

Unit 17: Heavy Vehicle Steering and Suspension Systems

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

This unit will give learners an understanding of the design, constructional details and fundamental operating principles of a range of heavy vehicle steering systems, suspension layouts, wheels and tyres.

The unit will cover vehicle steering and suspension systems, their function, principal components and operating principles. This will include a detailed examination of the steering system including hydraulic power assistance, a variety of suspension layouts currently used on heavy vehicles, including the leaf, rubber and pneumatic suspension systems.

Learners will be introduced to the range of heavy vehicle designs and body types used to meet the diverse and varying operational conditions experienced by goods vehicles and passenger carrying vehicles.

Finally, learners will carry out specific tests and checks to identify steering and suspension system faults such as failure of power assistance or excessive tyre wear. Learners will use these tests and checks, together with the legal information applicable to the class of vehicle, to maintain a vehicle's roadworthiness. This will include the maintenance requirements relating to driver/passenger safety and component reliability, whilst ensuring that learners work in a safe manner.

Learning outcomes

On completion of this unit a learner should:

- 1 Understand the construction and operation of heavy vehicle manual and power-assisted steering systems
- 2 Understand the various types of heavy vehicle body and suspension systems
- 3 Understand the construction, application and legal requirements for heavy vehicle wheels and tyres
- 4 Be able to carry out maintenance procedures on a heavy vehicle's steering and suspension systems.

Unit content

1 Understand the construction and operation of heavy vehicle manual and power-assisted steering systems

Manual steering system principles/construction: single and twin steer axles eg all connective linkage and geometry to obtain true rolling when cornering; rear axle steering systems applied to large heavy vehicles; steering systems on articulated passenger vehicles; application of Ackerman steering principles to large vehicles; effects of imposed loads on the steering compliance when cornering; effects of load on the accuracy of steering settings

Manual steering components: steering boxes eg recirculating ball, hour glass worm and roller; steering linkage on single and twin steering systems eg drag links, track rods, drop arms, ball joints, king pins and bushes; steering wheels and columns eg use of universal joint to facilitate cab tilting, ergonomic and anthropometrical factors of steering wheel position with or without power-assisted steering

Power-assisted steering system principles/construction: single and twin steer vehicles; integral type power-assisted steering boxes; externally fitted power rams and strut type reaction member; methods employed to apportion assistance eg torsion bar and rotary hydraulic valve, shuttle type, principles underpinning the method of obtaining assistance

Power-assisted steering components: hydraulic pump (position and operation); drive arrangements; pump reservoir; pressure control valves eg pressure relief, flow control; pipes, hoses, seals and gaiters; integral and external power servo rams; filtration; prevention of moisture and dirt ingress eg fluid cleanliness, checking fluid filters and reservoir condition, periodic replacement of hydraulic fluid, bleeding of the system

Steering geometry: non-steer eg wheel alignment requirements of single and twin drive axles; steering geometry eg caster, camber, king pin inclination, positive and negative off-set; wheel alignment checks on single and twin steer eg methods used to measure correct alignment between twin steer axles, effects of vehicle loads on the accuracy of the settings

2 Understand the various types of heavy vehicle body and suspension systems

Chassis and cab design: rigid and articulated vehicles; trailer systems eg semi and draw bar trailers; axle layouts eg two, three and four axle vehicles; drive arrangements eg twin drive and all wheel drive; body types eg flat bed tankers, refrigerated, box, municipal waste disposal, bus/coach; ergonomics of cab design eg vibration control, instrument positioning, driver controls and facilities

Leaf spring suspension system: springs eg fixed and variable rate, helper springs; centre bolt, bump stops, shackles eg fixed, swinging, shackle pins and bushes; load compensation mechanisms eg balance beam, interactive linkages; transmission of torque, axle location eg use of torque rods, A-frames, Panhard rods, trunnion bearing assemblies; vibration dampers eg function and location, single and double acting telescopic hydraulic dampers; trailing arm suspension; independent suspension eg double wishbone, anti-roll bars; forces acting on suspension members eg reactive and non-reactive systems

