Pearson BTEC International Level 3 Specialist Diploma in Vehicle Technology Motorsports

Specification

BTEC International Specialist qualification

First registration September 2023

Issue 1

About Pearson

We are the world's learning company operating in 70 countries around the world with more than 22,500 employees. We provide content, assessment and digital services to schools, colleges and universities, as well as professional and vocational education to learners to help increase their skills and lifelong employability prospects. We believe that wherever learning flourishes so do people.

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

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Contents

1 Introducing the qualification

What are BTEC International Specialist qualifications?

BTEC International Specialist qualifications are work-related qualifications available from Entry to Level 3. The qualifications put learning into the context of the world of work, giving students the opportunity to apply their research, skills and knowledge in relevant and realistic work contexts. This applied, practical approach means learners build the knowledge, understanding and skills they need for career progression or further study.

Qualification(s) purpose

The Pearson BTEC International Level 3 Specialist Diploma in Vehicle Technology Motorsports is for learners who are working in, or who are intending to work in the vehicle engineering sector.

The Pearson BTEC International Level 3 Specialist Diploma in Vehicle Technology Motorsports is suitable for learners to:

- develop knowledge related to motorsport vehicle technology
- develop skills related to motorsport vehicle operation, fault diagnosis and systems
- achieve a qualification to prepare for employment
- achieve a licence to practise
- achieve a globally-recognised Level 3 qualification
- develop own personal growth and engagement in learning.

Relationship with previous qualifications

This qualification is a direct replacement for the following BTEC qualifications and their Qualification Accreditation Numbers, which have expired:

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

2 Qualification summary and key information

Qualification title	Pearson BTEC International Level 3 Specialist Diploma in Vehicle Technology Motorsports
Regulation start date	September 2023
Operational start date	September 2023
Approved age ranges	16–18 18+ 19+
Total qualification time (TQT)	960 hours.
Guided learning hours (GLH)	720.
Assessment	Internal assessment.
Grading information	The qualification and units are graded Pass/Merit/Distinction.

3 Qualification structure

Pearson BTEC International Level 3 Specialist Diploma in Vehicle Technology Motorsports

The requirements outlined in the table below must be met for Pearson to award the qualification.

Unit number	Mandatory units	Level	Guided learning hours
1	Vehicle Engine Principles, Operation, Service and Repair	3	60
2	Vehicle System Fault Diagnosis and Rectification	3	60
3	Motorsport Workshop Practices	3	60
4	Motorsport Vehicle Preparation and Inspection	3	60
5	Professional Practice and Logistics for Motorsports	3	60
6	Operation of Vehicle Chassis Systems	3	60
7	Light Vehicle Suspension, Steering and Braking Systems	3	60
8	Motorsport Welding Technology	3	60
9	Function and Operation of Vehicle Petrol Injection Systems	3	60
10	Vehicle Engine Management Systems	3	60
11	Vehicle Project	3	120

4 Assessment requirements

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

Units	Assessment method
All units	Internal assessment (centre-devised assessments).

Language of assessment

Learners must use English only during the assessment of this qualification.

Further information on the use of language in qualifications is available in our *Use of languages in qualifications policy*, available on our website, qualifications.pearson.com.

Internal assessment

Internally assessed units are subject to standards verification. This means that centres set and mark the final summative assessment for each unit, using the examples and support that Pearson provides.

To pass each internally assessed unit, learners must:

- achieve all the specified learning outcomes
- satisfy all the assessment criteria by providing sufficient and valid evidence for each criterion
- prove that the evidence is their own.

Centres must ensure:

- assessment is carried out by assessors with relevant expertise in both the occupational area and assessment.
- internal verification systems are in place to ensure the quality and authenticity of learners' work, as well as the accuracy and consistency of assessment.

Learners who do not successfully pass an assignment, are allowed to resubmit evidence for the assignment or to retake another assignment.

Assessment of knowledge units

To pass each knowledge unit, learners must independently complete assignment(s) that show that the learning outcomes and assessment criteria for the unit have been met.

Format of assignments for knowledge units:

- all learning outcomes and assessment criteria must be covered
- assignments can include both practical and written tasks
- assignments are independently completed as a distinct activity after the required teaching has taken place
- the brief is issued to learners with a defined start date, a completion date and clear requirements for the evidence they are required to produce
- all or parts of units can be combined into a single assignment. Learning outcomes must not be split into more than one assignment.

Each unit contains suggested tasks that centres can use to form the basis of assignments for learners to complete. It is expected that centres will contextualise these and ensure that the final version is checked by their internal verifier.

Assessment of skills units

To pass each skills unit, learners must:

- gather evidence from their course in a portfolio showing that they have met the required standard specified in the learning outcomes, assessment criteria and Pearson's quality assurance arrangements
- have an assessment record that shows how each individual assessment criterion has been met. The assessment record should be cross-referenced to the evidence provided. The assessment record should include details of the type of evidence and the date of assessment. Suitable centre documentation should be used to form an assessment record.

Learners can use one piece of evidence to prove their knowledge, skills and understanding across different assessment criteria and/or across different units. The evidence provided for each unit must reference clearly the unit that is being assessed and learners should be encouraged to signpost evidence. Evidence must be available to the assessor, the internal verifier and the Pearson Standards Verifier.

Examples of forms of evidence include observation records, reflective accounts, witness testimony and products of learners' work. Learners must provide evidence of their achievement of the knowledge-based learning outcomes and the associated assessment criteria in skills units – achievement cannot be inferred from performance.

Any specific evidence requirements for a unit are given in the unit's *Assessment* section.

5 Centre recognition and approval

Centres must have approval prior to delivering or assessing any of the units in this qualification.

Centres that have not previously offered BTEC Specialist qualifications need to apply for, and be granted, centre recognition as part of the process for approval to offer individual qualifications.

Existing centres will be given 'automatic approval' for a new qualification if they are already approved for a qualification that is being replaced by a new qualification and the conditions for automatic approval are met.

Guidance on seeking approval to deliver BTEC qualifications is given on our website.

Approvals agreement

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

Centre resource requirements

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

- appropriate physical resources (for example vehicles, learning materials, teaching rooms) to support the delivery and assessment of the qualification
- suitable staff for delivering and assessing the qualification (see *Section 4 Assessment requirements*)
- systems to ensure continuing professional development (CPD) for staff delivering and assessing the qualification(s)
- health and safety policies that relate to the use of equipment by learners
- internal verification systems and procedures (see *Section 4 Assessment requirements*)
- any unit-specific resources stated in individual units.

6 Access to qualifications

Access to qualifications for learners with disabilities or specific needs.

Equality and fairness are central to our work. Our *Equality, diversity and inclusion policy* requires all learners to have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every learner.

We are committed to making sure that:

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

For learners with disabilities and specific needs, the assessment of their potential to achieve the qualification must identify, where appropriate, the support that will be made available to them during delivery and assessment of the qualification.

Centres must deliver the qualification in accordance with current equality legislation. For full details of the Equality Act 2010, please visit www.legislation.gov.uk

Reasonable adjustments and special consideration

Centres are permitted to make adjustments to assessment to take account of the needs of individual learners. Any reasonable adjustment must reflect the normal learning or working practice of a learner in a centre or a learner working in the occupational area.

Centres cannot apply their own special consideration – applications for special consideration must be made to Pearson and can be made on a case-by-case basis only.

Centres must follow the guidance in the Pearson document Guidance for reasonable adjustments and special consideration in vocational internally assessed units.

7 Recognising prior learning and achievement

Recognition of Prior Learning (RPL) 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 in and outside the workplace, 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. If 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 sufficient, reliable and valid.

Further guidance is available in our policy document *Recognition of prior learning policy and process*, available on our website.

8 Quality assurance of centres

Centre and qualification approval

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

- Centres must have access to appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualification.
- Staff involved in the assessment process must have relevant expertise and/or
- occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by learners.
- Centres must deliver the qualification in accordance with current equality and diversity legislation and/or regulations.

Continuing quality assurance and standards verification

On an annual basis, we produce the Pearson International Quality Assurance Handbook. It contains detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering
- the centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; the centre must abide by these conditions throughout the period of delivery
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.

The approach of quality-assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality-assurance processes, where practicable. We work to support centres and seek to make sure that our quality-assurance processes do not place undue bureaucratic processes on centres. We monitor and support centres in the effective operation of assessment and quality assurance.

The methods we use to do this include:

- making sure that all centres complete appropriate declarations at the time of approval
- undertaking approval visits to centres
- making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- an overarching review and assessment of a centre's strategy for delivering and quality assuring its BTEC programmes, for example making sure that synoptic units are placed appropriately in the order of delivery of the programme.

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

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

9 Units

This section of the specification contains the units that form the assessment for the qualification.

For explanation of the terms within the units, please refer to *Section 13 Glossary*.

It is compulsory for learners to meet the learning outcomes and the assessment criteria to achieve a Pass. Content is compulsory unless it is provided as an example and is therefore marked 'e.g.'. All compulsory content must be delivered, but assessments may not cover all content.

Where legislation is included in delivery and assessment, centres must ensure that it is current and up to date.

Unit 1: Vehicle Engine Principles, Operation, Service and Repair

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

Although the technology 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 covers the growing concern about future supplies of fossil fuels and environmental pollution by examining current and future developments in engine designs 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 on engines in a vehicle workshop environment. Learners will gain practical experience of using a range of tools and equipment and will work to vehicle service and repair industry standards.

Learning outcomes

In this unit you will:

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.

