Unit 34: Vehicle Electrical and Electronic Systems

NQF Level 3: **BTEC National**

Guided learning hours: **60**

Unit abstract

Modern motor vehicles are increasingly reliant on the use of complex electrical and electronic systems, and leading vehicle manufacturers typically direct a huge amount of resources into their development. This has resulted in a growing demand for motor vehicle technicians with the knowledge and skills needed to maintain such systems.

This unit aims to give learners an understanding of the electrical and electronic systems used in vehicle lighting, auxiliary systems and instrumentation systems. It will also provide them with the theoretical knowledge of these systems and the practical skills needed to check for their correct operation and if necessary remove and replace the systems.

Learning outcomes

On completion of this unit a learner should:

1. Understand vehicle lighting circuits and the operation of lighting circuit components
2. Understand the operation of vehicle wiper and auxiliary electrical systems
3. Understand analogue and digital vehicle instrumentation systems
4. Be able to isolate, remove and replace vehicle electrical systems

Unit content

1 Understand vehicle lighting circuits and the operation of lighting circuit components

Vehicle lighting wiring diagrams: lighting circuits eg side and rear lamps, main and dipped beam headlamps, front and rear fog lamp, stop, reverse, indicator and hazard warning lamps; lighting circuit symbols

Lighting circuit components: construction and design features of lighting components (lamps, eg filament, tungsten, halogen, gas discharge; beam forming; switching eg dipped and main beam, headlamp flasher, emergency warning, parking; lighting circuit relays; circuit protection devices); tests for serviceability against relevant road worthiness standards for lighting eg Ministry of Transport (MOT) test, Economic Commission for Europe (ECE) standards, other national road worthiness regulations

2 Understand the operation of vehicle wiper and auxiliary electrical systems

Wiper systems: wiper motor design and operation eg permanent field magnet, motor torque characteristic, gearing, wiper parking, two speed and intermittent operation, automatic wipe systems; wiper drives and linkages; tests for serviceability against relevant road worthiness standards eg MOT test, ECE standards, other national road worthiness regulations

Auxiliary electrical systems: eg horn, window winding, central locking, interior heater, rear-screen heater, vehicle security systems, air-conditioning operation and control circuit

3 Understand analogue and digital vehicle instrumentation systems

Vehicle instrumentation systems: traditional analogue vehicle gauges, sensors and signals eg bi-metal and air-cored gauges for uses such as fuel and temperature gauges; modern digital instrumentation systems eg liquid crystal displays (LCDs), stepping motor and digital devices used in speedometer, odometer, tachometer applications; instrumentation circuits and operation

Vehicle condition monitoring devices: function, operation and circuit layout of monitoring devices eg brake pad wear indicator, oil level indicator, fluid level indicators, air ambient temperature

4 Be able to isolate, remove and replace vehicle electrical systems

Removal and replacement procedures: use of test equipment and tooling eg multimeters, oscilloscopes, on-board diagnostics, hand-tools, soldering and mechanical jointing; relevant health and safety eg regulations, vehicle protection, personal protection, protection of others; replacement component identification and ordering eg vehicle manufacturer's manuals, component manufacturer's parts lists (paper-based and computer-based systems)

Vehicle electrical systems: lighting, wiper, auxiliary electrical systems, analogue/ digital instrumentation systems; use of relevant circuit information eg from manuals, circuit diagrams, manufacturers' information

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 describe 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 use vehicle lighting wiring diagrams to trace two different lighting circuits on two different vehicles and identify and describe the components in each circuit P2 explain the constructional features, switching arrangements and testing requirements for three different types of lighting circuit components P3 describe the function, layout and testing requirements of the components in typical front and rear wiper systems P4 describe the function and layout of the components in two different types of auxiliary electrical systems P5 explain the function, operation and circuit layout of a traditional vehicle instrumentation system P6 explain the function, operation and circuit layout of a modern vehicle instrumentation system P7 explain the function, operation and circuit layout of a vehicle condition monitoring device	M1 compare the advantages and disadvantages of two different types of lighting circuit component M2 compare the operation of two different wiper systems and two different auxiliary systems M3 justify the requirements and types of gauges and vehicle condition monitoring devices that could be used to match a given vehicle's performance requirements.	D1 evaluate and compare an analogue instrumentation system with an equivalent digital system D2 specify and justify a suitable test, removal and replacement procedure for a vehicle electrical system.

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**:
P8 remove and replace three different vehicle electrical systems following given procedures.		

Essential guidance for tutors

Delivery

This unit builds upon and is supported by *Unit 6: Vehicle Electrical and Electronic Principles*. There are also links with *Unit 13: Vehicle Electronic Ancillary and Information Systems*, which could be taught in parallel with this unit.