Rubber suspension: layout eg configuration of suspension unit to provide energy absorption (positioning in compression and shear); single and multi-axle; methods employed to enable the transmission of braking and driving torque; hub arrangements eg fully floating showing bearing arrangements, pre-packed bearing cassettes; lubrication eg type of lubricants and properties, means to ensure adequate lubricant at the contact faces; sealing methods eg use of lip seals, O-rings, sealing compounds

Pneumatic suspension system: axle layout eg two, three, four or more axles; components eg levelling valves, mechanically and pneumatically operated, air suspension pneumatic circuit components eg air springs using involute and rolling diaphragm; axle-lifting equipment eg suspension layout to enable dead axle to be lifted from the road surface, overweight protection, adjustment of trim height; electronic levelling control (ELC) eg electronic levelling sensors, control unit, self-diagnosis

3 Understand the construction, application and legal requirements for heavy vehicle wheels and tyres

Construction of heavy vehicle wheels: wheel rims eg two-piece, three-piece, one-piece (well based) rims

Tyre construction: tyre type eg radial ply, cross ply, super single tyres, re-cut tyres; tyre inflation valves eg types, remote sensors, position of the valves when fitted to the vehicle; causes and symptoms of defects eg irregular wear patterns, damage to tread, wall and bead region

Design features: operational factors eg ply ratings, load carrying capacities and load rating index, tubed/tubeless tyres, tread patterns and application, tread depths, aspect ratios, inflation pressures

Legal requirements: eg prescribed mixing of tyre construction on large vehicles, fitness for purpose, general condition as prescribed in the legislative source and the vehicle tester's manual

4 Be able to carry out maintenance procedures on a heavy vehicle's steering and suspension systems

Maintenance of steering and suspension systems: removal and refitting of main components; adjustment of main components eg alignment of axles, checking of suspension geometry; servicing/lubrication of main units eg using manufacturers' inspection sheets, awareness of the effects of harsh working environments on the service intervals; personal safety and protection of units against usual hazards during use or repair eg dangers associated with working on air suspension units, overstressing power steering systems during pressure tests; performance tests for the systems eg undertake a manufacturer's test of air suspension or power steering unit; completing report documentation; interpretation of results eg from given data make an interpretation of the systems condition; identification of symptoms and probable causes eg axle mal-alignment, excessive internal leakage in power steering box, failure to self trim on air suspension, poor handling under load, excessive tyre wear

Repair cycles: preventative and corrective action eg inspection procedures for the different systems (manufacturers' inspection sheets, tester's manual); statutory requirements eg for large goods vehicles (LGV), passenger carrying vehicle (PCV); annual tests eg appreciation of the wear limits imposed on components and systems as stated in the tester's manual, inspection of tyres/wheels and the effects of ply/load index on the plated vehicle weights

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 the principles of operation/construction and components of a manual heavy vehicle steering system	M1 compare and contrast the constructional details of two different heavy vehicle steering systems	D1 diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's steering system, including wheels and tyres, from given symptoms and data
P2 describe the principles of operation/construction and components of a heavy vehicle steering system with power steering	M2 compare and contrast the constructional details of two different heavy vehicle suspension systems	D2 diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's suspension system, including wheels and tyres, from given symptoms and data.
P3 describe and compare the steering geometry and wheel alignments checks for a single and a twin steer system	M3 evaluate and compare two different types of heavy vehicle body construction and layout.	
P4 describe two different types of heavy vehicle chassis and cab designs		
P5 describe the basic principles of operation/construction and components of a heavy vehicle suspension system employing leaf springs		

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:
<p>P6 describe the basic principles of operation/construction and components of a heavy vehicle suspension system employing rubber</p> <p>P7 describe the basic principles of operation/construction and components of a heavy vehicle suspension system employing pneumatics</p> <p>P8 explain the construction, design features and legal requirements of a heavy vehicle wheel and tyre</p> <p>P9 carry out a maintenance procedure on a heavy vehicle's steering system and describe a typical repair cycle for that system</p> <p>P10 carry out a maintenance procedure on a heavy vehicle's suspension system and describe a typical repair cycle for that system.</p>		

Essential guidance for tutors

Delivery

This unit can be delivered in the context of learners' chosen areas (eg heavy goods vehicle or passenger vehicle), although a generic approach is also suitable. The term 'maintenance' in this unit is used in a generic way and can be taken to mean either routine maintenance (a regular service) or less routine work (a repair due to a component failure or adjustment to correct a misalignment).