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Understand the principles of operation of an internal combustion engine		
P1 explain the operating cycles of two different internal combustion engines P2 explain the vehicle design and performance implications of an engine's configuration and layout P3 explain the function, operation and construction of the components/ assemblies of one type of engine	M1 identify and compare the advantages and disadvantages of the design and performance of two different engine configurations and layouts	D1 evaluate and justify the choice of an engine used for a current vehicle application, in terms of its layout, operation and performance
Learning outcome 2: Understand the principles of operation of fuel supply systems		
P4 explain the effects of different air fuel ratios on the petrol combustion process and exhaust emissions P5 explain the diesel combustion process P6 describe an application of an alternative fuel/power supply system	M2 identify and 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

Pass	Merit	Distinction
Learning outcome 3: Understand the principles of operation of engine cooling and lubrication systems		
P7 explain the principles of operation and differences between an air and a water-cooled engine P8 explain the layout, system components and operation of two different engine lubrication systems		
Learning outcome 4: Be able to carry out engine service and repair procedures		
P9 carry out a routine engine service by following given instructions P10 carry out a major engine repair following given instructions	M3 prepare a work schedule for a major engine repair procedure, carry out the repair and evaluate the effectiveness of the work schedule	

Unit content

What needs to be learned
Learning outcome 1: Understand the principles of operation of an internal combustion engine
• *Operating cycles*: internal combustion engines (ICE) e.g. four-stroke spark ignition (SI) and compression ignition (CI) cycles, two-stroke cycle, Wankel (rotary); pressure-volume diagrams and engine performance diagrams (torque/power) e.g. the Otto cycle, identification of induction, compression, ignition, exhaust strokes, effects of bore, stroke, swept and clearance volume; engine efficiency e.g. engine timing, pressure charging, compression ratio. • *Engine configurations and layout*: orientation (longitudinal/transverse); position of engine (front, mid and rear); cylinder arrangement e.g. single cylinder, multi cyclinder; cylinder configuration e.g. in-line, vee, horizontally opposed arrangements; vehicle design and performance e.g. space saving, arrangements for power transmission, vehicle function (passenger, people carrier, off-road, motorsport), cost, environmental issues. • *Engine assemblies*: engine types e.g. four-stroke SI and CI, two-stroke cycle, Wankel (rotary); components e.g. 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
Learning outcome 2: Understand the principles of operation of fuel supply systems
• *Petrol combustion process*: fuel principles e.g. composition of petrol, characteristics of petrol, composition of air, air/fuel ratio, lambda ratio; combustion process e.g. mixing of fuel/air, flame spread, exhaust emissions; effects of pollutants/causes of undesirable emissions e.g. weak mixture, rich mixture, oil control problems; symptoms of incorrect combustion process e.g. detonation, pre-ignition; fuel supply method e.g. fuel injection, mechanical, electrical; fuel system components e.g. tank, petrol filter, air filter, supply/pressure pump, pressure regulator, injectors. • *Diesel combustion process*: fuel principles e.g. composition of diesel, characteristics of diesel, air/fuel ratio; combustion process e.g. phases, delay, combustion/flame spread, spontaneous/direct burning, pressure/crank angle diagrams, diesel knock; exhaust emissions e.g. normal, excess air, excess fuel, effects of pollutants; fuel supply method e.g. rotary, inline, unit injector; fuel system components e.g. low pressure (tank, filter(s), supply pump), high pressure (in-line pump, governor, injector, cold start arrangements). • *Alternative fuel/power*: systems e.g. electric, liquefied petroleum gas (LPG), natural gas, hydrogen, hybrid; adapted/additional components e.g. batteries, fuel tank,

What needs to be learned
additional modifications, cooling system, management control system, performance; legislation e.g. emissions, tax, health and safety.
Learning outcome 3: Understand the principles of operation of engine cooling and lubrication systems
• *Engine cooling systems*: types of system e.g. 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 e.g. 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 e.g. overheating, fuel cut-off • *Engine lubrication system*: system components e.g. wet/dry sumps, oil pump, pressure relief valve; engine oil types and filtration methods e.g. viscosity, Society of Automotive Engineers (SAE) rating, multi-grade oil; filters e.g. full flow or bypass; lubrication control systems e.g. sensors, level indicator (mechanical, electrical); pressure sensors e.g. absolute and gauge or lamp; low pressure safety system e.g. engine management system fuel cut-off.
Learning outcome 4: Be able to carry out engine service and repair procedures
• *Routine engine service*: procedures e.g. changing engine lubricant, filters (air, lubricant, fuel), checking and adjusting engine timing (ignition, camshaft); working to instructions e.g. manufacturer's service schedules/data, dealership work schedules/job cards; use of tools and equipment e.g. hand tools, vehicle lift equipment, oil drainer, on-board service indicators; safe working procedures e.g. 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 e.g. strip and inspect bore and crankshaft journals for wear, cylinder head for distortion, valves for seating and damage; working to instructions e.g. manufacturer's repair manuals, web-based information, dealership work schedules/job cards/supervisor's instructions; use of tools and equipment e.g. engine crane, chains, slings, torque wrenches, micrometers, dial test indicators (DTI), timing tools, locking devices, cleaning equipment; safe working procedures e.g. 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.

Essential information for tutors and assessors

Essential resources

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

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 provides as its example '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 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 endeavour to make the most of these links to keep the number of assessment instruments down 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. 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 between an air- and a water-cooled engine). P6 could be achieved through a 'what if' scenario within one of the projects (e.g. 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 (e.g. 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 (e.g. engine timing, pressure charging and applicable compression ratios).

For P2, learners should 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 (e.g. 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 (e.g. 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 (e.g. tank, petrol filter, air filter, etc). 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, combustion process, exhaust emissions, fuel supply method and fuel system components for either low pressure or high-pressure diesel fuel systems.

For P6, learners should 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 (e.g. LPG, natural gas, hydrogen, hybrid) and the way that 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 differences between, an air and a water-cooled engine. Learners need to identify the types of system being considered as per the unit content (e.g. 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 (e.g. 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 photographic evidence that they have suitably annotated 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 M2, learners need to build on their understanding of fuel, cooling and lubrication systems (P4 to P8) to identify and compare the advantages and disadvantages of two engines.

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 and justify the choice 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 (e.g. 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 upon 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 have suitably annotated such images to indicate how they support their report.

For D2, learners should 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 (e.g. 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.

Unit 2: Vehicle System Fault Diagnosis and Rectification

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Be able to identify vehicle system faults		
P1 identify two mechanical system faults on each of two different vehicles from given symptoms P2 identify two electrical system faults on each of two different vehicles from given symptoms	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
Learning outcome 2: Be able to prepare and use diagnostic equipment and procedures to identify and confirm faults		
P3 prepare two vehicles for fault diagnosis P4 use appropriate diagnostic equipment and procedures to diagnose faults on two different mechanical systems on each of two different vehicles P5 use appropriate diagnostic equipment and procedures to diagnose faults on two different electrical systems on each of two different vehicles	M2 compare the advantages and disadvantages of two diagnostic procedures including the use of dedicated test equipment	

Pass	Merit	Distinction
Learning outcome 3: Know alternative rectification procedures		
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	M3 justify the selection of a rectification procedure in terms of safety, cost, performance and legal considerations	D2 review one vehicle diagnostic and rectification procedure carried out and make recommendations for improvement
Learning outcome 4: Be able to rectify faults and confirm system integrity		
P8 carry out rectification procedures on two different faulty mechanical systems, conforming with manufacturers' specifications and safety and legal requirements P9 carry out rectification procedures on two different faulty electrical/electronic systems, conforming with manufacturers' specifications and safety and legal requirements P10 use appropriate equipment, procedures and documentation to		

Pass	Merit	Distinction
confirm system integrity		

Unit content

What needs to be learned
Learning outcome 1: Be able to identify vehicle system faults
• *Mechanical system*: systems e.g. engine (pistons, belts, chains, bearings, shafts), ancillary systems (fuel, lubrication, cooling), transmission (clutch, torque converter, gearbox, rear axle, differential), steering and suspension, braking; faults e.g. internal engine component failure, failed head gasket, failed seal, fuel blockage, contamination (oil, fuel, coolant, hydraulic and pneumatic fluid), nonstarting, 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 (driveshafts, steering/suspension), defective steering/suspension components, inoperative braking system (faulty caliper, worn disc); symptoms e.g. 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 e.g. starting, charging, ignition, lighting and auxiliary, control systems (electronic, instrumentation, engine); faults e.g. 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 e.g. noisy operation, no charge, over charging, short circuit, open circuit, misfire, non-starting, incorrect information, inaccurate displays, confused control.
Learning outcome 2: Be able to prepare and use diagnostic equipment and procedures to identify and confirm faults
• *Preparation*: adherence to regulations e.g. Work Equipment Regulations, Control of Substances Hazardous to Health Regulations, Lifting Operations and Lifting Equipment Regulations, Manual Handling Operations Regulations, Personal Protective Equipment at Work Regulations, Confined Spaces Regulations, Electricity at Work Regulations, Control of Noise at Work Regulations, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, Health and Safety Regulations, motorsport specific; positioning e.g. use of ramps, jacks, stands; vehicle protection e.g. covers, sheeting; component/system access e.g. removal of bodywork, fairings and covers, removal of excessive oil, dust, grease and dirt, competition/road debris.

What needs to be learned

- *Diagnostic equipment*: mechanical equipment e.g. dial gauges, micrometers, feeler gauges, pressure gauges, specialist equipment e.g. auto transmission test equipment, steering geometry and suspension alignment equipment, wheel balancing and brake testing equipment; electrical and electronic equipment e.g. 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 e.g. 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 e.g. workshop manuals, diagnostic information, CD ROMs, IT-based data retrieval systems and fault code analysers.

Learning outcome 3: Know alternative rectification procedures

Rectification procedures: e.g.

- 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).