This unit aims to provide learners with a deeper understanding of vehicle electrical and electronic systems than might be gained solely through *Unit 6: Vehicle Electrical and Electronic Principles*. Delivery should include a significant amount of practical work, such as the use of different manufacturer wiring diagrams, checks to establish the correct operation of circuits and components and adherence to relevant roadworthiness standards. Practical work should also include opportunities for the isolation, removal and replacement of vehicle electrical systems, with a view to personal safety, the safety of those using the vehicle and possible damage to other vehicle systems.

It is suggested that delivery of this unit begins with learning outcome 4 (isolate, remove and replace vehicle electrical systems), as this will be required on all subsequent practical work.

The subsequent delivery of other topics may be taken in any order. Tutors should consider however, whether learning outcome 3 (understand analogue and digital vehicle instrumentation) should be left until later in their scheme of work. This particular area of work has a high level of technical content, which would probably be easier for learners after they have gained confidence in the other areas.

Delivery of this unit could include a variety of methods such as formal classroom teaching, tutor-led demonstrations, practical work, student-centred study and visits to manufacturers. However classroom sessions should always be supported by extensive practical demonstration and workshop investigation. The workshop investigations should be aimed at building learners' confidence and competence in understanding the relevant component function(s) and correctly determining correct circuit operation. Whenever possible, investigations and practical work should be conducted on real vehicles and their respective systems and components. However, it is also acceptable to make use of stripped out vehicle electrical systems and wiring harnesses when this is most practicable. Some of the work required for this unit will require the use of specialised vehicle electrical and electronic laboratory facilities and this must be a consideration for centres when preparing the necessary resources to deliver this unit.

Assessment

Assessment of this unit could be based upon a combination of classroom-based assignments and workshop-based practical activities. Tutors may assess the more theoretical aspects of the unit through time-constrained, supervised assessment activities when authenticity maybe an issue, but otherwise the use of more open, learner-focussed assignments is recommended.

Practical activities could be assessed through a combination of tutor observation, oral questioning and/or the production of clear written records of the practical task/tests carried out.

An assessment strategy could be to use learning outcome 4 as the focus for three assessment instruments that between them cover the main topic areas associated with the first three learning outcomes.

For example, the first assessment instrument could be designed to integrate P1, P2 and M1 within an activity that requires learners to isolate, remove and replace a

vehicle's lighting components. This would partially cover the practical requirements of learning outcome 4 and would therefore also meet P8 in part (for lighting systems). The second assessment instrument could then cover P3, P4 and M2 during further practical work, again associated with meeting P8 in part (for wiper and auxiliary systems). The third assessment instrument would then cover P5, P6, P7, M3, D1 and the final piece of practical work needed to meet P8 (for analogue/digital instrumentation systems). Assessment of D2 could then be built into any one of these instruments or could be covered in a stand-alone activity. It is important to appreciate that by using the strategy described above, learning outcome 4 will not be met in full until all three pieces of work have been successfully completed.

The following section identifies the key aspects for each criterion that must be kept in mind during the design of either the assessment instruments described above or any alternative strategy.

To achieve P1 learners will need to make use of vehicle lighting wiring diagrams to trace two different lighting circuits on two different vehicles so that they can identify and describe the components in each circuit. One of these could be a desk-based study of a wiring diagram and the other could be part of a practical task associated with P8.

There is a strong link between P1 and P2. Having described the components for P1, learners could then explain the constructional features, switching arrangements and testing requirements of three different types of lighting circuit component found in one of the wiring diagrams to meet the requirements of P2. It is important to ensure that the learners' explanation covers the construction and design features of three of the different areas described in the content (lamps, beam forming, switching, relays or circuit protection devices). In addition, learners will need to consider for each of the three chosen components, the required tests for serviceability against the relevant roadworthiness standards for lighting.

The work carried out to meet P1 and P2 can then be linked to M1. For example, students could compare the benefits of relatively new technologies, such as LED and gas discharge lamps with traditional lighting circuit components. Although this could be tackled as a stand-alone assignment, it would be more efficient for learners to compare an alternative to one of the lighting circuit components already considered during the practical removal and replacement activity for P8.

To achieve P3, learners will need to describe the design and operation of a front and a rear wiper system. This should include a description of how the systems are tested for serviceability against relevant roadworthiness standards. P4 requires learners to describe the function and layout of two different types of auxiliary electrical systems chosen from those listed in the unit content (ie vehicle's horn, window winding, central locking, interior heater, rear-screen heater, vehicle security systems, air-conditioning operation and control circuit systems).

