience and will provide support and guidance during the activities chosen for the final assessment.

Note that the use of 'eg' in the content is to give an indication and an illustration of the breadth and depth of the area of topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, scheme of work and method of assessment – explain the construction and principles of operation of manual steering systems – explain the function and construction of manual steering system components – explain the construction and principles of operation of power assisted steering systems – explain the function and construction of power assisted steering system components – explain the construction and operation of steering geometry ***Practical workshop activities:*** – practical investigation of steering systems and system components
Prepare for and carry out Assignment 1: Heavy Vehicle Steering Systems (P1, P2, P3, M1)
Whole-class teaching: – describe the different types of heavy vehicle body design and the differences between them – explain the construction and principles of operation of a heavy vehicle leaf spring suspension system – describe the main components of a heavy vehicle leaf spring suspension system – explain the construction and principles of operation of a heavy vehicle rubber suspension system – describe the main components of a heavy vehicle rubber suspension system – explain the construction and principles of operation of a heavy vehicle pneumatic suspension system – describe the main components of a heavy vehicle pneumatic suspension system ***Practical workshop activities:*** – practical investigation of suspension systems and system components
Prepare for and carry out Assignment 2: Heavy Vehicle Chassis and Cab Design (P4, M3)
Prepare for and carry out Assignment 3: Heavy Vehicle Suspension Systems (P5, P6, P7, M2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – describe the different types of heavy vehicle wheel construction – describe the construction of different types of heavy vehicle tyre and inflation valves – explain the causes and effects of defects in heavy vehicle wheels and tyres – describe the operational factors that affect the design of heavy vehicle tyres – describe the relevant legal requirements that relate to heavy vehicle wheels and tyres ***Practical workshop activities:*** – practical investigation of heavy vehicle wheels and tyres
Prepare for and carry out Assignment 4: Heavy Vehicle Wheels and Tyres (P8)
Whole-class teaching/demonstration: – describe the health and safety procedures that need to be followed when carrying out maintenance on vehicle steering and suspension systems – explain and demonstrate the processes used for the removal, refitting and adjustment of steering and suspension components – demonstrate performance testing, the completion of relevant documentation and explain the interpretation of results – describe the symptoms and probable causes of defects in steering and suspension systems – describe the preventative and corrective action that may be required for steering and suspension systems including annual testing and statutory requirements ***Practical workshop activities:*** – practise and use of maintenance procedures on heavy vehicle steering and suspension systems
Prepare for and carry out Assignment 5: Heavy Vehicle Steering and Suspension Systems Maintenance (P9, P10, P11, D1, D2)
Feedback to learners, unit evaluation and close

Assessment

A range of assessment methods can be used for this unit and evidence can be collected from a combination of activities/assignments, investigative projects and practical work.

Short tests can be used for the summative assessment of learners' knowledge or practical skills. These could comprise of short-answer questions or set-piece workshop tasks that enable learners to demonstrate specific aspects of the required practical skills (for example steering alignment). A variety of assessment strategies should be used to give learners with differing learning styles the opportunity to demonstrate their full ability and to add diversity to the subject.

Learners should be encouraged to research and use a range of resource materials during their investigations. However, tutors should provide guidance on how material can be referenced without infringing guidelines on authentic evidence, for example annotation of images, diagrams used to support/clarify their own text.

To achieve a pass, learners will need to describe the operation and components of a manual heavy vehicle steering system (P1) and a power-assisted heavy vehicle steering system (P2).

For P3, learners will need to describe the steering geometry and wheel alignment checks on single and twin steering systems.

Two different and contrasting vehicle chassis and cab designs should be used for P4, for example the draw bar and articulated vehicle combinations.

Learners will need to describe the operation and construction of suspension systems using leaf springs (P5), rubber (P6) and pneumatics (P7). Evidence for these criteria will also need to include descriptions of the relevant components.

For P8, learners should explain the construction, design features and legal requirements of wheels and tyres used on heavy vehicles.

For P9 and P10, learners need to carry out practical maintenance activities preferably on live heavy vehicle systems. For P11, they will need to describe a typical repair cycle for the steering and suspension systems inspected (for example checking fluid levels and operational pressures in hydraulic power-assisted system, checking steering system for excess wear in pins and bushes and rectifying accordingly).

A suitable steering and suspension system fault may need to be simulated for P9 and P10 and learners given the typical symptoms of the fault, as would be reported by a driver of the faulty vehicle. Evidence for these criteria is likely to be in three parts – a written inspection record that learners complete at the time of the inspection, a verbal report back to the supervisor/customer (tutor record of oral questioning/observation) and tutor observation of the process (for example use of logical and efficient diagnostic techniques, safe working).

Criteria P1 and P2 can be assessed together and linked through an additional task to M1, which would require learners to compare and contrast two different steering systems used on heavy vehicles. This can also be linked to some extent with P3 with respect to turning circles and steering geometry.

P4, dealing with heavy vehicle chassis layouts and cab designs, may be best covered as a piece of personal research, such as a project or presentation given to a group of peers. This would also offer opportunities for learners to achieve M3.

Criteria P5, P6 and P7 all relate to suspension types used on heavy vehicles and are best assessed together and can be linked to M2.

To achieve a distinction, learners need to diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's steering system, including wheels and tyres, from given symptoms and data (D1). They will also need to analyse the cause and effects of defects, wear and maladjustment in a heavy vehicle's suspension system (D2). Evidence for these criteria will draw on knowledge gained through the pass and merit criteria.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1	Heavy Vehicle Steering Systems	A technician needs to describe the construction and operation of heavy vehicle steering systems to a new apprentice	A written report
P4, M3	Heavy Vehicle Chassis and Cab Design	A technician needs to describe different types of heavy vehicle cab and chassis design to a new apprentice	A written report or oral/ visual presentation
P5, P6, P7, M2	Heavy Vehicle Suspension Systems	A technician needs to describe the construction and operation of heavy vehicle suspension systems to a new apprentice	A written report or oral/ visual presentation
P8	Heavy Vehicle Wheels and Tyres	A technician needs to explain the construction of heavy vehicle wheels and tyres to a new apprentice	A written report
P9, P10, P11, D1, D2	Heavy Vehicle Steering and Suspension Systems Maintenance	A technician needs to carry out maintenance on a heavy vehicle's steering and suspension systems and report to the customer the required repair procedure	A practical assignment evidenced by inspection records and tutor observation

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Heavy Vehicle Braking Systems

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Heavy Vehicle, particularly:

- Unit HV06: Inspect Vehicles
- Unit HV08: Diagnose and Rectify Motor Vehicle Chassis System Faults.

Essential resources

Learners will need access to a range of steering and suspension components and a variety of information and data sources specific to the steering and suspension systems covered. Specialist tools and equipment will be needed for learners to carry out investigations and routine maintenance operations.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Heisler H — *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002) ISBN 0750651318

Nunney M J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to the legal requirements of heavy vehicle wheels and tyres, judging its relevance and value
Self-managers	organising time and resources and prioritising actions when carrying out maintenance procedures on heavy vehicle steering, and suspension systems anticipating, taking and managing risks when carrying out maintenance procedures on heavy vehicle steering, and suspension systems

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with other when working as a group in carrying out maintenance procedures on heavy vehicle steering and suspension systems

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Functional Skills — Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing the basic principles of operation/construction and components of heavy vehicle suspension and steering systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the principles of operation/construction and components of heavy vehicle suspension and steering systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the basic principles of operation/construction and components of heavy vehicle suspension and steering systems

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Unit 18: Mathematics for Engineering Technicians

Unit code: A/600/0253

Level 3: BTEC Level 3 qualification

Credit value: 10

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to give learners a strong foundation in mathematical skills, which will help them to successfully complete many of the other units within the qualification.

Unit introduction

One of the main responsibilities of an engineer is to solve problems quickly and effectively. This unit will enable learners to solve mathematical, scientific and associated engineering problems at technician level.

This unit enables learners to build on knowledge gained at GCSE or BTEC Level 2 Diploma level and use it in a more practical context for their chosen discipline. Learning outcome 1 will develop learner knowledge and understanding of algebraic methods, from a look at the use of indices in engineering to the use of the algebraic formula for solving quadratic equations. Learning outcome 2 involves the introduction of the radian as another method of angle measurement, the shape of the trigonometric ratios and the use of standard formulae to solve surface areas and volumes of regular solids. Learning outcome 3 requires learners to represent statistical data in a variety of ways and calculate the mean, median and mode. Finally, learning outcome 4 is intended as a basic introduction to the arithmetic of elementary calculus.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use algebraic methods

2 Be able to use trigonometric methods and standard formula to determine areas

3 Be able to use statistical methods to display data

4 Be able to use elementary calculus techniques

Unit content

1 Be able to use algebraic methods

Indices and logarithms: laws of indices ($a^m \times a^n = a^{m+n}$, $\frac{a^m}{a^n} = a^{m-n}$, $(a^m)^n = a^{mn}$), laws of logarithms ($\log A + \log B = \log AB$, $\log A^n = n \log A$, $\log A - \log B = \log \frac{A}{B}$) eg common logarithms (base 10), natural logarithms (base e), exponential growth and decay

Linear equations and straight line graphs: linear equations eg $y = mx + c$; straight line graph (coordinates on a pair of labelled Cartesian axes, positive or negative gradient, intercept, plot of a straight line); experimental data eg Ohm's law, pair of simultaneous linear equations in two unknowns

Factorisation and quadratics: multiply expressions in brackets by a number, symbol or by another expression in a bracket; by extraction of a common factor eg $ax + ay$, $a(x + 2) + b(x + 2)$; by grouping eg $ax - ay + bx - by$; quadratic expressions eg $a^2 + 2ab + b^2$; roots of an equation eg quadratic equations with real roots by factorisation, and by the use of formula

2 Be able to use trigonometric methods and standard formula to determine areas

Circular measure: radian; degree measure to radians and vice versa; angular rotations (multiples of π radians); problems involving areas and angles measured in radians; length of arc of a circle ($s = r\theta$); area of a sector ($A = ½ r^2\theta$)

Triangular measurement: functions (sine, cosine and tangent); sine/cosine wave over one complete cycle; graph of tanA as A varies from 0° and 360° ;tanA = sin A/cosA; values of the trigonometric ratios for angles between 0° and 360°; periodic properties of the trigonometric functions; the sine and cosine rule; practical problems eg calculation of the phasor sum of two alternating currents, resolution of forces for a vector diagram

Mensuration: standard formulae to solve surface areas and volumes of regular solids eg volume of a cylinder = $\pi r^2 h$, total surface area of a cylinder = $2\pi rh + \pi r^2$, volume of sphere = $\frac{4}{3} \pi r^3$, surface area of a sphere = $4 \pi r^2$, volume of a cone = $\frac{1}{3} \pi r^2 h$, curved surface area of cone = $\pi r \times$ slant height

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3 Be able to use statistical methods to display data

Data handling: data represented by statistical diagrams eg bar charts, pie charts, frequency distributions, class boundaries and class width, frequency table; variables (discrete and continuous); histogram (continuous and discrete variants); cumulative frequency curves

Statistical measurement: arithmetic mean; median; mode; discrete and grouped data

4 Be able to use elementary calculus techniques

Differentiation: differential coefficient; gradient of a curve $y = f(x)$; rate of change; Leibniz notation ($\frac{dy}{dx}$); differentiation of simple polynomial functions, exponential functions and sinusoidal functions; problems involving evaluation eg gradient at a point

Integration: integration as reverse of differentiating; basic rules for simple polynomial functions, exponential functions and sinusoidal functions; indefinite integrals; constant of integration; definite integrals; limits; evaluation of simple polynomial functions; area under a curve eg $y = x(x - 3)$, $y = x^2 + x + 4$

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 manipulate and simplify three algebraic expressions using the laws of indices and two using the laws of logarithms	M1 solve a pair of simultaneous linear equations in two unknowns	D1 apply graphical methods to the solution of two engineering problems involving exponential growth and decay, analysing the solutions using calculus
P2 solve a linear equation by plotting a straight-line graph using experimental data and use it to deduce the gradient, intercept and equation of the line	M2 solve one quadratic equation by factorisation and one by the formula method.	D2 apply the rules for definite integration to two engineering problems that involve summation.
P3 factorise by extraction and grouping of a common factor from expressions with two, three and four terms respectively		
P4 solve circular and triangular measurement problems involving the use of radian, sine, cosine and tangent functions		
P5 sketch each of the three trigonometric functions over a complete cycle		

Assessment and grading criteria		
P6 produce answers to two practical engineering problems involving the sine and cosine rule		
P7 use standard formulae to find surface areas and volumes of regular solids for three different examples respectively		
P8 collect data and produce statistical diagrams, histograms and frequency curves [IE4]		
P9 determine the mean, median and mode for two statistical problems and explain the relevance of each average as a measure of central tendency [IE4]		
P10 apply the basic rules of calculus arithmetic to solve three different types of function by differentiation and two different types of function by integration.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

Before starting this unit, learners should be able to demonstrate proficiency in basic mathematical concepts and in the use of an electronic scientific calculator to carry out a variety of functions.

The learning outcomes are ordered logically and could be delivered sequentially. Learners need to be able to use algebraic methods before further skills can be developed and used within the unit. Much of learning outcome 1 can be practised in pure mathematical terms, however tutors could emphasise where these methods would be applied in an engineering context. Obviously a large amount of practise in these methods will prove a valuable foundation for the rest of the unit.

Once learners have mastered most of these methods, learning outcome 2 provides opportunities to apply these skills when solving circular and triangular measurement problems. The application of these skills should reflect the context/area of engineering that learners are studying. Formulae do not need to be remembered but correct manipulation of the relevant formulae is very important in solving these problems. Learners should have plenty of practise when drawing graphs for learning outcome 1 and sketching trigonometric functions in learning outcome 2.

During delivery of this unit there should be opportunities for learners to use statistical data that they have collected from engineering contexts or situations. It is much better to put statistics, required by learning outcome 3, in an engineering context than use generalities such as learners' height, etc.

Again, for learning outcome 4 learners must have opportunities to practise differentiation and integration to ensure they understand these activities within the range of the content and before they are given assessment activities. The range of these calculus techniques are listed within the content.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

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Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching:
– introduction to the unit content, scheme of work and assessment strategy
– discuss the laws of indices giving examples of each and define a logarithm to any base followed by an explanation of how to convert a simple indicial relationship into a logarithmic relationship and vice versa
– define a common logarithm and show how to work out common logarithms with a calculator (using log key) then lead into sketching the graph of a common logarithmic function
Individual learner activity:
– tutor-led exercises on the solution of problems involving common logarithms
Whole-class teaching:
– define a natural (Naperian) logarithm and explain how to use a calculator to evaluate a natural logarithm (using 1n key)
– lead the class in sketching the natural logarithmic graph and develop the laws of logarithms with reference to the laws of indices
– discuss the relationship between common logarithms and natural logarithms
Individual learner activity:
– tutor-led exercises on the use of logarithms and their laws to evaluate expressions in science and technology
Whole-class teaching:
– recall the basic rules of transposition and explain how to solve simple linear equations before showing how a linear equation can be represented by a straight graph
– explain the significance of the gradient (negative and positive) and intercept for the straight line law and then lead the class in the choice of suitable scales and plotting graphs from given data
Whole-class teaching:
– recap last week's work on straight line graphs and demonstrate the importance of application of straight line law to experimental data
Individual learner activity:
– tutor-led exercises in plotting straight line graphs and applying straight line law to experimental data

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – demonstrate how to solve a pair of simultaneous linear equations in two unknowns using elimination and substitution and then show how equations can be formed as a result of an engineering application (eg Kirchhoff's Laws) – explain how to solve a pair of simultaneous linear equations in two unknowns using the graphical method – explain and demonstrate how to factorise expressions containing two, three and four terms by extraction of a common factor and grouping ***Individual learner activities:*** – tutor-led exercises in the solution of simultaneous equations – tutor-led exercises in graphical solution of simultaneous equations – learner activity involving factorisation of different types of expression ***Whole-class teaching:*** – explain factorisation of a quadratic expression and develop to find roots of a quadratic equation – explain and demonstrate the formula method of solving quadratic equations ***Individual learner activities:*** – tutor-led exercises in the solution of quadratic equations by factorisation – tutor-led exercises in the solution of quadratic equations by using the formula
Preparation for and carrying out Assignment 1: Algebraic Methods (P1, P2, P3, M1, M2)
Whole-class teaching: – define a radian and explain the relationship between radian and degree, then show how to convert radians to degrees and vice versa – demonstrate angular rotations and show how to solve problems involving areas and angles measured in radians – revise trigonometrical ratios (sine, cosine and tangent) and explain the use of a calculator to find different values in degrees and radians – explain the use of a calculator to construct a table of values from 0° to 360° (2π) for each of the three functions. Plot graphs of the three functions and demonstrate the use of graphs in evaluation of values of trigonometric ratios for angles between 0° to 360° ***Individual learner activities:*** – tutor-led solutions of problems involving radians – tutor-led solution of problems involving functions (sine, cosine and tangent) – tutor-led solution of evaluation of values of trigonometric ratios between 0° to 360°

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – review previous weeks' work and summarise values of sine, cosine and tangent values (4 quadrant diagrams) then compare features of the three functions (periodic properties) – explain the use of the sine rule and conditions for solving non right- angled triangles. ***Individual learner activities:*** – tutor-led solution of problems on triangular measurement. – tutor-led solution of practical problems (electrical and mechanical) involving the sine rule ***Whole-class teaching:*** – explain the use of the cosine rule and conditions for use (eg where sine rule cannot be used) – explain and demonstrate the use of standard formulae to solve problems involving surface areas and volumes of regular solids. ***Individual learner activities:*** – tutor-led solution of practical problems (electrical and mechanical) involving just the cosine rule and then the use of both the sine and cosine rule together – tutor-led solution of problems on mensuration.
Preparation for and carrying out Assignment 2: Trigonometric Methods and Standard Formulae (P4, P5, P6, P7)
Whole-class teaching: – explain and demonstrate how statistical information can be displayed – explain and demonstrate evaluation of mean, median and mode for discrete data – explain and demonstrate evaluation of mean, median and mode for grouped data. ***Individual learner activities:*** – tutor-led solution of problems on data collection – tutor-led evaluation of problems involving mean, median and mode for discrete data – tutor-led evaluation of problems involving mean, median and mode for grouped data.
Preparation for and carrying out Assignment 3: Statistical Methods (P8, P9)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain and introduce differentiation as a measure of the gradient by evaluating various gradients on straight lines and curves. – introduce the idea of rate of change and explain the notation followed by an introduction of the general rule for differentiation and demonstration of use on simple algebraic functions – review the general rule for differentiation of simple polynomial functions and introduce and demonstrate the rules for exponential and sinusoidal functions. ***Individual learner activities:*** – tutor-led differentiation of simple algebraic functions. – tutor-led differentiation of exponential and sinusoidal functions.
Whole-class teaching: – consolidate all differential coefficients considered so far and explain and demonstrate valuation to find gradients and rates of charge – explain and introduce the basic rules for integration, the idea of indefinite integration and the constant of integration ***Individual learner activities:*** – tutor-led evaluation of problems involving all functions (polynomial, exponential and sinusoidal) using graphical and checking by differentiating. – tutor-led solution of problems on integration of simple polynomial, exponential and sinusoidal functions ***Whole-class teaching:*** – introduce definite integration as indefinite integration with the addition of limits. – demonstrate the evaluation of simple polynomial functions and show how integration can be used to evaluate the area under a curve. ***Individual learner activities:*** – revision documentation on differentiation and integration – tutor-led evaluation of problems on definite integration.
Preparation for and carrying out Assignment 4: Calculus Techniques (P10, D1, D2)
Feedback on assessment, unit evaluation and close

Assessment

The assessment strategy used will need to cover all the learning outcomes and associated pass criteria but not necessarily all the topics included in the unit content.

Criterion P1 may be best assessed in the form of a short written test which could possibly also include criterion P3.

P2 could be assessed through an assignment using data from *Unit 6: Electrical and Electronic Principles for Vehicle Technology*, which ideally would be delivered concurrently with this unit. If this is not possible, learners should be given a range of data sufficient for them to plot the graph and work out the gradient, intercept and the equation. Data forcing them to draw the line of best fit, as opposed to a set of points directly on the graphical line, might be most appropriate.

For P4, learners could be given a range of different values and assessed by an assignment or a short formal test. The problems given should collectively cover radian, sine, cosine and tangent functions. When considering the content part of this learning outcome it is important that these problems give the learner the opportunity to convert multiples of π radians to degrees and vice versa. The circular measurement problems also need to cover the length of an arc and area of a sector as well as areas and angles measured in radians. Obviously the triangular measurement problems are more basic and only expect application of the three functions.

P5 requires learners to sketch each of the three trigonometric ratios and this is probably best done as a classroom exercise. Similarly, P6 could take the form of a written assignment where learners must produce answers to two practical engineering problems involving the sine and cosine rule (for example calculate the phasor sum of two alternating currents and evaluate the resultant and the angle between two forces).

Criterion P7 requires learners to calculate the surface areas and volumes for three different regular solids. This could be achieved through an assignment or perhaps by combining it with other criteria in a short formal test.

An assignment could be used for P8 where learners collect meaningful data (for example classification of workers within their company) and display this information using different graphical methods (for example bar charts). They also need to produce a histogram and plot frequency curves (for example resistance values of 100 resistors or external diameter of pins).

For P9, learners must provide evidence that they are able to determine and then explain the relevance of the mean, median and mode for a set of discrete and grouped data (for example time taken to produce components on a machine rounded to the nearest ten seconds and the 100 resistor values or diameters of pins from P8). This could be done by an assignment. P10 may be assessed through a short formal test, with learners being given a list of the standard differential coefficients and integrals to use.

For M1, learners will need to provide evidence that they can solve a pair of simultaneous linear equations in two unknowns (for example equations formed after the application of Kirchhoff’s laws, power transmitted for different belt tensions in a mechanical system). It would be appropriate to use the same assessment method and instrument as P2, possibly combining these two criteria as one assessment activity.

M2 could also be assessed by assignment as it requires learners to evaluate the roots of a quadratic equation by factorisation and by the formula method (for example evaluation of an equation formed after the realisation of a practical situation).

Both the distinction criteria could be assessed through a written assignment. For D1, learners need to apply graphical methods to the solution of two engineering problems involving exponential growth and decay (for example growth of voltage in a capacitor, radioactive decay, application of Taylor's tool life equation $C = VT^n$) and then analyse the results by applying the appropriate method of differential calculus to check the results.