Learning outcome 4: Be able to rectify faults and confirm system integrity

- *Rectify faults associated with mechanical systems*: e.g. engine and ancillary systems, transmission, steering, wheels and tyres, suspension and braking systems.
- *Rectify typical faults associated with electrical/electronic systems*: e.g. 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 e.g. measuring equipment, analysers, on-board diagnostics, alignment

What needs to be learned
equipment, balancing equipment; for electrical/electronic systems e.g. scanning equipment meters. • *Documentation to confirm system integrity*: manufacturers' specifications and data; legal requirements; performance test data.

Essential information for tutors and assessors

Essential resources

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

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.

Unit 3: Motorsport Workshop Practices

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Understand how to maintain good housekeeping and health and safety procedures at a motorsport event		
P1 explain the ways that actions can reduce the risk to employees, others and vehicles in a temporary workshop at a motorsport event P2 describe the immediate and follow-up actions to be taken to deal with two different types of incidents at a motorsport event	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
Learning outcome 2: Be able to use appropriate tools and equipment for the disassembly and reassembly of motorsport vehicle components		
P3 select and use the most appropriate tools and equipment to efficiently disassemble a motorsport vehicle component P4 select and use the most appropriate tools and equipment to efficiently reassemble a motorsport vehicle component		

Pass	Merit	Distinction
Learning outcome 3: Know how and why temporary and permanent fasteners are used for specific motorsport applications		
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	M2 justify the use of two different fasteners for use in motorsport competition critical applications	
Learning outcome 4: Be able to select appropriate materials for specific motorsport applications		D2 compare the differences in the material selection criteria for a specific vehicle component used on both production and motorsport vehicles.
P7 select an appropriate material for a given motorsport engine component application P8 select an appropriate material for a given motorsport chassis component application	M3 justify the differences in surface finishing techniques used for a motorsport engine compared to a mass produced engine	

Unit content

What needs to be learned
Learning outcome 1: Understand how to maintain good housekeeping and health and safety procedures at a motorsport event
• *Actions to reduce risk*: risk to employees e.g. correct use of personal protective equipment (PPE), safe use of tools and equipment, safe use of fuels and lubricants; others e.g. containment of hazardous substances, warning signs correctly used and clearly visible; vehicles e.g. correct use of lifting and supporting equipment; housekeeping e.g. relevant regulations/codes of practice (health and safety, control of substances hazardous to health, work areas kept separate from public areas at all times. • *Dealing with incidents*: emergencies e.g. personal injury, fire, spillage, equipment failure, area evacuation, inhalation of noxious fumes; accidents e.g. slips, trips, falls, collision; immediate actions e.g. evacuate/cordon off area, report/fight fire, quarantine emergency; follow-up actions e.g. clear away spillage and dispose of waste, document incident, administer first aid, inform emergency services. • *Motorsport event*: e.g. rallying, go-karting, closed-circuit competition, off-road racing, motocross, sprint, hill climbs.
Learning outcome 2: Be able to use appropriate tools and equipment for the disassembly and reassembly of motorsport vehicle components
• *Tools and equipment*: hand tools e.g. spanners, screwdrivers, ratchets and sockets (metric and imperial); tool size recognition; power tools relevant to speed and efficiency at trackside e.g. pneumatic/electric ratchets, drills; measuring tools e.g. micrometer, vernier callipers, gauges; lifting and stabilising equipment e.g. pneumatic/mechanical lifts, hydraulic jacks, axle/vehicle stands. • *Disassembly/reassembly*: components e.g. body and chassis components in the event of a crash (panels and steering components), engine disassembly and reassembly; tasks e.g. maintenance, servicing and repair of consumable components during an event.
Learning outcome 3: Know how and why temporary and permanent fasteners are used for specific motorsport applications
Temporary fasteners: for components requiring frequent maintenance or replacement e.g. 'R' clips, split pins, nuts and bolts, quick release fasteners. *Permanent fasteners*: for components that do not require regular replacement or removal for maintenance e.g. rivets, locking nuts, stretch bolts, shear bolts; alternative methods e.g. the bonding of polymers, glass/carbon fibre and plastic welding, adhesives.

What needs to be learned
Learning outcome 4: Be able to select appropriate materials for specific motorsport applications
• *Material selection*: mechanical properties e.g. strength, hardness, ductility, durability, density and mass; performance versus weight; finish e.g. professional appearance for chassis components, weight and aerodynamic properties; aesthetic, ergonomic and durable properties; types of material e.g. metallic alloys and non-metallic materials, Kevlar, glass/carbon fibre; special treatments to obtain required properties e.g. shot/laser peening, heat treatment, specialised coatings; effects of loading e.g. compressive/tensile stress, fatigue, stress corrosion. • *Motorsport engine component*: e.g. pistons, connecting rods, crankshafts, camshafts, valves, engine mounting brackets. • *Motorsport chassis components*: e.g. 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.

Essential information for tutors and assessors

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.

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.

Unit 4: Motorsport Vehicle Preparation and Inspection

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Be able to record and collate documentation required to compete at a motorsports event		D1 compare the differences in the tools and equipment used in a motorsports workshop against those used at a competitive event
P1 record and collate vehicle, competitor and event documentation for a motorsport event	M1 compare the specifications required between two different classes of motorsport events	
Learning outcome 2: Be able to prepare a competition vehicle to a recognised specification		D2 evaluate your own and your team's performance after a motorsports event and recommend an improvement strategy
P2 use tools and equipment to prepare a competition vehicle to a given specification	M2 carry out a survey of a service/pit area and identify strengths and threats to the health and safety of self and others	
Learning outcome 3: Be able to carry out inspections before, during and after a motorsports event		
P3 describe the health and safety procedures to be followed when inspecting a motorsports vehicle P4 use appropriate personal protective equipment when inspecting a motorsport vehicle P5 carry out pre-competition vehicle inspection and set-up P6 carry out vehicle inspections during a motorsports event P7 carry out a post-competition	M3 produce a 'set-down' schedule and checklist for post-competition inspection and rectification	

Pass	Merit	Distinction
inspection following a motorsports event P8 identify and record vehicle rectification work required		

Unit content

What needs to be learned
Learning outcome 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 e.g. from DVLA, MSA, manufacturer. • *Competitor documentation*: club/membership cards; MSA licences e.g. clubman, national A, international, race, rally, speed medical certificate; doctor's medical report; collation of competition data e.g. entry applications and acceptances, final instructions, road books, circuit diagrams. • *Motorsport event documentation*: e.g. MSA permits, insurance waivers, land registry, final instructions, regulations (race/rally).
Learning outcome 2: Be able to prepare a competition vehicle to a recognised specification
• *Vehicle preparation*: tool use e.g. spanners, sockets, screwdrivers, torque wrenches, pressure gauges; specialist tools e.g. camber, caster, tracking, spring compression gauges, gas analysers; equipment use e.g. hoists and stands, auxiliary engine starting devices; safe operation of tools and equipment e.g. serviceable condition, correctly stored and accounted for (shadow boards, tool control methods), correct tool/equipment used in an appropriate manner; preparation routines e.g. conformation of class, scrutineering. • *Specifications*: MSA blue yearbook, FIA regulations e.g. technical regulations, competitor safety (cage mountings, cage design, fire extinguishers); yellow book e.g. technical regulation, homologation (type of vehicle, year of make); single make and class regulations e.g. engine cubic capacity (cc), design type.
Learning outcome 3: Be able to carry out inspections before, during and after a motorsports event
Health and safety: safe use and handling of lubricants/fluids e.g. fuel, oil, solvents, grease; safe use of lifting equipment and handling techniques e.g. tested and calibrated lifting equipment, Manual Handling Regulations; safe working practices e.g. 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 e.g. cleaning cloths, hydraulic fluids, contaminated fuel, scrap components (tyres, brake and clutch linings).

What needs to be learned
Personal protective equipment (PPE): overalls, safety-shoes, gloves, specialist motorsports equipment e.g. fire protection, hearing and eye protection, communications equipment. *Pre-competition inspection*: scrutineering; security of fastenings using a torque wrench e.g. nuts, bolts, critical securing devices; fuelling vehicle e.g. correct capacity, type of fuel; tyres e.g. suitability, condition, pressures; lubrication and coolant system levels and pressures e.g. warm up, operating temperature; testing throttle settings and operation e.g. idle, full throttle; hydraulic fluid system levels, check for leaks and operation e.g. for clutch, steering, brakes; vehicle brake balance settings; setting suspension dampers to suit event; transmission system operation e.g. function of clutch and gearbox through all gears; electrical system operation; running gear e.g. spherical bearings, wheel bearings; reporting of faults e.g. loss of fluid, abnormal pressure, excessive wear. *Pre-competition set-up*: event analysis e.g. 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 e.g. 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 e.g. compression/leak tests; cleaning of bodywork/removal of track debris. *Post-competition vehicle rectification*: using job sheets, type of rectification e.g. repair, adjustment, replacement.

Essential information for tutors and assessors

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.

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.

