Unit 35: Applications of New Technologies in Vehicle Design and Operation

NQF Level 3: **BTEC National**

Guided learning hours: **60**

Unit abstract

Advancing technology has always played a major part in the development of the motor vehicle. In the past, size, weight, power and cost were the major points of focus for design and development. However this focus has recently changed, with environmental concerns having a major impact on vehicle design, along with a major evolution in electrical and electronic technology.

This unit provides an excellent opportunity for learners to reflect on current technological developments and environmental demands. It assumes a relatively good working knowledge of standard modern vehicle technology and will enable learners to look forward to where this technology may lead and whether environmental constraints will limit such progress. For this reason the unit is best placed towards the end of a programme of study, when learners have gained the relevant underpinning knowledge.

Learners will at first consider how current vehicle technologies and design limit the ability to achieve environmentally friendly design solutions. They will then examine alternative technologies, efficient vehicle control using computer-based solutions and the impact of new technologies on the fundamentals of powertrain and chassis development.

Learning outcomes

On completion of this unit a learner should:

1 Know how current vehicle technologies and design limit the ability to achieve environmentally friendly design solutions

2 Understand the benefits and limitations of alternative motive technologies

3 Understand the principles of whole vehicle control based on computer-based vehicle architecture

4 Understand the operating principles and benefits of powertrain and chassis developments

Unit content

1 **Know how current vehicle technologies and design limit the ability to achieve environmentally friendly design solutions**

Limiting factors: consumer demands eg higher fuel efficiency, cleaner emissions; technical eg factors limiting the theoretical maximum thermodynamic efficiency (Carnot efficiency) of an internal combustion engine; legislative and government led influences eg the tightening of European Union (EU) exhaust emission limits, challenge for vehicle manufacturers to meet limits set for new vehicles produced or imported into the EU

Environmentally friendly: emissions; whole life costs eg carbon cost for manufacture, operation and disposal of vehicles; road transport systems eg traffic control and vehicle communication; cost modelling eg key factors in vehicle carbon budget, vehicle dealership considerations

2 **Understand the benefits and limitations of alternative motive technologies**

Conventional internal combustion engines (ICE): spark ignition (SI) and combustion ignition (CI); engine cycles eg Carnot and constant volume/Otto cycle; energy balance and efficiency; drive train losses eg calculation of typical SI and CI efficiency compared with that from a gas turbine engine

Alternative motive technologies: alternative environmentally friendly ICE fuels/power eg methanol, ethanol and biodiesel, electric vehicles (including battery and fuel cell technology); hybrid electric vehicle (HEV)

3 **Understand the principles of whole vehicle control based on computer-based vehicle architecture**

Computer-based vehicle control systems: controller area networks (CAN-Bus) and other multiplexed wiring systems eg local interconnect network (LIN-Bus), higher data rate/higher reliability systems; integrated approach to total control eg transmission, power and emissions; communications eg wireless technology, proprietary software, automotive and fleet management systems; on board diagnostic techniques

4 **Understand the operating principles and benefits of powertrain and chassis developments**

Powertrain control systems: electronic control of powertrain; transmission sensors and systems eg torque, position and pressure sensors; electronic clutch control; electronic manual and automatic gearbox design; electronic differential

Electronic adaptive chassis control systems: vehicle safety systems eg crash avoidance, electronic stability control (Electronic Stability Program (ESP)); active suspension systems eg based on electromechanical valves, magneto-rheological (MR) fluid-based mono-tube struts

Drive-by-wire systems: eg gas by wire, steer by wire, brake-by-wire

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 describe two factors that limit environmentally friendly vehicle design and operation P2 identify and describe the limitations of a conventional internal combustion engine and its drive components P3 describe the benefits and limitations of two different alternative motive technologies P4 describe the principles of operation of two different computer-based vehicle control systems P5 explain the operating principles of an electronic powertrain control system P6 explain the operating principles of vehicle electronic adaptive steering, suspension and braking control systems P7 explain the operating principles of a vehicle drive-by-wire system.	M1 evaluate and compare the environmental benefits of two different types of vehicle M2 prepare a comparison of the relative whole life running costs for operating a conventional and an alternative technology powered road vehicle M3 explain how an integrated approach to vehicle control can be used to improve vehicle performance in terms of economy and available torque/power.	D1 explain how the application of new vehicle technologies might influence the operation of vehicle servicing and dealership networks D2 evaluate the likely evolution of current road vehicle design from present day to 15 years in the future.