D2 requires learners to demonstrate that they can accurately evaluate two engineering problems involving definite integration (for example area under a velocity-time graph, area under a voltage-current graph).

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.

Criteria covered	Assignment Title	Scenario	Assessment Method
P1, P2, P3, M1, M2	Algebraic Methods	A written activity requiring learners to complete five tasks, one for each of the criteria.	A report containing written solutions to each of the five tasks carried out under controlled conditions.
P4, P5, P6, P7	Trigonometric Methods and Standard Formulae	A written activity requiring learners to use trigonometric methods and standard formula to determine areas and volumes.	A report containing the results of calculations, and graphic evidence to support the use of trigonometric methods and standard formula for the determination of areas and volumes.
P8, P9	Statistical Methods	A written activity requiring learners to collect and display data using different graphical methods, and also evaluate the mean, median and mode for a set of discrete and grouped data.	A report containing bar charts, pie charts and the results of calculations to determine the mean, median and mode for a set of discrete and grouped data.

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Criteria covered	Assignment Title	Scenario	Assessment Method
P10, D1, D2	Calculus Techniques	A written activity requiring learners to produce calculations, graphical solutions and analysis to demonstrate use of calculus techniques.	A report containing the solutions to calculations, graphs and analysis of several calculus techniques. Carried out under controlled conditions.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Mathematics for Engineering Technicians	Electrical and Electronic Principles
		Mechanical Principles and Applications
		Advanced Mechanical Principles and Application
		Further Mathematics for Technicians

Essential resources

Learners will need to possess an electronic scientific calculator and have access to software packages that support understanding of the principles and their application to engineering.

Employer engagement and vocational contexts

There is a range of organisations that may be able to help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI-University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Bird J — *Engineering Mathematics* (Elsevier Science & Technology, 2007) ISBN 9780750685559
Fuller A, Greer A, Taylor G. W, *BTEC Level 3 Qualification Mathematics for Technicians*, (Nelson Thomas, 2004) ISBN 9780748779499

Tooley M and Dingle L — *BTEC Level 3 Qualification Engineering, Second Edition* (Elsevier Science & Technology, 2007) ISBN 9780750685214

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Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating statistical information, judging its relevance and value.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	trying out alternatives or new solutions to mathematics problems
Reflective learners	reviewing progress when solving problems during the their activities and acting on the outcomes to make corrections to understanding/solutions
Team workers	collaborating with others when working on investigative group work to achieve a valid solution
Self-managers	organising time and resources, prioritising actions

Functional Skills — Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical and mechanical problems set within engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical and mechanical situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical/mechanical problems in engineering
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical and mechanical problems to evaluate their effectiveness and reality at each stage of the calculation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of mathematical concepts and issues in engineering
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate mathematical data sources to solve engineering problems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	taking notes and solving engineering mathematical problems to communicate accurate solutions effectively

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Unit 19: Properties and Applications of Engineering Materials

Unit code: R/600/0260

Level 3: BTEC Level 3 qualification

Credit value: 10

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to give learners the opportunity to extend their knowledge of engineering materials, their properties and applications.

Unit introduction

In-depth knowledge of the structure and behaviour of engineering materials is vital for anyone who is expected to select or specify them for applications within the engineering industry. This unit will give learners an understanding of the structures, classifications and properties of materials used in engineering and will enable them to select materials for different applications.

The unit is appropriate for learners engaged in manufacturing and mechanical engineering, particularly where materials are sourced in the form of stock to be used in a production process. The unit covers a range of materials, some of which learners may not be familiar with initially.

This unit will enable learners to identify and describe the structure of metals, polymers, ceramics and composites and classify them according to their properties. Learners will also be able to describe the effects of processing on the behaviour of given materials. Smart materials whose properties can be altered in a controlled fashion through external changes — such as temperature and electric and magnetic fields — are also covered.

Learners will apply their understanding of the physical and mechanical properties of materials, design requirements, cost and availability to specify materials for given applications.

All materials have limits beyond which they will fail to meet the demands placed on them. The common modes of failure will be both demonstrated and described to enable learners to recognise where an informed choice can make the difference between the success or failure of a product.

Learning outcomes

On completion of this unit a learner should:

1 Know the structure and classification of engineering materials

2 Know material properties and the effects of processing on the structure and behaviour of engineering materials

3 Be able to use information sources to select materials for engineering uses

4 Be able to test engineering materials

Unit content

1 **Know the structure and classification of engineering materials**

Atomic structure: element; atom eg nucleus, electron; compound; molecule; mixture; bonding mechanisms eg covalent, ionic, metallic

Structure of metals: lattice structure; grain structure; crystals; crystal growth; alloying eg interstitial, substitutional; phase equilibrium diagrams eg eutectic, solid solution, combination; intermetallic compounds

Structure of polymeric materials: monomer; polymer; polymer chains eg linear, branched, cross-linked; crystallinity; glass transition temperature

Structure of ceramics: amorphous; crystalline; bonded

Structure of composites: particulate; fibrous; laminated

Structure of smart materials: crystalline; amorphous; metallic

Classification of metals: ferrous eg plain carbon steel, cast iron (grey, white, malleable, wrought iron), stainless and heat-resisting steels (austenitic, martensitic, ferritic); non-ferrous eg aluminium, copper, gold, lead, silver, titanium, zinc; non-ferrous alloys eg aluminium-copper heat treatable – wrought and cast, non-heat-treatable – wrought and cast, copper-zinc (brass), copper-tin (bronze), nickel-titanium alloy

Classification of non-metals (synthetic): thermoplastic polymeric materials eg acrylic, polytetrafluoroethylene (PTFE), polythene, polyvinyl chloride (PVC), nylon, polystyrene; thermosetting polymeric materials eg phenol-formaldehyde, melamine-formaldehyde, urea-formaldehyde; elastomers; ceramics eg glass, porcelain, cemented carbides; composites eg laminated, fibre reinforced (carbon fibre, glass reinforced plastic (GRP), concrete, particle reinforced, sintered; smart materials eg electro-rheostatic (ER) fluids, magneto-rheostatic (MR) fluids, piezoelectric crystals

Classification of non-metals (natural): eg wood, rubber, diamond

2 **Know material properties and the effects of processing on the structure and behaviour of engineering materials**

Mechanical properties: strength (tensile, shear, compressive); hardness; toughness; ductility; malleability; elasticity; brittleness

Physical properties: density; melting temperature

Thermal properties: expansivity; conductivity

Electrical and magnetic properties: conductivity; resistivity; permeability; permittivity

Effects of processing metals: recrystallisation temperature; grain structure eg hot working, cold working, grain growth; alloying elements in steel eg manganese, phosphorous, silicon, sulphur, chromium, nickel

Effects of processing thermoplastic polymers: polymer processing temperature; process parameters eg mould temperature, injection pressure, injection speed, mould clamping force, mould open and closed time

Effects of processing thermosetting polymers: process parameters eg moulding pressure and time, mould temperature, curing

Effects of processing ceramics: eg water content of clay, sintering pressing force, firing temperature

Effects of processing composites: fibres eg alignment to the direction of stress, ply direction; de-lamination; matrix/reinforcement ratio on tensile strength; particle reinforcement on cermets

Effects of post-production use: smart materials eg impact (piezoelectric), electric field (electro-rheostatic), magnetic field (magneto-rheostatic), temperature (shape memory alloys), colour change (temperature or viscosity)

3 Be able to use information sources to select materials for engineering uses

Information sources: relevant standard specifications eg British Standards (BS), European Standards (EN), International Standards (ISO); material manufacturer and stockholder information eg data sheets, catalogues, websites, CD ROMs

Design criteria: properties eg mechanical, physical, thermal, electrical and magnetic; surface finish; durability eg corrosion resistance, solvent resistance, impact resistance, wear resistance

Cost criteria: initial cost eg raw material, processing, environmental impact, energy requirements; processing eg forming, machining, casting, joining (thermal, adhesive, mechanical); quantity; mode of delivery eg bulk, just-in-time (JIT); recycling

Availability criteria: standard forms eg sheet and plate, bar-stock, pipe and tube, sectional, extrusions, ingots, castings, forgings, pressings, granular, powder, liquid

4 Be able to test engineering materials

Principles of ductile and brittle fracture: effects of gradual and impact loading eg tensile, compressive, shear; effects of grain size; transition temperature; appearance of fracture surfaces

Principles of fatigue: cyclic loading; effects of stress concentrations eg internal, external; effects of surface finish; appearance of fracture surfaces

Principles of creep: primary; secondary; tertiary; effects of temperature; strain versus time curve; creep limit; effect of grain size; effect of variations in the applied stress

Tests: destructive eg tensile, hardness, impact, ductility, fatigue, creep; non-destructive eg dye penetrant, ultrasonic, radiographic (x-ray, gamma ray), magnetic powder, visual

Degradation processes: on metals eg oxidation, erosion, stress corrosion; on polymers eg solvent attack, radiation and ageing; on ceramics eg thermal shock, sustained high temperature

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the structure (including the atomic structure) of a given metal, polymer, ceramic, composite and smart material	M1 explain how the properties and structure of different given engineering materials affect their behaviour in given engineering applications	D1 justify your selection of an engineering material for one given application describing the reasons the selection meets the criteria
P2 classify given engineering materials as either metals or non-metals according to their properties	M2 explain how one destructive and one non-destructive test procedure produces useful results	D2 evaluate the results of one test procedure.
P3 describe mechanical, physical, thermal and electrical and magnetic properties and state one practical application of each property in an engineering context	M3 explain how two given degradation processes affect the behaviour of engineering materials.	
P4 describe the effects on the properties and behaviour of processing metals, polymers, ceramics and composites and of post-production use of smart materials		

Table continues on next page

Assessment and grading criteria		
P5 use information sources to select a different material for two given applications, describing the criteria considered in the selection process [IE1, IE4]		
P6 describe the principles of the modes of failure known as ductile/brittle fracture, fatigue and creep		
P7 perform and record the results of one destructive and one non-destructive test method using one metal and one non-metallic material		
P8 describe a different process of degradation associated with each of metals, polymers and ceramics.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Ideally, this unit would be delivered using a combination of practical demonstrations and investigative assignments.

To enable learners to understand both the mechanical and physical properties of engineering materials, workshop-based tests can be used to demonstrate the properties in a practical context. As an example, the differing effects of hot and cold working on the properties of copper and carbon steel can be demonstrated by lightly hammering specimens of both metals. By comparing the effort required to bend the cold-worked and untreated specimens, learners will gain first-hand experience of the effects of work hardening. If the specimens are then heat treated and cooled at different rates the results should provide evidence that can be evaluated during classroom-based theory sessions.

Delivery of the structure and properties of materials could be related to applications learners are familiar with, providing flexibility in terms of the sources of evidence used to satisfy the grading criteria.

Tutors should ensure that learners are aware of the hazards and safe working practices associated with the use of heating equipment and common hand tools before supervising practical activities.

The learning outcomes are designed to be integrated across a range of assignments. For employed learners, assignments could be designed to reflect aspects of their work. The use of industrial visits can also be used to enhance learners' knowledge of the processes carried out by local companies.

Centres should have access to an appropriate range of specialist equipment to allow learners to perform both destructive and non-destructive tests. Learners will require instruction in the safe operation of this equipment. Radiographic and ultrasonic tests may not be readily available; however, if they are known to exist within a local industrial setting, centres may wish to arrange visits to enable learners to gain further experience.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content – describe and discuss atomic structure of elements and bonding mechanisms – outline the periodic table and give a brief description of periodicity – define the range of mechanical, physical, thermal, electrical and magnetic properties as applied to engineering materials – describe and discuss the structure, classification and properties of the range of engineering metals and alloys ***Individual activity:*** – carry out visual and tactile inspection of specimen materials
Whole-class teaching: – describe and discuss the structure, classification and properties of the range of polymers used in engineering – describe and discuss the structure, classification and properties of the range of ceramics used in engineering – describe and discuss the structure, classification and properties of the range of composite materials used in engineering ***Individual activity:*** – carry out visual and tactile inspection of specimen materials
Whole-class teaching: – describe and discuss the structure, classification and properties of the range of smart materials used in engineering – describe and discuss the structure, classification and properties of the range natural non-metallic materials used in engineering ***Individual activity:*** – carry out visual and tactile inspection of specimen materials
Preparation for and carrying out Assignment 1: Structure and Classification of Engineering Materials (P1, P2, P3)

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Topic and suggested assignments/activities and/assessment
Whole-class teaching: – describe and discuss the effects of cold and hot working on metal grain structure – explain re-crystallisation and the effects of the annealing and normalising processes for metals – explain and discuss the hardening, tempering and case hardening of steels – explain and discuss the effects of alloying and impurity elements in steels – explain and discuss precipitation hardening in aluminium alloys ***Individual or small-group activity:*** – carry out research on the processing of given materials and deliver a presentation of findings
Whole-class teaching: – describe and discuss the forming processes for thermoplastics and the processing parameters – describe and discuss the forming processes for thermosetting polymers and the processing parameters – describe and discuss ceramic forming processes and the processing parameters – describe and discuss the forming processes for composite materials and the processing parameters – describe and discuss the effects of post-production use for smart materials ***Individual or small-group activity:*** – carry out research on the processing of given materials and deliver a presentation of findings
Preparation for and carrying out Assignment 2: Properties of Engineering Materials (P4, M1)
Whole-class teaching: – explain and discuss the functions of the British, European and International Standards organisations – describe and discuss design, cost and availability criteria that affect the selection of engineering materials – discuss the use of exemplar manufacturers’ and suppliers’ catalogues and data sheets for engineering materials – demonstrate the use of internet and CD R0M databases for engineering materials ***Individual or small- group activity:*** – select materials to suit given specifications using a range of information sources and deliver a presentation of findings
Preparation for and carrying out Assignment 3: Selection of Engineering Materials (P5, D1)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – describe and discuss the contributory factors that lead to ductile and brittle fracture in engineering materials – describe and discuss the contributory factors that lead to fatigue failure in engineering materials – describe and discuss the contributory factors that lead to creep failure in engineering materials – describe and discuss degradation processes that affect engineering materials ***Individual or small group activity:*** – view failed components and identify possible modes of failure
Preparation for and carrying out Assignment 4: Failure and Degradation of Engineering Materials (P6, P8, M3)
Whole-class teaching: – distinguish between destructive and non-destructive tests – describe and discuss the range of destructive tests – describe and discuss the range of non-destructive tests – demonstrate material testing procedures ***Individual or small-group activity:*** – carry out given tests and analyse test results
Preparation for and carrying out Assignment 5: Testing Engineering Materials (P7, M2, D2)
Feedback on assessment, unit evaluation and close

Assessment

To achieve a pass grade, all the pass criteria must be met. Centres have the option to decide on the number of tasks and the order in which the criteria are covered.

The evidence to satisfy the pass criteria P1, P2 and P3 could be achieved by means of a written assignment following a combination of tutor-led practical and theory sessions and individual research. P2 would require the range of materials given to include at least one ferrous, one non-ferrous, one non-ferrous alloy, one thermoplastic polymer, one thermosetting polymer, an elastomer, one ceramic, one composite, one smart material and one natural material.

Achievement of P4 and M1 could involve learners in both practical and theoretical tasks in which they relate the effects of processing on the properties of materials within real engineering applications. For smart materials they need to consider the effects on the properties of the materials used after production. Examples here may be related to the change in their properties as a result of the effects of external stimuli. For example, when a force is applied to piezoelectric material it produces an electric charge which can be used to trigger a car's airbag in the event of an accident. In many applications the behaviour is reversible for example a colour change in response to a change in temperature or a variation in the viscosity of a liquid in response to the application of an electric or magnetic field. To satisfy P5, it is likely that learners would apply the knowledge gained in meeting criteria P1 to P4. Written responses would satisfy this criterion.

P7 could be met using a combination of practical and research activities involving tutor-led demonstrations of available laboratory tests. Learners could then carry out a series of tests and produce a written record of the test results. A witness statement could confirm learner involvement. Depending on available resources it may be best to carry out the destructive test on the non-metallic material and the non-destructive test on the metallic material. This would allow a wider choice of tests for the latter. To achieve P6 and P8, learners could be given the opportunity to research modes of failure and degradation processes reflected in local conditions for example a marine environment, or, for employed learners, failure and degradation pertinent to their company's products.

To achieve a merit grade, learners will need to explain how the structure and properties of given materials will affect their behaviour in use. Evidence would be best demonstrated by a written task related to the activities carried out to meet P1, P2 and P3. To satisfy M2, learners could produce a written explanation of the test procedures followed in P7 and the usefulness of the results. In producing evidence for some of this criterion it may be appropriate to include the responses to oral questions. However, centres should ensure that questions and learner responses are recorded for verification and also that they are not the sole source of evidence. M3 could be achieved through an extension of the task given for P8. The processes used in the explanation could be selected to meet local conditions or industrial applications.

To achieve D1, learners need to justify their selection of one of the materials used to satisfy P5, giving reasons why other materials considered for the application were not selected. To satisfy D2, learners are expected to complete a written task to evaluate the results of one of the tests used to meet P7 and M2. The evidence would depend on the test used but it could include the mathematical results of a tensile test, the values of a hardness test or detailed information gained from a non-destructive test.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3	Structure and Classification of Engineering Materials	Questions relating to the structure and classification of the range of engineering materials.	A written report containing reasoned answers to the set questions.

Criteria covered	Assignment title	Scenario	Assessment method
P4, M1	Properties of Engineering Materials	Questions relating to the properties and behaviour of engineering materials.	A written report containing reasoned answers to the set questions.
P5, D1	Selection of Engineering Materials	Selection of engineering materials for given applications.	A written report listing selection criteria, information sources and justification for selected materials.
P6, P8, M3	Failure and Degradation of Engineering Materials	Questions relating to the range of failure modes and degradation processes in engineering materials.	A written report containing reasoned answers to the set questions.
P7, M2, D2	Testing Engineering Materials	Carry out and report the results of destructive and non-destructive tests on engineering materials.	A written report containing a description of test procedures and an evaluation of test results.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Selecting Engineering Materials	Engineering Design
		Engineering Primary Forming Processes
		Engineering Secondary/ Finishing Processes

Essential resources

Centres will need a selection of exemplar materials and components for viewing, tactile inspection and discussion. Degraded and failed component specimens will also be of value. Learners will also require access to equipment to conduct at least one destructive and one non-destructive test and related materials as specified in the unit content.

Employer engagement and vocational contexts

Industrial visits would give learners an opportunity to see the processing of different materials and its effects. There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI-University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Darbyshire A — *Mechanical Engineering* (Newnes, 2008) ISBN 9780750686570

Higgins R — *Materials for Engineers and Technicians* (Newnes, 2006) ISBN 0750668504

Timings R L — *Engineering Materials, Volume 1* (Longman, 1998) ISBN 0582319285

Timings R L — *Engineering Materials, Volume 2* (Longman, 2000) ISBN 0582404665

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	using information sources to select a different material for two given applications and describing the criteria considered in the selection process

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	trying out alternative solutions to problems
Reflective learners	inviting feedback and dealing positively with praise, setbacks and criticism
Team workers	part of a small group performing and recording the results of one destructive and one non-destructive test method using one metal and one non-metallic material
Self-managers	organising their time and resources and prioritising actions during assignment work

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Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	using ICT-based information sources to select materials for given applications
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	recording and interpreting the results of material tests
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing and describing material structures, properties and applications
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	investigating and researching the properties and uses of different engineering materials
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing material structures, properties and applications

Unit 20: Fabrication Processes and Technology

Unit code: L/600/0273

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to give learners knowledge of the processes used to safely measure, mark out, cut, form and assemble fabricated structures using sheet metal.

Unit introduction

Fabrication processes and technology are used in the production of metal structures in a wide range of manufacturing industries. The fabrication of metal structures involves four essential stages: measuring and marking out, preparation of the material for fabrication, forming processes and the assembly of the materials.

This unit gives learners with no previous fabrication experience an understanding of the processes and technologies used throughout the fabrication industry, whilst learning to work in a safe environment. The unit is appropriate for work-based learners or for those who are preparing for employment in an industrial environment where fabrication is an integral part of the manufacturing process.

Learners will work with ferrous or non-ferrous metals in the form of sheet, plate and sectional materials to construct a fabricated structure. They will learn how to use a range of industrial hand tools and machinery to complete fabrication tasks. The unit will give learners the ability to identify the correct processes and equipment to use, and the tools and equipment appropriate to each stage of the fabrication process.