Unit 5: Professional Practice and Logistics for Motorsports

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Know the organisation, administrative structure and associated professional bodies of motorsport activities		D1 evaluate the influence of a professional governing body for a motorsport activity and its effect on professional drivers and teams
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	
Learning outcome 2: Be able to communicate with the media to provide information about a motorsport activity		D2 evaluate the effectiveness of a media interview, providing recommendations for change and/or amendments
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	
Learning outcome 3: Be able to plan motorsport vehicle transportation		
P3 select appropriate transport vehicles for two different types of motorsport activity P4 interpret the legislation relating to a specific transport vehicle and driver P5 produce a transport schedule and route plan for a specific 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	

Pass	Merit	Distinction
Learning outcome 4: Be able to plan the sponsorship and financial management of a motorsport team		
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		

Unit content

What needs to be learned
Learning outcome 1: Know the organisation, administrative structure and associated professional bodies of motorsport activities
• *Organisation*: types of organisation e.g. local motor club, regional associations, national associations, international associations; level of competition e.g. local, regional, national, international championships; forms of motorsport activity e.g. motocross, rallying, formula 1 (F1), saloon racing, formula ford. • *Administrative structure*: organisation e.g. structured administration charts, officials and their responsibilities, related rules, regulations; schedules/frequency of events; marketing methods. • *Professional bodies*: e.g. Motorsports Association (MSA), Federation International de l'Automobile (FIA), Auto Cycle Union (ACU), National Association for Stock Car Auto Racing (NASCAR).
Learning outcome 2: Be able to communicate with the media to provide information about a motorsport activity
• *Media*: e.g. television, radio, internet, press (local, national, specialist magazines). • *Media interview*: planning e.g. purpose/aims/objectives, data research (available resources, information gathering, use of information and communication technology), content/message to be conveyed; preparation e.g. scripts/prompt sheets, rehearsals, evaluation (strengths/weaknesses, use of feedback, video analysis, modifications to improve and/or change performance); delivery e.g. speech (technical vocabulary, pace, tone, clarity) communication style, body language, presentation methods, appearance, timing.
Learning outcome 3: Be able to plan motorsport vehicle transportation
Transport vehicles: purpose e.g. number/size, weight and types of vehicles to be transported, spares, equipment, people/accommodation (cooking, eating, sleeping), workshop facilities; types e.g. tow vehicle and trailer, adapted and purpose-built light goods vehicle (LGV), passenger service vehicle (PSV); vehicle construction e.g. materials, steel, aluminium, wood, glass-fibre, carbon fibre, sheeting; wheels and tyres; chassis e.g. maximum weights (nose, axle, train, towing); characteristics e.g. 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 e.g. licence requirements, driving hours, insurance; lighting and markers; health and safety e.g. weight distribution, risk assessments (responsibilities, safe lifting, manual handling aids). *Transport schedule and route planning*: human and physical resource requirements e.g. accommodation, equipment, vehicles, staffing; schedules e.g. depart/arrival time, work

What needs to be learned
loading, loading sheets, tool list and inventories, ancillary equipment sheet, spares and consumable requirements; route plan e.g. use of route planning software, alternative routes, costs (fuel, wages, tolls).
Learning outcome 4: Be able to plan the sponsorship and financial management of a motorsport team
• *Sources of income*: prize money, loans, endorsed clothing/equipment, advertising e.g. vehicles, clothing, equipment; sponsorship e.g. use, purpose, advantages and limitations; types of sponsorship e.g. clothing and equipment, individual and corporate sponsorship. • *Business planning*: team structure, income and expenditure e.g. capital expenditure, wages, fees; financial management e.g. investments, royalties, tax, expenses, insurance; use of experienced personnel to manage finances e.g. accountant, financial advise.

Essential information for tutors and assessors

Essential resources

There are no essential resources for this unit.

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).

Unit 6: Operation of Vehicle Chassis Systems

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

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 ride in and be able to cope with the many forces that act upon it.

This unit will provide learners with an understanding of the operation of the main chassis systems found in modern vehicles. This will include the vehicle transmission, steering, suspension and braking systems. It will introduce learners to the layout, function and operation of the systems, sub-systems and components involved in these areas.

Learners will develop an understanding of the operating principles of a range of transmission, steering, suspension and braking systems. This broad knowledge, together with a greater understanding of the construction of system components will enhance learners' comprehension of vehicle systems and how they interrelate.

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

Learning outcomes

In this unit you will:

1 Understand how a transmission system and its components operate

2 Understand how a steering system and its components operate

3 Understand how a suspension system and its components operate

4 Understand how a braking system and its components operate.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning outcome 1: Understand how a transmission system and its components operate</td><td rowspan="13">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</td></tr>
<tr><td>P1 describe a vehicle's transmission layout
P2 describe the operation of a transmission system and its components</td><td>M1 compare two different types of transmission systems</td></tr>
<tr><td colspan="2">Learning outcome 2: Understand how a steering system and its components operate</td></tr>
<tr><td>P3 describe a vehicle's steering system layout
P4 describe the operation of a steering system and its components</td><td>M2 compare two different types of steering systems</td></tr>
<tr><td colspan="2">Learning outcome 3: Understand how a suspension system and its components operate</td></tr>
<tr><td>P5 describe the layout of a vehicle's suspension system
P6 describe the operation of a suspension system and its components</td><td>M3 compare two different types of suspension systems</td></tr>
<tr><td colspan="2">Learning outcome 4: Understand how a braking system and its components operate</td></tr>
<tr><td>P7 describe a vehicle's braking system layout
P8 describe the operation of a braking system and its components</td><td>M4 compare two different types of braking systems</td></tr>
</table>

Unit content

What needs to be learned
Learning outcome 1: Understand how a transmission system and its components operate
• *Transmission layout*: drive method e.g. front-wheel drive, rear-wheel drive, four-wheel drive; power path e.g. 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 e.g. number of plates, diameter, friction; gearing arrangements e.g. ratios, simple and compound gear trains • *Transmission components*: clutch e.g. single plate spring, diaphragm; release mechanisms e.g. linkage, cable, hydraulic, pneumatic, electrical; gearbox (input shaft, lay shaft, main shaft, idler); types of gear (straight cut, helical); universal joints e.g. 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 e.g. semi, three quarter, fully floating; wheel hubs e.g. taper, roller bearings; transmission lubricant e.g. hypoid, multi-grade
Learning outcome 2: Understand how a steering system and its components operate
• *Steering system layout*: steering method e.g. 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 e.g. 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 e.g. track rod, drag link, drag link ends; steering arm, tie rod (bushes, joints); steering box (seals, bearing)
Learning outcome 3: Understand how a suspension system and its components operate
Suspension systems layout: suspension method e.g. beam axle, independent front suspension (IFS), independent rear suspension (IRS); vibration and damping methods e.g. metal, rubber, hydraulic, hydro-pneumatic *Suspension operation*: interaction of components e.g. vehicle loaded/unloaded, cornering, 'bump' reaction *Suspension components*: spring systems e.g. leaf, coil, rubber, hydraulic; fittings and mounting e.g. shackles, U-bolts, saddle, tie bar; hydraulic/hydro-pneumatic systems e.g.

What needs to be learned
fluid supply, storage, actuation, control; suspension damping e.g. oil, gas, friction; tyres e.g. type (radial, cross-ply, markings) and impact on vehicle suspension system
Learning outcome 4: Understand how a braking system and its components operate
• *Layout*: braking methods e.g. disc brakes, drum brakes; braking circuit e.g. hydraulic circuit, split braking circuits • *Braking system operation*: application of mechanical forces e.g. pedal force, transmission of force (fluid pressure, piston sizes); brake shoes/pads; heat dissipation e.g. mechanical to heat energy, vented brake arrangement; brake efficiency e.g. vehicle testing, axle efficiencies, brake balance; leading and trailing brake shoe action • *Components*: hydraulic circuit components e.g. single/tandem circuit, master/slave cylinders (machined surfaces, seals, pistons, springs), brake lines (fixed and flexible piping); brake servo e.g. diaphragm, spring, valve; pressure limiting valve e.g. seal, actuation; brake adjuster e.g. manual, automatic; brake discs/drums e.g. machined surface, vented, solid; callipers/actuators e.g. piston(s), seals, mounting; brake shoes (leading, trailing, springs); brake drums (machined surface, mounting); handbrake mechanism (actuation) e.g. mechanical linkage, cables, electronic control systems

Essential information for tutors and assessors

Essential resources

Centres need to provide learners with access to a range of suitable reference material (e.g. manuals and manufacturer's data) for the systems covered. Access to vehicle components (e.g. bevel, hypoid and helical gears), demonstration rigs (e.g. sectioned clutches, gearboxes, steering boxes) and vehicles to support and provide sufficient coverage and understanding of the content is also essential.

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. In particular, care should be taken to ensure that learners describe both the operation and the components of each system. Opportunities to meet the pass and merit criteria that relate to each system should be provided, e.g. to be able to describe a vehicle's transmission layout (P1), 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 (e.g. 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, e.g. annotation of images, diagrams used to support/clarify own text. Development of these research and presentation skills may also provide suitable evidence for key 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 (e.g. 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 (e.g. to clearly identify the path taken by the power between the flywheel and the driven road wheels). In addition, for each system a suitable description of its operation and components is needed. Again, drawings or sketches can be used to good effect to support any written evidence (e.g. 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).

Descriptions could also be supplemented with evidence from practical activities carried out in other units or from work experience (e.g. 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 (e.g. 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 variety in their study and exposure to a greater range of industry standards. 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, e.g. the impact of the type of suspension on the steering and handling of the vehicle.

Unit 7: Light Vehicle Suspension, Steering and Braking Systems

Level:	**3**
Unit type:	**Mandatory**
Assessment type:	**Internal**
Guided learning hours:	**60**

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Know the function and operation of different types of suspension system		
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 P2 describe the function and operation of the main components of an adaptive suspension system	M1 compare the relative advantages and disadvantages of an adaptive suspension system and one other type of 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	
Learning outcome 2: Know the function and operation of steering system components		
P3 describe the function and operation of the main components of power assisted steering P4 distinguish the range of steering characteristics		
Learning outcome 3: Know the function and operation of braking system components		D1 evaluate two different braking system

Pass	Merit	Distinction
P5 describe the functional differences between two different wheel and tyre combinations P6 describe the function and operation of the components found in a given type of braking system	M3 describe the function and operation of the components found in an anti-lock braking system	applications for efficiency and safety when used in conjunction with an anti-lock braking system
Learning outcome 4: Be able to carry out fault-finding procedures on steering, braking and suspension systems		
P7 carry out fault-finding on a suspension system to check for satisfactory operation P8 carry out fault-finding on a steering system to check for satisfactory operation P9 carry out fault- finding on a braking system to check for satisfactory operation P10 state the corrective action to be taken for each of the faults found		

Unit content

What needs to be learned
Learning outcome 1: Know the function and operation of different types of suspension system
• *Suspension systems*: types of independent front suspension e.g. unequal length wishbones, transverse link and strut; types of independent rear suspension e.g. trailing arm, pure and semi, unequal transverse links, transverse link and strut, air suspension; dampers (construction, operation and typical faults); suspension requirements e.g. sprung weight, unsprung weight; impact of chassis design on suspension type e.g. ladder, monocoque, space frame, welded shell constructions. • *Adaptive suspension system main components*: Electronic Control Unit (ECU); regulator; solenoid valve; sensors; dampers; system operation.
Learning outcome 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 e.g. 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 e.g. 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 e.g. belt and brace construction, ply construction; tyre profile and tyre markings e.g. width, aspect ratio, type of construction, load index, speed index, ply ratings, direction indicators; applications e.g. high performance, light/heavy vehicles, motorcycle, agriculture, industrial; valve types.
Learning outcome 3: Know the function and operation of braking system components
Main components: types of system e.g. 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) e.g. 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.

