# Unit 20: Applications of Science in Land-based Engineering

**Unit code:** T/601/4250

**QCF Level 3:** BTEC National

**Credit value:** 5

**Guided learning hours:** 30

## Aim and purpose

This unit aims to introduce learners to the skills and knowledge in applications of science and how these can be applied in practice. It is designed for learners in centre-based settings looking to progress into the sector or onto further/higher education.

## Unit introduction

In this unit learners will explore the science behind the design of vehicle systems such as the engine and clutch. This unit seeks to give learners the skills required to design these systems taking into account all practicable requirements.

## Learning outcomes

**On completion of this unit a learner should:**

1 Be able to apply scientific principles related to heat, force and machines to solve vehicle-related tasks

2 Be able to carry out engine testing and apply scientific principles related to vehicle and engine performance.

# Unit content

## 1 Be able to apply scientific principles related to heat, force and machines to solve vehicle-related tasks

*Force*: laws of friction; friction in a clutch; stress and strain; Young's modulus; forces in tension/compression; vehicle component subjected to tension/compression eg tie rod, cylinder head bolt, push rod, valve stem, piston, connecting rod, braking components

*Heat*: gas laws eg Boyle's law, Charles' law, general gas equation $pV/T = C$, ideal gas equation $pV = mRT$; change of dimension eg linear, superficial, cubical, heat dissipation; pressure eg fluid, gas, air; gauge pressure, atmospheric pressure

*Machines*: ratios eg steering box, gear ratio, final drive ratio, compression ratio; vehicle mechanism eg alternator and power steering, pulleys, winches, levers eg handbrake lever, brake operation, cylinder, gearbox

## 2 Be able to carry out engine testing and apply scientific principles related to vehicle and engine performance

*Vehicle performance*: equations of motion; Newton's laws; performance eg work, power, velocity, acceleration, retardation

*Engine testing*: safe use of equipment eg rolling road, dynamometer rig, engine analyser; collection of data eg torque, power (indicated and brake), fuel consumption

*Engine performance*: performance to report on eg torque, power (indicated and brake), mechanical efficiency, thermal efficiency, volumetric efficiency, specific fuel consumption, brake mean effective pressure, indicated mean effective pressure; presentation within report eg engine indicator diagrams, calculations using data (such as efficiency, frictional loss, temperature variations)

# Assessment and grading criteria

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

| Assessment and 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 the laws of friction to find the friction in a clutch and determine Young's modulus for a given tension/ compression on a given vehicle component [IE] | **M1** design a clutch of appropriate size and specification for a given land based vehicle or implement and using worked examples, justify their choice | **D1** compare and analyse actual data and calculated data for engine or vehicle performance. |
| **P2** use a gas law to determine the change in dimensions of the gas [SM] | | |
| **P3** describe how ratios help a given vehicle mechanism function properly [IE, CT] | **M2** explain, with examples, the importance of the accuracy of data that is used to solve a range of problems related to engine and vehicle performance. | |
| **P4** calculate vehicle performance using Newton's laws and the equations of motion [RL] | | |
| **P5** carry out engine testing to obtain data and report on engine performance. [EP, TW] | | |

**PLTS**: This summary references where applicable in the pass criteria, in the square brackets, the elements of the personal, learning and thinking skills. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

| Key | | | |
|---|---|---|---|
| | IE – independent enquirers | RL – reflective learners | SM – self-managers |
| | CT – creative thinkers | TW – team workers | EP – effective participators |

# Essential guidance for tutors

## Delivery

Delivery of this unit will involve practicals, written examinations, written assessments, visits to suitable collections and will link to industrial experience placements.

Before starting the unit, learners should be able to demonstrate proficiency in basic mathematical concepts and in the use of an electronic scientific calculator to carry out a variety of functions.

It is essential that the unit content is delivered in a vehicle context. Ideally, this will be achieved through integration with other units which will also help reduce the assessment burden on learners.

## Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan gives **an indication of the volume of learning it would take the average learner** to achieve the learning outcomes. It is **indicative and is one way of achieving the credit value.**

Learning time should address all learning (including assessment) relevant to the learning outcomes, regardless of where, when and how the learning has taken place.

| Topic and suggested assignments/activities and/assessment |
|---|
| Introduction to the unit and discussion of the effects of friction on vehicle performance. Introduce the formula for torque capacity of clutches. |
| **Assignment 1: Transmission of Power** (P1, M1)<br>Introduction to the assignment and learner-centred research. |
| Introduce the formula for stress strain and Young's modulus using worked examples. |
| Introduce the formula for ratios, simple gear rations, compound gear ratios, mechanical advantage ratios. |
| Engine compression ratios: discussion on efficiency and stoichiometric ratio. |
| Kinematic equations: introduction and use of the four kinematic equations relating to vehicle performance. |
| **Assignment 2: Vehicle Science Open Book Exam** (P2, P3, P4)<br>Open book exam set in a classroom environment using learner's own notes as reference. |
| Vehicle performance: discuss aspects of vehicle performance. |
| **Assignment 3: Vehicle Engine Performance Testing** (P5 M2 D1)<br>Carry out tests and report on results. |
| Unit review. |

## Assessment

Evidence for P1 would naturally link to clutch or brake linings and the use of components for applying loads, such as handbrake cables, to determine Young's modulus. Learners will need to show proficiency in the use of the torque capacity of clutches equation $T = F*Rg*n*\mu$

Assessment of P2 could be integrated with that of other units. The task used should focus on vocational gas applications, such as within engine technology, suspension or brake systems. Learners must use one of the gas laws outlined in the unit content and include data on pressure.