Learning outcomes

On completion of this unit a learner should:

1 Know about health and safety legislation, regulations and safe working practices in the fabrication industry

2 Know the processes used to mark out and prepare materials to produce fabricated structures

3 Know how materials are formed and assembled to produce fabricated structures

4 Be able to interpret the specification of a fabricated structure and plan and carry out its manufacture

Unit content

1 **Know about health and safety legislation, regulations and safe working practices in the fabrication industry**

Legislation and regulations: applicable to the fabrication industry eg Health and Safety at Work Act 1974, Employment Act 2002, Factories Act 1961, Fire Precautions Act 1971; regulations eg Management of Health and Safety at Work Regulations 1999, Provision and Use of Work Equipment Regulations 1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Electricity at Work Regulations 1989, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Working Time Regulations 1998, Workplace (Health, Safety and Welfare) Regulations 1992, Health and Safety (First Aid) Regulations 1981

Safe working practices: safety in the workshop and on site; fire prevention; accident prevention and reporting; risk assessment; manual handling; checking conditions eg gas leaks, voltage and amperage, correct fuses, leads, guarding of machinery and power tools; action to be taken when machinery and equipment are dangerous or in poor condition; personal protective equipment (PPE); ventilation and extraction; closing down eg equipment safety, storing equipment, safe disposal of waste materials

2 **Know the processes used to mark out and prepare materials to produce fabricated structures**

Marking out: measuring and marking out equipment eg rule, protractor, tee square, set square, tape measure, compass, dividers, trammel, templates, marker pen, scriber, chalk line, laser level; detailed drawing eg dimensions, tolerances; reference points eg datum line, centre line datum; setting out eg radial line, triangulation, projection, true lengths; calculations eg bend allowance, allowance for springback, intersection points, overlap; calibration of equipment

Fabricated structures: examples from local industry; made in a centre's workshop eg equipment storage systems (ie tool rack, tool box), work bench, car maintenance equipment (ie axle stand, ramp, crawler board), ventilation ducting (ie collector hood, reducing section, tee connector)

Preparing materials: obtaining materials eg sheet, bar, plate, section; standard bought out condition eg hot-rolled, cold rolled, standard dimensions, profiles, thickness; metallic materials eg ferrous, non-ferrous; cutting to size and shape eg flame, plasma, powder, water jet, laser, band saw, hacksaw, reciprocating saw; shearing eg hand, bench, rotary, reciprocating; guillotining eg bench, power; nibbling eg hand, power; presswork eg piercing, blanking, punching; material removal eg chiselling, drilling, trepanning, filing, grinding; automated methods eg numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), mechanical copying using templates

3 Know how materials are formed and assembled to produce fabricated structures

Forming: principles eg spring back, bend allowance; forming by hand eg hammer and former, fly press, bench mounted bending machine; forming by machine eg folding machine, press brake; rolling tools (eg rolling rolls, pyramid rolls, slip rolls, cone rolls, angle ring-bending; swaging; deep drawing and pressing; web stiffeners; edge preparation; pipe bending; use of templates and patterns; automated methods eg numerical control (NC), computer numerical control (CNC), direct numerical control (DNC)

Fabricated structures: examples from local industry; made in a centre's workshop eg equipment storage (ie tool rack, tool box), work bench, car maintenance equipment (ie axle stand, ramp, crawler board), ventilation ducting (ie collector hood, reducing section, tee connector

Assembly: trial assembly or 'physical mock up' eg offering up, alignment, clamping, dimensional checks, adjustment, modification; workshop clamps eg mitre joint, toggle, G clamp, rivet clamps/skin pins, magnetic clamping devices; joining methods eg spot welding, continuous welding, laser welding, brazing, soldering, structural adhesives, riveting; mechanical fixings eg nuts, bolts, screws, clamps, pipe connectors; web stiffeners; inspect and check against specification

4 Be able to interpret the specification of a fabricated structure and plan and carry out its manufacture

Structure specification: engineering drawing eg assembly, detailed, development; material eg steel, aluminium; material supply forms eg plate of appropriate thickness, hollow section, solid section, pipe, tube; reference points eg edge datum, centre line datum; dimensions eg overall, reference, installation, tolerance; permanent and non-permanent assembly methods eg thermal, adhesive, riveting, mechanical fixings; finish eg paint, polymer coat, electro-plate, polish; quantity eg one off, small batch, large volume

Plan and manufacture: calculations eg bend allowance, allowance for springback, intersection points, quantity of material required, minimisation of waste material; select suitable equipment eg marking out, preparation, templates, patterns, forming and assembly; mark out; produce manufacturing aids eg formers, jigs, templates; prepare and form individual parts of the assembly eg cutting to size, edge preparation, piercing, bending; assemble the fabrication and join parts together eg trial assembly or 'physical mock up', modification, weld, braze, rivet, fixings; meet the required accuracy as specified eg dimensions, tolerances, finish, visual appearance, joint quality; inspect and check against specification

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify the health and safety legislation, regulations and safe working practices applicable in a fabrication workshop [IE4]	M1 explain the effect, including aspects of safety and quality, of using incorrect equipment and processes to produce a fabricated structure	D1 justify the methods used to prepare materials when producing a fabricated structure
P2 describe the process of marking out when producing fabricated structures	M2 explain the factors that influence the assembly methods used in the production of a fabricated structure.	D2 evaluate the quality of manufacture against that specified for a fabricated structure.
P3 describe the process of materials preparation when producing fabricated structures		
P4 describe how materials are formed before they are assembled into a fabricated structure		
P5 describe the assembly process for a given fabricated structure		
P6 interpret the specification of a fabricated structure to plan its manufacture		
P7 produce a fabricated structure to specification [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

To establish the context of this unit, delivery should begin with a general overview of what is meant by a 'fabricated structure' and the reasons for producing it by this method. The starting point could be to look at how a common material such as steel plate can be turned into a quality product by using a series of relatively simple processes. It would be useful to provide a brief overview of the production of a fabricated structure, taking account of local industries, so that learners can appreciate how fabrication processes are used to produce a quality product.

Learning outcome 1 covers legislation and safe working and care should be taken to ensure that delivery concentrates only on the specific issues relating to fabrication processes. There is a huge amount of health and safety information available and when learners are required to carry out research they should be given structured tasks which lead them to relevant information.

Tutors must ensure that learners understand the hazards and safe working practices associated with fabrication equipment before they are allowed to carry out the processes. Learners should be introduced to the processes using a series of formative tasks which enable them to improve their skills and demonstrate their competence before attempting the summative practical task associated with learning outcome 4.

Grading criteria P2, P3, P4 and P5 require evidence to be presented in the form of written reports derived from a range of activities. The unit may therefore be best delivered using tutor-led demonstrations followed by practical tasks, during which learners can gain experience of working with appropriate tools and equipment. Underpinning knowledge can be delivered by integrating practical demonstrations with classroom-based theory sessions and directed research. Learners should be encouraged to evaluate their performance by completing formative tasks which may be self or peer assessed. This should be reinforced with appropriate tutor feedback, to further encourage the development of skills and knowledge.

Centres may wish to consider industrial visits so that learners can investigate and observe fabrication processes not generally available within the centre (for example automated material handling, preparation and bending, laser welding). The internet is also a good resource for obtaining information and short video clips of these processes.

The learning outcomes follow a natural progression which should enable learners to develop an understanding of the fundamental stages involved in the production of fabricated structures, irrespective of the process used. Job instructions should be written in a logical format that will lead learners to consider all aspects of the task. These should include interpretation of technical drawings and specifications, safety, selection of tools, equipment and materials, correct use of process, and inspection.

Work-based learners should be encouraged to relate the learning outcomes to the processes and techniques used at work. They should also gain a wider knowledge of the fabrication processes used throughout the fabrication industry. It may be helpful if centres can relate tasks to the needs of local industries. This will give learners not currently employed the appropriate skills and knowledge for when they do enter employment.

Learners will require instruction in the safe application of fabrication processes, and should have access to a wide range of publications, reference data, manufacturers' products, information and computer facilities. The centre should have access to an appropriate range of fabrication equipment.

There is scope within the content of learning outcome 4 to select joining methods appropriate to the materials being fabricated. For learners who are producing a steel fabrication but are not studying *Unit 23: Welding Technology*, the use of spot welding may be appropriate for joining assembled parts, as this is an easy process to learn.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Practical workshop session: – introduction to unit content, scheme of work and assessment – induction into fabrication workshops and general safety and emergency procedures – identify specific processes used in the fabrication industry ***Whole-class teaching:*** – health and safety related to fabrication and sheet metal working environments and safe working practices – health and safety legislation and regulations
Preparation for and carrying out Assignment 1: Health and Safety in the Fabrication Industry (P1, M1)
Whole-class teaching: – stock material types – sheet, plate, tube, sectional materials – types of material – ferrous, non-ferrous – tools and equipment required when measuring and marking out – marking out fabricated structures - examples ***Workshop practical session:*** – measurement techniques and marking out tools – marking of sheet, plate, tube and sectional materials – marking out according to material type and surface form

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – safety when using machinery for the preparation of materials – types of hand operated, power tools, and machines used in the preparation of materials – machine and tool maintenance – automated methods of preparing materials – NC, CNC, DNC ***Workshop practical session:*** – safety in the workshop when preparing materials – selecting processes for the preparation of materials – correct tool set up and maintenance – material characteristics when preparing materials
Preparation for Assignment 2: Marking Out and Preparing Fabrication Materials (P2, P3, D1)
Whole-class teaching: – safety when using forming tools and machinery – theory of bending – spring back, bend allowance – forming by hand – hammers, formers, fly press – forming by machine – bending, folding and rolling theory. Introduction to types of machine and tooling. Pipe bending and use of templates – examples of forming in fabricated structures – automated forming machines – NC, CNC, DNC ***Workshop practical session:*** – safety in the workshop when using forming equipment – bending and folding – safety, set up, maintenance, spring back, bend allowance – rolling - safety, set up, maintenance – hand power tools used for forming operations – manual forming processes – hammers, formers, fly press
Whole-class teaching: – safety in the workshop and in industry during assembly – thermal joining processes – mechanical fastenings – structural adhesives – types of assembly and best use of materials in fabricated structures

Topic and suggested assignments/activities and/assessment
Workshop practical session:
– preparation of joints for assembly – safe joining and assembly techniques – joining materials – thermal, mechanical and bonding with adhesives – working to specifications and checking assembled components
Preparation for Assignment 3: Forming and Assembling Fabrication Materials (P4, P5, M1, M2)
Whole-class teaching:
– specifications – detail drawings, materials, assembly – working to specifications – planning, visual checks, joint quality, assembly quality, inspection techniques and reports – quality standards – dimensional accuracy, tolerances and geometrical tolerances – recording and interpreting accuracy and tolerances – working to specifications and checking assembled components
Preparation for Assignment 4: Manufacturing from a Specification (P6, P7, D2)
Feedback on assessment and unit review

Assessment

Assessment of this unit could be achieved through the use of four assignments.

The first assignment could cover P1, with learners being asked to produce a written report. Evidence presented for P1 must be specific to fabrication processes and learners will need to be given clear guidelines about what to present. There is a huge amount of generic material which learners will have access to. Care should be taken to ensure that what they present is referenced properly and not directly copied from the internet or any other source. Grading criteria P1 and M1 complement each other and centres may wish to cover them both in the first assignment. However, learners might do better if M1 is assessed later once they have a better understanding of the problems associated with using the wrong equipment and processes. If this is the case, then M1 could be assessed through the assignment which addresses grading criterion P5.

P2 and P3 can be assessed through a second assignment. Evidence could be in the form of a written report supported by drawings, diagrams and photographic images of formative practical work carried out by learners as they investigated the various marking out and materials preparation techniques. Records of responses to oral questioning by the tutor may also be appropriate. D1 requires learners to demonstrate an understanding of the techniques used to prepare materials for fabrication by justifying the use of a selected method.

A third assignment could cover P4, P5, M2 (and M1 if not already covered in the first assignment). This should follow a similar format as assignment 2, with much of the evidence being based on the practical investigations carried out by learners on forming and assembly techniques. Learner evidence should also demonstrate further understanding of what influences the use of assembly methods for M2. If M1 is covered in this assignment learner reports/evidence will also need to evidence their understanding of the consequences of using incorrect equipment and processes.

In P6 and P7 learners will use a given specification to plan and produce a fabricated structure. Care should be taken when designing the assignment brief for P6 and P7 to make sure that it does not just become a test of learners' practical skills. Due to the time constraints of delivering the unit, it is not reasonable to expect learners to carry out joining processes that require a higher level of skill at an expert level.

There is scope to assess learning outcome 4 as a group activity so that learners can appreciate working as a team to produce a larger fabrication. Each learner could be given a part to work on, although care needs to be taken to ensure that the evidence presented by each learner addresses the whole of the unit content and can be substantiated. Digital annotated photographic images, together with witness statements and observation records, should be used to consolidate learner evidence of practical competence.

To achieve D2 learners should check the quality of the fabricated structure produced in P7 and report on the quality of the structure compared to that set out in the given specification. This offers an opportunity for learners to evaluate the preparation, forming and assembly techniques they have used and identify where they can develop skills and techniques to improve quality.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Health and Safety in the Fabrication Industry	An activity based assignment that requires learners to research and identify health and safety legislation and safe working practices within the fabrication industry	A report that outlines legislation and safe working practices applicable to the fabrication industry. The report should identify and clearly reference all research materials.

Criteria covered	Assignment title	Scenario	Assessment method
P2, P3, D1	Marking Out and Preparing Fabrication Materials	A written assignment that evidences and further investigates the formative practical tasks that have been carried out in a fabrication workshop.	A written report will form a summative assessment that contains drawings, diagrams and photographs to evidence the range of marking out and preparation processes. Learners will justify the methods they have used to prepare materials in a fabrication workshop.
P4, P5, M1 and M2	Forming and Assembling Fabrication Materials	A written assignment that evidences the practical investigations that the learner has carried out in a fabrication workshop.	Summative assessment will require a written report that contains evidence of the range of forming and assembly processes used in a fabrication workshop. The report will be supported with diagrams and photographs of their work. The report will examine the possible effects of using incorrect tools and processes. It will also include learner interpretation of why particular assembly processes have been used.

Criteria covered	Assignment title	Scenario	Assessment method
P6, P7, D2	Manufacturing from a Specification	A practical assignment that requires the learner to plan and make a fabricated structure from a given specification.	The learner will interpret information from a given specification and produce a plan of the processes and fabrication techniques to be used. Having planned the work, and agreed the plan with the tutor, the learner will produce the fabricated structure given in the specification. Learners will produce a report which evaluates the quality of their work against the original specification.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Fabrication Techniques and Sheet Metal Work	Welding Technology
		Welding Principles

The unit also covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Fabrication and Welding Engineering, particularly:

- Unit 22: Marking Out Components for Metalwork
- Unit 23: Cutting Sheetmetal to Shape Using Hand and Machine Tools
- Unit 24: Forming Sheetmetal Using Hand and Machine Tools
- Unit 25: Producing Sheetmetal Assemblies
- Unit 27: Developing and Marking Out Templates for Metalwork

- Unit 28: Joining Fabricated Components using Mechanical Fasteners
- Unit 29: Bonding Engineering Materials Using Adhesives
- Unit 30: Joining Materials by Resistance Spot Welding
- Unit 32: Cutting Plate and Sections using Shearing Machines
- Unit 33: Cutting and Shaping Materials using Portable Thermal Cutting Equipment
- Unit 34: Cutting Materials using Saws and Abrasive Discs
- Unit 35: Bending and Forming Plate using Press Brakes or Bending Machines
- Unit 36: Forming Platework using Power Rolling Machines
- Unit 37: Producing and Finishing Holes using Drilling Machines
- Unit 38: Producing Platework Assemblies.

Essential resources

Learners will need access to workshop facilities equipped with a range of marking out, forming and assembly tools and equipment, along with a variety of fabrication materials. Access to current health and safety legislation and regulations would also be useful for learning outcome 1.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. The materials and processes used should reflect those used in the learners' workplace, or be based on case studies of local employers for those preparing for employment. Learners may benefit from industrial visits to gain an understanding of fabrication processes and techniques in an industrial context, and to also appreciate the range of processes and materials used in industry.

Work-based learners would also benefit if the structure in learning outcome 4 was related to their industry or directly to their workplace. Engaging with employers could also provide suitable examples for learners who are not employed to aid their appreciation of local industry.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI -University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Larry F, Jeffus, Robert H Burris — *Welding and Metal Fabrication* (Delmar Cengage Learning, 2011) ISBN 9781111308056

Robinson, A — *The Repair of Vehicle Bodies* (Butterworth-Heinemann, 2005) ISBN 9780750667531

Timings, RL — *Fabrication and Welding Engineering* (Newnes, 2008) ISBN 0750666919

Wakeford, RE — *Sheet Metal Work* (Special Interest Model,1987) ISBN 9780852428498

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying and using health and safety information to discuss safe working practices
Self-managers	planning and manufacturing a fabricated structure

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Independent enquirers	evaluating the quality of their manufactured product
Creative thinkers	planning the manufacture of a fabricated structure
Reflective learners	evaluating the quality of their manufactured product

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Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	searching for health and safety information
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	calculating spring back and bend allowances
Identify the situation or problem and the mathematical methods needed to tackle it	measuring and marking out patterns
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	working with dimensions and tolerances and assessing the extent of inaccuracies
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and interpreting specifications, quality standards and safety information relating to fabrication processes
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing marking out, preparing, forming and assembling processes

Unit 21: Engineering Design

Unit code: **Y/600/0258**

Level 3: **BTEC Level 3 qualification**

Credit value: **10**

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to give learners the opportunity to explore the design process and how it is applied within an engineering context.

Unit introduction

An understanding of how the design process operates within an engineering business is important for anyone considering a career in the design and manufacture of products. This unit provides learners with the opportunity to consider design in a holistic way. It combines study of the technical aspects of engineering design with wider issues such as the environment, sustainability and legislation.

The unit introduces and develops the concept of design for manufacture. It is crucial that the design process is effective. Success in the marketplace can be achieved only if products are fit for purpose, marketable and meet customer requirements. The importance of market research, generation of new ideas and the consequences of poor design are investigated.

Learners will also investigate the issues which influence whether a design proposal should be developed into a final solution suitable for manufacture. These issues include the impact of legislation and standards, the need to conform to environmental and sustainability requirements, materials selection and the types of manufacturing process available. On completion of the unit learners will understand the wider implications of engineering design and the reasons why it cannot be carried out in isolation from the rest of the manufacturing/production process.

The unit content is linked together through a practical task which starts with learners interpreting the requirements of a customer and producing a product design specification (PDS). This is followed by an investigation into the legislation, standards and reference sources that are used by designers who work in manufacturing engineering. This knowledge is then used to influence the production of learners' own design proposals. These proposals are refined and developed into a final design solution which meets the requirements of the customer. Design ideas will have been communicated using a number of techniques including sketching and formal engineering drawing, design calculations and written commentary.

Learning outcomes

On completion of this unit a learner should:

1 Know how the design process operates when dealing with customers

2 Know the impact that legislation, standards and environmental and manufacturing constraints can have on the design function

3 Be able to prepare design proposals that meet the requirements of a product design specification

4 Be able to produce and present a final design solution

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Unit content

1 Know how the design process operates when dealing with customers

The design process: triggers eg market pull, demand, profitability, technology push, innovation, market research; process of design for manufacture; decision making; use of new technologies eg computer aided design (CAD), simulation, rapid prototyping, computer integrated manufacture (CIM); lines of communication

Customer: customer/client relationship; types of customer eg external, internal; requirements of customer eg performance specifications (physical dimensions, mass), compliance to operating standards, reliability and product support, end of life disposal, production quantities (custom built, modification to an existing product, small batch, large volume)

Product design specification (PDS): analysis of customer requirements; production of an agreed PDS; documentation eg physical dimensions, materials, mass, operation and performance

2 Know the impact that legislation, standards and environmental and manufacturing constraints can have on the design function

Legislation and standards: relevant and current legislation, standards and codes of practice eg British Standards (BS), electromagnetic compatibility (EMC) directive, European legislation (European Conformity (CE marking))

Environmental and sustainable constraints: energy efficiency; environmental impact; constraints eg Environmental Protection Act, Waste Electronic and Electrical Equipment Directive; end-of-life disposal eg refurbishment, recycling, disassembly, material recovery, non- recyclable components

Manufacturing constraints: availability of resources eg labour, material, equipment; influence of physical and mechanical properties of a material in relation to manufacturing methods; cost effective manufacture eg set up cost (jigs, tools), production quantities; health and safety in the workplace eg Health and Safety at Work Act, Control of Substances Hazardous to Health (COSHH) Regulations

3 Be able to prepare design proposals that meet the requirements of a product design specification

Requirements of a PDS: interpretation of technical requirements eg operating performance, physical dimensions; interpret economic requirements eg production quantities, product life, market place positioning

Prepare design proposals: ideas generation eg research into existing products, freehand sketching, simulation, flow charts; realistic design proposals eg fitness for purpose, manufacturability, aesthetics, ergonomics

Design reference material: manufacturers' catalogues eg screw fixings, bearings,

seals, electrical connectors, drive belts, gear drives; materials databases eg mechanical properties, physical properties; design databases eg structural beam sections, corrosion protection, anthropometric data

4 **Be able to produce and present a final design solution**

Final design solution: evaluation of proposals and selection of most appropriate for further development eg suitability for available manufacturing processes, cost effectiveness, contribution to profits, visual appearance; development of design proposal into a feasible solution suitable for prototype manufacture eg specify materials, appropriate manufacturing processes, estimation of manufacturing cost, quality; conformity to relevant legislation and design standards

Presentation techniques: 2D engineering drawings eg general arrangement drawing, assembly drawing, detail drawings, circuit diagrams, flow diagrams, schematic diagrams; drawing conventions and relevant British Standards eg BS308, BS8888, BS7307, BS3939, BS2197; documentation eg design diary, logbook, product specification; design calculations eg sizes of materials to meet strength requirements, electric motor power, electronic circuit performance, battery life

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Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the operation of the design process in an engineering company	M1 explain the possible impact of a poor customer design process on customer relationships and requirements	D1 evaluate the impact of legislation and standards on the design process in relation to the profitability of the business
P2 interpret the requirements of a given customer and produce a product design specification (PDS) [IE1]	M2 explain the importance of using a range of accurate design reference materials when developing design proposals	D2 evaluate a final design solution against customer requirements and a PDS, and suggest improvements.
P3 describe the appropriate legislation and standards which apply to the design of two different products	M3 explain the issues which influence whether a design proposal should be developed into a final solution suitable for manufacture.	
P4 describe the environmental, sustainability and manufacturing constraints which influence the design of a given product		
P5 produce design proposals which meet the requirements of a given PDS [CT1]		

Table continues on next page

Assessment and grading criteria		
P6 extract reference information from component manufacturers' catalogues and materials and design databases		
P7 use a range of techniques to present a final design solution which meets the requirements of a given PDS and relevant legislation and design standards [CT5].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

There are strong links between the four learning outcomes and the delivery strategy should ensure that these links are emphasised. Learners need to gain a coherent view of the design process within engineering and understand that for a business to remain profitable it is crucial that the design process is effective. Learners must be made aware that success in the marketplace can be achieved only if manufactured products are fit for purpose, marketable and meet customer requirements.

Delivery of the unit should start with some case study analysis. This is best carried out in the form of a group discussion examining example products that learners are familiar with. It is important to contrast successful design icons, like the Dyson Vacuum Cleaner™ and the Apple iPod™, with those that have failed, such as the Sinclair C5. A wider discussion could follow about why some products are hugely successful whereas others are not. It would also be useful to provide an overview of the design process as it applies to automotive engineering, starting with the initial 'concept' and following through to the production model for the mass market. Why is the production model different to the designer's original? Tutors need to get across the idea of compromise in the design process — the trade off between what we would like and what we can actually have when economics, legislation, manufacturability etc are taken into account.

To effectively cover learning outcome 1, learners will benefit from a visit to the design department of an engineering company in order to find out about the systems that are in place and the links between design and manufacture. If learners are employed it may be useful to base their research on their own company. Delivery should be, as far as possible, activity based, but care must be taken when covering learning outcome 2. There is a huge amount of data available which relates to the impact of legislation, standards and the environment on the design process, so learners will need to be given guidance when searching for information. Tutors need to consider how this data will be presented as evidence because there is a danger that some learners might include large amounts of unedited material. Learning outcomes 3 and 4 are best covered by a learner-centred activity, based around a single assignment which will produce evidence for grading criteria P5, P6 and P7. Learners should be applying knowledge gained *from Unit 10: Properties and Applications of Engineering Materials*, particularly from the learning outcome covering material selection.