Learning outcome 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.

Essential information for tutors and assessors

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.

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, M3 and D1. Initially, learners could describe the function and operation of the components found in braking systems (P6) and anti-lock braking systems (P8). 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 P7, P8, P9 and P10. 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.

Unit 8: Motorsport Welding Technology

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

Learners examine the principles and technology used in common welding processes and produce welded joints in differing materials and welding positions.

A diverse range of welding processes are used in the manufacturing sector and in industry, including manual, automated and mechanised processes. The selection and application of these welding processes is vital in terms of the integrity, safety and the economic viability of the finished product.

In this unit, you will examine the common welding processes used to produce high-quality, permanent metal joints. You will select the most appropriate welding processes for a specific application. You will understand and apply strict safe working practices designed to protect you and colleagues from various hazards that are inherent to the welding process, such as electric currents, combustible gas mixtures and parts rotating at high speed. You will examine the materials and their behaviour during the welding process, helping you to create 'good' welded joints. Finally, you will plan and carry out a welding task to join different materials and joints together in different welding positions safely.

As an engineer, it is important to understand the welding technology, processes and the mechanisms of planning and creating joints and components. This unit helps to prepare you for employment, for example as a welding technician, for a traineeship/apprenticeship or for entry to higher education to study engineering.

Learning outcomes

In this unit you will:

1 Examine common welding processes used to produce welded joints safely for different applications

2 Examine weldable materials and their behaviours during the welding process

3 Carry out practical welding skills safely to join metallic materials together.

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Examine common welding processes used to produce welded joints safely for different applications		D1 Justify, using language that is technically correct, the choice of welding processes, parameters and settings for two given welding applications, explaining the equipment, terminology and safe working practices that apply
P1 Explain the choice of welding processes, parameters and settings for two given welding applications, explaining the equipment, terminology and safe working practices that apply	M1 Analyse the choice of welding processes, parameters and settings for two given welding applications, explaining the equipment, terminology and safe working practices that apply	
Learning outcome 2: Examine weldable materials and their behaviours during the welding process		D2 Evaluate the structure, mechanical properties and defects of alloyed and unalloyed steel and non-ferrous materials used in welding processes, including the effects of irregularities, forces and loading on the joints
P2 Explain the structure and mechanical properties of alloyed and unalloyed steel and non-ferrous materials used in welding processes P3 Explain the effect of forces and loading on welded joints P4 Explain the defects and irregularities that occur in alloyed and unalloyed steel and non-ferrous materials used in welding processes	M2 Analyse the structure, mechanical properties, and defects of alloyed and unalloyed steel and non-ferrous materials used in welding processes, including the effects of irregularities, forces and loading on the joints	
Learning outcome 3: Carry out practical welding skills safely to join metallic materials together		D3 Refine, during the process, the planning and production of welded joints using two different materials, processes and welding positions
P5 Produce a plan to create two welded joints, using two	M3 Produce a detailed and accurate plan to create two welded joints, using two	

Pass	Merit	Distinction
different welding processes safely P6 Produce welded joints using two different materials, processes and welding positions safely	different welding processes safely M4 Produce welded joints using two different materials, processes and welding positions, safely and accurately	safely, accurately, efficiently and effectively

Unit content

What needs to be learned
Learning outcome 1: Examine common welding processes used to produce welded joints safely for different applications
• **A1 Welding terminology for processes and equipment** • Types of manual welding process, e.g. manual metal arc (MMA), tungsten inert gas (TIG), metal inert gas (MIG)/metal active gas (MAG), flux-cored arc welding (FCAW). • Automated and mechanised welding processes, e.g. orbital welding, resistance welding. • The major differences between types of welding process, correct use of abbreviations, range of applications, advantages and disadvantages, potential problems, and potential hazards and methods of safe handling and working. • **A2 Gas-shielded arc welding – shielding gases** • The characteristics and operating principles: • processes, including TIG, MIG/MAG, flux-cored welding • shielding gas used for each process • safe handling and storage of shielding gases • standards for shielding gases and filler materials • potential hazards and methods of safe handling and working. • **A3 Common welding processes** • Welding processes: • TIG welding process, including arc ignition methods and their applications, common applications for each type of current, polarity and electrode type, use of and care for the equipment and accessories, standards for consumables, joint preparation and potential problems to overcome and potential hazards, and methods of safe handling and working • MIG/MAG welding, including metal transfer modes and their applications, selection of appropriate type of current, polarity and electrode according to application, appropriate joint preparations and potential problems to be overcome, welding parameters on the weld bead and be able to outline the welding parameters for particular applications, main components of the equipment and accessories, appropriate standards for consumables and how they are to be selected, care for the equipment and accessories, potential hazards and methods of safe handling and working • FCAW process, including common applications for each type of current, polarity

What needs to be learned
• and electrode, appropriate joint preparations and potential problems to be overcome, appropriate welding parameters on the weld bead and outlining welding parameters for particular applications, potential hazards and methods of safe handling and working, functions of the main components of the equipment and accessories, appropriate standards for consumables, how consumables should be selected, and care for the equipment and accessories • MMA welding process, including principles of MMA welding, selection of the appropriate type of current, polarity and electrode according to application, applications, appropriate joint preparations and potential problems to be overcome, range of welding parameters for particular applications, hazards and methods of safe handling and working, component of the equipment and accessories, handling, control and storage of the various types of electrodes, use of appropriate standards, influence of electrode coating on droplet transfer and weld metal properties. • **A4 Welding electrotechnics** • The function of welding power source components: o alternating current (AC) and direct current (DC) and give examples of their individual application to different welding processes o transformers o rectifiers, including bridge (half and full wave). • Power sources for arc welding: o how a welding power source works (AC and DC), including the most common devices used o arc welding power source, including the voltage static characteristic, operation point and control of arc stability o open-circuit voltage, arc voltage short-circuit current, duty cycle of a power source, voltage losses, and current to cable section relationship o appropriate power sources for a given welding process o settings and switches on different power sources and their effects on the welding process.
Learning outcome 2: Examine weldable materials and their behaviours during the welding process
• **B1 The properties and behaviours of metallic materials** • Properties of metallic materials: o mechanical properties of metals, e.g. plasticity, elasticity, cold and hot deformation, work hardening and strain ageing

What needs to be learned

- loading conditions on the properties of metallic materials, e.g. temperature,
- loading speed, environment.

- The behaviour of metallic structures under loading:
  - stress – normal stress, shear stress
  - deformation – axial strain, shear strain
  - stress-strain relationship graphically
  - stress resulting from internal forces and moments.
- **B2 Unalloyed steel materials**
- Behaviour of structural steels in fusion welding:
- temperature distribution in welds and the microstructure formed as a result for a single-pass weld versus a multi-pass weld
- effects of heat input, cooling rate and multi-pass operation on weld metal solidification
- the microstructure formed for a single-pass weld versus a multi-pass weld
- the effects of the weld protection, the type of consumables on the microstructure of the weld metal and on the properties for a single-pass weld versus a multi-pass weld
- recognise areas of the heat-affected zone (HAZ), the reasons for grain size and microstructure changes and their effects on properties for a single-pass weld versus a multi-pass weld.
- **B3 Alloyed steel and non-ferrous materials**
- Nickel and nickel alloys:
  - nickel and nickel alloy weldability
  - applicable welding processes and types of consumable for nickel and nickel alloys.
- Aluminium and aluminium alloys:
  - aluminium and aluminium alloy weldability
  - applicable welding processes and types of consumable for aluminium and
  - aluminium alloys.
- Titanium and other metals and alloys:
  - the welding metallurgy of specified metals, e.g. titanium, magnesium
  - the weldability of the specified metals

What needs to be learned

- appropriate welding processes.

- Joining dissimilar materials, including the weldability aspects involved when joining dissimilar materials.
- **B4 Defects and irregularities in welded joints**
- Cracking phenomena in welded joints:
  - metallurgical mechanisms for each of the major types of cracking
  - susceptibility to cracking and suggest appropriate precautions to avoid cracking
  - type of cracking and the reason for its occurrence from study of fractured material and its history
  - reduce or eliminate the occurrence of lamellar tearing in welded construction/fabrication.
- Fractures and different kinds of fractures:
  - recognise the differences between cracks and fractures
  - recognise the differences between ductile and brittle fractures.
- Heat treatment of base materials and welded joints:
  - recognise the necessity to perform heat treatment after welding, depending on the type and thickness of steel and the application
  - post weld heat treatment (stress relieving).
- The various types of corrosion:
  - the chemical and electrochemical phenomena involved in corrosion
  - the most common types of corrosion, including intercrystalline, transcrystalline, knife-line attack, pitting, crevice, and stress-corrosion
  - common protection methods.
- Destructive and non-destructive testing of materials and welded joints:
  - destructive testing and the limitations of the data generated
  - testing methods and the parameters to be measured, including destructive and non-destructive, e.g. tensile, bend, impact, hardness, creep, root and face bend, nick break, and x-ray
  - recognise when and why special testing should be specified.