The work undertaken for P3 and P4 can then be related to M2, which requires learners to compare the operation of two different wiper systems and two different auxiliary systems. This can be linked to the practical work carried out for P8 by comparing an alternative system to that being removed and replaced.

P5 and P6, which require an explanation of the function, operation and circuit layout of traditional and modern vehicle instrumentation systems are probably best completed together. Again, one of these systems could be the vehicle instrumentation system used for removal and replacement in P8, which could be either traditional or digital. It then leaves the learner to choose or be allocated a second system to meet the remaining requirement of P5/P6.

The merit criterion M3 is closely related to the work undertaken for P5 and P6. An option here might be to select (as the focus for meeting M3) a vehicle with quite different performance requirements to the vehicle used for the removal and replacement activity associated with the criteria P5/P6 and P8. This would effectively link and provide relevance within the assessment instrument. It is

expected that the learner may well consider and Justify the way in which information is presented to the driver/vehicle technician and the types of gauges and sensors that would be applicable to chosen vehicle's performance monitoring requirements.

There is a further link from P5, P6 and M3 through to D1. To achieve this the learner will need to evaluate and compare an analogue instrumentation system with that of an equivalent digital instrumentation system. Reference could be made to what they feel is important in each system and might include such factors as visibility, vehicle interior style, ease of interpretation, accuracy, driver's need to know, cost and possible maintenance and repair requirements/costs. The system chosen for the removal and replacement task of P8 could be one of the systems evaluated (either analogue or digital) and then compared with another opposite system.

It is intended that the vehicle electrical system for which the learner specifies and justifies the test, removal and replacement procedure for in D2 should be different to that for P8. It is anticipated that tutors will provide a relatively complex practical task for this to show a high level of synthesis and assimilation of knowledge and understanding that is expected at distinction level. The learner is not required to carry out the test or to remove and replace the system but simply produce a realistic procedure for say a wiper motor, a window winder motor, headlight unit with self-levelling or an immobiliser system, that could be followed by a competent motor vehicle technician.

The criterion P8 could be covered in full by the strategies described above. However, the design of any instruments used to assess P8 needs to ensure that the all the requirements of this criterion are met. That is, the learner can use relevant test equipment and tooling, all work complies with relevant health and safety requirements and the learner is able to identify and order replacement components. This needs to be achieved for three of the four areas listed in the content - lighting, wiper, auxiliary electrical systems, analogue or digital instrumentation systems.

Much of the work towards P8 will be assessed using tutor observation and oral questioning. However, the learner could also present additional photographic evidence, sketches and notes plus records of test procedures and associated data. To track the learner's work towards the achievement of this criterion (since it stretches across all the work of the other three learning outcomes), it may be helpful to adopt a logbook-style of approach. The learner would then be able to record the dates, nature of task and associated evidence in the logbook as it occurs. It would also enable assessors to sign-off against each task as it is achieved.

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

The unit builds upon the BTEC NQF Level 3, Unit 6: Vehicle Electrical and Electronic Principles and complements the work of Unit 13: Vehicle Electronic Ancillary and Information Systems.

This unit also supports the following units in the Level 3 Automotive Skills National Occupational Standards for Vehicle Maintenance and Repair:

- Unit MR 15: Enhance vehicle system features.
- Unit AE 06: Electrical

Essential resources

To deliver this unit it is essential that the centre has access to a range of electrical components for classroom demonstration, an auto-electronics laboratory and workshop with a range of equipment to meet the requirements detailed in the content section of the unit plus wiring diagrams and component specifications from a range of manufacturer sources. Access to 'live' vehicles will also be necessary to allow the learner to remove and replace onboard systems; simulation of removal and replacement on training rigs would not be sufficient for assessment purposes.

Indicative reading for learners

Hillier V A W – Fundamentals of Automotive Electronics, Nelson Thornes Ltd, ISBN 97807 48784356

Hillier V A W – Fundamentals of Motor Vehicle Technology, Nelson Thornes Ltd, ISBN 97807 48780822

Tranter A – Automobile Electrical & Electronic Systems Manual, Haynes Manuals Inc, ISBN 978 1859600498

Denton T – Automotive and Electrical and Electronic Systems, Butterworth Heinmann, ISBN 0-7506-6219-0

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. Staff 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**:
• extracting information from vehicle and equipment manufacturer's data (eg paper-based manuals, parts lists, etc.). • preparing service records to indicate removal and refitting procedures carried out.	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. 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.

Information communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence**:
• extracting information from vehicle and equipment manufacturer's data (eg computer-based information). • preparing a report that may include photographic evidence of removal and refitting procedures, sketches/ diagrams plus test data.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.

Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence**:
• planning for the removal and replacement of electrical/ electronic vehicle systems	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.