There is scope here for learners to be given a PDS that is tailored to their particular interest but it may be more interesting to give them all the same one and to treat the activity as a design competition. The tutor would assume the role of customer with each learner pitching to get their final design solution accepted. There may be scope to develop this activity into a group discussion with all the design solutions being evaluated and learners using it as a lead into what is required for the evaluation in criterion D2.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, scheme of work and assessment – introduction to the design process – the customer/client relationship, case studies of innovative design and the triggers and market conditions necessary – examples of customer requirements and the generation of a PDS ***Case study:*** – generating a PDS from given customer requirements
Preparation for and carrying out Assignment 1: Design Report (P1, P2 and M1)
Whole- class teaching: – standards and legislation ***Small- group exercise:*** – researching relevant standards for given products ***Whole class teaching:*** – environmental and sustainable constraints ***Paired activity:*** – researching and reporting on legislation and environmental issues for given consumer products ***Whole- class teaching:*** – manufacturing constraints – an investigation into the appropriate manufacturing techniques for a range of component parts and assemblies including health and safety requirements
Preparation for and carrying out Assignment 2: Product Evaluation (P3, P4, and D1)
Whole- class teaching: – interpreting a PDS – key technical requirements and economic considerations – design proposals, methods for presenting solutions, worked examples and case studies ***Case study:*** – presenting design proposals for a given PDS

Topic and suggested assignments/activities and/assessment
Individual activities: – learners to generate design proposals from simple PDS requirements using a range of techniques   ***Whole- class teaching:***   – using design reference material   – identifying components and data from reference material   – final design solutions - evaluation of proposals and selection techniques   ***Small- group activity:***   – presenting design solutions and using appropriate techniques to evaluate and select a final design
Preparation for and carrying out Assignment 3: Design Proposals (P5, P6, P7, M2, M3 and D2)
Feedback on assessment and unit review

Assessment

Assessment of this unit could be covered through three assignments. To achieve a pass grade learners are expected to describe how the design process operates in an engineering company and its links to other aspects of the business. It is suggested that during the first assignment the evidence for P1 could be gained by learners visiting the design department of an engineering company, carrying out an interview with an engineering designer and preparing a short report. It is important that learners understand that design cannot be carried out in isolation and that it is an income-generating function with the customer having the final say.

After the visit or similar activity, a written task for P2 should be given that asks learners to produce a PDS from the requirements of a given customer.

A second assignment could involve a research activity. Two different products need to be given to each learner and research carried out to allow them to describe the legislation and standards that apply to each product (P3) and the environmental, sustainability and manufacturing constraints that influenced the design of one of these products (P4).

Learners will need to demonstrate a basic mastery of design and drawing skills and they should be producing sketches and drawings which are broadly in line with British Standards and which use simple drawing conventions. There should be some evidence of design calculations when presenting evidence for P5, P6 and P7.

For assessment of these criteria a third assignment could be set where a PDS should be given and learners asked to produce a range of design proposals (P5). Three proposals would generally be sufficient although, if the solutions are complex, two would be enough. In doing this, it is important that learners use design reference material (P6) and a range of techniques to present the final solution (P7). The techniques used are dependent on the solution (for example if it involves an electronic system then circuit diagrams will be needed as well as perhaps general arrangement drawings).

Learners will demonstrate a basic understanding of the use of information sources such as books, technical reports, data sheets, catalogues, CD ROMs and online databases. They should be selecting, interpreting and applying data extracted from a limited range of sources and will have been given guidance on what to look for.

Design work must show good evidence of knowledge gained from the linked units so that learners can be critical about their evolving designs and adapt them, rather than pursue a single idea. Grading criteria P5 and P6 link the extraction of reference information about materials and components to the design proposals being put forward by the learner. This will give more focus when gathering resource material. It is intended that the assessment evidence for P6 is based on development ideas generated in P5.

To achieve a merit grade, learners will need to apply evaluative skills and explain the impact of poor design. To achieve M1 the manufacturer/client relationship should be explored in some depth with evidence supported by examples taken from case studies based on real products. These could be discussed during the visit in the first assignment.

M1 builds on knowledge used to achieve P1 and P2 and may be best attempted in the first assignment.

To achieve M2 learners should explain their reasons for having accurate reference material by using examples taken from documented sources of products which are mission critical (for example correct specification of dimensions and material for a load bearing structure such as a roof beam). As such, a further written task could be set in assignment three to facilitate M2.

M3 builds on P5 and P7 and a further written could be set task in assignment 3. There should be evidence of thought being given to economic issues and the pressure on a designer to design to a price in order to be competitive. Explanations should be supported by examples relating to real products that learners are familiar with.

To achieve a distinction grade, learners should be able to focus on specific legislation and standards when working towards D1. Learners should support their evaluation of the impact of legislation and standards on the design process with examples drawn from documented sources (for example businesses that have either lost market share by being caught out by changes in legislation or others that have benefited through anticipating changes and beating competitors in the market). As such, a task targeting D1 could be set as part of assignment 2.

To achieve D2, evaluation could relate to a design solution provided by the tutor but it may be better to link with P7 so that learners evaluate their own work. A written task in assignment 3 may be appropriate for this.

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.

Criteria covered	Assignment Title	Scenario	Assessment Method
P1, P2 and M1	Design Report	An activity requiring learners to research and/or visit a design department and investigate the relationship between designer and customer.	A report containing written responses about the design process and its impact on customer relationships. In addition a PDS should be generated from a given customer specification.
P3, P4 and D1	Product Evaluation	An activity requiring learners to research legislation and standards that apply to two different products as well as the manufacturing, environmental and sustainability constraints for one of them.	A report containing written responses outlining legislation and standards that apply to two different products and an evaluation of the manufacturing, environmental and sustainability constraints for one of them in terms of profitability for the business.
P5, P6, P7, M2, M3 and D2	Design Proposals	An activity requiring learners to interpret a given PDS and, by using appropriate research techniques, present a final design solution from a selection of design proposals.	A portfolio of design solutions and a written report explaining how a final design solution has been selected. In addition explanations of the importance of accurate design reference materials and an evaluation of the chosen design solution with reference to the given PDS.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Using Computer Aided Drawing Techniques in Engineering	Business Operations in Engineering
		Properties and Applications of Engineering Materials
		Engineering Drawing for Technicians
		Computer Aided Drafting in Engineering
		Engineering Secondary and Finishing Techniques and Processes
		Computer Aided Manufacturing

The unit has been mapped against the SEMTA National Occupational Standards and current NVQs at Level 3. Achievement of the learning outcomes of this unit will contribute skills, knowledge and understanding towards the following units from the Level 3 NVQ in Engineering Technical Support:

- Unit 2: Using and Interpreting Engineering Data and Documentation
- Unit 47: Producing Technical Information for Engineering Activities
- Unit 58: Developing and Maintaining Effective Customer Relationships.

Essential resources

To meet the requirements of this unit it is essential that learners have, or have access to, some if not all of the following:

- a range of customer design requirements
- a range of products to investigate design requirement features
- manual drawing equipment
- 2D commercial CAD software
- extracts and illustrations from appropriate drawing standards and conventions
- access to reference material which provides information about the physical and mechanical properties of materials
- access to legislation and design standards
- component and material suppliers' catalogues.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be based around real engineering design requirements and drawings/specifications. In addition, the use of engineering artefacts from local and national employers is to be encouraged.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI-University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Dieter G and Schmidt L — *Engineering Design* (McGraw-Hill, 2008) ISBN 0071263411

Simmons C, Maguire D and Phelps N — *Manual of Engineering Drawing* (Butterworth-Heinemann, 2009) ISBN 0750689854

Tooley M and Dingle L — *BTEC Level 3Qualification Engineering* (Newnes, 2002) ISBN 0750651660

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	evaluating customer requirements to produce a product design specification
Creative thinkers	generating design proposals presenting final design solutions explaining issues which influence design solutions

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	reviewing progress made against individual tasks and assignments

Functional Skills — Level 2

Skill	When learners are …
ICT — Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a CAD system to create a variety of design solutions
ICT — Find and select information	
Select and use a variety of sources of information independently for a complex task	using online or electronic reference materials
ICT — Develop, present and communicate information	
Present information in ways that are fit for purpose and audience	plotting/printing a variety of designs generated using CAD
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the design process writing a PDS describing environmental, sustainability and manufacturing constraints describing legislation and standards

Unit 22: Engineering Drawing for Technicians

Unit code: T/600/0266

Level 3: BTEC Level 3 qualification

Credit value: 10

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to enable learners to produce engineering drawings of different components, assemblies and circuits using a variety of sketching, drawing and computer-aided drafting techniques.

Unit introduction

It is important that when a product has been designed it is manufactured correctly and to specification. To achieve this it is crucial that the people making the product in a workshop are provided with well-presented engineering drawings, produced to international standards and conventions. This avoids errors of interpretation which can lead to the scrapping of expensive parts.

An understanding of how graphical methods can be used to communicate information about engineering products is an important step for anyone thinking of taking up a career in engineering. This unit introduces learners to the principles of technical drawings and their applications using hand drawing and computer-aided drafting (CAD) techniques.

Learners will start by carrying out freehand sketching of simple engineering products using pictorial methods that generate three-dimensional images. A range of standard components, such as fixing devices, will be sketched together with other solid and hollow items. Learners are then introduced to a more formalised drawing technique that conforms to British Standards and will put this into practice through a number of drawing exercises. A consistent presentation style will be used as learners draw single part components and simple engineering assemblies.

These drawings will contain all the information needed to manufacture or assemble the product, including information such as dimensions, manufacturing notes and parts lists. The use of conventions to represent standard items will be investigated, such as screw threads and springs in mechanical type drawings or circuit symbols such as solenoids and resistors in electrical/electronic type drawings.

Having learned the principles of engineering drawing, learners will then move on to using a two-dimensional (2D) CAD system for the production of drawings, using basic set-up, drawing and editing commands. The first task is to produce a drawing template which can be saved to file, as this reinforces the concept of standardisation and consistency of presentation. This is followed by drawing exercises of single-part components, a simple multi-part assembly and circuit diagrams.

Overall, the unit will develop learners' ability to create technical drawings and allow them to compare the use of manual and computer- aided methods of producing engineering drawings.

Learning outcomes

On completion of this unit a learner should:

1 Be able to sketch engineering components

2 Be able to interpret engineering drawings that comply with drawing standards

3 Be able to produce engineering drawings

4 Be able to produce engineering drawings using a computer aided drafting (CAD) system

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Unit content

1 **Be able to sketch engineering components**

Sketches: regular solids eg cube, rectangular block, 90^0 angle bracket; hollow objects eg circular tube, square section tube; standard components eg nuts, bolts, screws, pulleys; engineering components eg pulley support bracket, machine vice

Sketching techniques: sketching equipment eg paper (plain, squared, isometric), pencil, eraser; pictorial eg oblique drawing (cavalier and cabinet), isometric; orthographic eg single and linked views; sketching in good proportion; dimensions eg overall sizes, detail

Benefits and limitations of using pictorial techniques: benefits eg speed of production, visual impact; limitations eg lengths and shapes not true, not produced to a recognised standard, dimensions difficult to read; consequences of interpretation errors eg incorrect manufacture, incorrect assembly, cost to scrap

2 **Be able to interpret engineering drawings that comply with drawing standards**

Interpret: obtaining information from engineering drawings eg component features, dimensions and tolerances, surface finish, manufacturing detail, assembly instructions, parts list, circuit operation

Drawing standards: British Standards eg BS8888, BS3939, BS2917, PP7307; company-standardised layouts eg drawing number, title and issue number, projection symbols (first angle, third angle), scale, units, general tolerances, name of person responsible for producing drawing; line types eg centre, construction, outline, hidden, leader, dimension; lettering eg titles, notes; orthographic projection eg first angle, third angle; views eg elevation, plan, end, section, auxiliary; representation of common features eg screw threads, springs, splines, repeated items; section views eg hatching style, webs, nuts, bolts and pins, solid shafts; symbols and abbreviations eg A/F, CHAM, Φ, R, PCD, M; circuit symbols eg electrical, electronic, hydraulic, pneumatic

3 **Be able to produce engineering drawings**

Detail drawings of single-piece engineering components: projection method; scale; title block; line work; views; sections; dimensions; tolerances; surface finish; notes

Assembly drawings: line work eg centre lines, construction, outline, cutting plane, sectional view, hatching; representation of standard components eg nuts, bolts, screws, keys; parts referencing eg number referencing, parts list; notes eg assembly instructions, installation features, operating instructions

Circuit diagrams: circuits eg electrical, electronic, hydraulic, pneumatic; components eg transformers, rectifiers, solenoids, resistors, capacitors, diodes, valves, pumps, actuators, cylinders, receivers, compressors

4 Be able to produce engineering drawings using a computer aided drafting (CAD) system

Prepare a template: standardised drawing sheet eg border, title block, company logo; save to file

CAD systems: computer systems eg personal computer, networks; output devices eg printer, plotter; storage eg server, hard disc, CD, pen drive; 2D CAD software packages eg AutoCAD, Microstation, Cattia, Pro/Engineer, Pro/Desktop

Produce engineering drawings: set-up commands eg extents, grid, snap, layer; drawing commands eg coordinate entry, line, arc, circle, snap, polygon, hatch, text, dimension; editing commands eg copy, move, erase, rotate, mirror, trim, extend, chamfer, fillet

Store and present engineering drawings: save work as an electronic file eg hard drive, server, pen drive, CD; produce paper copies eg print, plot, scale to fit

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Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 create sketches of engineering components using a range of techniques	M1 explain the importance of working to recognised standards when producing engineering drawings	D1 evaluate the use of different methods of producing engineering drawings including manual and computer aided methods.
P2 describe the benefits and limitations of using pictorial techniques to represent a given engineering component	M2 explain how a given engineering drawing would be used and the reasons it is suitable for its intended audience.	
P3 interpret the main features of a given engineering drawing which complies with drawing standards [IE4]		
P4 produce detail drawings of three given single-piece components [CT1]		
P5 produce an assembly drawing of a product containing three parts [CT1]		

Table continues on next page

Assessment and grading criteria		
P6 produce a circuit diagram with at least five different components which uses standard symbols [CT1]		
P7 prepare a template drawing of a standardised A3 sheet using a CAD system and save to file		
P8 produce, store and present 2D CAD drawings of a given single-piece component and an assembly drawing of a product containing three parts [CT1].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	
	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

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Essential guidance for tutors

Delivery

All four learning outcomes of this unit are strongly linked and the delivery strategy should ensure that these links are emphasised. The method of delivery should be activity based with learners being shown examples of engineering drawings sourced from actual companies.

Learners need to understand that if products are to be manufactured correctly it is crucial that the people cutting metal or assembling components are given accurate and unambiguous information to work from. Whilst it is not intended that learners become expert draftspersons, it is expected that they will gain the necessary skills in manual and computer- aided drafting to be able to communicate effectively using graphics. Delivery of this unit will need to develop learners' practical skills in graphical communication and knowledge of drawing standards.

The starting point for delivering this unit is pictorial freehand sketching using pencil and paper. Very simple items such as a cube of wood can be used to get learners thinking about size and proportion and how to fit the drawing onto a piece of paper. It is useful, even at this introductory level, to introduce the idea of standardisation and to encourage learners to put a border and simple title block onto their work. During the course of studying the unit learners will produce a portfolio of sketches and drawings and it is good practice to develop the concept of a corporate presentation, as would happen in industry.

Some learners will have no knowledge of engineering components and delivery needs to be supported with actual examples that they can hold, look at and sketch. This brings in the idea of pictorial sketching in good proportion. There is no need to use colour or shading effects; just produce outline shapes which can be looked at and used as the basis for development into orthographic form. For example, a simple bracket with a single hole could be sketched using isometric projection and a few leading dimensions added. Then, the problem of drawing the hole so that it appears to be circular could be discussed (time need not be wasted using the geometrical construction method), leading on to the idea that, if the component is drawn out using a set of linked 2D views, circles can be easily drawn and lengths become true.

Care should be taken when delivering learning outcome 2 because there is a huge amount of information relating to drawing standards and learners will need to be given a structure to work to when being asked to interpret drawings.

Learning outcome 3 is practical and should be achieved by carrying out a number of developmental drawing exercises, starting with a very simple component. Some centres may wish to start learners on CAD at this point and there is nothing in the unit content to prevent this happening. However, care should be taken to ensure that learners do not get sidetracked by the technicalities of the CAD system and lose sight of what they should really be learning (ie the principles of engineering drawing). When deciding on a method of projection to use, either first or third angle can be chosen but there should be an understanding of the principles of both.

In learning outcome 4 learners are required to produce a standard drawing template. This is a straightforward task and some learners may want to do this early on in the unit so that they can print off their own personalised drawing paper.

When delivering this part of the unit, thought needs to be given to authentication of learners' work.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed. For example, grading criterion P6 asks for a circuit diagram to be drawn. This may depend on the learner's workplace experience or chosen area of expertise — they could choose an electrical, electronic, hydraulic or pneumatic system provided that the correct components are picked and represented properly.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching/practical demonstration: – introduction to unit, scheme of work and assessment – explain and demonstrate the use of sketching equipment and different sketching techniques – explain the benefits and limitations of pictorial techniques and the consequences of making interpretation errors ***Practical activities:*** – practise use of a range of techniques to sketch regular solid objects, hollow objects, standard and engineering components
Preparation for and carrying out Assignment 1: Producing Engineering Sketches (P1 and P2)
Whole-class teaching: – explain how to interpret and obtain information from engineering drawings – explain the use and purpose of relevant British and company standards and their use when presenting line types, lettering, orthographic projections, views and common features – explain use of symbols, abbreviations and circuit symbols
Preparation for and carrying out Assignment 2: Interpreting and Using Drawing Standards (P3 and M1)
Whole-class teaching/practical demonstration: – explain and demonstrate the production of detail drawings of single-piece components – explain and demonstrate the production of assembly drawings including line work, representation of components, the use of parts referencing and notes – explain and demonstrate the production diagrams of circuits and circuit components

Topic and suggested assignments / activities and / assessment
Practical activities: practise the production of component drawings, assembly drawings and circuit diagrams
Preparation for and carrying out Assignment 3: Producing Engineering Drawings (P4 and P5)
Preparation for and carrying out Assignment 4: Producing Circuit Drawings (P6)
Whole-class teaching / practical demonstration: – explain and demonstrate the production of standardised drawing sheets and saving them to file – demonstrate the use of computer systems, output devices, storage and CAD software – demonstrate the use of set-up, drawing and editing commands to produce engineering drawings using CAD – demonstrate how to store, retrieve and present drawings. ***Practical activities:*** – use of CAD systems and software to produce engineering drawings
Preparation for and carrying out Assignment 5: Producing Engineering Drawings Using CAD (P7 and P8)
Preparation for and carrying out Assignment 6: Using Engineering Drawings (M2 and D1)
Feedback on assessment, unit review and close

Assessment

Assessment of this unit could be through the use of six assignments. To achieve a pass learners are expected to show competence in a number of graphical techniques and able to apply these to the production of engineering drawings which meet recognised standards.

The first assignment, to cover P1 and P2, could consist of a small portfolio of sketches and written explanations. Items drawn must include regular solids and hollow objects, standard and engineering components. The techniques used must involve sketching equipment, pictorial and orthographic representation and sketching in good proportion with the addition of some dimensions (as specified in the unit content).

The second assignment, to cover P3 and M1, will need to be carefully structured and should be based on a drawing of a component or assembly rather than a circuit diagram so that the unit content can be properly covered.

The third assignment could cover P4 and P5, with the three single-piece components being used for the assembly drawing. This would then make the assignment more realistic in terms of what happens in industry.

The fourth assignment could cover P6, with learners being given a choice of the type of circuit they produce depending on their interest (ie from electrical, electronic, hydraulic and pneumatic). The circuit can be drawn by hand but using CAD may be the preferred method if a library of components is available.

P7 and P8 can be covered by a fifth assignment, which could ask for increased competence in the application of standards when producing drawings. To help authenticate learner work, additional evidence could be in the form of witness statements, tutor observation records and 'screen dumps' which show the range of commands used during the development of the drawings.

As mentioned above, M1 builds on the evidence presented for P3 and these two criteria could be assessed using a single assignment. The wider issues of standardisation and manufacturing for the global marketplace should be addressed with learners supporting their explanations with case study evidence.

The sixth assignment could cover M2 and would be based on knowledge gained to achieve P6, P7 and P8, together with a wider understanding of the use of engineering drawings to communicate information effectively. It will be a piece of explanative writing and can be extended to include D1. As there is only the one distinction criterion in this unit, learners must produce some high-level reflective writing, using fully supported argument, if they are to achieve it. The assignment brief should ask for an evaluation of the various drawing techniques used by the learner and link directly with P1, P5, P6 and P8. To add depth to their evidence, learners could be asked to look more widely at what is used in industry – particularly the use of 3D CAD systems which generate solid models. This would then bring them full circle back to the start of the unit, where they were producing pictorial sketches.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2	Producing Engineering Sketches	Learners have been asked to produce sketches of a range of different objects	A practical assignment requiring learners to produce a portfolio of engineering sketches with accompanying written explanations

Criteria covered	Assignment title	Scenario	Assessment method
P3, M1	Interpreting and Using Drawing Standards	Learners have to read and interpret an engineering drawing in order to report the key features of the component, circuit or assembly to a colleague	A written assignment for which learners need to produce a short report detailing the main features of a given engineering drawing that complies with drawing standards. A further task would require them to explain the importance engineering standards.
P4, P5	Producing Engineering Drawings	Learners need to produce engineering drawings of three components and an assembly drawing for use by the manufacturing department of their company.	A practical assignment in which learners produce component and assembly drawings.
P6	Producing Circuit Drawings	Learners need to produce a circuit diagram for use by the manufacturing department of their company.	A practical assignment in which learners produce a circuit diagram.
P7, P8	Producing Engineering Drawings Using CAD	Learners need to prepare and produce 2D CAD drawings for use by the manufacturing department of their company.	A practical assignment in which learners produce 2D CAD drawings of a component and an assembly.

Criteria covered	Assignment title	Scenario	Assessment method
M2, D1	Using Engineering Drawings	Learners prepare a report explaining the use of a given drawing and evaluating the drawing techniques that they have used.	A written assignment requiring learners to justify the use of a given engineering drawing for its intended use and evaluate different methods of producing engineering drawings.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		Engineering Design
		Electro, Pneumatic and Hydraulic Systems and Devices
		Secondary/Finishing Processes and Techniques
		Computer Aided Drafting in Engineering

This unit covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Engineering Technical Support, particularly:

- Unit 2: Using and Interpreting Engineering Drawings and Documents
- Unit 4: Producing Mechanical Engineering Drawings using Computer Aided Techniques
- Unit 6: Producing Electrical Engineering Drawings using Computer Aided Techniques
- Unit 7: Producing Electronic Engineering Drawings using Computer Aided Techniques
- Unit 9: Producing Fluid Power Engineering Drawings using Computer Aided Techniques.

