

Unit 1: Operation of Vehicle Systems

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

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

On completion of this unit a learner should:

- 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.

Unit content

1 Understand how a transmission system and its components operate

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

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

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

2 Understand how a steering system and its components operate

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

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

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

3 Understand how a suspension system and its components operate

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

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

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

4 Understand how a braking system and its components operate

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

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

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

Grading grid

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

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

Essential guidance for tutors

Delivery

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

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

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

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

To support delivery, centres should ensure that there are sufficient components (eg clutch plates, brake callipers, joints and fittings) available to enable a full understanding of the principles, function, layout and operation of the systems in each area. References to specific manufacturers and models can often improve the focus for learners. They should be encouraged to carry out their own research on other models to improve their understanding of different types of systems and the engineering approaches that can be taken. This will help them develop and practise their skills of comparison and evaluation and therefore improve their chance of achieving the merit and distinction criteria.

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, eg 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 (eg 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, eg 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 (eg 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 (eg 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 (eg 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 (eg 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 (eg 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, eg the impact of the type of suspension on the steering and handling of the vehicle.

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

This unit can be linked to several other units within the BTEC Nationals in Vehicle Technology, especially *Unit 3: Vehicle Fault Diagnosis and Rectification*, *Unit 12: Light Vehicle Transmission Systems*, *Unit 14: Light Vehicle Suspension, Steering and Braking Systems*, *Unit 15: Heavy Vehicle Braking Systems*, *Unit 16: Heavy Vehicle Transmissions* and *Unit 17: Heavy Vehicle Steering and Suspension Systems*.

The unit contributes towards the knowledge and understanding needed for the Level 3 Automotive Skills National Occupational Standards in Vehicle Maintenance and Repair, particularly units:

- MR12: Remove and Replace Vehicle Transmission Driveline Units and Components
- MR12HV: Remove and Replace Commercial Vehicle Transmission Driveline Units and Components.

It also supports the following units within the SEMTA Level 3 National Occupational Standards in Automotive Engineering:

- Unit 4: Assembling Sub-Assembly Units to Vehicles
- Unit 6: Assembling the Rear Axle Sub-Assembly
- Unit 7: Assembling the Front Suspension Sub-Assembly
- Unit 8: Assembling Braking systems to Vehicles.

Essential resources

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

Indicative reading for learners

Hillier V and Coombes P – *Hillier's Fundamentals of Motor Vehicle Technology* (Nelson Thornes, 2004) ISBN 0748780823

Zammit S – *Motor Vehicle Engineering Science for Technicians Level 2* (Pearson, 1987) ISBN 0582413028

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> working with gear ratios and considering the application of forces on the vehicle due to the type of system being considered presenting the results of their findings in the description of the transmission, steering, suspension and braking systems examined. 	<p>N3.2 Use this information to carry out multi-stage calculations to do with:</p> <ul style="list-style-type: none"> a amounts or sizes b scales or proportion d using formulae. <p>N3.3 Interpret the results of your calculations, present your findings and justify your methods.</p>
Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> researching and preparing their descriptions of transmission, steering, suspension and braking systems from manufacturers' manuals and other sources writing descriptions of vehicle systems. 	<p>C3.2 Read and synthesise information from at least two documents about the same subject. Each document must be a minimum of 1000 words long.</p> <p>C3.3 Write two different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.</p>

Information and communication technology Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> researching information on the layout, operation and components of transmission, steering, suspension and braking systems developing their descriptions of transmission, steering, suspension and braking systems presenting their final descriptions of the systems. 	<p>ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case.</p> <p>ICT3.2 Enter and develop the information and derive new information.</p> <p>ICT3.3 Present combined information such as text with image, text with number, image with number.</p>