What needs to be learned

Learning outcome 3: Carry out practical welding skills safely to join metallic materials together

C1 Prepare for welding operations

- Information sources, e.g. safety instructions, job instructions, engineering drawings, quality control documentation, weld procedure specification (WPS), record and reporting sheets.
- Tools and equipment:
  - function and condition relevant to the welding process, e.g. cables, hoses, torches and electrode holders, gas pressure regulators, flow meters
  - working environment, e.g. workshop, site work, conditions for machinery and plant
  - assembling welding equipment, e.g. cables, weld return clamps, electrode holders, gas cylinders, regulators, valves, safety devices.

C2 Welding parameters and settings

- Manual processes, including gas pressure, flow rates, voltage, current (either AC or DC), according to electrode or filler size.
- Mechanised processes:
  - safety devices
  - welding speed
  - parameters, including electrical current and voltage, wire feed rate, filler diameter, gas shielding system
  - mechanical functions, including handling, loading, work holding, transfer.
- Weld bead and morphology in relation to the settings and parameters used, e.g. parameters affecting bead shape.
- Consumables, e.g. appropriate to process, electrode (rutile, basic, nickel alloy, cellulosic, stainless steel, other electrodes), filler wire, gases (oxygen, shielding gases), inert and active gases, and safe storage of consumables.

C3 Welding of joints safely

- Safe working practices:
  - fire prevention
  - electrical safety
  - electromagnetic (EM) and ultraviolet (UV) radiation
  - accident prevention and reporting
  - using risk assessments

What needs to be learned

- manual handling
- equipment maintenance
- checking conditions, e.g. gas leaks, voltage and amperage, fuses,
- circuit breakers, leads
- wearing personal protective equipment (PPE)
- ventilation and extraction fumes
- using ventilation and extraction
- closing down equipment safely after use.

- Joints and components:
  - for manual processes – butt, fillet, autogenous weld (without filler wire)
  - for semi-automatic processes – two different joint configurations, two different material groups.
- Welding positions, e.g. flat (PA), horizontal vertical (PB), horizontal (PC), vertical upwards (PF), vertical downwards (PG), overhead (PE).
- Welding technique, e.g. torch angle, filler angle.
- Material:
  - forms, e.g. plate (thickness appropriate to process, up to 6 mm, section,
  - sheet < 3 mm), other forms
  - types, e.g. carbon steel, stainless steel, aluminium.
- Welding discontinuities and faults, considering the chosen welding process and the applied parameters.

Essential information for tutors and assessors

Essential resources

For this unit, learners must have access to appropriate:

- welding equipment
- welding consumables and materials
- destructive and non-destructive testing equipment
- health and safety materials and procedures.

Assessment

Learning outcome 1

For distinction standard, learners will give a balanced justification for the choice of at least two welding process for two different welding applications given to them. For example, their evidence could cover why welders use the MIG process in preference to MMA for thin sheet steel, particularly exploring why warping (distortion) occurs and the HAZ effects on the material. The justification will also cover different types of materials, shielding gases and safety considerations. For example, learners could examine the welding of aluminium using the optimum electrode, filler rod and inert gas and compare this to the MIG process. Learners will also detail how safe working practices vary by process.

Overall, the report will be easy to read and understand by a third party, who may or may not be an engineer. It will be logically structured and use correct technical engineering terms.

For merit standard, learners will analyse the choice of at least two welding processes for two different welding applications given to them. For example, welding using the MIG process is considered easier to learn and quicker to master than MMA, although a comparison of the joint quality may contradict this argument. The evidence will demonstrate how the material and joint can influence the welding process. For example, why 18/8 (chromium/nickel) stainless steel may produce a better weld than welding stainless steel with 12% chromium.

Overall, the analysis should be logically structured, be technically accurate and easy to understand.

For pass standard, learners will explain the choice of welding process for at least two different welding applications given to them, for example the reasons why low carbon steel can be welded using most processes, but cast iron requires a specific process and special welding rods. Learners will also explain the equipment and safe working practices required.

Overall, the evidence, such as a report, will be logically structured, although basic in parts. Learners will likely include minor technical inaccuracies relating to engineering terminology, such as mentioning 'MIG' instead of 'MAG'.

Learning outcome 2

For distinction standard, learners will give a balanced evaluation of different welding processes with regard to the weldable materials used and their behaviours. For example, their evaluation could cover why temperature differences cause a HAZ and a change in material properties and to the materials' microstructure. In addition, certain materials require the HAZ to be removed for cosmetic reasons and others due to the material becoming hard and brittle. Learners will evaluate the defects found in weldable materials. For example, they could examine how and why a longitudinal crack has occurred along the centre of a weld. They will explore the rationale for propagating cracks and their detection using non-destructive tests, including why it is advantageous to use an x-ray method in some cases and dye penetrate in others.

Learners will also evaluate the effects of forces and loading on welded joints, such as those caused by fatigue. For example, the internal structure of the weld may be porous or contain internal tensile stresses, which cause the welded joint to fail under fatigue loads. Therefore, it is important to understand the relationship between maximum stress and the loading or cyclic loading on the weld.

Overall, the justification will be easy to read and understand by a third party, who may or may not be an engineer.

For merit standard, learners will give a balanced analysis of different welding processes with regard to weldable materials and their behaviours. For example, they could cover why it is important to remove the thin layer of aluminium oxide before welding and the effect on temperatures and the cleaning solution that gives the best and safest results. Learners will also give a rationale for welding defects. For example, some metals, such as pure aluminium, do not show any colour change due to temperature increase, which makes it difficult for technicians to know when to start welding.

Learners will analyse the effects of forces and loading on welded joints. Their analysis will cover why the creation of stress points is an issue in welded joints and how the application of preheating or stress relieving can mitigate this issue.

Overall, the analysis will be logically structured, be technically accurate and easy to understand.

For pass standard, learners will give a balanced explanation of the materials and their behaviours during welding. For example, they could cover why it is important to use the correct flux so that it may improve the alloying elements across the arc. Learners will give reasons for fractures occurring and the testing methods employed. For example, hidden porosity or lack of fusion and a destructive test such as 'nick break' may be used to check for this. Non-ferrous alloys have different material properties when compared to alloyed or unalloyed steels. For example, pure aluminium is very reactive and an oxide film forms

quickly. This oxide needs removing before welding, but it is highly flammable, especially when mixed with steel dust.

Learners will also explain the effects of forces and loading on welded joints. For example, the effect on loaded joints of an effective throat thickness to ensure that sufficient heat is generated to give a good bond between the parent metal and the weld metal. This would then enable the weld to carry the designed forces.

Overall, the evidence, such as a report, will be logically structured, although basic in parts. Learners will likely include minor technical inaccuracies relating to engineering terminology, such as mentioning 'stress' instead of 'strain'.

Learning outcome 3

For distinction standard, learners will refine during the process the WPS plan to ensure that the equipment parameters and settings produce 'good' results, and that all preparation is completed methodically and thoroughly. For example, learners could discuss and decide on the most appropriate welding settings for voltage, wire speed and gas flow rates to ensure a 'good' weld using a specific material and electrode. Learners will select appropriate materials and welding positions to successfully complete two welds safely and accurately. The welds must each be a minimum 50 mm in length, using two different materials and in two different welding positions. For example, learners may select a vertical up-weld, in 3 mm low-carbon steel plate, using the MMA process for one weld, while ensuring it meets the appropriate weld specification. Effectiveness and efficiency of weld production will also be demonstrated, for example:

- effectiveness will be evidenced by considering the electrode selection and welding parameters to complete the weld with compliance to all safety requirements
- efficiency will be evidenced by optimising run speed and monitoring for weld quality to ensure there are no distortion, cracks, or porosity and minimising slag.

Overall, the evidence will be presented clearly in a way that would be understood by a third party, who may or may not be an engineer. There will be a comprehensive record of the safety procedures followed, together with accurately and correctly completed planning and checking documentation for each of the tasks completed. Learners' evidence, such as annotated photographs and observation records, will show clearly how they worked effectively, efficiently, accurately and safely during the welding processes.

For merit standard, learners will create a detailed and accurate WPS plan to ensure that the correct equipment is selected for the process and all preparation is completed. For example, learners will probably follow the vast majority of the manufacturers' recommended settings, except to use trial and error to select the most appropriate gas flow rate setting to ensure enough heat is available without burning a hole in the component. Learners will select appropriate materials and welding positions to successfully complete two welds. The welds must each be a minimum 50 mm in length, using two different materials and in two different welding positions. For example, learners could select a flat fillet weld, in 6 mm low-carbon steel plate, using MIG safely and accurately, ensuring it meets the appropriate weld specification.

Overall, the evidence will be logically presented, technically accurate and easy to understand. It will include the safe working practices that were applied throughout the welding tasks. Learners' evidence, such as annotated photographs and observation records, will show clearly how working accurately and safely was considered throughout the welding processes.

For pass standard, learners will create a welding plan to ensure that suitable equipment is selected for each welding process and some preparation is completed. Learners will probably follow the manufacturers' recommended settings for all parameters. Learners will select appropriate materials and welding positions to successfully complete two welds, using two different welding processes (two welds for each process). The welds must each be a minimum 50 mm in length, using two different materials and in two different welding positions. For example, learners could safely produce a flat butt weld, in 2 mm aluminium sheet, using the TIG process for one weld, while ensuring it meets the appropriate welding specification.