Essential resources

To meet the requirements of this unit it is essential that centres have, or have access to, manual drawing equipment and a CAD system which uses a 2D commercial engineering software package. Learners will also need extracts and illustrations from appropriate drawing standards and conventions.

Employer engagement and vocational contexts

The use of relevant vocational contexts and real engineering information, documentation and materials should underpin the delivery and assessment of this unit. Much of the work could be set in the context of learners' work placements or be based on relevant local employers. Site and company visits could provide opportunities to reinforce learners' understanding of the use of engineering drawings in industry.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks - Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk

Indicative reading for learners

Textbooks

Byrnes, D — *AutoCAD 2009 for Dummies* (John Wiley and Sons, 2009) ISBN 3527704833

Cheng R — *Using Pro/Desktop 8* (Delmar Publishing, 2003) ISBN 1401860249

Conforti F — *Inside Microstation* (Onward Press, 2006) ISBN 1418020842

Simmons, C/Maguire, D and Phelps, N — *Manual of Engineering Drawing* (Butterworth-Heinemann, 2009) ISBN 9780750689854

Tooley M and Dingle L — *BTEC Level 3 qualification Engineering* (Newnes, 2007) ISBN 0750685212

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information when interpreting an engineering drawing, judging its relevance and value
Creative thinkers	generating ideas and exploring possibilities when producing engineering drawings

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Self-managers	working towards goals, showing initiative, commitment and perseverance organising time and resources, prioritising actions

Functional Skills — Level 2

Skill	When learners are …
ICT — Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a CAD system to prepare a template drawing and produce 2D CAD drawings of components and assemblies
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	using a CAD system to prepare a template drawing and produce 2D CAD drawings of components and assemblies
Present information in ways that are fit for purpose and audience	using a CAD system to prepare a template drawing and produce 2D CAD drawings of components and assemblies
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the benefits and limitations of using pictorial techniques and explaining the importance and use of engineering standards and drawing techniques

Unit 23: Welding Technology

Unit code: R/600/0274

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

This unit is imported from the BTEC engineering qualifications.

Aim and purpose

The aim of this unit is to give learners an understanding of manual, mechanised and machine-based welding processes, including laser, friction and resistance welding.

Unit introduction

A diverse range of welding processes is used within the manufacturing engineering industry, including manual, mechanised and machine-based techniques. The selection and application of these joining processes is vital in terms of the weld quality, and the economic viability of the finished product.

Learners will appreciate the need to produce high-quality welded joints in components based on the selection of the most appropriate process. To enable learners to make an informed choice they will be required to select joining processes to satisfy a given application. The unit is appropriate for work-based learners where their industrial environment utilises welding as an integral part of the manufacturing process. It is also suited to learners who are preparing for employment in the welding industry.

Learners will perform a range of formative practical tasks that will include planning and preparing for work and ensuring that health and safety legislation and safe working practices are understood and followed at all times. Learners will select and check the condition of appropriate equipment, which is particularly important considering that learners could be working with electric currents, combustible gas mixtures or parts rotating at high speed.

Continuous formative assessment allows learners to develop their practical skills and knowledge which lead to summative assessments. Assignments will require them to report and record the development of their skills in the preparation and production of welded joints. Learners will inspect their work with reference to relevant quality standards, ensuring that they are capable of producing welded joints and are able to recognise defects.

Learning outcomes

On completion of this unit a learner should:

1 Know about health and safety legislation, regulations and safe working practices in the welding industry

2 Be able to prepare for welding operations

3 Be able to produce welded joints to a quality standard

4 Understand how quality inspection processes are applied to welded joints in components

Unit content

1 **Know about health and safety legislation, regulations and safe working practices in the welding industry**

Legislation and regulations: legislation eg Health and Safety at Work Act 1974, Employment Act 2002, Factories Act 1961, regulations eg The Fire Precautions (Workplace) Regulations 1997, Management of Health and Safety at Work Regulations 1999, Provision and Use of Work Equipment Regulations (PUWER)1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations (LOLER)1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Electricity at Work Regulations 1989, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Working Time Regulations 1998, The Workplace (Health, Safety and Welfare) Regulations 1992, Health and Safety (First Aid) Regulations 1981, Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007, Simple Pressure Vessels (Safety) Regulations 1994

Safe working practices: fire prevention; accident prevention and reporting; risk assessment; manual handling eg materials, safe handling of gas cylinders; checking conditions eg gas leaks, voltage and amperage, correct fuses, circuit breakers, leads, earthing of equipment; personal protective equipment (PPE); ventilation and extraction; closing down eg equipment safety, storing equipment, safe disposal of waste materials; emergency procedures eg within the learning environment and the workplace; hazards associated with welding eg burns, electric shock, radiation

2 **Be able to prepare for welding operations**

Information sources: safety instructions; job instructions; engineering drawings; quality control documentation eg weld procedure specification (WPS), record and reporting sheets

Tools and equipment: check equipment availability; function and condition relevant to the welding process eg cables, hoses, torches and electrode holders, gas pressure regulators, flow meters; working environment eg workshop, site work, conditions for machinery and plant; assembling welding equipment eg cables, weld return clamps, electrode holders, gas cylinders, regulators, valves, safety devices

Welding parameters: setting and adjusting eg:

- for manual processes: gas pressure, flow rates, voltage, current (either alternating (AC) or direct (DC)), according to electrode or filler size
- for mechanised processes: safety devices, welding speed, other parameters (electrical parameters, flux dispensing and recovery mechanisms, wire feed rate, filler diameter, gas shielding system, mechanical functions (handling, loading, workholding, transfer))

- for resistance welding machines: welding current, welding and squeeze times, electrode pressure cycle, electrode size, welding speed (seam), weld pitch (spot), mechanical functions, electrode diameter and condition
- for laser welding machines: electrical parameters, welding speed, weld alignment and characteristics, beam tracking, beam characteristics (focal spot), gas shielding, mechanical mechanisms for workholding, traversing and transfer
- for friction welding machines: friction and forge cycle time, friction and forge loads (forces), rotational speed or other friction conditions (orbital, frictional burn-off characteristics, forge displacement, braking effort), weld appearance (correct upset)

Welding processes: manual eg manual metal-arc (MMA), metal inert gas (MIG), metal active gas (MAG), metal-arc gas shielded, flux cored wire, tungsten inert gas (TIG), plasma-arc, gas welding; mechanised eg MIG/MAG, cored wire, TIG, plasma-arc, submerged arc; machine based eg resistance welding machines (spot, seam, projection), laser welding machines, friction welding machines

Consumables: appropriate to process eg electrode (rutile, basic, nickel alloy, cellulosic, stainless steel, other electrodes), filler wire, gases (oxygen, acetylene, shielding gases), inert and active gases, flux/agglomerated flux, forms of supply, care when handling flux; safe storage of consumables

3 Be able to produce welded joints to a quality standard

Safely: fire prevention; accident prevention and reporting; using risk assessment; manual handling; equipment maintenance; checking conditions eg gas leaks, voltage and amperage, fuses, circuit breakers, leads; wearing PPE; fumes; using ventilation and extraction; closing down equipment safely after use

Joints/components: eg

- for manual processes: butt, fillet, autogeneous weld (without filler wire)
- for mechanised processes: two different joint configurations, two different material groups
- for resistance welding machines: two different material thicknesses, two different joint configurations
- for laser and friction welding machines: two different components, two different material groups

Welding positions: to a relevant standard eg British Standard (BS) EN 287 flat (PA), horizontal vertical (PB), horizontal (PC), vertical upwards (PF), vertical downwards (PG), overhead (PE), inclined tube/pipe (H-L045 or J-L045); welding technique eg torch angle, filler angle

Material: forms eg plate (thickness appropriate to process, up to 6 mm for resistance welding), section, pipe/tube, sheet (<3 mm), other forms; types eg carbon steel, stainless steel, aluminium

Quality standard: minimum weld quality standard equivalent to the level given in the relevant standard eg European/International Standard BS EN ISO 5817, BS EN ISO 10042, BS EN ISO 13919-2; meet the required accuracy as specified eg dimensions, tolerances, weld quality, spot and projection welds are correctly located

4 Understand how quality inspection processes are applied to welded joints in components

Quality standard: safety in the use of test equipment and chemicals; minimum weld quality standard equivalent to the level given in the relevant standard eg European and International Standard BS EN ISO 5817, BS EN ISO 10042, BS EN ISO 13919-2, BS EN 12062; meet the required accuracy as specified eg dimensions, tolerances, weld quality, spot and projection welds are correctly located

Testing: non-destructive inspection eg dye penetrant, ultrasonic, radiographic (x-ray, gamma ray), pressure tests (hydraulic, pneumatic), fluorescent particle, magnetic particle; destructive eg macroscopic examination, nick break (fracture) tests, bend tests visual inspection; weld gauges eg fillet, leg length, undercut and hi-lo gauges

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify aspects of health and safety legislation, regulations and safe working practices applicable to welding	M1 analyse the effect of using incorrect welding parameters for a selected welding process including the effects on quality and safety when producing welded components	D1 justify the selection of a welding process for a given application when producing welded components
P2 use information sources to select a welding process for a given application, and suggest suitable parameters for the welding process [IE4]	M2 discuss the advantages and disadvantages of two welding processes considering consumables, equipment, technique and quality for a given welding application.	D2 evaluate the benefits and limitations of using a non-destructive inspection methods on welded components.
P3 produce a list of consumables that are required for a selected welding process		
P4 plan the tools and equipment needed to produce welded components safely using a selected welding process [SM3, SM4]		

Assessment and grading criteria		
P5 use appropriate welding positions and materials to produce two welded joints safely with a manual or mechanised welding process [SM3, SM4]		
P6 produce two welded joints/components to a quality standard using a manual or mechanised welding process [SM3, SM4]		
P7 use appropriate welding positions and materials to produce two welded joints safely with a machine-based welding process [SM3, SM4]		
P8 produce two welded joints/components to a quality standard using a machine-based welding process [SM3, SM4]		
P9 explain the results of a destructive and non-destructive test on a given joint/component when welded to a quality standard.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit could be delivered using tutor-led demonstrations followed by practical tasks where learners gain experience of working with appropriate tools and equipment used in the welding industry. Underpinning knowledge can be delivered by integrating practical demonstrations, classroom-based theory sessions and directed research, using a variety of learning resources including information technology. Centres may wish to consider industrial visits so that learners can investigate and observe joining processes not generally available within the centre (for example laser and friction welding machines). Learners may benefit from the use of DVD footage, while the internet may also be used for information and video clips of the various welding processes.

Tutors must ensure that learners understand the hazards and safe working practices associated with welding equipment before they are allowed to carry out the processes. Learners should be introduced to the processes using a series of graded formative tasks to enable them to develop their skills and demonstrate their competence before attempting the summative tasks.

Learners should be encouraged to evaluate their performance in the formative tasks using a combination of tutor, self and peer assessment methods. The inspection of welded joints and components within the workshop will encourage self, and peer assessment. Learners can relate the results of the inspection process to the adjustment of process parameters to enable them to experiment, in an attempt to improve weld quality. This should be supported with formative feedback from the tutor.

The four learning outcomes follow a natural progression which should enable learners to develop an understanding of the fundamental stages involved in the production of welded joints and components, irrespective of the process used. Job instructions should be written in a logical format that will lead learners to consider all aspects of the task from safety, selection of tools, equipment and materials, process set-up and operation through to the production and inspection of welded joints in components.

The summative tasks will assess learners' competence in the use of certain welding processes and their ability to control process parameters to produce welded components that meet a specified quality standard.

Work-based learners should be encouraged to relate the learning outcomes to the processes and techniques used in the workplace. They should also be provided with a wider knowledge of welding processes used in industry, and not just those in their own place of work. Centres should relate tasks to the needs of local industries to prepare learners for employment and to provide them with appropriate skills and knowledge.

Learners will require instruction in the safe application of welding processes and will need access to a wide range of publications, reference data, manufacturers' product/information and computer facilities. The centre should have access to an appropriate range of welding equipment.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments / activities and / assessment
Whole-class teaching: – introduction to unit, scheme of work and assessment methods – introduction to welding for producing permanent joints – introduction to health and safety related to welding – introduction to health and safety legislation and regulations – explain safe working practices
Preparation for and carrying out Assignment 1: Safe Working Practices when Welding (P1)
Whole-class teaching: – describe information sources – drawings, job specifications, quality documentation – explain use of information required when welding – explain selection of welding processes for different applications – explain and demonstrate use of tools and equipment required during welding – explain and demonstrate use of manual, mechanised, and machine-based processes ***Workshop practical session:*** – overview of relevant processes and process selection – introduction to welding equipment used – parameters for manual, mechanised, and machine-based processes – preparation for use, shutdown procedures and storage of equipment
Preparation for and carrying out Assignment 2: Using Information and Preparing for Work (P2, P3, P4, M1, D1)
Whole-class teaching: – explain welding theory and demonstrate use of welding techniques for different joints, materials and positions – explain weld quality standards for materials, joints and components – describe common defects and irregularities in welded joints

Topic and suggested assignments/activities and/assessment
Workshop practical session: – safety in welding workshops (manual, mechanised, and machine-based processes) – use of correct techniques when welding different joints and process constraints – use of correct techniques when welding different materials – process specific – use of correct techniques when welding different positions – process specific – ensuring weld quality and application of weld standards in inspection
Preparation for and carrying out Assignment 3: Producing Quality Welded Joints (P5, P6, P7, P8, M2)
Whole-class teaching: – explain weld testing theory and demonstrate visual, destructive and non-destructive testing techniques – explain use of test standards – variety of standards, tolerances, dimensions, weld quality – explain and demonstrate test procedures - visual, destructive and non-destructive – explain methods of reporting ***Workshop practical session:*** – safe practice for preparing joints and using equipment – preparation of joints for testing – testing of welded joints – reporting results of weld tests
Preparation for and carrying out Assignment 4: Inspecting Welded Joints (P9, D2)
Feedback and unit evaluation

Assessment

Assessment of this unit could be through the use of four assignments.

The first assignment could cover P1 where learners are asked to produce a written report. Evidence for P1 must be specific to welding and the processes used within the industry. Learners will need clear guidelines in respect of what they should present. There is a large amount of generic material that learners will need to access. Care should be taken to ensure that what is presented is properly referenced and not directly copied from the internet or any other source.

A second assignment covering P2, P3 and P4 could be used to demonstrate the preparatory requirements for welding. Evidence could be presented in the form of a written report or by an oral presentation, supported by diagrams and photographs of formative practical work. Learners will need to select a welding process for a given application. The expectation within this task is that all areas of the process will be described and the stated quality standards will be taken into account. The practical experience will influence learners' ability to answer this task. M1 and D1 can also be achieved by analysing the effect of incorrect welding parameters and justifying a selected process for a given welding application. Learners will need to demonstrate their knowledge of both joining processes and the properties of engineering materials.

Criteria P5 and P6 are assessed through a third practical assessment. The evidence for the practical investigations will be in a written report format, or may be assessed as part of a logbook or portfolio that records the types of joint, materials and positions used, and the consumables required for the process. This may be supported by witness statements or observation records used to show the evidence required. This will provide evidence of the joints produced using either a manual or mechanised welding process. The choice of whether a manual or mechanised process should be used is left to the centre and may be decided by the pathway that learners are following in their workplace. More freedom of choice may exist with centre-based learners but attention should be given to likely local employment opportunities.

Criteria P7 and P8 require joints to be welded using machine-based processes which should be assessed in a similar format to P5 and P6. Care must be taken to consult the content section of the unit to ensure that the range of welding positions, joints, materials and consumables appropriate to the joining process being assessed for the manual, mechanised and machine-based welding processes. M2 can be achieved by the learner comparing two processes, which could be the processes used in P6 and P8, and demonstrating further knowledge of the processes. Care will be required when selecting the given application to ensure learners have opportunities to carry out this comparison. Although it is not compulsory to have a manual and mechanised process, this is where opportunities may be maximised during a comparison.

A fourth assignment could be in assessing P9 where the learner produces a report to explain the results of quality inspection processes used for the joints produced in P6 and P8. Learners should include their findings, and refer to the standards, accuracy, destructive, non-destructive and visual inspection methods used. Reference should be made to the original guidelines for the given application and any quality standards that are indicated. D2 will require learners to use the results of the practical work carried out to achieve P6 and P8. The information in the written outcome from M2 may also be of use in enabling them to evaluate non-destructive inspection.

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Safe Working Practices when Welding	Learners need to produce an information poster on health and safety requirements and safe working practices applicable to the welding industry.	A written report that describes the legislation and safe working practices used in the welding industry with clear referencing to appropriate sources of information.
P2, P3, P4, M1, D1	Using Information and Preparing for Work	Learners need to select a suitable process and welding parameters, identify consumables and plan the tools and equipment needed for a given welding application (eg a number of welded joints to form a simple component).	A written report could be used to assess the pass criteria using diagrams and photographs of relevant information. Further analysis and justification would assess M1 and D1. It may be considered that an oral presentation, supported with appropriate graphics, may be more suitable in the assessment of all criteria in this assignment. The tutor should consider the method of maintaining evidence of the presentation.

Criteria covered	Assignment title	Scenario	Assessment method
P5, P6, P7, P8, M2	Producing Quality Welded Joints	Learners need to produce welded joints to a required quality standard.	A written report supported by a logbook or portfolio that records the range of consumables, joints, materials and welding positions used. Evidence of the weld quality may include photographs, diagrams, witness statements, and quality reports. The report should identify the quality standards used and compliance to that standard. A comparison of two welding processes clearly identifying the processes and the advantages and disadvantages of each process for a given application should be included.
P9, D2	Inspecting Welded Joints	Learners test welded joints that they have previously made in a material or component.	A practical activity evidenced by a report that discusses the quality inspection processes used for the joints produced in P6 and P8 and the results. The report can further investigate the benefits and limitations of using non-destructive testing techniques on welded components.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Application of Welding Processes	Fabrication Processes and Technology
		Welding Principles

This unit also covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Fabrication and Welding Engineering, particularly:

- Unit 4: Welding Materials by the Manual Metal Arc Process
- Unit 5: Welding Materials by the Manual MIG/MAG and other Continuous Wire Processes
- Unit 6: Welding Materials by the Manual TIG and Plasma Arc Welding Process
- Unit 7: Welding Materials by the Manual Gas Welding Process
- Unit 16: Welding Materials with Mechanised Arc Welding Equipment
- Unit 17: Welding Materials using Resistance Spot, Seam and Projection Welding Machines
- Unit 18: Welding Materials using Laser Welding Machines
- Unit 20: Welding Materials using Friction Welding Machines
- Unit 65: Inspecting Welded Components or Structures for Visual Quality and Dimensional Accuracy.

Essential resources

Centres delivering this unit will need access to appropriate welding equipment, consumables and materials as outlined in the unit content. Centres must also have access to appropriate destructive and non-destructive test equipment.

Employer engagement and vocational contexts

The materials and processes used in the delivery of this unit should be in the context of the learners' workplace or may be based on case studies of local employers. Learners may benefit from industrial visits to gain an understanding of welding processes in an industrial context, and to also appreciate the range of processes and materials used in industry.

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the investigative activity can be set in the context of learners' work placements supported by case studies of local employers and well- known national companies. All four learning outcomes lend themselves well to visits or input from visiting speakers from local employers.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks Centre for Education and Industry (CEI-University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Davies, A C — *Science and Practice of Welding*, *Volume 1* (Cambridge University Press, 1993) ISBN 9780521435659

Davies, A C — *Science and Practice of Welding*, *Volume 2* (Cambridge University Press, 1993) ISBN 9780521435666

Raj B, Shankar V and Bhaduri A — *Welding Technology for Engineers* (Alpha Science International Ltd, 2005) ISBN 9781842651940

Timings, R — *Fabrication and Welding Engineering* (Newnes, 2008) ISBN 9780750666916

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

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

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information sources to select welding processes
Self-managers	selecting materials, processes and consumables for a given application planning the tools and equipment needed for a given application anticipating, taking and managing risks when welding

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	analysing the outcome of changing welding parameters and experimenting with a range of settings

Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching health and safety information and safe working practices used in the welding industry
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to peers and tutors when reviewing weld quality, weld parameters and the results of weld testing
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using sources of information during welding tasks and when researching health and safety information
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	reporting on health and safety information and safe working practices writing reports to effectively communicate plans, process parameters, techniques and test results of welding processes and welded components

Unit 24: Motorsport Workshop Practices

Unit code: J/502/5906

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner understanding of the safety procedures applicable in a motorsport workshop and to enable them to disassemble and reassemble motorsport vehicle components and select materials for motorsport applications.

Unit introduction

This unit is designed to prepare learners for trackside operations and reinforce their understanding of the need for safe working practices. Learners will develop an understanding of how actions can reduce the risk to employees, others and vehicles in a temporary workshop at an outdoor motorsport event. In addition, learners will gain an appreciation of the procedures required to deal with trackside incidents.

Learners will also develop the skills needed to use tools and equipment, including hand and power tools, through carrying out disassembly and reassembly tasks. This will involve an understanding of fasteners and materials used in motorsport vehicle construction, and their appropriate usage.

Finally, the unit introduces learners to the properties of engineering materials and their specific applications for motorsport engine and chassis components.

Learning outcomes

On completion of this unit a learner should:

1. Understand how to maintain good housekeeping and health and safety procedures at a motorsport event
2. Be able to use appropriate tools and equipment for the disassembly and reassembly of motorsport vehicle components
3. Know how and why temporary and permanent fasteners are used for specific motorsport applications
4. Be able to select appropriate materials for specific motorsport applications.