Essential guidance for tutors

Delivery

Delivery of this unit needs to give learners an understanding of new vehicle technologies, how these technologies can be used in vehicle design and the benefit to vehicle operation.

Since much of the unit is aimed at understanding the fundamentals of new vehicle technologies, a large proportion of the work will be classroom based. However it is strongly recommended that this work is reinforced with other activities whenever possible. These might include workshop demonstrations, organised visits to vehicle development facilities, visits to commercial workshops that maintain hybrid vehicles and industry speakers. There may also be opportunities to visit museums such as the Science Museum, where past exhibitions have included discussion of alternative fuels, and electric and hybrid vehicles exhibits.

The unit would be best delivered towards the end of the qualification, as learners will need to have an understanding of mechanical engine, transmission and chassis systems, as well vehicle control systems.

It is likely that the unit will be delivered in the order of the learning outcomes. In doing so, learners will first consider the limitations of current technology before going on to examine possible alternatives. It is intended that the unit can be kept up to date with developments in materials, electrical/electronic and computer-based technologies used in vehicle technology. Centres delivering the unit should therefore regularly review and amend the content of their delivery plan on to ensure the unit remains relevant to the technologies of today and the future.

Assessment

Assessment of this unit could be through a project/case study approach, although a series of four assignments could be used, based on each of the learning outcomes. The merit and distinction criteria all relate back to the pass criteria and as such opportunities to work at these higher levels should be built into each assignment.

The following assessment guidance is based upon a project/case study approach. For example, each learner could select a modern vehicle (either a current production model that uses alternative motive technologies or a manufacturer's concept model) for which they research and produce a portfolio record/case study of their own findings. Each step of their research must be led by the criteria. As such, they may need to step outside the parameter of their chosen vehicle at times and introduce other illustrative vehicles or components that will allow them to meet the demands of each criterion. The context of their chosen vehicle however should provide them with the common thread throughout the project/case-study. This learner-centred approach to assessment will require careful management by the unit tutor(s). If the unit is delivered towards the end of a learning programme then this should ensure that the learner also has the maturity to self-manage such a learner-centred approach.

The following assessment guidance looks at each criterion in turn and considers how they could be dealt with using the project/case study approach.

The first two criteria (P1 and P2) will enable learners to put their project/case study into context. P1 requires learners to describe two factors that limit environmentally friendly vehicle design and operation, which could be achieved within the context of their chosen vehicle. For example, what technological limits have prevented it from having lower emissions or better fuel efficiency? Also, how does current legislation limit the design and operation of the vehicle?

For P2, learners need to identify and describe the limitations of a conventional internal combustion engine and its drive components. This could be achieved

within the context of their chosen vehicle if it makes use of ICE technology, otherwise they may need to introduce another vehicle into the project/case study. Either way, the learner needs to show that they know how to identify and describe the limitations that vehicle emissions, whole life costs, and road transport systems currently impose upon development. Cost modelling techniques may be a useful way of putting this into a real world context.

To achieve P3, the learner is required to describe the benefits and limitations of two different alternative motive technologies. This could be based on the learner's chosen vehicle and another vehicle. Having described the benefits at P3 there is then a direct link here to the merit criterion M1, for which the learner needs to evaluate and compare the environmental benefits of two different types of vehicles. The learner should then be able to consider M2 by preparing a comparison of the relative whole life running costs for operating a conventional and an alternative technology powered road vehicle. It is unlikely that definite costs can be obtained directly but ranking of indicative whole life costs would be quite acceptable.