Overall, any supporting evidence may be limited, for example there may only be some evidence of preparation tasks and the inspection documentation may lack the required detail. Learners' evidence, such as annotated photographs and observation records, will show clearly how working safely was considered and applied throughout the welding tasks.

Unit 9: Function and Operation of Vehicle Petrol Injection Systems

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Understand the operational differences of petrol injection systems		
P1 explain the operation of two different petrol injection systems used on modern fuel injected engines P2 describe the methods used to position the fuel injector for an induction port injection and a direct injection into the cylinder	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
Learning outcome 2: Understand the function and operation of air and fuel supply components and systems		
P3 describe the principles of stoichiometric and lean burn technology with reference to petrol injection engines P4 explain the function and operation of the air and fuel supply components of a given fuel injection system	M2 compare the injection, combustion cycle and exhaust emissions within a stoichiometric air fuel ratio engine and a lean burn stratified charge engine	
Learning outcome 3: Understand the operation of electronic control systems and components		
P5 describe the function and operation of four major input sensors, their related switches and actuators and how the electronic control unit uses	M3 compare the diagnostic tests and repair strategies that can be performed on two different modern petrol injection systems, including the	

Pass	Merit	Distinction
feedback from these devices to calculate quantity of fuel injected P6 explain the emission control measures and associated components used for a given fuel injected engine system	equipment that may be used	
Learning outcome 4: Know the methods used to test, maintain and repair petrol fuel injection systems		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
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	M4 describe the symptoms associated with three different injection system faults found in modern engines and the repair strategy for each	

Unit content

What needs to be learned
Learning outcome 1: Understand the operational differences of petrol injection systems
• *Petrol injection system*: principles of fuel combustion e.g. 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 e.g. 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 e.g. up-stream, down-stream or direct into the cylinder; quality of the homogeny of the charge and volumetric efficiency e.g. requirements for compensatory enrichment, effects of fuel condensation on manifolds walls. • *Stoichiometric and lean burn technology*: phasing of injection e.g. induction cycle injection (stoichiometric cycle), compression stroke injection (direct injection, stratified engine operation); fuel injection strategies e.g. continuous injection, intermittent injection, semi sequential and sequential injection, asynchronous and grouped injection; operational conditions e.g. cold starting, idling, maximum power; thermal efficiency and the formation of pollutants; exhaust gas composition e.g. composition of the exhaust gases under rich, lean and stoichiometric conditions, legal requirements.
Learning outcome 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 e.g. steel with soldered joints, welded joints, moulded plastic, use of internal baffles and swirl pots; electric fuel pump e.g. vane, roller gear, plunger; valves e.g. pressure relief, non-return; fuel lines e.g. accumulator, pipelines, fuel pipe connections, fuel filter; continuous injection mechanical systems; pressure regulator with induction manifold pressure correction; common fuel rail injection (direct injection) e.g. low pressure supply pump, low pressure sensor, high pressure pump, high pressure injectors, high pressure sensor; methods employed to reduce fuel vapour escape e.g. charcoal canister, purge control valve.

Learning outcome 3: Understand the operation of electronic control systems and components
Sensors, switches and actuators: sensors e.g. 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 e.g. thermo-time switch, idle speed switch, inertia switch; actuators e.g. 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 e.g. use of input parameters to enable the software to calculate correct fuel quantity for injection; software updating e.g. use of specialised software to change fuel map setting at varying engine/operational conditions; software self- diagnostics; controller area network (CAN) data bus e.g. single wire, twin wire, fibre optic. *Emission control principles and components*: exhaust gas oxygen sensing; catalytic converter e.g. reduction, oxidising, nitrogen oxides (NOx); exhaust gas recirculation (EGR) and components e.g. outline of the process to reduce NOx formation, operation strategies, EGR valve, vacuum modulator, vacuum sensing valve; air injection and components e.g. air pump, air injector, pulse air injection, electronic control of EGR and air injection systems; effect of engine operating conditions e.g. cranking, cold start enrichment, hot start enrichment, cold idle, hot idle, light load, full load, acceleration, deceleration, engine speed limitation.
Learning outcome 4: Know the methods used to test, maintain and repair petrol fuel injection systems
• *Diagnostic equipment and tests*: exhaust gas analysis e.g. use of exhaust gas analysers, lambda values, air/fuel ratio, idle speed adjustments; on-board diagnostics (OBD) e.g. fault code reading, data logging, use of break out box to locate faults, data link connection to dedicated code readers; vacuum pump e.g. induction system leakage, simulation of manifold depression to check fuel pressure regulator; multimeter e.g. system voltage and circuit tests, circuit resistance, circuit integrity; pressure gauge e.g. fuel line pressure and regulator settings; injector delivery and spray pattern e.g. injection quantity, spray pattern and leakage; oscilloscope e.g. engine/camshaft speed sensor patterns, injection duration, lambda sensor output. • *Injection systems faults and symptoms*: e.g. throttle position sensor, mass air flow sensor, coolant sensor, crankshaft/camshaft speed/position sensor, exhaust oxygen sensor, idle speed control valve.

Essential information for tutors and assessors

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.

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 gauge, 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.

M4 is linked to P7. 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.

Unit 10: Vehicle Engine Management Systems

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 60

Unit introduction

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.

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.

Learning outcomes

In this unit you will:

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

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Understand the operating principles and characteristics of an engine management system		
P1 explain the operating principles and characteristics associated with an engine management system P2 explain the operating principles and application of three different types of engine management system sensor	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
Learning outcome 2: Understand the operating principles of engine management system sensors and actuators		
P3 explain the operating principles and application of three different types of engine management system actuator		
Learning outcome 3: Understand the interrelationships and interaction of engine management systems and components		
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	M2 compare the performance of three engine management system sensors in terms of their sensitivity, accuracy, linearity and stability	

Pass	Merit	Distinction
P6 explain the effect of different engine management functions during fuel, emission and performance control		
Learning outcome 4: Be able to carry out tests on an engine management system to locate a system fault		
P7 use appropriate equipment to carry out tests on five different engine management system components/circuits to establish their serviceability P8 carry out a diagnostic check to locate an engine management system fault	M3 explain the benefits of an integrated control system on engine performance	D2 evaluate an engine management system diagnostic procedure and recommend possible improvements

Unit content

What needs to be learned
Learning outcome 1: Understand the operating principles and characteristics of an engine management system
• *Operating principles and characteristics*: systems modelling e.g. diagrammatic representation of system input/process/output, characteristics of open and closed-loop system control strategies used in engine management systems; control systems e.g. analogue, digital, programmable, non-programmable; main elements of a digital processing system e.g. central processing unit (CPU), memory devices (such as volatile, non-volatile), buses, input/output ports; principal functions of a digital processing system e.g. multiplexing, controller area network (CAN) systems; characteristics e.g. 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 e.g. fuel, mechanical to full electronic; interaction between other vehicle systems e.g. sport mode on gearbox selection; fuel management (spark and combustion ignition) systems; ignition control and combined fuel/ignition control; emission control e.g. active to reactive such as use of lambda system and knock sensor control; vehicle performance monitoring e.g. throttle position, driver selection.
Learning outcome 2: Understand the operating principles of engine management system sensors and actuators
• *Operating principles of sensors*: types e.g. Electromagnetic, Hall effect, photo-electric, resistive, inductive, piezo-electric element effect, capacitive; factors affecting performance and application e.g. sensitivity, accuracy, linearity and stability; influence of environmental factors e.g. heat, vibration, moisture, contaminants. • *Operating principles of actuators*: e.g. 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.
Learning outcome 3: Understand the interrelationships and interaction of engine management systems and components
Interfacing and signal processing: compatibility between components and systems e.g. 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 e.g. energy transfer, power output stages, buffer circuits. *Functional interrelationships*: location e.g. units and components within the vehicle, position/location of components relative to others in the system; functional relationships between the elements of the system e.g. data input from sensors and electronic control unit (ECU) process to affect actuation; impact of a component's

What needs to be learned
failure on other components within the system, the operation of the system and on external systems e.g. the effect of speed sensor failure, Lambda sensor fault. *System interactions*: e.g. integration fuel and emission control and/or vehicle performance control, achieved by common data sources and actuator responses.
Learning outcome 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 e.g. on-board diagnostics, test instruments, voltage drop tester, ECU tester, spark advance and retard tester; safe working practice e.g. common rail fuel pressures, working with ECU, HT voltage; components and circuits e.g. 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 e.g. moisture, dirt, corrosion, fault code reading, gap, data link connection, output and resistance, condition, ignition timing, sensor output, sensor operation.

Essential information for tutors and assessors

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.

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.

Unit 11: Vehicle Project

Level: 3

Unit type: Mandatory

Assessment type: Internal

Guided learning hours: 120

Unit introduction

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.

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

In this unit you will:

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.