Unit content

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1 **Understand how to maintain good housekeeping and health and safety procedures at a motorsport event**

Actions to reduce risk: risk to employees eg correct use of personal protective equipment (PPE), safe use of tools and equipment, safe use of fuels and lubricants; others eg containment of hazardous substances, warning signs correctly used and clearly visible; vehicles eg correct use of lifting and supporting equipment; housekeeping eg relevant regulations/codes of practice (Health and Safety at Work Act, Control of Substances Hazardous to Health (COSHH)), work areas kept separate from public areas at all times

Dealing with incidents: emergencies eg personal injury, fire, spillage, equipment failure, area evacuation, inhalation of noxious fumes; accidents eg slips, trips, falls, collision; immediate actions eg evacuate/cordon off area, report/fight fire, quarantine emergency; follow-up actions eg clear away spillage and dispose of waste, document incident, administer first aid, inform emergency services

Motorsport event: eg rallying, go-karting, closed-circuit competition, off-road racing, motocross, sprint, hill climbs

2 **Be able to use appropriate tools and equipment for the disassembly and reassembly of motorsport vehicle components**

Tools and equipment: hand tools eg spanners, screwdrivers, ratchets and sockets (metric and imperial); tool size recognition; power tools relevant to speed and efficiency at trackside eg pneumatic/electric ratchets, drills; measuring tools eg micrometer, vernier callipers, gauges; lifting and stabilising equipment eg pneumatic/mechanical lifts, hydraulic jacks, axle/vehicle stands

Disassembly/reassembly: components eg body and chassis components in the event of a crash (panels and steering components), engine disassembly and reassembly; tasks eg maintenance, servicing and repair of consumable components during an event

3 **Know how and why temporary and permanent fasteners are used for specific motorsport applications**

Temporary fasteners: for components requiring frequent maintenance or replacement eg 'R' clips, split pins, nuts and bolts, quick release fasteners

Permanent fasteners: for components that do not require regular replacement or removal for maintenance eg rivets, locking nuts, stretch bolts, shear bolts; alternative methods eg the bonding of polymers, glass/carbon fibre and plastic welding, adhesives

4 **Be able to select appropriate materials for specific motorsport applications**

Material selection: mechanical properties eg strength, hardness, ductility, durability, density and mass; performance versus weight; finish eg professional appearance for chassis components, weight and aerodynamic properties; aesthetic, ergonomic and durable properties; types of material eg metallic alloys and non-metallic materials, Kevlar, glass/carbon fibre; special treatments to obtain required properties eg shot/laser peening, heat treatment, specialised coatings; effects of loading eg compressive/tensile stress, fatigue, stress corrosion

Motorsport engine component: eg pistons, connecting rods, crankshafts, camshafts, valves, engine mounting brackets

Motorsport chassis components: eg steering components (such as steering racks and columns), braking components (such as callipers and discs), suspension components such as wishbones, pushrods, uprights, body panels and wings

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the ways that actions can reduce the risk to employees, others and vehicles in a temporary workshop at a motorsport event [EP4]	M1 take the necessary action to deal with an incident at a motorsports event	D1 evaluate a temporary workshop at a motorsport event for potential hazards and recommend action to be taken
P2 describe the immediate and follow-up actions to be taken to deal with two different types of incidents at a motorsport event	M2 justify the use of two different fasteners for use in motorsport competition critical applications	D2 compare the differences in the material selection criteria for a specific vehicle component used on both production and motorsport vehicles.
P3 select and use the most appropriate tools and equipment to efficiently disassemble a motorsport vehicle component [SM3, SM4]	M3 justify the differences in surface finishing techniques used for a motorsport engine compared to a mass produced engine.	
P4 select and use the most appropriate tools and equipment to efficiently reassemble a motorsport vehicle component [SM3, SM4]		

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Assessment and grading criteria		
P5 describe the use of three different temporary fasteners with regard to suitability for purpose in motorsport applications		
P6 describe the use of three different permanent fasteners with regard to suitability for purpose in motorsport applications		
P7 select an appropriate material for a given motorsport engine component application [IE2, IE4]		
P8 select an appropriate material for a given motorsport chassis component application [IE2, IE4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	
	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

Because of the nature of motorsport events, delivery of learning outcome 1 must emphasise the wide range of associated health and safety issues. Many more people could potentially be involved in an incident at a motorsport event than within a confined automotive workshop. Therefore, learners must have a competent working knowledge of the required safety procedures to ensure the safety of personnel, spectators and vehicles.

Delivery must focus on ensuring learners understand the actions required to reduce risk to those directly involved with motorsport vehicles and others (for example spectators, guests, visitors). This will involve raising learners' awareness of the importance of tools, equipment and consumables being kept in their rightful place, so as not to cause hazard by way of obstacles, slips or trips. Also, that even in 'self-contained' temporary workspaces at events, it is still important that relevant legislation and regulations relating to safety and materials storage and handling (for example Health and Safety at Work Act, COSHH) are strictly observed to ensure minimum risk.

In particular, high-speed vehicles are a constant hazard to pit crew unless health and safety procedures are rigidly observed. Service personnel must be aware of how to deal with an incident and the relevant safety procedures to be observed in the event of a collision (vehicle/vehicle or personnel/vehicle) or other incident. Delivery of the unit must ensure that learners are aware of the appropriate action to be taken for such incidents to ensure the safety of personnel, spectators and vehicles.

The delivery of the 'dealing with incidents' section of the unit must also ensure that learners are aware of the regulations regarding fire safety (for example which extinguisher to use on what type of fire, actions to be taken in the event of a fire). For example, motorsport vehicles may use materials that pose specific risks when burning (for example magnesium, glass/carbon fibre and other non-metallic materials), give off noxious fumes, or require specialist treatment (for example burns from burning rubber or plastic components). Post-incident procedures and effective incident documentation must also be in place to ensure the continued safety of personnel and spectators (for example disposal of harmful waste, spillage control).

Learners must be made aware that for each individual motorsport event, there are specific and general risks which apply whether the event is tarmac based, off-road, rallying, karting, or any other motorsport event. Centres should ensure that the methods of delivery are such that each learner has a working knowledge of these risks and how to deal with them irrespective of the type of event.

Learning outcome 2 considers tools and equipment and their use to disassemble and reassemble components. The focus of this unit is set within the context of trackside work and this should be reflected in the delivery methods used for this section of the unit. During a motorsport event speed is vital and the vast majority of work is time-critical. However, this should not be at the expense of accuracy and attention to detail.

Delivery of this section must ensure that learners are able to select and use the correct tools to complete any job, without compromising either the tools or components. Hand tool selection should cover the range of tools listed in the unit content (for example spanners, screwdrivers, ratchets and sockets). Learners should be given sufficient opportunities to practise with tools to ensure that they are able to recognise different tool sizes, as this can be a critical factor in the speed with which a job is completed. This section should also deal with the power tools used at events and to complete disassembly/reassembly swiftly. Again, it is expected that delivery will introduce learners to tools such as air powered/electric ratchets and other pneumatic equipment.

In addition to the use of hand and power tools, it is expected that the range of measuring tools (for example micrometer, vernier callipers, gauges), lifting and stabilising equipment (for example pneumatic/mechanical vehicle lifts, hydraulic jacks, axle/vehicle stands) will also need to be covered during delivery.

Learning outcome 3 focuses on the fasteners used for assembly and disassembly. For applications where service adjustments or component substitutions/repairs are made frequently, temporary fasteners must be used. There are many factors involved in the selection of these fasteners, such as the load placed on the fastener, the frequency and required ease of removal and replacement, the type of material to be joined, and the required joint strength of the fastener. During delivery learners should be encouraged to compare the relative merits, suitability and purpose of a variety of temporary fasteners and joining methods (such as nuts/bolts, r-clips, split pins, cable ties and quick release fasteners).

For situations where components are removed and replaced infrequently, if at all, fastenings that are more permanent may be required. Once again, delivery should ensure that learners have the widest possible experience of these fastenings. For example, learners should gain experience with rivets, self-clinching fasteners, self-tapping screws, vibration-proof and self-locking fasteners, tamper-proof or shear bolts and screws. Some of the fasteners may overlap (such as nuts and bolts) but in such cases it is important to focus on the key aspects of the fastenings (for example thread size, pitch, shank length, material construction and properties such as tensile strength, shear strength and hardness) through workshop/classroom-based investigations.

Learners should also be given an opportunity to investigate and apply alternative permanent joining techniques for a variety of materials (such as polymers, glass/carbon fibre) which are now frequently used in modern motorsport vehicles.

Delivery of learning outcome 4 should focus on the materials used for motorsport components. Learners will need to develop their ability to select materials based on the mechanical properties, required finish, the type of material and its suitability for a particular task. For most motorsport applications performance versus weight will always be an important factor in final choice. Providing learners with an opportunity to work with materials (for example cutting, bending, fabricating) would reinforce the theoretical aspects of material properties. There is also a link to learning outcome 1 that could be reinforced here in terms of the health and safety issues surrounding the use of materials in an engineering environment (for example working with glass/carbon fibre, metals such as aluminium, steel, stainless steel and alloys).

Learners should also be given an opportunity to investigate the surface treatment of motorsport engine components. For example how shot peening, laser peening, heat treatment and the use of specialised coatings increase a component's ability to withstand compressive stress and reduce the effects of fatigue or stress corrosion, and protect against oxidation.

The range of materials to be covered during delivery will depend on the main motorsport focus in a centre. In general, when looking at how metals are used in motorsport vehicle construction, learners should investigate the types of alloys typically used (for example duralumin, Alclad and magnalium) and the various applications of these materials (for example use for body skins, spars and stiffeners).They should also look at applications where stronge, more lightweight metals are required (for example magnesium, stainless steel and titanium alloys) and alternative non-metallic materials (for example carbon fibre, Kevlar and fibre glass).

The most important aspect about the delivery of learning outcome 4 will not be coverage of an extensive range of materials but that learners have a good grasp of the important features of material properties and their range of applications in motorsport engine and chassis components.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

<table>
<tr><th>Topic and suggested assignments/activities and/assessment</th></tr>
<tr><td>Whole-class teaching:
– introduction to unit content, overview of activities and assessment methodology
– explain actions to reduce risk to employees, others and vehicles
– explain requirements and procedures for good housekeeping
– explain the immediate and follow-up actions that need to be taken after a range of emergencies and accidents at a motorsport event
– tour of motorsport workshop to identify hazards and risks
Individual learner activities:
– investigation and research of good housekeeping, health and safety procedures and procedures for dealing with incidents at a motorsport event</td></tr>
<tr><td>Prepare for and complete Assignment 1: Housekeeping and Health and Safety Procedures (P1, P2, M1, D1)</td></tr>
<tr><td>Whole-class teaching/practical demonstration:
– explain and demonstrate use of hand and power tools, measuring tools and lifting and stabilising equipment for disassembling and reassembling motorsport vehicle components
Practical activities:
– practise and use of disassembly and reassembly tools and techniques</td></tr>
<tr><td>Prepare for and complete Assignment 2: Assembling and Disassembling Motorsport Vehicle Components (P3, P4)</td></tr>
</table>

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Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the use of temporary fasteners for components that require frequent maintenance or replacement – explain the use of permanent fasteners for components that require less frequent maintenance or replacement ***Practical activities:*** – investigation of motorsport components and their corresponding fasteners
Prepare for and complete Assignment 3: Applications of Temporary and Permanent Fasteners (P5, P6, M2)
Whole-class teaching/practical demonstration: – explain the properties of a range of materials used on motorsport vehicles and their suitability for different applications ***Practical activities:*** – investigation of the properties of motorsport engine and chassis components
Prepare for and complete Assignment 4: Motorsport Applications of Materials (P7, P8, M3, D2)
Feedback to learners, unit evaluation and close

Assessment

Assessment of this unit is likely to be through the use of four assignments, one for each learning outcome.

The first assignment could cover learning outcome 1 and the related criteria (P1 and P2). The assignment could also be designed to provide an opportunity to work towards M1 and D1.

To achieve P1, learners must be able to explain the ways in which actions can reduce the risk to employees, others and vehicles in a temporary workshop or motorsport event. The evidence for this criterion could be achieved through a time-constrained test. However, it is recommended that learners produce their own observation record during one or more actual events. The record could be in the form of a logbook in which learners record their observations in such a way as to cover risks to employees, others and vehicles and housekeeping.

P2 could be dealt with in a similar way to P1. Although learners might have had experience of, or witnessed an emergency/accident, the use of role play or a 'what if' scenario is a much more likely means of gathering evidence.

M1 can be linked to P1 and P2 and evidence is likely to be in the form of tutor observation of learner performance during a particular incident (which could be real or simulated). There is a further link through to D1, for which learners need to use their understanding from P1, P2 and M1 to carry out a risk assessment. It is important that the situation used provides learners with an opportunity to make recommendations for action to be taken (ie there needs to be some real or simulated problems in the temporary workshop). In order to gain D1, learners must attend a competition event and carry out the risk assessment. Centres must therefore make adequate provision for this to happen.

The two pass criteria associated with learning outcome 2 (P3 and P4) cover the disassembly and reassembly of components. For P3, learners will require a specific task to be set for them to disassemble a motorsport vehicle component. The tools that learners select and use will be determined by the task and therefore, not all the unit content is necessarily going to be covered. Centres should, however, ensure that the choice of component demands the use of a reasonable number of the items listed in the unit content (for example hand tools, power tools, measuring tools, lifting and stabilising equipment). The same would apply to P4 but for reassembly.

The evidence for P3 and P4 is likely to be in the form of a tutor observation record supported by the learner's own records of how they dealt with the tasks. This could be in the form of a technical report or logbook.

P5 and P6 relate to learning outcome 3, which covers temporary and permanent fasteners. Learners will need to describe the use of three different temporary fasteners and three different permanent fasteners with regard to suitability in motorsport applications. Although it would be possible to assess these criteria using a written test, a more practical approach is recommended. There is an opportunity to link the work undertaken for P3 and P4 with this learning outcome, since it is likely that when disassembling and reassembling components learners will experience such fastenings.

An integrated approach could also be used to assess M2. An extension task could be built onto the work for P3, P4, P5 and P6 requiring learners to justify fastenings used within a maintenance or repair task.

Learning outcome 4 is covered by P7 and P8, which also link to M3 and D2. In order to meet P7 and P8, evidence of independent research of the materials involved must be shown. For both P7 and P8, learners are expected to select a material for a given motorsport engine and chassis component application, respectively. The components selected for this task must enable learners to investigate the mechanical properties of a material, issues of performance versus weight, the material's finish, and any aesthetic, ergonomic and durable properties as appropriate to the component. The types of material investigated could be chosen from the list of examples in the content (for example metallic alloys and non-metallic materials used in engine tuning, Kevlar, glass fibre) or any other relevant material. It is expected that special treatments to obtain required properties and the effects of loading will be dealt with for at least one of the components (ie either for the engine component or chassis component). This could then be linked through to M3 and D2.

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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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Housekeeping and Health and Safety Procedures	A technician needs to carry out a risk assessment for a motorsport workshop	Written report
P3, P4	Assembling and Disassembling Motorsport Vehicle Components	A technician is required to disassemble and reassemble a motorsport vehicle component	Practical work evidenced through records/log of work carried out and tutor observation records
P5, P6, M2	Applications of Temporary and Permanent Fasteners	A technician needs to describe the use of different fasteners to a new member of a motorsports team	A written report
P7, P8, M3, D2	Motorsport Applications of Materials	A technician needs to select materials for motorsport engine and chassis components	Practical work evidenced through records/log of work carried out and observation records

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC vehicle sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Motorsport Vehicle Preparation and Inspection
		Professional Practice and Logistics for Motorsport

The unit contributes towards the knowledge and understanding needed for the IMI Level 3 National Occupational Standards in Maintenance and Repair – Light Vehicle, particularly:

- Unit G01: Contribute to Housekeeping in Motor Vehicle Environments
- Unit G02: Reduce Risks to Health and Safety in the Motor Vehicle Environment
- Unit G04: Use of Hand Tools and Equipment in Motor Vehicle Engineering.

Essential resources

Learners will need access to outdoor motorsports events at which they can take an active part in field/temporary workshops. Centres will also need workshop facilities fitted with a range of the tools and equipment listed in the unit content. A range of fastenings and components (engine and chassis) will need to be available for demonstration purposes and for learners to work with.

Learners will also need access to sufficient data and research resources to enable them to study and research different engineering materials for motorsports applications.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

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

Health and Safety Executive — *Five Steps to Risk Assessment* (HSE Books, 2006) ISBN 9780717661893

Health and Safety Executive — *A Short Guide to Personal Protective Equipment at Work Regulations 1992* (HSE Books, 2005) ISBN 9780717661411

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	planning and carrying out research and analysing and evaluating information relating to the properties of materials, judging its relevance and value
Self-managers	organising time and resources, prioritising actions when selecting and using appropriate tools and equipment
Effective participators	identifying improvements that can reduce risks in a temporary motorsport workshop, benefiting themselves and others

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others as part of a motorsports team to work towards common goals

Functional Skills — Level 2

Skill	When learners are …
Mathematics	
Select and apply a range of skills to find solutions	carrying out calculations on material properties and behaviour
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	selecting materials based on mechanical properties
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading relevant regulations and codes of practice to establish guidelines for workshop housekeeping and health and safety
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	preparing technical reports on health and safety issues, disassembly/reassembly tasks, fastenings and materials

Unit 25: Motorsport Vehicle Preparation and Inspection

Unit code: L/502/5907

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to enable learners to prepare a motorsports vehicle for competition, including completing relevant documentation, and carrying out vehicle inspections before, during and after a motorsport event.

Unit introduction

The preparation and inspection of motorsport vehicles plays a vital part in their overall safety, performance and reliability. Any motorsport vehicle must be prepared to withstand the forces it is subjected to, the environment that it is used in and to conform to relevant standards.

The correct preparation of a vehicle's chassis, braking, suspension, steering, engine and transmission systems is imperative if it is going to perform at its best. Preparation is also a vital aspect in maintaining the safety requirements of a vehicle involved in competitive activities.

Each form of motorsport requires specific types of preparation but there are also aspects of preparation that span the whole spectrum of the sport. Vehicle inspection is a critical part of the process, ensuring conformity to both set standards and safety requirements. It also goes a long way in ensuring a vehicle's reliability, which is an extremely important factor for any motorsport vehicle. Inspections should be carried out post- build, pre-competition, during competition and post- competition.

This unit focuses on both the technical and practical aspects of preparation and inspection. It will enable learners to gain the skills required of a competent member of a motorsport team. The areas covered will include preparing a motorsport vehicle to a given standard and ensuring that the correct documentation has been gathered and completed during the inspection process. It will also cover the documentation required by the sport's governing bodies.

Learning outcomes

On completion of this unit a learner should:

1 Be able to record and collate documentation required to compete at a motorsports event

2 Be able to prepare a competition vehicle to a recognised specification

3 Be able to carry out inspections before, during and after a motorsports event.

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Unit content

1 **Be able to record and collate documentation required to compete at a motorsports event**

Vehicle documentation: ministry of transport (MOT) test (if required); Motorsports Association (MSA) logbooks; road tax; vehicle and competition insurance; driver and vehicle licensing agency (DVLA) log books, pre-inspection documentation, set-up sheets; collation of competition data eg from DVLA, MSA, manufacturer

Competitor documentation: club/membership cards; MSA licences eg clubman, national A, international, race, rally, speed medical certificate; doctor's medical report; collation of competition data eg entry applications and acceptances, final instructions, road books, circuit diagrams

Motorsport event documentation: eg MSA permits, insurance waivers, land registry, final instructions, regulations (race/rally)

2 **Be able to prepare a competition vehicle to a recognised specification**

Vehicle preparation: tool use eg spanners, sockets, screwdrivers, torque wrenches, pressure gauges; specialist tools eg camber, caster, tracking, spring compression gauges, gas analysers; equipment use eg hoists and stands, auxiliary engine starting devices; safe operation of tools and equipment eg serviceable condition, correctly stored and accounted for (shadow boards, tool control methods), correct tool/equipment used in an appropriate manner; preparation routines eg conformation of class, scrutineering

Specifications: MSA blue yearbook, FIA regulations eg technical regulations, competitor safety (cage mountings, cage design, fire extinguishers); yellow book eg technical regulation, homologation (type of vehicle, year of make); single make and class regulations eg engine cubic capacity (cc), design type

3 **Be able to carry out inspections before, during and after a motorsports event**

Health and safety: safe use and handling of lubricants/fluids eg fuel, oil, solvents, grease; safe use of lifting equipment and handling techniques eg tested and calibrated lifting equipment, Manual Handling Regulations; safe working practices eg motorsport specific applications of regulations and legislation (Health and Safety at Work Act 1974, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Provision and Use of Work Equipment Regulations (PUWER) 1998); safe disposal of waste materials and components eg cleaning cloths, hydraulic fluids, contaminated fuel, scrap components (tyres, brake and clutch linings)

Personal protective equipment (PPE): overalls, safety-shoes, gloves, specialist motorsports equipment eg fire protection, hearing and eye protection, communications equipment

Pre-competition inspection: scrutineering; security of fastenings using a torque wrench eg nuts, bolts, critical securing devices; fuelling vehicle eg correct capacity, type of fuel; tyres eg suitability, condition, pressures; lubrication and coolant system levels and pressures eg warm up, operating temperature; testing throttle settings and operation eg idle, full throttle; hydraulic fluid system levels, check for leaks and operation eg for clutch, steering, brakes; vehicle brake balance settings; setting suspension dampers to suit event; transmission system operation eg function of clutch and gearbox through all gears; electrical system operation; running gear eg spherical bearings, wheel bearings; reporting of faults eg loss of fluid, abnormal pressure, excessive wear

Pre-competition set-up: event analysis eg data from previous event used to provide a set-up sheet for setting-up the vehicle for an event including gearing, cambers, springs, anti-roll bars, other suspension geometry adjustments, corner weights, aerodynamic elements and steering geometry

Inspections during an event: scheduling of inspections within certain timeframes; types of inspections eg fuel draining/weighing, fluid level checks, spanner checks, visual checks for leaks/damage, brake condition/temperature checks and bodywork security/condition

Post-competition inspection: initial post-competition assessment; set-down of vehicle; engine condition eg compression/leak tests; cleaning of bodywork/removal of track debris

Post-competition vehicle rectification: using job sheets, type of rectification eg repair, adjustment, replacement

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 record and collate vehicle, competitor and event documentation for a motorsport event [IE4]	M1 compare the specifications required between two different classes of motorsport events	D1 compare the differences in the tools and equipment used in a motorsports workshop against those used at a competitive event
P2 use tools and equipment to prepare a competition vehicle to a given specification [SM3, SM4]	M2 carry out a survey of a service/pit area and identify strengths and threats to the health and safety of self and others	D2 evaluate your own and your team's performance after a motorsports event and recommend an improvement strategy.
P3 describe the health and safety procedures to be followed when inspecting a motorsports vehicle	M3 produce a 'set-down' schedule and checklist for post-competition inspection and rectification.	
P4 use appropriate personal protective equipment when inspecting a motorsport vehicle		
P5 carry out pre-competition vehicle inspection and set-up [SM3, SM4, TW1, TW5]		

Table continues on next page

Assessment and grading criteria		
P6 carry out vehicle inspections during a motorsports event [SM3, SM4]		
P7 carry out a post-competition inspection following a motorsports event [SM3, SM4]		
P8 identify and record vehicle rectification work required.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	
	IE – independent enquirers
	CT – creative thinkers
	RL – reflective learners
	TW – team workers
	SM – self-managers
	EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit will need to focus on learners' understanding the varied event structures and their documentation processes. The importance of meticulous preparation will need to be emphasised, along with interpreting relevant regulations and standards.