Delivery of this unit would ideally be a balance of theoretical and practical study. Whatever approach is taken should provide learners with the knowledge and skills needed to perform routine heavy vehicle workshop operations and diagnose steering and suspension system faults in an industrial setting. Health and safety considerations should be emphasised whenever learners undertake practical activities.

The learning outcomes could be delivered in the order they are listed. In this way, learners will gain an understanding of the function and operating principles of the relevant parts of steering systems, the configuration of heavy vehicle chassis and suspension types and layouts.

For the final learning outcome learners will need access to heavy vehicles and workshop facilities. Delivery of this part of the unit could consist of lectures to introduce the steering/suspension system and likely faults, learner-led research into the maintenance requirements followed by practical application on vehicles in the workshop. Learners should be given opportunities to experience a range of routine maintenance operations in line with those suggested in the unit content.

During practical work, the critical health and safety procedures of each operation need to be emphasised. Learners should be encouraged to recognise and explain these safety aspects during their practical workshop activities to reinforce the importance to themselves and to others.

The use of a record of practical work carried out during the delivery phase of the unit should be standard practice. This is likely to be in the form of a workshop logbook. Such a record will enable learners to capture and reflect on their experience and will provide support and guidance during the activities chosen for the final assessment.

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

Assessment

A range of assessment methods can be used for this unit and evidence can be collected from a combination of activities/assignments, investigative projects and practical work.

Centres may use short tests for the summative assessment of learners' knowledge or practical skills. These could comprise of short answer questions or set-piece workshop tasks that enable learners to demonstrate specific aspects of the required practical skills (eg steering alignment). A variety of assessment strategies should be used to give learners with differing learning styles the opportunity to demonstrate their full ability and to add diversity to the subject.

Learners should be encouraged to research and use a range of resource materials during their investigations. However, tutors should provide guidance on how material can be referenced without infringing guidelines on authentic evidence, eg annotation of images, diagrams used to support/clarify their own text.

To achieve a pass, learners will need to identify and describe the operation and components of a manual heavy vehicle steering system (P1) and a power-assisted heavy vehicle steering system (P2).

For P3, learners will need to describe the principles of steering geometry and wheel alignment on single and twin steering heavy vehicles.

Two different and contrasting vehicle chassis and cab designs should be used for P4, for example the draw bar and articulated vehicle combinations.

Learners will need to understand the operating principles and construction of suspension systems using leaf springs (P5), rubber (P6) and pneumatics (P7). Evidence for these criteria will also need to include descriptions of the relevant components.

For P8, learners should explain the construction, design features and legal requirements of wheels and tyres used on heavy vehicles.

For P9 and P10, learners need to carry out practical maintenance activities preferably on live heavy vehicle systems. For P9 they will need to carry out a maintenance procedure on a heavy vehicle steering system and describe a typical repair cycle (eg checking fluid levels and operational pressures in hydraulic power-assisted system). Similarly for P10 they need to carry out a maintenance procedure on a heavy vehicle suspension system and describe a typical repair cycle for that system (eg checking for excess wear in pins and bushes and rectifying accordingly).

A suitable steering and suspension system fault for may need to be simulated for P9 and P10 and learners provided with the typical symptoms of the fault, as would be reported by a driver of the faulty vehicle. Assessment of these criteria is likely to be in three parts – a written inspection record completed by learners at the time of the inspection, a verbal report back to the supervisor/customer (tutor record of oral questioning/observation) and tutor observation of the process (eg use of logical and efficient diagnostic techniques, safe working).