Assessment criteria

Pass	Merit	Distinction
Learning outcome 1: Be able to specify a project, keep records, agree procedures and choose a solution		
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	
Learning outcome 2: Be able to plan and monitor a project		
P2 prepare a project specification P3 agree and prepare the procedures that will be followed when implementing the project P4 use appropriate techniques to evaluate three potential solutions and select the best option for development P5 outline the project solution and plan its implementation P6 monitor and record achievement over the lifecycle of the project	M2 use a wide range of techniques and selection criteria to justify the chosen option	D1 independently manage the project development process, seeking support and guidance where necessary

Pass	Merit	Distinction
Learning outcome 3: Be able to implement the project plan within agreed procedures		D2 evaluate the whole project development process, making recommendations for improvements
P7 implement the plan and produce the project solution P8 check the solution conforms to the project specification	M3 evaluate the project solution and suggest improvements	
Learning outcome 4: Be able to present the project outcome		
P9 prepare and deliver a presentation to a small group outlining the project specification and proposed solution	M4 present coherent and well-structured development records and final project report	

Unit content

What needs to be learned
Learning outcome 1: Be able to specify a project, keep records, agree procedures and choose a solution
• *Project records*: written e.g. notes, sketches, drawings; plans and modified plans; targets (setting, monitoring); use of planning tools e.g. paper based, electronic; recording initial concepts e.g. lists, notes, mind mapping, flow diagrams, sketches. • *Initial concepts*: setting limits e.g. time, cost, feasibility, need; value–cost–benefit analysis; generating ideas e.g. group discussion, brainstorming, mind mapping; research techniques; lines of communication. • *Specification*: type of project e.g. product/system design, modification, testing and evaluating or similar vehicle related topics; technical information e.g. 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 e.g. decision making, budget planning and control; reporting methods; resource allocation and limits. • *Techniques*: comparison methods e.g. statistical, graphical, quality and resource requirements/limitations, process capability, fitness-for-purpose; analysis e.g. cost–benefit, feasibility.
Learning outcome 2: Be able to plan and monitor a project
• *Planning*: long-term planning e.g. planners, charts and scheduling techniques (flow charts, Gantt charts, critical path methods, software packages); setting priorities; useful resource information e.g. human and physical. • *Monitoring*: monitor and record achievement e.g. use of logbook and/or diary for record keeping (names, addresses, telephone numbers, meeting dates, email and other correspondence lists); use of logbook e.g. 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.
Learning outcome 3: Be able to implement the project plan within agreed procedures
Implement: proper use of resources e.g. equipment, tools, materials, within agreed timescale, use of appropriate techniques for generating solutions, adapting project plan where appropriate, maintaining appropriate records.

What needs to be learned
Checking solutions: use of evaluative and analytical techniques e.g. graphs, matrix methods, statistics, Gantt charts, sequencing, scheduling, critical path methods, computer software packages.
Learning outcome 4: Be able to present the project outcome
• *Presentation*: deliver a presentation to a small group e.g. 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 e.g. 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 e.g. CAD, DTP, spreadsheets, databases, word processing software.

Essential information for tutors and assessors

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.

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. 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.

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.

10 Appeals

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

Centres must document all learners' appeals and their resolutions. Further information on the appeals process can be found in the document *Internal assessment in vocational qualifications: Reviews and appeals policy*, available on our website.

11 Malpractice

Dealing with malpractice in assessment

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

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

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

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

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

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

Learner malpractice

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

Learners must be informed at the earliest opportunity of the specific allegation and the centre's malpractice policy, including the right of appeal. Learners found guilty of

malpractice may be disqualified from the qualification for which they have been entered with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Teacher/centre malpractice

The head of centre is required to inform Pearson's Investigations team of any incident of suspected malpractice (which includes maladministration) by centre staff before any investigation is undertaken. The head of centre is requested to inform the Investigations team by submitting a *JCQ M2* Form (downloadable from www.jcq.org.uk/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff, anonymous informants), the Investigations team will conduct the investigation directly or may ask the head of centre to assist.

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

You should be aware that Pearson may need to suspend certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties, such as:

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

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

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

The centre will be notified if any of these apply.

Pearson has established procedures for considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will

normally be accepted only from the head of centre (on behalf of learners and/or members or staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in the *JCQ Appeals booklet* (www.jcq.org.uk/exams-office/appeals).

12 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in awarding a qualification and in providing an overall qualification grade for each learner. It shows how this qualification is graded.

Eligibility for an award

In order to be awarded a qualification, a learner must complete all units, achieve a Pass or above in all units unless otherwise specified. Refer to the structure in *Section 2 Structure*.

To achieve any qualification grade, learners must:

- complete and have an outcome (D, M, P or U) for all units within a valid combination
- achieve the required units at Pass or above shown in Section 2
- achieve the minimum number of points at a grade threshold.

It is the responsibility of a centre to ensure that each learner completes every unit. Learners who do not achieve the required minimum grade (P) in units shown in the structure will not achieve a qualification.

Calculation of the qualification grade

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

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

This BTEC International Level 3 Specialist qualification is awarded at the grade range shown in the table below.

Qualification	Available grade range
Diploma (720 GLH)	P to D*D*

The Calculation of qualification grade table, given later in this section, shows the minimum thresholds for calculating these grades. The table will be kept under review over the lifetime of the qualification. In the event of any change, centres will be informed before the start of teaching for the relevant cohort and an updated table will be issued on our website.

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

Points available for units

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

	Unit size	
	60 GLH	120GLH
U	0	0
Pass	6	12
Merit	10	20
Distinction	16	32

Claiming the qualification grade

Subject to eligibility, Pearson will automatically calculate the qualification grade for your learners when the internal unit grades are submitted and the qualification claim is made. Learners will be awarded qualification grades for achieving the sufficient number of points within the ranges shown in the relevant Calculation of qualification grade table for the cohort.

Calculation of qualification grade

Specialist Diploma	
720 GLH	
Grade	Points threshold
U	0
PP	72
MP	88
MM	104
DM	124
D	144
D*D	162
D*D*	180

This table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued via our website.

Examples of grade calculations based on table applicable to registrations from September 2023

Example 1: Achievement of a Specialist Diploma with a MP grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int	Merit	10
Unit 2	60	Int	Pass	6
Unit 3	60	Int	Merit	10
Unit 4	60	Int	Pass	6
Unit 5	60	Int	Merit	10
Unit 6	60	Int	Pass	6
Unit 7	60	Int	Merit	10
Unit 8	60	Int	Pass	6
Unit 9	60	Int	Merit	10
Unit 10	60	Int	Pass	6
Unit 11	120	Int	Pass	12
Totals	**720**		**MP**	**92**

The learner has sufficient points for an MP grade.

Example 2: Achievement of a Specialist Diploma with a MM grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int	Pass	6
Unit 2	60	Int	Pass	6
Unit 3	60	Int	Pass	6
Unit 4	60	Int	Pass	6
Unit 5	60	Int	Distinction	16
Unit 6	60	Int	Merit	10
Unit 7	60	Int	Pass	6
Unit 8	60	Int	Merit	10
Unit 9	60	Int	Merit	10
Unit 10	60	Int	Distinction	16
Unit 11	120	Int	Pass	12
Totals	**720**		**MM**	**104**

12 Further information and publications

- Edexcel, BTEC and Pearson Work Based Learning contact details: qualifications.pearson.com/en/contact-us.html.
- Our publications catalogue lists all the material available to support our qualifications. To access the catalogue and order publications, please visit our website.

All centres offering external assessments must comply with the Joint Council for Qualifications (JCQ) document *Instructions for conducting examinations.*

Further documents that support the information in this specification:

- *Access arrangements and reasonable adjustments* (JCQ)
- *A guide to the special consideration process* (JCQ)
- *Collaborative and consortium arrangements for the delivery of vocational qualifications policy* (Pearson)
- *UK information manual* (updated annually and available in hard copy) **or** *Entries and information manual* (available online) (Pearson).
- *Distance learning and assessment policy* (Pearson)

Publisher information

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

Pearson Progress

Pearson Progress is a digital support system that helps you to manage the assessment and quality assurance of the Pearson BTEC International qualifications. It supports delivery, assessment and quality assurance of BTECs in centres and supports teachers and students as follows:

- course creation
- creating and verifying assignments
- creating assessment plans and recording assessment decisions
- upload of assignment evidence
- tracking progress of every learner.

The system is accessible for teachers and learners so that both teachers and learners can track their progress.

13 Glossary

Part A – General terminology used in specification

Term	Description
Level	Units and qualifications have a level assigned to them. The level assigned is informed by the level descriptors defined by Ofqual, the qualifications regulator.
Guided learning hours (GLH)	This indicates the number of hours of activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, for example lectures, tutorials, online instruction and supervised study. Units may vary in size.
Total qualification time (TQT)	This indicates the total number of hours that a typical learner will take to complete the qualification. This is in terms of both guided learning hours but also unguided learning, for example private study, time spent in the workplace to master skills.
Learning outcomes	The learning outcomes of a unit set out what a learner knows, understands or is able to do as the result of a process of learning.
Assessment criteria	The assessment criteria specify the standard the learner is required to meet to achieve a learning outcome.
Unit content	This section sets out the required teaching content of the unit and specifies the knowledge, skills and understanding required for achievement of the unit. It enables centres to design and deliver a programme of learning that will enable learners to achieve each learning outcome and to meet the standard determined by the assessment criteria.
Summative assessment	Assessment that takes place after the programme of learning has taken place.
Valid assessment	The assessment assesses the skills or knowledge/understanding in the most sensible, direct way to measure what it is intended to measure.
Reliable assessment	The assessment is consistent and the agreed approach delivers the correct results on different days for the same learners and different cohorts of learners.

Part B – Terms used in knowledge and understanding criteria

Term	Description
Analyse	Examine methodically and in detail, typically in order to interpret.
Assess	Consideration of all factors or events that apply, to identify those which are the most important or relevant and make a judgement.
Compare	Identify the main factors relating to two or more items/situations, explaining the similarities and differences or advantages and disadvantages, and in some cases say which is best and why.
Describe	Give a clear account in their own words, including all the relevant information (e.g. qualities, characteristics or events, etc.). Description shows recall and in some cases application.
Detailed	Having additional facts or information beyond a simple response.
Evaluate	Bring together all information and review it to form a supported conclusion, drawing on evidence, including strengths, weaknesses, alternative actions, relevant data or information.
Explain	Provide details and give reasons and/or evidence to support an opinion, view or argument. **OR** Provide details and give relevant examples to clarify and extend a point. This would usually be in the context of learners showing their understanding of a technical concept or principle.
Identify	Shows the main features or purpose of something. Can recognise it and/or name characteristics or facts that relate to it.
Outline	Provide a summary or overview or brief description.
State	Express information in clear and precise terms.

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