The ultimate focus of the unit will be a real motorsports event where all the knowledge and skills learned will be put to use. This may be through learners' own participation in an event, through working with an established motorsports team or through the centre's own motorsports activities.

Attendance at a number of different events (initially just to observe and eventually in an active role) is highly recommended. Supervised workshop sessions and practise of routines is vital in ensuring that learners gain the required skills and knowledge of procedures. In particular, learners need to adhere to relevant health and safety requirements and demonstrate that they can apply their skills in a real motorsports situation competently.

Centres will need to ensure that learners have experience (through controlled simulation, if necessary) of all aspects of the unit content. Careful consideration will need to be given as to how to best cover post-event evaluations and critical evaluation of whole events.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments / activities and / assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the vehicle, competitor and event documentation that is required to compete in a motorsports event – visit to motorsport event(s) and presentation from member of a motorsports team to identify and discuss relevant documentation required ***Individual learner activities:*** – investigation of documentation required for a motorsports event
Prepare and complete Assignment 1: Motorsport Documentation (P1)

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Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain and demonstrate the correct and safe use of tools and equipment to prepare a motorsports vehicle – explain the requirements of MSA and FIA specifications and single make and class regulations – visit to motorsport event(s) to view competition vehicle preparation routines ***Practical workshop activities:*** – use of tools and equipment and practise of routines to prepare a motorsport vehicle to specification
Prepare and complete Assignment 2: Preparing a Motorsport Vehicle to Specification (P2, M1)
Whole-class teaching: – explain the health and safety procedures that need to be followed when inspecting a motorsports vehicle – explain the correct use of personal protective equipment – explain relevant pre-competition inspection and set-up routines – explain motorsport vehicle inspection during an event – explain post-competition inspection routines and vehicle rectification – visit to motorsport event(s) to view vehicle inspection routines ***Practical workshop activities:*** – practise of inspection routines ***Participation in a motorsports event:*** – working as part of a motorsports team to carry out vehicle inspections pre-competition, during and after an event
Prepare and complete Assignment 3: Health and Safety in a Motorsport Service Area (P3, M2)
Prepare and complete Assignment 4: Inspecting Motorsport Vehicles (P4, P5, P6, P7, P8, M3)
Prepare and complete Assignment 5: Evaluating a Motorsports Event (D1, D2)
Feedback to learners, unit evaluation and close

Assessment

Assessment of the unit should predominantly focus on learners demonstrating their skills and knowledge during motorsports events. It is expected that each learner will prepare their own portfolio of evidence to cover all the assessment criteria through participation in real motorsport activities. Centres will need to consider how this can be supported and managed on an individual basis. Some simulation may be appropriate for assessment purposes, although this should be kept to an absolute minimum wherever possible.

The three learning outcomes cover documentation, pre-motorsport activity vehicle preparation and pre/during/post- event inspection. Assessment is likely to follow this order although this is not essential. It should be noted that learning outcomes 1 and 2 only have one related pass criterion each, with the bulk of assessment relating to learning outcome 3, with six pass criteria.

For learning outcome 1, learners must be able to record and collate vehicle, competitor and event documentation for a motorsport event (P1). It is important that this criterion is not fragmented and that the assessment activity that is used allows learners to collect all the required documentation at one event. The actual documentation will depend on the nature/type of event used, but centres must ensure that the chosen event provides sufficient coverage of the unit content for the assessment to be valid and reliable.

Learning outcome 2 requires learners to use tools and equipment to prepare a competition vehicle to a given specification (P2). This is one of the criteria that could be simulated. However, whether simulation is used or the vehicle is actually being prepared for an event, learners must be able to demonstrate their ability to select appropriate general tools, specialist tools and equipment and use them safely following a given specification. Evidence for this criterion is likely to be in several forms. Firstly, a tutor observation record of the learner’s selection and use of tools and equipment, plus a logbook record (maintained by the learner) of the work carried out together with any data/information gathered. Finally, it is likely that the tutor will carry out an observation/inspection of the success of the vehicle’s preparation against the specification together with the use of oral questioning of the learner.

Merit criterion M1 can be effectively linked to P2. One of the specifications used for the comparison is likely to be that used for the vehicle preparation undertaken for P2. A second, and quite different, specification should be used to add depth and breadth to the learner’s assessment evidence.

All the remaining pass criteria relate to learning outcome 3. It is expected that P4, P5, P6, P7 and P8 will be undertaken and assessed under actual motorsport activity conditions.

To achieve P3 learners must describe the health and safety procedures to be followed when inspecting a motorsports vehicle. This must include safe use and handling of lubricants/fluids, safe use of lifting equipment and handling techniques, safe working practices and safe disposal of waste materials and components. Examples of each of these are given in the unit content but it is the actual task(s) undertaken that will determine which of these examples is most appropriate. It is for the centre to determine sufficiency of evidence but, clearly, the task(s) used will need to be chosen carefully to include opportunities to meet all the requirements of the unit content. Since this is a descriptive criterion, a paper-based response could be used, although it might be more appropriate for evidence to be gathered through oral questioning of learners as they carry out relevant tasks.

M2 is related to P3 and provides an opportunity for learners to demonstrate and apply the knowledge. Evidence for M2 could be a written report of the learner's findings or feedback from their survey in the form of a briefing. The tutor will need to ensure that there are a number of typical health and safety issues (specifically created for the purpose of assessment if necessary) for learners to report back on under the heading 'threats'.

For P4, learners should be observed using the range of personal protective equipment listed in the unit content. With respect to the specialist equipment, it would not be unreasonable to expect all the examples to be used but as a minimum learners should select and use at least two under the appropriate conditions.

It is expected that P5, P6, P7 and P8 will be assessed during an actual motorsport activity. Ideally, the criteria should not be fragmented and should all be covered at one event. Once again, the assessment evidence for all of these criteria will be a mix of tutor observation and logbook records and data collection. It is essential for the achievement of P8 that the motorsport vehicle requires rectification. For this reason, it may be that this criterion cannot be assessed at the same event as the others. Although it is likely that some rectification will be required following an event, the question for the tutor will be one of sufficiency.

M3 could be linked to the work of P7 and P8. The 'set down' schedule must cover the post-competition inspection and rectification and is expected to include timetables, checklists, job cards, parts requisitions and invoicing/costing information.

It is likely that the evidence for D1 and D2 will come from the overview that the learner has gained during their work towards P5, P6, P7 and P8. Although D1 could be covered at the same event as that used at pass, it is more likely that a completely different event is used when learners are less involved and can stand back and take a broader view of the event. It is intended that the evidence for D1 will come from an analytical exercise that allows learners to compare motorsport workshop equipment with the type of tools and equipment used in the field during an event. Typically, this would include lists of the type of tools and equipment used and the related costs, safety and security considerations. It should also include an evaluation of which tools can double up for both purposes and the reasons behind the choices.

Finally, for D2, learners should carry out a full evaluation of their team's performance following an event. The evaluation might include the learner's reflection on the team's preparation, inventories, scheduling, loading lists, movements and individual personal performance. The evaluation must include a strategy for how the team can do things better and this is likely to touch on the cost efficiencies that can be made.

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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.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Motorsport Documentation	A motorsport technician needs to collate the relevant documentation for an event	Practical assignment evidenced through observation records and records of information collated
P2, M1	Preparing a Motorsport Vehicle to Specification	A technician needs to prepare a motorsport vehicle	Practical assignment evidenced through observation records and learner's record/logbook
P3, M2	Health and Safety in a Motorsport Service Area	A technician needs to explain to a new apprentice the health and safety procedures to be followed when inspecting a motorsports vehicle	A written report
P4, P5, P6, P7, P8, M3	Inspecting Motorsport Vehicles	A technician needs to inspect a vehicle before, during and after a motorsport event	Practical assignment evidenced through observation records and learner's record/logbook
D1, D2	Evaluating a Motorsports Event	A technician needs to report on a motorsports event and suggest possible improvements	A written report

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Motorsport Workshop Practices
		Professional Practice and Logistics for Motorsports

This unit contributes towards the knowledge and understanding needed for the SEMTA Level 3 National Occupational Standards in Automotive Engineering, particularly:

- Unit 49: Carrying out Motorsports Vehicle Inspections During a Competition
- Unit 57: Carrying out Fault Diagnosis and Rectification Activities on Motorsport Vehicles During a Competition.

Essential resources

Learners will need access to actual motorsport activities and events. In addition, centres will need to provide learners with access to a realistic motorsport vehicle preparation and inspection area, including relevant tools and equipment. Relevant health and safety documentation and regulations relating to motorsport activities will also need to be available for learners.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thorne, 2010) ISBN 978-1408515181

Nunney, M — *Light and* 1408515181 *Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information when identifying, recording and collating documentation for a motorsport event and when preparing a competition vehicle to specification
Team workers	collaborating with others to work towards common goals and taking responsibility for their contribution when working as part of a motorsports team
Self-managers	organising time and resources, prioritising actions when preparing a competition vehicle to specification and when carrying out motorsport vehicle inspections

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	identifying improvements that could be made within a motorsports team that would benefit others and themselves

Functional Skills — Level 2

Skill	When learners are …
ICT — Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching information on vehicle documentation, health and safety and relevant regulations
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching information on vehicle documentation, health and safety and relevant regulations
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing vehicle inspection reports and collating relevant evidence of vehicle/driver records

Unit 26: Professional Practice and Logistics for Motorsports

Unit code: F/502/5905

Level 3: BTEC Level 3 qualifications

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to develop learner knowledge of the organisation, administrative procedures and professional bodies associated with motorsport activities. It will also enable them to communicate with the media and plan motorsport logistics, sponsorship and team finances.

Unit introduction

This unit examines the appropriate behaviour expected of high-profile drivers, including their responsibilities to the media, fans, sponsors, officials, team members, agents and managers. Learners will examine ways of dealing with the media, both in terms of using the media to their advantage and minimising media intrusion. Learners will also develop the skills needed to carry out an effective media interview.

Learners will also look at the logistics and transportation associated with motorsport competitions both at national and international level. Some motorsport disciplines demand that participants are involved in travelling considerable distances. This can range simply from an individual driving to (and from) an event with a single vehicle, to being a member of a large, multi-vehicle team. The unit will also look at transport movement schedules, route planning, costing and motorsport team logistics.

The financial responsibilities of a motorsports team will also be looked at, as will the potential sources of finance available through sponsorship for a full-time driver/team.

Learning outcomes

On completion of this unit a learner should:

1. Know the organisation, administrative structure and associated professional bodies of motorsport activities
2. Be able to communicate with the media to provide information about a motorsport activity
3. Be able to plan motorsport vehicle transportation
4. Be able to plan the sponsorship and financial management of a motorsport team.

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Unit content

1 Know the organisation, administrative structure and associated professional bodies of motorsport activities

Organisation: types of organisation eg local motor club, regional associations, national associations, international associations; level of competition eg local, regional, national, international championships; forms of motorsport activity eg motocross, rallying, formula 1 (F1), saloon racing, formula ford

Administrative structure: organisation eg structured administration charts, officials and their responsibilities, related rules, regulations; schedules/frequency of events; marketing methods

Professional bodies: eg Motorsports Association (MSA), Federation International de l'Automobile (FIA), Auto Cycle Union (ACU), National Association for Stock Car Auto Racing (NASCAR)

2 Be able to communicate with the media to provide information about a motorsport activity

Media: eg television, radio, internet, press (local, national, specialist magazines)

Media interview: planning eg purpose/aims/objectives, data research (available resources, information gathering, use of information and communication technology), content/message to be conveyed; preparation eg scripts/prompt sheets, rehearsals, evaluation (strengths/weaknesses, use of feedback, video analysis, modifications to improve and/or change performance); delivery eg speech (technical vocabulary, pace, tone, clarity) communication style, body language, presentation methods, appearance, timing

3 Be able to plan motorsport vehicle transportation

Transport vehicles: purpose eg number/size, weight and types of vehicles to be transported, spares, equipment, people/accommodation (cooking, eating, sleeping), workshop facilities; types eg tow vehicle and trailer, adapted and purpose-built light goods vehicle (LGV), passenger service vehicle (PSV); vehicle construction eg materials, steel, aluminium, wood, glass-fibre, carbon fibre, sheeting; wheels and tyres; chassis eg maximum weights (nose, axle, train, towing); characteristics eg types of hitch, braking systems, loading methods, positioning, centre of gravity, load security and limiting factors, bulk loads and relative densities

Legislation: weight, dimensions (length, width, height), speed; security of load; driving eg licence requirements, driving hours, insurance; lighting and markers; health and safety eg weight distribution, risk assessments (responsibilities, safe lifting, manual handling aids)

Transport schedule and route planning: human and physical resource requirements eg accommodation, equipment, vehicles, staffing; schedules eg depart/arrival time, work loading, loading sheets, tool list and inventories, ancillary equipment sheet, spares and consumable requirements; route plan eg use of route planning software, alternative routes, costs (fuel, wages, tolls)

4 Be able to plan the sponsorship and financial management of a motorsport team

Sources of income: prize money, loans, endorsed clothing/equipment, advertising eg vehicles, clothing, equipment; sponsorship eg use, purpose, advantages and limitations; types of sponsorship eg clothing and equipment, individual and corporate sponsorship

Business planning: team structure, income and expenditure eg capital expenditure, wages, fees; financial management eg investments, royalties, tax, expenses, insurance; use of experienced personnel to manage finances eg accountant, financial adviser

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the organisation, administrative structure and associated professional bodies of two different forms of motorsport activity	M1 compare two different motorsport professional governing bodies	D1 evaluate the influence of a professional governing body for a motorsport activity and its effect on professional drivers and teams
P2 plan, prepare and deliver a media interview	M2 compare the legislation relating to driver's hours and the respective codes of practice relating to vehicle construction for two given motorsport activities	D2 evaluate the effectiveness of a media interview, providing recommendations for change and/or amendments.
P3 select appropriate transport vehicles for two different types of motorsport activity	M3 evaluate a transport schedule and route plan for a specific motorsport activity and identify and justify possible areas where improvements could be made.	
P4 interpret the legislation relating to a specific transport vehicle and driver		

Table continues on next page

Assessment and grading criteria		
P5 produce a transport schedule and route plan for a specific motorsport activity		
P6 describe the sources of income that are available for a professional motorsport team		
P7 prepare and present a sponsorship proposal for a motorsport activity		
P8 prepare a business plan to operate a professional motorsport team for a twelve month season [IE4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers RL – reflective learners TW – team workers SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

A wide range of delivery methods can be used for this unit including individual research, group research/discussion, case studies and role play.

The learning outcomes are generally related but are not linked in such a way as to require a specific order of delivery. As such, each learning outcome could be delivered without reference to the others. The only exception to this might be the possible link between transportation costs covered in learning outcome 3 and the business planning in learning outcome 4.

Learning outcome 1 requires learners to investigate and understand the organisation, administration and professional bodies associated with motorsports. This might be best covered through research and group discussion. One approach might be for tutors to select a local motorsport event to evaluate and discuss with learners. A visit and a talk could be organised, and learners could prepare for the visit by carrying out research and writing a series of questions to be put to the speaker/organisers of the event.

For learning outcome 2 learners will need to be prepared for media contact. This will include an appreciation of what constitutes appropriate behaviour for high-profile racing drivers and the expectations of a range of people including fans, media, team mates and sponsors. Learners should be shown examples of effective media interviews from TV, radio and the press and have the opportunity to role play a variety of media situations.

Delivery of learning outcome 3 should encourage learners to investigate as wide a range of motorsport transportation as possible, including different types of transport vehicles, their construction and use. Learners should examine both the benefits and drawbacks of schedules and route planning and the associated legislation and responsibilities. This could be covered by a combination of taught material, group discussions and individual research.

Finally, delivery of learning outcome 4 should enable learners to understand the range of sources of income available for professional motorsport teams and drivers. This should cover the relative importance of different sources of income and how best to manage the funds through effective business planning. Tutors could arrange for a financial manager with experience of motorsports activities to give a guest lecture.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – introduction to unit content, overview of activities and assessment methodology – explain the types of organisation involved at different levels of competition and in different forms of motorsport – explain the administrative structure of motorsport activities – identify and describe the roles of a range of different professional motorsport bodies – visit to motorsport event(s) and presentation from member of a motorsports team to identify and discuss organisation and administrative structure ***Individual learner activities:*** – investigation of motorsport organisation, administrative structure and professional bodies
Prepare for and carry out Assignment 1: Motorsport Organisation, Structure and Professional Bodies (P1, M1, D1)
Whole-class teaching: – explain the types of media that a motorsports team may need to communicate with – explain the planning and preparation required to deliver a media interview – explain the delivery techniques used to ensure successful communication with the media ***Individual learner activities:*** – investigation of methods of communicating with the media ***Small- group activities:*** – review examples of interviews and discuss what makes a good or bad motorsport media interviews – plan for and practise delivering a media interview
Prepare for and carry out Assignment 2: Delivering a Media Interview (P2, D2)

Topic and suggested assignments/activities and/assessment
Whole-class teaching: – explain the purpose and type of motorsport transportation vehicles, their construction and characteristics – explain the legislation that applies to motorsport vehicle transportation – explain the resources that need to be considered when planning motorsport vehicle transportation – explain the purpose, content and production of transport schedules and route plans ***Individual learner activities:*** – investigation of motorsport vehicle transportation – evaluation of schedules and route planning and the associated legislation and responsibilities
Prepare for and carry out Assignment 3: Motorsport Vehicle Transportation (P3, P4, P5, M2, M3)
Whole-class teaching: – explain the sources of income available to motorsports teams – explain the types, advantages and disadvantages of sponsorship and the different types that may be available ***Individual learner activities:*** – investigation and research into motorsport team finances and sponsorship
Prepare for and carry out Assignment 4: Motorsport Sponsorship and Financial Management (P6, P7, P8)
Feedback to learners, unit evaluation and close

Assessment

Because there are no direct links between the learning outcomes they can be assessed in any order. The unit does not necessarily require learners to have access to motorsport events for assessment and most of the evidence produced will probably be paper based in one form or another (for example reports, plans, schedules, etc). Exceptions to this might be the use of tutor observation for the presentations for P2 (media interview) and P7 (sponsorship proposal). However, observation should be suitably recorded and supported by additional written evidence prepared by the learner (for example the interview plan and preparation notes, the data collected for the proposal).

Learning outcome 1 has only one associated pass criterion (P1). This could be assessed through an activity in which learners are required to research two motorsport activities, which they could choose or which could be set by the tutor. The main issue for tutors will be to ensure that a sufficient range of motorsport activities is covered by any one group of learners to ensure authenticity of the evidence presented for assessment. Evidence is likely to be collated and presented as a portfolio. Learners should also be encouraged to work towards the related merit and distinction criteria (M1 and D1), which could form a natural extension to the work for P1.

Learning outcome 2 also only has one related pass criterion (P2) and learners need to show that they can communicate with the media to provide information about a motorsport activity. There is sufficient scope within this learning outcome to ensure that each learner is preparing a different interview (for example TV, radio, internet, press) and as such, authenticity of evidence should be less of an issue. However, it is important that each learner provides evidence of their planning and preparation for the interview as well as its actual delivery. The interview could be carried out by the tutor or one of the learner's peers. In addition to paper-based evidence of planning and preparation, tutor observation records of the final interview will also be required (for example the learner's use of appropriate technical vocabulary, the pace, tone and clarity of speech, communication style, body language, presentation methods, appearance and timing).

A further task could be added to the assessment activity used for P2, giving learners an opportunity to work towards D2. The interview being evaluated could be one delivered by one of their peers for P2. However, it is recommended that learners evaluate the results of an interview carried out by a well-known motorsports driver/personality (for example a pre-recorded interview or an article from a newspaper or magazine). This would give tutors more control over the potential for critical evaluation and would avoid any issues that might arise from peer-on-peer evaluation.

Learning outcome 3 is covered by P3, P4 and P5 and it is recommended that a single assignment be designed to cover all three criteria. Learners could choose one of the two different types of motorsport activities considered for P3 and use it for P4 and P5. However, tutors should check that learners' choice of motorsport activity provides sufficient scope to cover the requirements of the unit content for these criteria. The assessment instrument used should also provide learners with an opportunity to work towards M2 and M3, which build on P4 and P5 respectively.

The remaining pass criteria cover learning outcome 4, which deals with financial management and sponsorship. For P6, learners need to describe the sources of income that are available for a professional motorsport team. It is expected that evidence for this criterion would be drawn from a real example of a professional motorsport team and should cover the key aspects of the unit content relevant to that team (for example what prize money is available, is it typical for the team to use loans, what about endorsed clothing/equipment and what opportunities are there for sponsorship?).

P7 requires learners to prepare and present a sponsorship proposal for a motorsport activity. The scenario for this is likely to be set using a relevant case-study that includes sufficient background information for learners to build a case for a sponsor to consider backing their team. The proposal should make clear how the team is prepared to promote the sponsor (for example clothing, equipment, vehicles). The presentation could be either a short oral presentation using visual aids or a written proposal. Where an oral presentation is used, tutors should ensure that learners are assessed on the content of their presentation and not the quality of the presentation methods (for example how good specific images look, whether a presentation package has been used or just handwritten overhead transparencies/flipchart notes).

Finally, P8 requires learners to prepare a business plan to operate a professional motorsport team for a 12-month season. This could be an extension of the scenario used for P7. The business plan should include information on team structure, income and expenditure, financial management and the use of experienced personnel to manage finances (examples of each of these are given in the unit content).