The remaining pass criteria (P4, P5, P6 and P7) have a common thread of electronic control. It should be possible to cover most of these remaining criteria within the context of the vehicle chosen by the learner. However, certain aspects of electronic control may not be used on the chosen vehicle and in such cases, an alternative vehicle could be introduced into the project/case study again. There is a direct link from these pass criteria to D1, which requires learners to reflect on how the use of new vehicle technologies will affect vehicle servicing and dealership networks in the future. Learners could approach this within the context of their chosen vehicle by considering the changes that have had to take place to accommodate it within a conventional vehicle workshop. They could then look forward to possible future developments and identify those that may have the biggest impact. Examples, other than the obvious need for new service spares, may include the need for specialist training and equipment, the use of telematic vehicle data for fleet operators or even the storage requirements of hydrogen fuel for fuel cell technology. It is expected that students will perform their own research and provide justified conclusions with suitable references.

At this point in the project/case-study, learners could begin to summarise their findings by using the remaining merit (M3) and distinction (D2) criteria as their guide. By working towards M3 learners should be able to explain how increasing integrated control can improve vehicle performance in terms of economy and available torque/power. One possible approach would be to compare performance data from the chosen vehicle with a range of vehicles that have a similar engine capacity and weight, but with different control strategies (eg those with carburettor, those with engine managed systems and those with integrated transmission control).

Finally, D2 will enable learners to focus on their own researched view of vehicle developments over the next 15 years. A convenient way of doing this may be through the use of a pictorial and annotated 'timeline' supported by an explanation of the dates chosen and developments. Some thought will need to be given to the factors which may drive developments forward, such as environmental legislation, fuel costs, competitive edge, manufacturers lead times and consumer demand, ie the market demands and environmental necessity.

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

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

- Unit MR 07: Diagnose and Rectify Vehicle Engine and Component Faults
- Unit AE 04: Diagnose and Rectify Engine Electrical Faults.

The unit can also be effectively linked with other BTEC National units such as *Unit 1: Operation of Vehicle Systems*, *Unit 2: Vehicle Engine Principles, Operation, Service and Repair* and *Unit 6: Vehicle Electrical and Electronic Principles*.

Essential resources

Tutors should be familiar with modern vehicle technologies before attempting to teach this unit. This will require adequate time for continuous background reading and research within a rapidly changing topic.

Equipment that will enable demonstrations to aid understanding of new vehicle technologies (eg controller networks, drive-by-wire systems) should be provided whenever possible and tutors should look beyond their own workshops in support of this (eg the centre's own science, computing and electronic laboratories).

Ready access to the internet will be essential for research purposes.

Indicative reading for learners

Hillier, V / Combs P, and Rogers, D — *Hillier's Fundamentals of Motor Vehicle Technology – Powertrain Electronics* (Nelson Thornes, 2006) ISBN 0748780998

Denton T — *Automobile and Electronic Systems* (Butterworth Heinemann, 2004) ISBN 0750662190

Larminie, J and Lowry, J — *Electric Vehicle Technology Explained* (Wiley and Sons, 2003) ISBN 0470851635

Nunney, J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 0750680377

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 skills 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.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence**:
• planning and presenting the comparative cost of current, modern and future vehicle technologies. • carrying out calculations on relative costs, interpreting and presenting the results.	N3.1 Plan an activity and get relevant information from relevant sources. N3.2 Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion c handling statistics d using formulae. N3.3 Interpret the results of your calculations, present your findings and justify your methods.
Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence**:
• researching information on the range of technologies applied in modern vehicles and alternatives. • preparing reports on environmentally friendly design solutions, benefits and limitations of alternative technologies, computer-based control techniques and powertrain/chassis developments.	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 and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence**:
• researching and using a variety of different sources for information on current, modern and future vehicle technologies. • developing and presenting information on vehicle technologies including text, relevant images and technical 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.