Criteria P1 and P2 can be assessed together and linked through an additional task to M1, which would require learners to compare and contrast two different steering systems used on heavy vehicles. This can also be linked to some extent with P3 with respect to turning circles and steering geometry.

P4, dealing with heavy vehicle chassis layouts and cab designs, may be best covered as a piece of personal research, such as a project or presentation given to a group of peers. This would also offer opportunities for learners to achieve M3.

Criteria P5, P6 and P7 all relate to suspension types used on heavy vehicles and are best assessed together and can be linked to M2.

To achieve a distinction, learners need to diagnose and analyse the cause and effect of defects, wear and maladjustment in a heavy vehicle's steering system, including wheels and tyres, from given symptoms and data (D1). They will also need to analyse the cause and effects of the same for defects, wear and maladjustment in a heavy vehicle's suspension system (D2). Evidence for these criteria will draw on knowledge gained through the pass and merit criteria.

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

This unit supports aspects of the Level 3 Automotive Skills National Occupational Standards in Vehicle Maintenance and Repair, particularly:

- Unit MR01: Carry Out Routine Vehicle Maintenance
- Unit MR06: Inspect Vehicles
- Unit MR04 HV: Remove and Replace Commercial Vehicle Chassis Unit and Components
- Unit MR08 HV: Diagnose and Rectify Commercial Vehicle Chassis System Faults.

It can also provide some of the knowledge and understanding associated with the Level 3 SEMTA National Occupational Standards in Automotive Engineering:

- Unit 4: Assembling Sub-Assembly units to Vehicles
- Unit 7: Assembling the front Suspension Sub-Assembly
- Unit 52: Fitting Pipe work Systems to Commercial and Passenger Carrying Vehicles.

The unit can be linked with *Unit 3: Vehicle Fault Diagnosis and Rectification* and *Unit 15: Heavy Vehicle Braking Systems*.

Essential resources

Learners will need access to a range of steering and suspension components for this unit. A variety of information and data sources specific to the steering and suspension systems covered will also be required. The necessary special tools and equipment will be needed for investigations and routine maintenance operations on the selected vehicles as defined in the unit content and grading criteria.

Indicative reading

Heisler H – *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002)
ISBN 0750651318

Nunney M J – *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 1998)
ISBN 0750638273

The Stationery Office – *Road Vehicles (Construction and Use) Regulations*
ISBN 0110670787

The Stationery Office – *The Public Service Vehicles (Condition of Fitness, Equipment, Use and Certification) Regulations* ISBN 011016257

Vehicle and Operator Services Association (VOSA) – *Vehicle Testing Manuals and Guides:*

- *HGV Inspection Manual*
- *Passenger Carrying Vehicle Inspection Manual*

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.

Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> describing the principles of operation and components of heavy vehicle steering systems describing and comparing steering geometry and wheel alignments describing different types of heavy vehicle cab and chassis design describing the principles of operation and components of heavy vehicle suspension systems explaining the construction, design features and legal requirements of heavy vehicle wheels and tyres. 	<p>C3.1a Contribute to a group discussion about a complex subject.</p> <p>C3.1b Make a formal presentation of at least eight minutes using an image or other support material.</p> <p>C3.2 Read and synthesise information from two extended documents about a complex 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>
Improving own learning and performance Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> diagnosing defects, wear and maladjustment in heavy vehicle steering and suspension systems. 	<p>LP3.1 Set targets using information from appropriate people and plan how these will be met.</p> <p>LP3.2 Take responsibility for your learning, using your plan to help meet targets and improve your performance.</p> <p>LP3.3 Review progress and establish evidence of your achievements.</p>

Problem solving Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none">diagnosing defects, wear and maladjustment, in heavy vehicle steering and suspension systems.	<p>PS3.1 Explore a complex problem and identify different ways of tackling it.</p> <p>PS3.2 Plan and implement at least one way for solving and review your approach to problem solving.</p>