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.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1, D1	Motorsport Organisation, Structure and Professional Bodies	An investigation of motorsport professional bodies	A written report
P2, D2	Delivering a Media Interview	A member of a motorsports team needs to give a media interview	Role play observation
P3, P4, P5, M2, M3	Motorsport Vehicle Transportation	A member of a motorsports team needs to plan the transport for an upcoming event	Presentation of proposals
P6, P7, P8	Motorsport Sponsorship and Financial Management	A proposal is required to present to potential sponsors	A presentation and financial plan

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Motorsport Workshop Practices
		Motorsport Vehicle Preparation and Inspection

Essential resources

There are no essential resources for this unit.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks — Centre for Education and Industry (CEI-University of Warwick) — www.warwick.ac.uk/wie/cei/
- Learning and Skills Network — www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme — www.stemnet.org.uk
- National Education and Business Partnership Network — www.nebpn.org
- Local, regional Business links — www.businesslink.gov.uk
- Work-based learning guidance — www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Hillier, V — *Hillier's Fundamentals of Motor Vehicle Technology 6th Edition* (Nelson Thornes, 2010) 978-1408515181

Nunney, M — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 9780750680370

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Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information when interpreting relevant legislation
Team workers	collaborating with others to work towards common goals and taking responsibility for their contribution when working as part of a motorsports team

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work

Functional Skills — Level 2

Skill	When learners are …
ICT — Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using presentation software
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	planning transportation
Manage information storage to enable efficient retrieval	
Follow and understand the need for safety and security practices	
Troubleshoot	
ICT — Find and select information	
Select and use a variety of sources of information independently for a complex task	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	planning assessment material
Bring together information to suit content and purpose	
Present information in ways that are fit for purpose and audience	
Evaluate the selection and use of ICT tools and facilities used to present information	

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Skill	**When learners are …**
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	preparing and presenting a sponsorship proposal for a motorsport activity preparing a business plan to operate a professional motorsport team for a 12-month season
Identify the situation or problem and the mathematical methods needed to tackle it	
Select and apply a range of skills to find solutions	
Use appropriate checking procedures and evaluate their effectiveness at each stage	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	
Draw conclusions and provide mathematical justifications	
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	writing reports
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	gathering information to prepare report and vehicles
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	

Further information and useful publications

To get in touch with us please call Customer Services on 0844 578 0026 or visit our 'Contact us' pages:

- Pearson: **qualifications.pearson.com**
- 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 go to 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.

Professional development and training

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

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- developing student-centred learning and teaching approaches
- building Functional Skills into your programme
- building in effective and efficient quality assurance systems.

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GCE	0844 576 0025
The Diploma	0844 576 0028
DIDA and other qualifications	0844 576 0031

Calls may be recorded for training purposes.

The training we provide:

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

Our training is underpinned by the LLUK standards for those preparing to teach and for those seeking evidence for their continuing professional development.

Annexe A

The Pearson BTEC qualification framework for the automotive sector

Progression opportunities within the framework

Level	BTEC vocationally-related qualifications	BTEC specialist qualification / professional	NVQ / competence
5	Pearson BTEC Level 5 HND Diploma in Vehicle Operations Management		
4	Pearson BTEC Level 4 HNC Diploma in Vehicle Operations Management		
3	Pearson BTEC Level 3 Subsidiary Diploma in Vehicle Technology Pearson BTEC Level 3 Diploma in Vehicle Technology Pearson BTEC Level 3 Extended Diploma in Vehicle Technology	Pearson BTEC Level 3 Diploma in Light Vehicle Maintenance and Repair Principles Pearson BTEC Level 3 Diploma in Heavy Vehicle Maintenance and Repair Principles Pearson BTEC Level 3 Diploma in Auto Electrical and Mobile Electrical Principles Pearson BTEC Level 3 Diploma in Vehicle Fitting Supervisory Principles Pearson BTEC Level 3 Diploma in Vehicle Accident Repair Body Principles Pearson BTEC Level 3 Diploma in Vehicle Accident Repair Paint Principles	Pearson Edexcel Level 3 Diploma in Light Vehicle Maintenance and Repair Competence Pearson Edexcel Level 3 Diploma in Heavy Vehicle Maintenance and Repair Competence Pearson Edexcel Level 3 Diploma in Auto Electrical and Mobile Electrical Competence Pearson Edexcel Level 3 Diploma in Vehicle Fitting Supervisory Competence Pearson Edexcel Level 3 Diploma in Vehicle Accident Repair Body Competence Pearson Edexcel Level 3 Diploma in Vehicle Accident Repair Paint Competence

Level	BTEC vocationally-related qualifications	BTEC specialist qualification / professional	NVQ / competence
3		Pearson BTEC Level 3 Diploma in Lift Truck Maintenance & Repair Principles Pearson BTEC Level 3 Diploma in Motorcycle Maintenance and Repair Principles Pearson BTEC Level 3 Diploma in Vehicle Sales Principles Pearson BTEC Level 3 Diploma in Body Building Principles	Pearson Edexcel Level 3 Diploma in Lift Truck Maintenance & Repair Competence Pearson Edexcel Level 3 Diploma in Motorcycle Maintenance and Repair Competence Pearson Edexcel Level 3 Diploma in Vehicle Sales Competence Pearson Edexcel Level 3 Diploma in Body Building Competence
2	Pearson Edexcel Level 2 Certificate in Vehicle Technology Pearson Edexcel Level 2 Extended Certificate in Vehicle Technology Pearson Edexcel Level 2 Diploma in Vehicle Technology	Pearson BTEC Level 2 Diploma in Light Vehicle Maintenance and Repair Principles Pearson BTEC Level 2 Diploma in Heavy Vehicle Maintenance and Repair Principles Pearson BTEC Level 2 Diploma in Auto Electrical and Mobile Electrical Principles Pearson BTEC Level 2 Diploma in Vehicle Fitting Principles Pearson BTEC Level 2 Diploma in Vehicle Accident Repair Paint Principles Pearson BTEC Level 2 Diploma in Vehicle Accident Repair Body Principles	Pearson Edexcel Level 2 Diploma in Light Vehicle Maintenance and Repair Competence Pearson Edexcel Level 2 Diploma in Heavy Vehicle Maintenance and Repair Competence Pearson Edexcel Level 2 Diploma in Auto Electrical and Mobile Electrical Competence Pearson Edexcel Level 2 Diploma in Vehicle Fitting Competence Pearson Edexcel Level 2 Diploma in Vehicle Accident Repair Paint Competence Pearson Edexcel Level 2 Diploma in Vehicle Accident Repair Body Competence

Level	BTEC vocationally-related qualifications	BTEC specialist qualification / professional	NVQ / competence
2		Level 2 Diploma in Lift Truck Maintenance & Repair Principles Pearson BTEC Level 2 Diploma in Motorcycle Maintenance and Repair Principles Pearson BTEC Level 2 Diploma in Vehicle Sales Principles Pearson BTEC Level 2 Diploma in Vehicle Accident Repair Mechanical, Electrical and Trim (MET) Principles Pearson BTEC Level 2 Diploma in Body Building Principles Pearson BTEC Level 2 Diploma in Heavy Vehicle Trailer Maintenance & Repair Principles	Pearson Edexcel Level 2 Diploma in Lift Truck Maintenance & Repair Competence Pearson Edexcel Level 2 Diploma in Motorcycle Maintenance and Repair Competence Pearson Edexcel Level 2 Diploma in Vehicle Sales Competence Pearson Edexcel Level 2 Diploma in Vehicle Accident Repair Mechanical, Electrical and Trim (MET) Competence Pearson Edexcel Level 2 Diploma in Body Building Competence Pearson Edexcel Level 2 Diploma in Heavy Vehicle Trailer Maintenance & Repair Competence
1			
Entry			

Annexe B

Grading domains: BTEC Level 3 generic grading domains

Grading domain 1	Indicative characteristics — merit	Indicative characteristics — distinction
Application of knowledge and understanding (Learning outcome stem *understand* or *know*)	• Shows depth of knowledge and development of understanding in familiar and unfamiliar situations (for example explain why, makes judgements based on analysis). • Applies and/or selects concepts showing comprehension of often complex theories. • Applies knowledge in often familiar and unfamiliar contexts. • Applies knowledge to non-routine contexts (eg assessor selection). • Makes reasoned analytical judgements. • Shows relationships between pass criteria.	• Synthesises knowledge and understanding across pass/merit criteria. • Evaluates complex concepts/ ideas/actions and makes reasoned and confident judgements. • Uses analysis, research and evaluation to make recommendations and influence proposals. • Analyses implications of application of knowledge/understanding. • Accesses and evaluates knowledge and understanding to advance complex activities/contexts. • Shows relationships with p/m criteria. • Responds positively to evaluation.

Grading domain 2	**Indicative characteristics — merit**	**Indicative characteristics — distinction**
Development of practical and technical skills (Learning outcome stem *be able to*)	• Deploys appropriate advanced techniques/processes/skills. • Applies technical skill to advance non-routine activities. • Advances practical activities within resource constraints. • Produces varied solutions (including non-routine). • Modifies techniques/processes to situations. • Shows relationship between p criteria.	• Demonstrates creativity/ originality/own ideas. • Applies skill(s) to achieve higher order outcome. • Selects and uses successfully from a range of advanced techniques/processes/skills. • Reflects on skill acquisition and application. • Justifies application of skills/methods. • Makes judgements about risks and limitations of techniques/ processes. • Innovates or generates new techniques/processes for new situations. • Shows relationship with p and m criteria.

Grading domain 3	Indicative characteristics — merit	Indicative characteristics — distinction
Personal development for occupational roles (Any learning outcome stem)	• Takes responsibility in planning and undertaking activities. • Reviews own development needs. • Finds and uses relevant information sources. • Acts within a given work-related context showing understanding of responsibilities. • Identifies responsibilities of employers to the community and the environment. • Applies qualities related to the vocational sector. • Internalises skills/attributes (creating confidence).	• Manages self to achieve outcomes successfully. • Plans for own learning and development through the activities. • Analyses and manipulates information to draw conclusions. • Applies initiative appropriately. • Assesses how different work-related contexts or constraints would change performance. • Reacts positively to changing work-related contexts • Operates ethically in work-related environments. • Takes decisions related to work contexts. • Applies divergent and lateral thinking in work-related contexts. • Understands interdependence.

Grading domain 4	Indicative characteristics — merit	Indicative characteristics — distinction
Application of generic skills (Any learning outcome stem)	• Communicates effectively using appropriate behavioural and language registers. • Communicates with clarity and influence. • Makes judgements in contexts with explanations. • Explains how to contribute within a team. • Demonstrates positive contribution to team(s). • Makes adjustments to meet the needs/expectations of others (negotiation skills). • Selects and justifies solutions for specified problems.	• Presents self and communicates information to meet the needs of a variety of audience. • Identifies strategies for communication. • Shows innovative approaches to dealing with individuals and groups. • Takes decisions in contexts with justifications. • Produces outputs subject to time/resource constraints. • Reflects on own contribution to working within a team. • Generates new or alternative solutions to specified problems. • Explores entrepreneurial attributes.

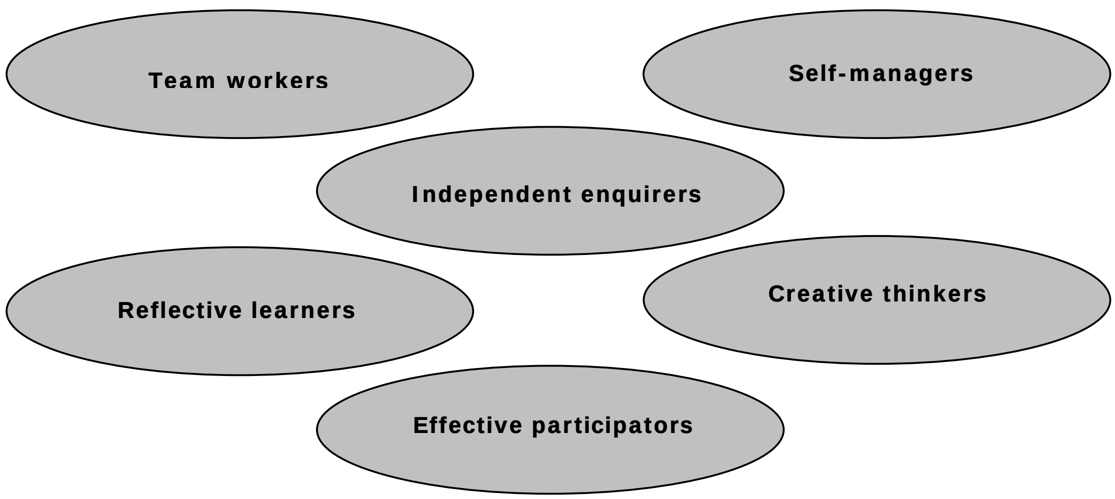
Annexe C

Personal, learning and thinking skills

A FRAMEWORK OF PERSONAL, LEARNING AND THINKING SKILLS 11–19 IN ENGLAND

The framework comprises six groups of skills that, together with the Functional Skills of English, mathematics and ICT, are essential to success in learning, life and work. In essence the framework captures the essential skills of: managing self; managing relationships with others; and managing own learning, performance and work. It is these skills that will enable young people to enter work and adult life confident and capable.

The titles of the six groups of skills are set out below.



For each group there is a focus statement that sums up the range of skills. This is followed by a set of outcome statements that are indicative of the skills, behaviours and personal qualities associated with each group.

Each group is distinctive and coherent. The groups are also inter-connected. Young people are likely to encounter skills from several groups in any one learning experience. For example an independent enquirer would set goals for their research with clear success criteria (reflective learner) and organise and manage their time and resources effectively to achieve these (self-manager). In order to acquire and develop fundamental concepts such as organising oneself, managing change, taking responsibility and perseverance, learners will need to apply skills from all six groups in a wide range of learning contexts 11-19.

The Skills

Independent enquirers
Focus: Young people process and evaluate information in their investigations, planning what to do and how to go about it. They take informed and well-reasoned decisions, recognising that others have different beliefs and attitudes.
Young people: – identify questions to answer and problems to resolve – plan and carry out research, appreciating the consequences of decisions – explore issues, events or problems from different perspectives – analyse and evaluate information, judging its relevance and value – consider the influence of circumstances, beliefs and feelings on decisions and events – support conclusions, using reasoned arguments and evidence.

Creative thinkers
Focus: Young people think creatively by generating and exploring ideas, making original connections. They try different ways to tackle a problem, working with others to find imaginative solutions and outcomes that are of value.
Young people: – generate ideas and explore possibilities – ask questions to extend their thinking – connect their own and others' ideas and experiences in inventive ways – question their own and others' assumptions – try out alternatives or new solutions and follow ideas through – adapt ideas as circumstances change.

Reflective learners
Focus: Young people evaluate their strengths and limitations, setting themselves realistic goals with criteria for success. They monitor their own performance and progress, inviting feedback from others and making changes to further their learning.
Young people: – assess themselves and others, identifying opportunities and achievements – set goals with success criteria for their development and work – review progress, acting on the outcomes – invite feedback and deal positively with praise, setbacks and criticism – evaluate experiences and learning to inform future progress – communicate their learning in relevant ways for different audiences.

Team workers

Focus:

Young people work confidently with others, adapting to different contexts and taking responsibility for their own part. They listen to and take account of different views. They form collaborative relationships, resolving issues to reach agreed outcomes.

Young people:

- collaborate with others to work towards common goals
- reach agreements, managing discussions to achieve results
- adapt behaviour to suit different roles and situations, including leadership roles
- show fairness and consideration to others
- take responsibility, showing confidence in themselves and their contribution
- provide constructive support and feedback to others.

Self-managers

Focus:

Young people organise themselves, showing personal responsibility, initiative, creativity and enterprise with a commitment to learning and self-improvement. They actively embrace change, responding positively to new priorities, coping with challenges and looking for opportunities.

Young people:

- seek out challenges or new responsibilities and show flexibility when priorities change
- work towards goals, showing initiative, commitment and perseverance
- organise time and resources, prioritising actions
- anticipate, take and manage risks
- deal with competing pressures, including personal and work-related demands
- respond positively to change, seeking advice and support when needed
- manage their emotions, and build and maintain relationships.

Effective participators

Focus:

Young people actively engage with issues that affect them and those around them. They play a full part in the life of their school, college, workplace or wider community by taking responsible action to bring improvements for others as well as themselves.

Young people:

- discuss issues of concern, seeking resolution where needed
- present a persuasive case for action
- propose practical ways forward, breaking these down into manageable steps
- identify improvements that would benefit others as well as themselves
- try to influence others, negotiating and balancing diverse views to reach workable solutions
- act as an advocate for views and beliefs that may differ from their own.

PLTS performance indicator (suggested recording sheet)

Name:	Date:				
	Level of success **1 = low, 5 = high**				
Independent enquirers					
Identify questions to answer and problems to resolve	1	2	3	4	5
Plan and carry out research, appreciating the consequences of decisions	1	2	3	4	5
Explore issues, events or problems from different perspectives	1	2	3	4	5
Analyse and evaluate information, judging its relevance and value	1	2	3	4	5
Consider the influence of circumstances, beliefs and feelings on decisions and events	1	2	3	4	5
Support conclusions, using reasoned arguments and evidence	1	2	3	4	5
Creative thinkers					
Generate ideas and explore possibilities	1	2	3	4	5
Ask questions to extend their thinking	1	2	3	4	5
Connect their own and others' ideas and experiences in inventive ways	1	2	3	4	5
Question their own and others' assumptions	1	2	3	4	5
Try out alternatives or new solutions and follow ideas through	1	2	3	4	5
Adapt ideas as circumstances change	1	2	3	4	5
Reflective learners					
Assess themselves and others, identifying opportunities and achievements	1	2	3	4	5
Set goals with success criteria for their development and work	1	2	3	4	5
Review progress, acting on the outcomes	1	2	3	4	5
Invite feedback and deal positively with praise, setbacks and criticism	1	2	3	4	5
Evaluate experiences and learning to inform future progress	1	2	3	4	5
Communicate their learning in relevant ways for different audiences	1	2	3	4	5

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Team workers					
Collaborate with others to work towards common goals	1	2	3	4	5
Reach agreements, managing discussions to achieve results	1	2	3	4	5
Adapt behaviour to suit different roles and situations, including leadership roles	1	2	3	4	5
Show fairness and consideration to others	1	2	3	4	5
Take responsibility, showing confidence in themselves and their contribution	1	2	3	4	5
Provide constructive support and feedback to others	1	2	3	4	5
Self-managers					
Seek out challenges or new responsibilities and show flexibility when priorities change	1	2	3	4	5
Work towards goals, showing initiative, commitment and perseverance	1	2	3	4	5
Organise time and resources, prioritising actions	1	2	3	4	5
Anticipate, take and manage risks	1	2	3	4	5
Deal with competing pressures, including personal and work-related demands	1	2	3	4	5
Respond positively to change, seeking advice and support when needed	1	2	3	4	5
Manage their emotions, and build and maintain relationships	1	2	3	4	5
Effective participators					
Discuss issues of concern, seeking resolution where needed	1	2	3	4	5
Present a persuasive case for action	1	2	3	4	5
Propose practical ways forward, breaking these down into manageable steps	1	2	3	4	5
Identify improvements that would benefit others as well as themselves	1	2	3	4	5
Try to influence others, negotiating and balancing diverse views to reach workable solutions	1	2	3	4	5
Act as an advocate for views and beliefs that may differ from their own	1	2	3	4	5

Note to learner: The circled number represents an indication of your PLTS performance so far.

Note to tutor: Indicate the level of success by circling the appropriate number during your feedback with the learner.

Annexe D

Generic examples of calculating qualification grade above pass grade

This annexe shows the principles of calculating qualification grade above pass.

Pearson will automatically calculate the qualification grade for your learners when your learner unit grades are submitted.

The generic examples below demonstrate how the qualification grade above pass is calculated using the following two tables which are also shown in the section earlier in the specification *Calculation of the qualification grades above pass grade*.

Points available for credits achieved at different levels and unit grades

The table below shows the **number of points scored per credit** at the unit level and grade.

	Points per credit		
Unit level	**Pass**	**Merit**	**Distinction**
Level 2	5	6	7
Level 3	**7**	**8**	**9**
Level 4	9	10	11

Learners who achieve the correct number of points within the ranges shown in the 'qualification grade' table below will achieve the qualification merit, distinction or distinction* grades (or combinations of these grades appropriate to the qualification).

Qualification grade

BTEC Level 3 Certificate

Points range above pass grade	Grade	
230-249	Merit	M
250-259	Distinction	D
260 and above	Distinction*	D*

BTEC Level 3 Subsidiary Diploma

Points range above pass grade	Grade	
460-499	Merit	M
500-519	Distinction	D
520 and above	Distinction*	D*

BTEC Level 3 Diploma

Points range above pass grade	Grade
880-919	MP
920-959	MM
960-999	DM
1000-1029	DD
1030-1059	DD*
1060 and above	D*D*

BTEC Level 3 Extended Diploma

Points range above pass grade	Grade
1300-1339	MPP
1340-1379	MMP
1380-1419	MMM
1420-1459	DMM
1460-1499	DDM
1500-1529	DDD
1530-1559	DDD*
1560-1589	DD*D*
1590 and above	D*D*D*

Example 1

Achievement of pass qualification grade

A learner completing a 30-credit Pearson BTEC Level 3 Certificate **does not** achieve the points required to gain a merit qualification grade.

	Level	**Credit**	**Grade**	**Grade points**	**Points per unit = credit x grade**
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Merit	8	10 × 8 = 80
Qualification grade totals		**30**	**Pass**		**220**

Example 2

Achievement of merit qualification grade

A learner completing a 30-credit Pearson BTEC Level 3 Certificate achieves the points required to gain a merit qualification grade.

	Level	**Credit**	**Grade**	**Grade points**	**Points per unit = credit x grade**
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Merit	8	10 × 8 = 80
Qualification grade totals			**Merit**		**230**

Example 3

Achievement of distinction qualification grade

A learner completing a 60-credit Pearson BTEC Level 3 Subsidiary Diploma achieves the points required to gain a distinction qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	2	10	Distinction	7	10 × 7 = 70
Unit X	3	10	Distinction	9	10 × 9 = 90
Qualification grade totals		**60**	**Distinction**		**500**

Example 4

Achievement of distinction merit qualification grade

A learner completing a 120-credit Pearson BTEC Level 3 Diploma achieves the points required to gain a distinction merit qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	2	10	Distinction	7	10 × 7 = 70
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	4	10	Merit	10	10 × 10 = 100
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	20	Merit	8	20 × 8 = 160
Qualification grade totals		**120**	**Distinction Merit**		**980**

Example 5

Achievement of merit qualification grade

A learner completing a 180-credit Pearson BTEC Level 3 Extended Diploma achieves the points required to gain a merit qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	2	10	Distinction	7	10 × 7 = 70
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	4	10	Pass	9	10 × 9 = 90
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Pass	7	10 × 7 = 70
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	20	Pass	7	20 × 7 = 140
Unit X	3	10	Distinction	9	10 × 9 = 90
Unit X	3	10	Merit	8	10 × 8 = 80
Unit X	3	10	Distinction	9	10 × 9 = 90
Qualification grade totals		**180**	**Merit Merit Merit**		**1410**

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