Using a system application such as the handbrake, complete with its lever mechanism, would enable learners to generate evidence for P3. There needs to be clear direction to ensure that responses include a description of how mechanical ratios help the system function.

For P4, learners need to produce evidence of calculating vehicle performance using Newton's laws and the equations of motion.

For P5, learners need to complete engine testing to obtain a range of performance data, as set out in the unit content. Assessment of P5 could be linked to that for M2 and D1.

For M1, learners need to apply the use of the torque capacity of clutches equation to design a clutch of suitable dimensions for a given application and torque requirement. The application should be chosen in discussion with learners. The application chosen should ensure that manipulation of the equation is necessary. For M2, learners need to fully explain any data inaccuracies in their work and show how they rectified the error. They will need to explain the importance of accurate records.

For D1, learners will use ICT to analyse actual data and produce torque and power curves for a given land-based vehicle. They will report on any discrepancies between published information and actual data.

### Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, M1 | Power Transmission | Clutches are used in many applications in the land-based sector. The amount of torque they are able to transmit is often limited by size constraints. Investigate the limiting factors for torque transmission and then design a clutch based around specific requirements. | Assignment/report. |
| P2, P3, P4 | Vehicle Science | There are many aspects to vehicle science. Use your knowledge of vehicle science to answer vehicle- related questions. | Open Book Exam. |
| P5, M2, D1 | Engine Performance | Manufactures publish engine performance figures as a marketing tool. Investigate these figures and conduct your own tests to see if they are correct. Any inaccuracies need to be discussed. | Report.<br>Presentation.<br>Assignment. |

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

This unit forms part of the BTEC land-based sector suite. This unit links with many other units in this specification and has particular links with:

| Level 2 | Level 3 |
|---|---|
| Land Based Engineering Operations – Applying Mechanical principles | Mathematics for Engineering Technicians |

## Essential resources

As a minimum, centres will need to provide learners with access to workshop facilities to enable practical investigation of engine performance. Centres will need access to engine performance measuring equipment.

## Employer engagement and vocational contexts

Learners could be introduced to a variety of professionals from different companies and organisations such as workshop managers, product designers, component testers, etc. to broaden their knowledge and make the learning experience interesting and contextualised. This could be through guest lectures or off-site visits to different establishments.

## Indicative reading for learners

### Textbooks

Taylor G, Fuller A and Greer A – *BTEC National Mathematics for Technicians, 3rd Edition* (Nelson Thornes, 2004) ISBN 0748779493

Twigg P – *Science for Motor Vehicle Engineers* (Butterworth-Heinemann, 1995) ISBN 034064527X

### Journals

*International Journal of Mechanical Sciences*

### Websites

| | |
|---|---|
| www.epi-eng.com | specialists in the design and development of piston engines and of power transmission systems |
| www.greendieseltechnology.com | sustainable innovation |
| www.physicsclassroom.com | online interactive tutorial of basic physics concepts |

## Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | researching the performance of engines<br>using formulae |
| **Creative thinkers** | designing types of clutch<br>describing how ratios affect vehicle performance |
| **Reflective learners** | describing how ratios affect vehicle performance |
| **Team workers** | planning and carrying out engine performance testing |
| **Self-managers** | discussing characteristics of friction |
| **Effective participators** | recording data<br>discussing limiting aspects of clutch design. |

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | planning and carrying out research activities related to the unit<br>evaluating and carrying out extended thinking |
| **Creative thinkers** | asking questions to extend their thinking during lectures and practical sessions<br>trying out alternatives or new solutions |
| **Reflective learners** | identifying opportunities for their own achievements |
| **Team workers** | assisting is group activities |
| **Self-managers** | setting own targets for accurate completion of work<br>asking for assistance |
| **Effective participators** | encouraging debate. |

## Functional Skills – Level 2

| Skill | When learners are ... |
|---|---|
| **ICT – Use ICT systems** | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | producing graphs and reports for engine performance |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| **Mathematics** | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | using formulae to determine appropriate clutch sizes |
| Identify the situation or problem and the mathematical methods needed to tackle it | |
| Select and apply a range of skills to find solutions | |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | |
| **English** | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | reporting the findings of their engine performance test. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | |